# Supplemental Report – May 2003

# 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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***Prepared For:***

**State of Maine**
**Department of Environmental Protection**
**Contract No. 2000R-33**
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# 1.0 SUMMARY

Recent work on the Dead River dam model includes:

- revision of the model to account for a crest elevation of 275.3
- improved measurement of storage areas on Androscoggin Lake and Dead River floodplain
- calibration of the model to recorded events
- revision of Androscoggin River peak flows and hydrograph shapes for selected storms
- running predictions for options which include no dam, dam configuration before recent rehabilitation, rehabilitated dam with 3'/3.5' boards, and rubber dam with a crest elevation above the 5-year flood
- tabulation of predictions of lake level, and time to drain for each dam option, for selected storms
- migrated model to HEC-RAS Version 3.1

The following sections describe each task in detail, and results are summarized in a final section.

# 2.0 REVISED CREST, RE-MEASURED STORAGE AREAS, MODEL CALIBRATION

A field survey by the USGS revealed that the dam crest is at elevation 275.3 rather than the 274 assumed for the April, 2002 study. Additional data was collected on flood elevations and flows at the USGS gage at Route 106, and on storage areas in the lake and floodplain. With the crest elevation change, and storage area revisions, the model was checked for accuracy using the gaged data. Specific tasks included:

- The dam crest elevation was revised to 275.3 and all model cross section elevations that were based on the dam crest datum were revised.
- The storage areas along the Dead River floodplain and around Androscoggin Lake were re-measured using GIS data, and resulting storage volumes on the Lake side of the dam were recomputed.
- A simulation was run for a recorded flood that occurred in the spring of 2002, and for which flow and stage data were available at the USGS gages on the Dead River and on the Androscoggin River at Rumford.
- For this simulation, the dam was assumed to have 2' boards over 65% of its crest length.
- The simulation was run for the time when water was flowing from the Androscoggin River to Androscoggin Lake.

The following narrative follows the columns in summary table 1 and describes the source of data for each column.

## *2.1 Recorded overtopping event on Dead River*

Records from the recently installed USGS gage on the Dead River were reviewed to find evidence of an overtopping event. The period of record, July 28, 2001, to December 2002 was reviewed. The period April 12 through April 22, 2002, was selected for analysis because the Dead River gage indicated that the lake level had risen significantly during this time period. The data are plotted in figures 1 and 2. No other suitable overtopping event was identified for the time period that the gage has been operating.

## *2.2 Flow Data on Androscoggin River*

The US Geological Survey in Augusta was contacted to obtain flow data at the USGS gage on the Androscoggin River at the Rumford Gage. Figure 3 is a plot of the data, and flows in column 2 of the spreadsheet are taken from the graph, and from the data file. This data is preliminary and has not been reviewed for publication by the USGS.

## *2.3 Flow Data on Androscoggin River at Dead River Junction*

Two means were used to transpose the flow data at Rumford, to the point where the Dead River joins the Androscoggin. First, in E/PRO's April, 2002 report, Figure 2 is a plot of flow vs. drainage area along the Androscoggin River. Second, the flows were multiplied by a ratio of drainage area at the Dead River over drainage area at Rumford. Both methods yielded very similar results. Flows at the Dead River junction are listed in column 3 and are based on the April, 2002 report's Figure 2.

## *2.4 Elevation in Androscoggin River at Dead River junction*

The April, 2002 report included a HEC-RAS model of the Androscoggin River for the reach north of the Route 219 bridge. From this model, a rating curve showing flow vs. elevation was plotted at the location of the Dead River junction. Using the flows in the summary table column 3, the rating curve was then used to find water surface elevation in the Androscoggin River. These elevations are shown in column 4. The rating curve of flow vs. elevation for the section of the Androscoggin River at the Dead River junction is shown in Figure 4.

## *2.5 Flow into Dead River*

The April 2002 report included a HEC-RAS hydraulic model for the Dead River. This model was modified to reflect the crest elevation being 275.3 and to reflect about 35% of the crest having no boards and 65% of the crest having 2' boards. The model resulted in a rating curve of flow vs. elevation at the junction with the Androscoggin River. At this location, the elevation of the Androscoggin River, the configuration of the Dead River dam, and the level of Androscoggin Lake all affect the rate of flow in the Dead River. Flows into the Dead River were than taken from the rating curve (Figure 5) based on the elevation in the Androscoggin River at 12-hour intervals. The resulting flow hydrograph into the Dead River is listed in column 5 of the summary table.

It should be noted that the elevation in the lake would only affect flow in the Dead River if it were above the crest of the dam (>275.3). Several model trials were run for the Dead River model with varying lake levels, so that inflow could be adjusted as the lake level rose.

### *2.6 Volumetric Inflow to Androscoggin Lake*

The flows in the Dead River were summed over time to obtain inflow volumes. Average flows in cubic feet per second for each 12-hour period were transformed to inflow in acre-feet. Incremental volumes were summed for the entire simulation period. Incremental volumes are shown in column 6, and total inflow volume is shown in column 7 of the summary table.

### *2.7 Elevation in Androscoggin Lake*

Storage area for the lake and for the Dead River floodplain were measured using contours for 269, 270, 280 and 290, between the Dead River dam and Pocasset Lake. Incremental areas for each foot of elevation between these contours were interpolated. Incremental storage volume was then computed for each foot of elevation above 269. This data is shown in figure 6. It has been reported that the lake level varies from about 269 to 272 or so, without overtopping of the dam. Total available storage was computed for starting lake levels of 269, 270, 271 and 272. Review of the April 2002 flood event indicated that the lake level was about 272 when the overtopping event occurred, so storage above that level was considered for the analysis. The total inflow volume in column 7 was compared to available storage volume above elevation 272, and a lake level was computed for each time step. Column 8 shows lake level.

### *2.8 Comparison of computed/modeled lake level with recorded level*

Column 9 shows lake levels recorded by the Dead River gage. A review of the plot of gage data, and the record shows that the data is suspect for April 18 to April 21, but it appears that an interpolated curve can be plotted to account for this time period.

Comparing the modeled/predicted elevations with the recorded elevations shows very good correlation, generally predicting lake surface elevation within 0.1 to 0.2 feet. It appears that the lake level peaks at about 276.3 feet, and that the Dead River and the lake equilibrate on about April 20. Before this time, there is sufficient gradient going from the Androscoggin River to the lake, such that lake level does not affect the flow rates predicted by the rating curve. In other words, the flood peak passes on the Androscoggin River before the lake level rises enough (above the crest elevation of 275.3) to impede flow. This effect was noted in the April 2002 report for larger floods as well.

### *2.9 Comparison of computed/modeled flow rate with USGS gage flow rate*

Flows at the USGS Dead River gage are computed by USGS based on the recorded elevations at the gage. Lower flow rates below 500 cfs may not be accurate according to USGS due to a lack of calibration data for that range of flows. Several flood events have been measured by USGS to develop a flow/elevation curve at this location.

Flows computed by USGS at the gage were compared to flows predicted by the model and showed good correlation. Column 5 of the summary table is predicted flow in the Dead River, and column 10 in the summary table shows flows as computed by USGS. Negative flows in this column reflect flow INTO the lake. These are average daily flow rates. Again, the correlation between the model and the USGS flow data is quite good.

### *2.10 Calibration Summary and Conclusion*

The model components are used to translate the recorded or predicted flow in the Androscoggin River at Rumford to a water surface elevation and duration in Androscoggin Lake. Model components include gaged data at Rumford and computed flow rates at the Dead River junction, a hydraulic model of the Androscoggin River, a hydraulic model of the Dead River, which can have varying dam configurations and lake levels, and storage-elevation relationship for Androscoggin Lake and the river floodplain.

The model components were tested using a recorded overtopping event in April of 2002. Recorded flow data at Rumford was routed through the model components to predict lake levels and flow rates in the Dead River. Model results showed good correlation with recorded data.

## 3.0 ANDROSCOGGIN RIVER FLOWS

Flood frequencies chosen for further analysis included the minimum overtopping flood, and the 1-, 2-, 5-, 10- and 25-year floods. In the April, 2002 report, the effect on the Androscoggin River of losing the storage provided by Androscoggin Lake was evaluated at a representative location. For the 50- and 100-year floods, Androscoggin Lake stores as much as 14% of the total river flow. Blocking off this storage basin with a high dam could result in significantly higher flood elevations in reaches of the Androscoggin River downstream of the Dead River. Blocking off the 5-year flood could cause a rise of about one foot at the Route 219 twin bridges, while blocking off the 50- or 100-year floods, could cause a rise of 3-6' above current flood levels.

Inflow from the 50- and 100-year storms is not significantly altered, unless dam crest elevation is more than 5 feet above the current crest. Because it is not practical to modify the Dead River dam enough to impact these rare events at its present location, effort in this analysis was focused on smaller, but more frequent storm events. A crest elevation of 282 was selected as the upper practical limit due to topographic constraints (elevation of fields near current dam) and to the unacceptable effect of higher dams on flooding on the Androscoggin River, if the dam were relocated.

For the April, 2002 report, peak flood flows for the Androscoggin River were taken from the 1977 FEMA Flood Insurance Study of Leeds. Analysis of river gage records since that time yields a lower set of peak flows for selected storm frequencies. This discrepancy was discussed in the April report. For this final analysis, the gage record flow-frequency curves were used to predict peak flows at the Dead River. The following peak flows were used for this analysis for the Androscoggin River at the Dead River:

**Peak Flows by Frequency, Androscoggin River at Junction with Dead River**

| Frequency | Flow rate, cfs |
|---|---|
| Minimum Overtopping | 25,000 |
| 1-year | 28,000 |
| 2-year | 31,500 |
| 5-year | 42,000 |
| 10-year | 49,000 |
| 25-year | 56,000 |

To create hydrographs of flow vs. time, which accurately reflect typical flood events on the Androscoggin River, historical floods from April, 2002 and 2000, March 2000, and April 1994, 1993, and 1987 for the Rumford gage were collected and plotted. The flows were then transferred to the Dead River based on the difference in drainage areas, as shown in Figure 2 of the April, 2002 report. Figure 7 shows these flood events, plotted as flow vs. time from start of flooding. These hydrograph shapes were used to plot synthetic hydrographs for each flow-frequency. The synthetic hydrographs used in the Dead River analysis are shown in Figure 8.

Flow at 12-hour intervals is summarized in Table 2. The relationship between flow and flood elevation in the Androscoggin River was calculated using model HEC-RAS, as described in the April, 2002 report. The flow-elevation relationship is approximate because no survey was conducted for cross sections on the Androscoggin River. However, the calibration run indicates that the flow-elevation curve at the Dead River is a reasonable approximation. Table 2 also shows flood elevations at 12-hour intervals for each selected flood-frequency.

### *3.1 Use of Model Data for Depth/Inundation/Frequency Studies*

Continued review of the record of flooding on the Androscoggin River indicates that typical 1- to 5-year events may occur as a series of two flood peaks within a week or so of each other. The flow frequency curve for the Androscoggin River is based on an annual series, not a partial duration series, and would therefore include only one peak per year. All flood hydrographs used for the analysis of the Dead River dam were assumed to have a single peak, where the river would rise and fall, and the lake would respond to a single flood event.

However, experience and the model would show that in years where two events occur within a week of each other, the lake would fill to the projected level for a single event, and where the lake would normally begin to drain, a second flood event on the river would prevent that from occurring. This two-event flood, would then fill the lake a second time to the predicted depth, except that it would occur on top of the first event, with no decrease in lake level between the events. It appears that this phenomenon may result in lake levels more typical of a 10-year event or more, although the peak flow rate for one or both events would be more like a 1- to 5-year event.

The calibration event resulted in this type of phenomenon. Although the event had only one peak, the river stayed above the dam crest for 6-7 days. Thus, the lake could not drain, and flows continued to enter the lake basin. The duration of a typical single peak event is only about 2-2.5 days. Although the peak flow for this event was typical of about a 3-4 year storm, the lake reached a level that would occur with a single peak event of approximately 10-year frequency. These lower-peak, longer duration flood events would be kept out by the new flashboards.

For the dam evaluation, single peak events were selected for analysis. However, for ecological studies, where depth and duration of inundation are critical, the double peak events should be analyzed. A means to accomplish this would be to obtain the total flow record for the Rumford gage, transpose it to the Dead River mouth, and calculate the depth and duration of inundation in the lake for several representative two-peak events based on the hydraulic models as described in this study. The total flow record would greatly assist in developing an accurate depth/duration curve for the lake for double events as well as for single events.

## 4.0 FINAL HECRAS MODEL

The calibrated HEC-RAS model of flow in the Dead River was revised to account for flow into Androscoggin Lake for options including:

- no dam
- current board configuration (3' and 3.5' boards for half of dam)
- new dam, crest elevation at 282 (just above 5-year flood).

The calibrated model included boards as shown on the cover of the April 2002 report, where about 65% of the dam has 2' flashboards. A profile of water surface elevation for representative flows vs. stream distance for the Dead River is shown as Figure 9.

For each dam configuration, a rating curve of flow vs. elevation was created at the junction point with the Androscoggin River. These curves are shown as figures 10, 11 and 12. Knowing the elevation in the Androscoggin River (Figure 4), and using the rating curves, flow into the Dead River was computed for each 12-hour time step. For each dam configuration, Table 2 summarizes:

- flow in cubic feet per second (cfs) into the Dead River/Androscoggin Lake, and
- total volume of flow in acre-feet into Androscoggin Lake, in 12-hour increments.

As discussed in the section on model calibration, a relationship between storage volume and lake elevation was created, allowing calculation of lake level based on known inflow volume.

Table 2 also summarizes predicted lake elevation for each flood-frequency and dam configuration.

River models were also revised for flow from the lake to the river for the selected floods. A rating curve of flow vs. lake elevation was created for the section nearest to the lake. These rating curves are shown as figures 13-16. A representative flood profile for the Dead River for flow from the lake to the river is shown as Figure 17.

For modeling flow from the lake to the river, the water surface elevation in the Androscoggin River was approximated. Conditions in the river for times of outflow will vary for every flood. In order to compare the four different dam configurations, the identical river condition was assumed for each dam, and outflow rates were developed based on that assumption.

Time to drain the lake for each dam configuration and each flood frequency was then computed as summarized in table 3. Again, these times may vary from flood to flood, but for the theoretical events modeled, the same condition was used for each dam, so that results are comparable to each other. For each 12-hour time step, lake level, outflow volume, and outflow in cfs were computed, and the resulting lake level was determined for the end of each time step.

Finally, a summary table of the effects of each dam configuration was compiled. Table 4 lists flood frequency, peak inflow rate in cfs, inflow volume in acre-feet, lake level, and time to drain.

## 5.0 SUMMARY AND CONCLUSIONS

The set of models developed to simulate flow from the Androscoggin River to Androscoggin Lake via the Dead River were checked with a recorded flood event. Model results showed good correlation with elevation and timing of flood levels in Androscoggin Lake and for rate of flow in the Dead River.

The models include a step-backwater (HEC-RAS) model of the Androscoggin River, HEC-RAS models of the Dead River for four dam configurations, for flow to the lake and from the lake, and a storage-elevation curve for Androscoggin Lake.

The models show that the new board configuration of 3'/3.5' boards is effective to keep typical annual events from overtopping and flooding the lake. A small amount of flow enters the lake during a 2-year event. Without the dam, significant amounts of river water enter the lake and levels may stay high for as long as with a dam, because so much water has entered the lake.

# Tables and Figures Section

**Summary Table 1**

**Calibration/Check Run of Models for flow from Androscoggin River to Dead River**

| Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 | Col 9 | Col 10 |
|---|---|---|---|---|---|---|---|---|---|
| Date | Androscoggin River | | | Dead River | Androscoggin lake | | | Calibration Data | |
| | Flow in cfs | | Elevation | | | | | | |
| | Rumford see Fig 1 | at Dead river 4/22 report see Fig. 2 | at Dead River HECRAS rating curve | Inflow cfs HECRAS rating curve | Incremental vol acre-feet summation of column 5 | Cumulative volume acre-feet | Elev in lake model Table 1 | Recorded Elevation Figure 7 and Excel file * see note below | Recorded Flow Figure 8 and Excel file |
| 12-Apr | 7,500 | 9,400 | 270.2 | 0 | | | | | |
| | | | | | | | | | |
| 13-Apr | 7,000 | 8,800 | 270.0 | 0 | | | | | |
| | | | | | | | | | 16 |
| 14-Apr | 12,500 | 15,700 | 273.6 | 0 | | | | | |
| | 24,000 | 30,200 | 279.0 | 2000 | 992 | 992 | 272.2 | 272.0 | -850 |
| 15-Apr | 31,000 | 39,000 | 281.0 | 4000 | 2975 | 3967 | 272.9 | 272.8 | |
| | 30,000 | 37,700 | 280.5 | 3300 | 3620 | 7587 | 273.6 | 273.5 | -3570 |
| 16-Apr | 27,000 | 33,900 | 279.5 | 2500 | 2876 | 10463 | 274.2 | 274.2 | |
| | 24,000 | 30,200 | 279.0 | 2000 | 2231 | 12694 | 274.7 | 274.6 | -2400 |
| 17-Apr | 22,000 | 27,700 | 278.0 | 950 | 1463 | 14157 | 275.2 | 275.0 | |
| | 22,000 | 27,700 | 278.0 | 950 | 942 | 15099 | 275.3 | 275.4 | -854 |
| 18-Apr | 22,000 | 27,700 | 278.0 | 950 | 942 | 16041 | 275.4 | *275.6* | |
| | 22,000 | 27,700 | 278.0 | 950 | 942 | 16983 | 275.6 | *275.7* | -681 |
| 19-Apr | 22,000 | 27,700 | 278.0 | 950 | 942 | 17926 | 275.8 | *275.9* | |
| | 21,000 | 26,400 | 276.5 | 800 | 868 | 18793 | 276.1 | *276.0* | -530 |
| 20-Apr | 20,000 | 25,100 | 275.5 | 750 | 769 | 19562 | 276.2** | *276.1* | |
| | 18,500 | 23,300 | 274.5 | 0 | 372 | 19934 | 276.2 | *276.1* | -113 |
| 21-Apr | 17,500 | 22,000 | 273.0 | 0 | 0 | | | *276.2* | |
| | 14,000 | 17,600 | | | | | | *276.3* | 502 |
| 22-Apr | 10,000 | 12,600 | | | | | | *276.3* | |

| | |
|---|---|
| Drainage Area Rumford | 2068 |
| Drainage Area at Dead River | 2600 |
| Ratio | 1.257 |

* Elevations in itallics are not recorded - interpolated from data plot

** Note..flow gradient reverses

**Table 2**
**Flows into Dead River**

**Volume Inflow to Lake**

| hour | Androscoggin River | | no dam | existing | 3/3.5' bds | elev 282 | no dam | | | existing | | | 3/3.5' bds | | | elev 282 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow, cfs | elev. | flow | flow | flow | flow | acre feet | cum.acre ft | lake el. | acre feet | cum.acre ft | lake el. | acre feet | cum.acre ft | lake el. | acre feet | cum.acre ft | lake el. |
| **< 1-year** | | | | | | | | | | | | | | | | | | |
| 0 | 25000 | 275.3 | 2000 | 0 | | | 992 | 992 | 272.2 | 0 | 0 | 272.0 | 0 | 0 | | 0 | 0 | |
| 12 | 26500 | 276 | 2000 | 300 | | | 1983 | 2975 | 272.6 | 149 | 149 | 272.0 | 0 | 0 | | 0 | 0 | |
| 24 | 25000 | 276 | 2000 | 500 | 0 | 0 | 1983 | 4959 | 273.0 | 397 | 545 | 272.1 | 0 | 0 | | 0 | 0 | |
| 36 | 27000 | 276 | 2000 | 300 | | | 1983 | 6942 | 273.5 | 397 | 942 | 272.2 | 0 | 0 | | 0 | 0 | |
| 48 | 27000 | 275.3 | 2000 | 0 | | | 1983 | 8926 | 273.9 | 149 | 1091 | 272.2 | 0 | 0 | 272.0 | 0 | 0 | 272.0 |
| | | | | | | | | | | | | | | | | | | |
| **1-year** | | | | | | | | | | | | | | | | | | |
| 0 | 25000 | 275.3 | 2000 | 0 | | | | | | | | | | | | | | |
| 12 | 27000 | 277 | 2800 | 500 | | | 2380 | 2380 | 272.6 | 248 | 248 | | 0 | 0 | | 0 | 0 | |
| 24 | 28000 | 278 | 3200 | 1000 | 0 | 0 | 2975 | 5355 | 273.1 | 744 | 992 | | 0 | 0 | | 0 | 0 | |
| 36 | 27000 | 277 | 2800 | 500 | | | 2975 | 8331 | 273.7 | 744 | 1736 | | 0 | 0 | | 0 | 0 | |
| 48 | 25000 | 275.3 | 2000 | 0 | | | 2380 | 10711 | 274.2 | 248 | 1983 | | 0 | 0 | | 0 | 0 | |
| | | | | | | | 992 | 11702 | 274.5 | 0 | 1983 | 272.4 | 0 | 0 | 272.0 | 0 | 0 | 272.0 |
| **2-year** | | | | | | | | | | | | | | | | | | |
| 0 | 25000 | 275.3 | 2000 | 0 | | | | | | | | | | | | | | |
| 12 | 29000 | 279 | 4000 | 1800 | 300 | | 2975 | 2975 | 272.6 | 893 | 893 | 272.2 | 149 | 149 | | 0 | 0 | |
| 24 | 31500 | 279.1 | 4200 | 2000 | 400 | 0 | 4066 | 7041 | 273.5 | 1884 | 2777 | | 347 | 496 | | 0 | 0 | |
| 36 | 29000 | 279 | 4000 | 1800 | 300 | | 4066 | 11107 | 274.3 | 1884 | 4661 | | 347 | 843 | | 0 | 0 | |
| 48 | 25000 | 275.3 | 2000 | 0 | | | 2975 | 14083 | 275.0 | 893 | 5554 | | 149 | 992 | | 0 | 0 | |
| | | | | | | | 992 | 15074 | 275.2 | 0 | 5554 | 273.2 | 0 | 992 | 272.2 | 0 | 0 | 272.0 |
| **5-year** | | | | | | | | | | | | | | | | | | |
| 0 | 25000 | 275.3 | 2000 | 0 | 0 | | | | | | | | | | | | | |
| 12 | 33000 | 279.5 | 4300 | 2000 | 350 | | 3124 | 3124 | 272.9 | 992 | 992 | 272.2 | 174 | 174 | 272.0 | 0 | 0 | |
| 24 | 39000 | 281 | 5000 | 4000 | 2000 | | 4612 | 7736 | 273.6 | 2975 | 3967 | | 1165 | 1339 | | 0 | 0 | |
| 36 | 42000 | 281.8 | 5800 | 5000 | 3200 | 0 | 5355 | 13091 | 274.7 | 4463 | 8430 | | 2579 | 3917 | | 0 | 0 | |
| 48 | 37000 | 280.3 | 4800 | 3500 | 1200 | | 5256 | 18347 | 275.9 | 4215 | 12645 | 274.7 | 2182 | 6099 | | 0 | 0 | |
| 60 | 25000 | 275.3 | 2000 | 0 | 0 | | 3372 | 21719 | 276.6 | 1736 | 14380 | 275.0 | 595 | 6694 | 273.5 | 0 | 0 | 272.0 |
| | | | | | | | | | | | | | | | | | | |
| **10-year** | | | | | | | | | | | | | | | | | | |
| 0 | 25000 | 275.3 | 2000 | 0 | 0 | 0 | | | | | | | | | | | | |
| 12 | 35000 | 279.8 | 4400 | 2100 | 800 | 0 | 3174 | 3174 | 272.6 | 1041 | 1041 | 272.2 | 397 | 397 | 272.1 | 0 | 0 | |
| 24 | 43000 | 282 | 6000 | 5100 | 3500 | 0 | 5157 | 8331 | 273.7 | 3570 | 4612 | | 2132 | 2529 | 272.5 | 0 | 0 | |
| 36 | 49000 | 283.5 | 8000 | 7500 | 6800 | 2500 | 6942 | 15273 | 275.2 | 6248 | 10860 | | 5107 | 7636 | 273.6 | 1240 | 1240 | |
| 48 | 43000 | 282 | 6000 | 5100 | 3500 | 0 | 6942 | 22215 | 276.7 | 6248 | 17107 | | 5107 | 12744 | 274.7 | 1240 | 2479 | |
| 60 | 37000 | 280.3 | 4800 | 3500 | 1200 | 0 | 5355 | 27570 | 277.8 | 4264 | 21372 | 276.5 | 2331 | 15074 | 275.2 | 0 | 2479 | |
| 72 | 25000 | 275.3 | 2000 | 0 | 0 | 0 | 3372 | 30942 | 278.5 | 1736 | 23107 | 276.9 | 595 | 15669 | 275.3 | 0 | 2479 | 272.5 |
| | | | | | | | | | | | | | | | | | | |
| **25-year** | | | | | | | | | | | | | | | | | | |
| 0 | 25000 | 275.3 | 2000 | 0 | 0 | 0 | | | | | | | | | | | | |
| 12 | 38000 | 280.6 | 4900 | 3700 | 1400 | 0 | 3421 | 3421 | 272.7 | 1835 | 1835 | 272.3 | 694 | 694 | 272.1 | 0 | 0 | |
| 24 | 49000 | 283.5 | 8000 | 7200 | 5600 | 2500 | 6397 | 9818 | 274.1 | 5405 | 7240 | | 3471 | 4165 | | 1240 | 1240 | |
| 36 | 56000 | 285 | 9700 | 9200 | 9000 | 6500 | 8777 | 18595 | 275.9 | 8132 | 15372 | | 7240 | 11405 | | 4463 | 5702 | |
| 48 | 52000 | 284 | 8200 | 8000 | 7000 | 3000 | 8876 | 27471 | 277.8 | 8529 | 23901 | | 7934 | 19339 | | 4711 | 10413 | |
| 60 | 46000 | 282.3 | 6500 | 5800 | 4200 | 300 | 7289 | 34760 | 279.3 | 6843 | 30744 | 278.5 | 5554 | 24893 | | 1636 | 12050 | |
| 72 | 38000 | 280.6 | 4900 | 3700 | 1400 | 0 | 5653 | 40413 | 280.5 | 4711 | 35455 | 279.4 | 2777 | 27669 | 277.8 | 149 | 12198 | |
| 84 | 25000 | 275.3 | 2000 | 0 | 0 | 0 | 3421 | 43835 | 281.2 | 1835 | 37289 | | 694 | 28364 | 278.0 | 0 | 12198 | 274.6 |

Table 3
Androscoggin Lake

Flooding Conditions - Lake Levels and Estimated Time to Drain

| Frequency | No Dam | | | Existing dam | | | 3'/3.5' boards | | | Crest at el.282 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Elevation | Volume acre feet | Outflow | Elevation | Volume acre feet | Outflow | Elevation | Volume acre feet | Outflow | Elevation | Volume acre feet | Outflow |
| <1-year | 273.9 | 8926 | 1500 | 272.2 | 1091 | 500 | 272 | 0 | | 272 | | |
| 12 | 273.6 | 7438 | 1400 | 272.1 | 595 | 500 | | | | | | |
| 24 | 273.3 | 6050 | 1000 | 272.0 | 99 | 500 | | | | | | |
| 36 | 273.1 | 5058 | 1000 | | | | | | | | | |
| 48 | 272.9 | 4066 | 1000 | | | | | | | | | |
| 60 | 272.6 | 3075 | 950 | | | | | | | | | |
| 72 | 272.4 | 2133 | 950 | | | | | | | | | |
| 84 | 272.2 | 1190 | 950 | | | | | | | | | |
| 96 | 272.1 | 248 | 950 | | | | | | | | | |
| 1-year | 274.5 | 11702 | 1800 | 272.4 | 1983 | 800 | 272 | 0 | | 272 | 0 | |
| 12 | 274.1 | 9917 | 1500 | 272.2 | 1190 | 500 | | | | | | |
| 24 | 273.8 | 8429 | 1200 | 272.1 | 694 | 500 | | | | | | |
| 36 | 273.5 | 7239 | 1000 | 272.0 | 198 | 500 | | | | | | |
| 48 | 273.3 | 6247 | 1000 | | | | | | | | | |
| 60 | 273.1 | 5256 | 1000 | | | | | | | | | |
| 72 | 272.9 | 4264 | 950 | | | | | | | | | |
| 84 | 272.7 | 3322 | 950 | | | | | | | | | |
| 96 | 272.5 | 2380 | 950 | | | | | | | | | |
| 108 | 272.3 | 1438 | 950 | | | | | | | | | |
| 120 | 272.1 | 495 | 950 | | | | | | | | | |
| 132 | 271.9 | -447 | | | | | | | | | | |
| 2-year | 275.2 | 15074 | 1900 | 273.2 | 5554 | 1000 | 272.2 | 992 | 800 | 272 | 0 | |
| 12 | 274.8 | 13190 | 1900 | 273.0 | 4562 | 950 | 272.0 | 199 | | | | |
| 24 | 274.4 | 11305 | 1800 | 272.8 | 3620 | 900 | | | | | | |
| 36 | 274.0 | 9520 | 1300 | 272.6 | 2728 | 900 | | | | | | |
| 48 | 273.7 | 8231 | 1100 | 272.4 | 1835 | 800 | | | | | | |
| 60 | 273.5 | 7140 | 1000 | 272.2 | 1042 | 500 | | | | | | |
| 72 | 273.3 | 6148 | 1000 | 272.1 | 546 | 500 | | | | | | |
| 84 | 273.1 | 5157 | 1000 | 272.0 | 50 | 500 | | | | | | |
| 96 | 272.9 | 4165 | 950 | | | | | | | | | |
| 108 | 272.7 | 3223 | 950 | | | | | | | | | |
| 120 | 272.5 | 2281 | 950 | | | | | | | | | |
| 132 | 272.3 | 1338 | 950 | | | | | | | | | |
| 144 | 272.1 | 396 | 950 | | | | | | | | | |
| 156 | 271.9 | -546 | | | | | | | | | | |
| 5-year | 276.6 | 21719 | 2300 | 275.0 | 14380 | 1400 | 273.5 | 6694 | 900 | 272 | 0 | |
| 12 | 276.1 | 19438 | 2100 | 274.7 | 12992 | 1300 | 273.2 | 5801 | 800 | | | |
| 24 | 275.6 | 17355 | 1900 | 274.5 | 11702 | 1300 | 273.1 | 5008 | 750 | | | |
| 36 | 275.2 | 15471 | 1900 | 274.2 | 10413 | 1200 | 272.9 | 4264 | 750 | | | |
| 48 | 274.9 | 13587 | 1900 | 273.9 | 9223 | 1100 | 272.7 | 3520 | 750 | | | |
| 60 | 274.5 | 11702 | 1800 | 273.7 | 8132 | 1000 | 272.6 | 2777 | 750 | | | |
| 72 | 274.1 | 9917 | 1400 | 273.5 | 7140 | 950 | 272.4 | 2033 | 750 | | | |
| 84 | 273.8 | 8529 | 1000 | 273.3 | 6198 | 950 | 272.3 | 1289 | 700 | | | |
| 96 | 273.6 | 7537 | 1000 | 273.1 | 5256 | 900 | 272.1 | 595 | 700 | | | |
| 108 | 273.4 | 6545 | 1000 | 272.9 | 4363 | 900 | 272.0 | -99 | | | | |
| 120 | 273.2 | 5554 | 1000 | 272.7 | 3471 | 900 | | | | | | |
| 132 | 273.0 | 4562 | 1000 | 272.5 | 2578 | 800 | | | | | | |
| 144 | 272.7 | 3570 | 950 | 272.4 | 1785 | 800 | | | | | | |
| 156 | 272.6 | 2628 | 950 | 272.2 | 992 | 800 | | | | | | |
| 168 | 272.4 | 1686 | 950 | 272.0 | 198 | | | | | | | |
| | 272.2 | 744 | 950 | | | | | | | | | |
| 10-year | 278.5 | 30942 | 3600 | 276.9 | 23107 | 1900 | 275.3 | 15669 | 1300 | 272.5 | 2479 | 750 |
| 12 | 277.7 | 27372 | 3300 | 276.5 | 21223 | 1850 | 275.0 | 14380 | 1250 | 272.4 | 1735 | 750 |
| 24 | 277.1 | 24099 | 3000 | 276.1 | 19388 | 1800 | 274.8 | 13140 | 1200 | 272.2 | 991 | 700 |
| 36 | 276.4 | 21124 | 2600 | 275.7 | 17603 | 1500 | 274.5 | 11950 | 1200 | 272.1 | 297 | 700 |
| 48 | 275.9 | 18545 | 2000 | 275.4 | 16115 | 1400 | 274.3 | 10760 | 1100 | | | |
| 60 | 275.5 | 16562 | 1900 | 275.1 | 14727 | 1300 | 274.0 | 9669 | 1000 | | | |
| 72 | 275.1 | 14678 | 1800 | 274.8 | 13438 | 1300 | 273.8 | 8677 | 1000 | | | |
| 84 | 274.7 | 12793 | 1900 | 274.6 | 12148 | 1300 | 273.6 | 7686 | 1000 | | | |
| 96 | 274.3 | 10909 | 1800 | 274.3 | 10859 | 1200 | 273.4 | 6694 | 900 | | | |
| 108 | 273.9 | 9124 | 1200 | 274.0 | 9669 | 1100 | 273.2 | 5801 | 800 | | | |
| 120 | 273.7 | 7934 | 1000 | 273.8 | 8578 | 1000 | 273.1 | 5008 | 750 | | | |
| 132 | 273.5 | 6942 | 1000 | 273.6 | 7586 | 950 | 272.9 | 4264 | 750 | | | |
| 144 | 273.2 | 5950 | 1000 | 273.4 | 6644 | 950 | 272.7 | 3520 | 750 | | | |
| 156 | 273.0 | 4959 | 1000 | 273.2 | 5702 | 900 | 272.6 | 2776 | 750 | | | |
| 168 | 272.8 | 3967 | 950 | 273.0 | 4809 | 900 | 272.4 | 2033 | 750 | | | |
| 180 | 272.6 | 3025 | 950 | 272.8 | 3917 | 950 | 272.3 | 1289 | 700 | | | |
| 192 | 272.4 | 2082 | 950 | 272.6 | 2975 | 950 | 272.1 | 595 | 700 | | | |
| 204 | 272.2 | 1140 | 950 | 272.4 | 2033 | 900 | | | | | | |
| 216 | 272.0 | 198 | 950 | 272.2 | 1140 | 900 | | | | | | |
| 25-year | 281.2 | 43835 | 4700 | 279.4 | 35455 | 3000 | 278 | 28364 | 2000 | 274.6 | 12198 | 1200 |
| 12 | 280.2 | 39174 | 4000 | 278.8 | 32480 | 2900 | 277.5 | 26381 | 1900 | 274.3 | 11008 | 1100 |
| 24 | 279.4 | 35207 | 3800 | 278.2 | 29604 | 2800 | 277.1 | 24496 | 1800 | 274.1 | 9917 | 1000 |
| 36 | 278.6 | 31438 | 3400 | 277.6 | 26827 | 2100 | 276.8 | 22711 | 1800 | 273.9 | 8925 | 1000 |
| 48 | 277.9 | 28066 | 3100 | 277.2 | 24744 | 1950 | 276.4 | 20926 | 1800 | 273.7 | 7934 | 1000 |
| 60 | 277.2 | 24992 | 2700 | 276.8 | 22810 | 1900 | 276.0 | 19141 | 1750 | 273.5 | 6942 | 1000 |
| 72 | 276.7 | 22314 | 2100 | 276.4 | 20926 | 1850 | 275.7 | 17405 | 1700 | 273.2 | 5950 | 800 |
| 84 | 276.2 | 20232 | 2000 | 276.0 | 19091 | 1800 | 275.3 | 15719 | 1700 | 273.1 | 5157 | 750 |
| 96 | 275.8 | 18248 | 1900 | 275.6 | 17306 | 1600 | 274.9 | 14033 | 1300 | 272.9 | 4413 | 750 |
| 108 | 275.4 | 16364 | 1900 | 275.3 | 15719 | 1500 | 274.7 | 12744 | 1250 | 272.8 | 3669 | 750 |
| 120 | 275.0 | 14480 | 1800 | 275.0 | 14232 | 1300 | 274.4 | 11504 | 1200 | 272.6 | 2925 | 750 |
| 132 | 274.7 | 12695 | 1300 | 274.7 | 12943 | 1300 | 274.2 | 10314 | 1200 | 272.5 | 2181 | 750 |
| 144 | 274.4 | 11405 | 1000 | 274.4 | 11653 | 1300 | 273.9 | 9124 | 1000 | 272.3 | 1438 | 700 |
| 156 | 274.2 | 10414 | 1000 | 274.2 | 10364 | 1200 | 273.7 | 8133 | 1000 | 272.2 | 743 | 700 |
| 168 | 274.0 | 9422 | 1000 | 273.9 | 9174 | 1200 | 273.5 | 7141 | 1000 | 272.0 | 49 | 700 |
| 180 | 273.8 | 8430 | 1000 | 273.7 | 7984 | 1000 | 273.3 | 6149 | 1000 | | | |
| 192 | 273.6 | 7438 | 1000 | 273.5 | 6992 | 950 | 273.1 | 5157 | 900 | | | |
| 204 | 273.4 | 6447 | 950 | 273.3 | 6050 | 950 | 272.9 | 4265 | 750 | | | |
| 216 | 273.2 | 5504 | 950 | 273.1 | 5108 | 950 | 272.7 | 3521 | 750 | | | |
| 228 | 273.0 | 4562 | 900 | 272.9 | 4166 | 950 | 272.6 | 2777 | 750 | | | |
| 240 | 272.8 | 3670 | 900 | 272.7 | 3224 | 950 | 272.4 | 2033 | 750 | | | |
| 252 | 272.6 | 2777 | | 272.5 | 2281 | 950 | 272.3 | 1290 | 750 | | | |
| 264 | | | | 272.3 | 1339 | 950 | 272.1 | 546 | 750 | | | |
| 276 | | | | 272.1 | 397 | 900 | 272.0 | -198 | 750 | | | |

**Table 4**
**Dead River Dam**

**Summary of Dam Options**

| Frequency | Maximum Inflow | | Lake Level | Time to drain |
|---|---|---|---|---|
| | cfs | acre-feet | | days |
| | No Dam | | | |
| <1-year | 2000 | 8926 | 273.9 | 4 |
| 1-year | 3200 | 11702 | 274.5 | 5 |
| 2-year | 4200 | 15074 | 275.2 | 7.5 |
| 5-year | 5800 | 21719 | 276.6 | 8.5 |
| 10-year | 8000 | 30942 | 278.5 | 9 |
| 25-year | 9700 | 43835 | 281.2 | 11 |
| | Existing Dam | | | |
| <1-year | 500 | 1091 | 272.2 | 1.5 |
| 1-year | 1000 | 1983 | 272.4 | 2 |
| 2-year | 2000 | 5554 | 273.6 | 4 |
| 5-year | 5000 | 14380 | 275.2 | 7 |
| 10-year | 7500 | 23107 | 276.9 | 9 |
| 25-year | 9200 | 35455 | 279.4 | 12 |
| | 3/3.5' boards | | | |
| <1-year | 0 | 0 | 272 | 0 |
| 1-year | 0 | 0 | 272 | 0 |
| 2-year | 400 | 992 | 272.2 | 0.1 |
| 5-year | 3200 | 6697 | 273.5 | 4 |
| 10-year | 6800 | 15669 | 275.3 | 8 |
| 25-year | 9000 | 28364 | 278 | 11.5 |
| | Crest elev. 282 | | | |
| <1-year | 0 | 0 | 272 | 0 |
| 1-year | 0 | 0 | 272 | 0 |
| 2-year | 0 | 0 | 272 | 0 |
| 5-year | 0 | 0 | 272 | 0 |
| 10-year | 2500 | 2479 | 272.5 | 2 |
| 25-year | 6500 | 12198 | 274.6 | 7.5 |

Figure 1
Dead River Gage Flow

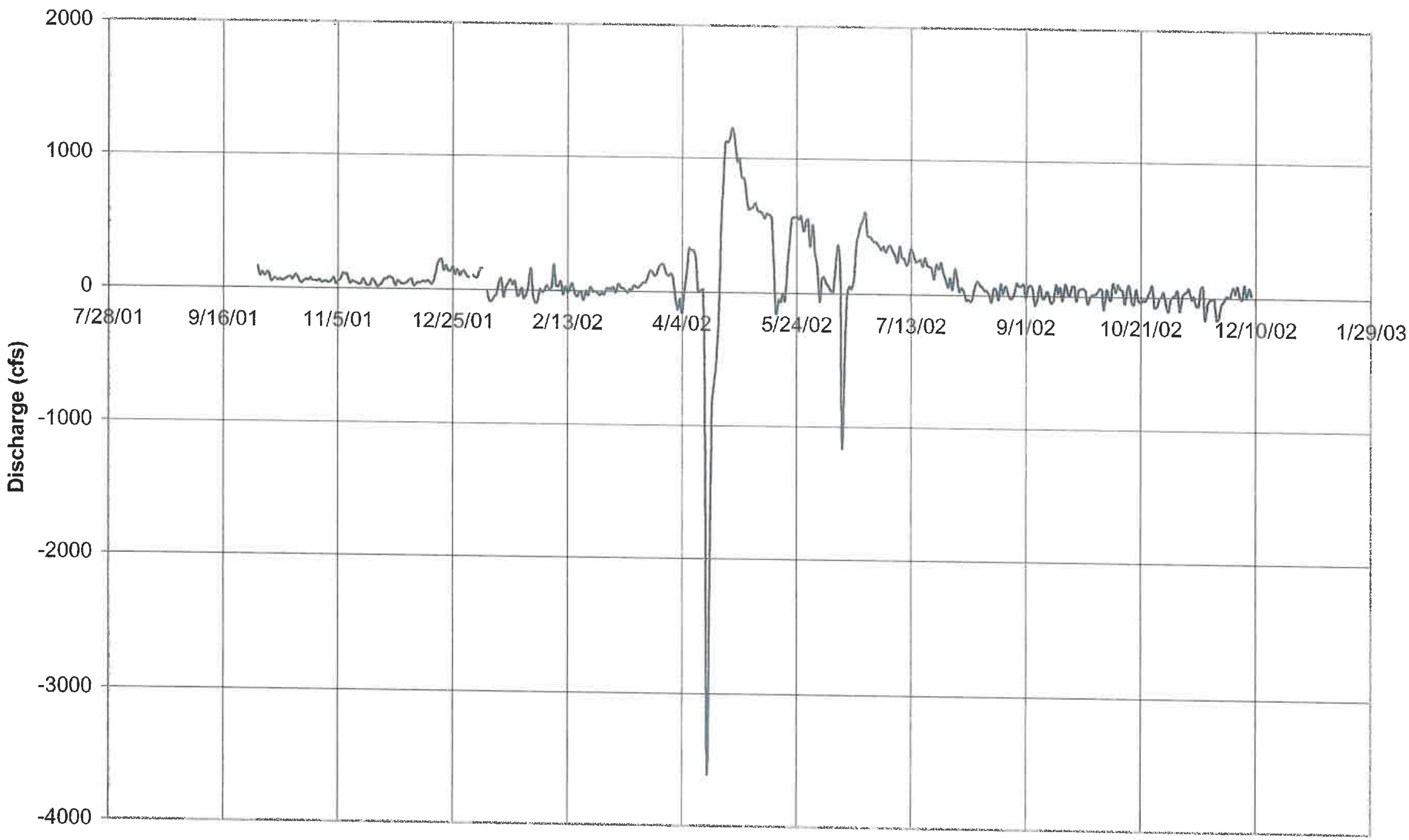


**Figure 2**
**Dead River Elevation**

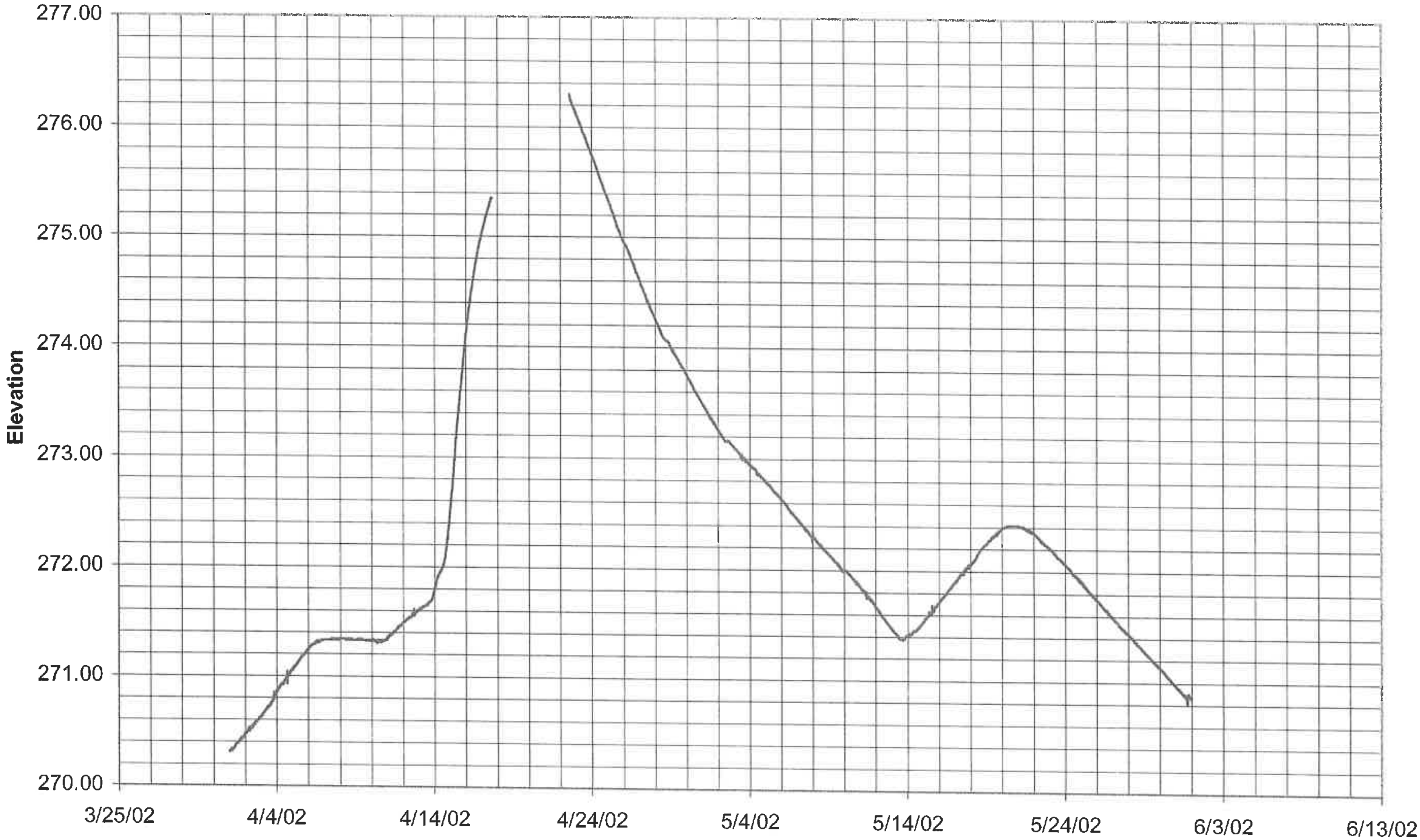
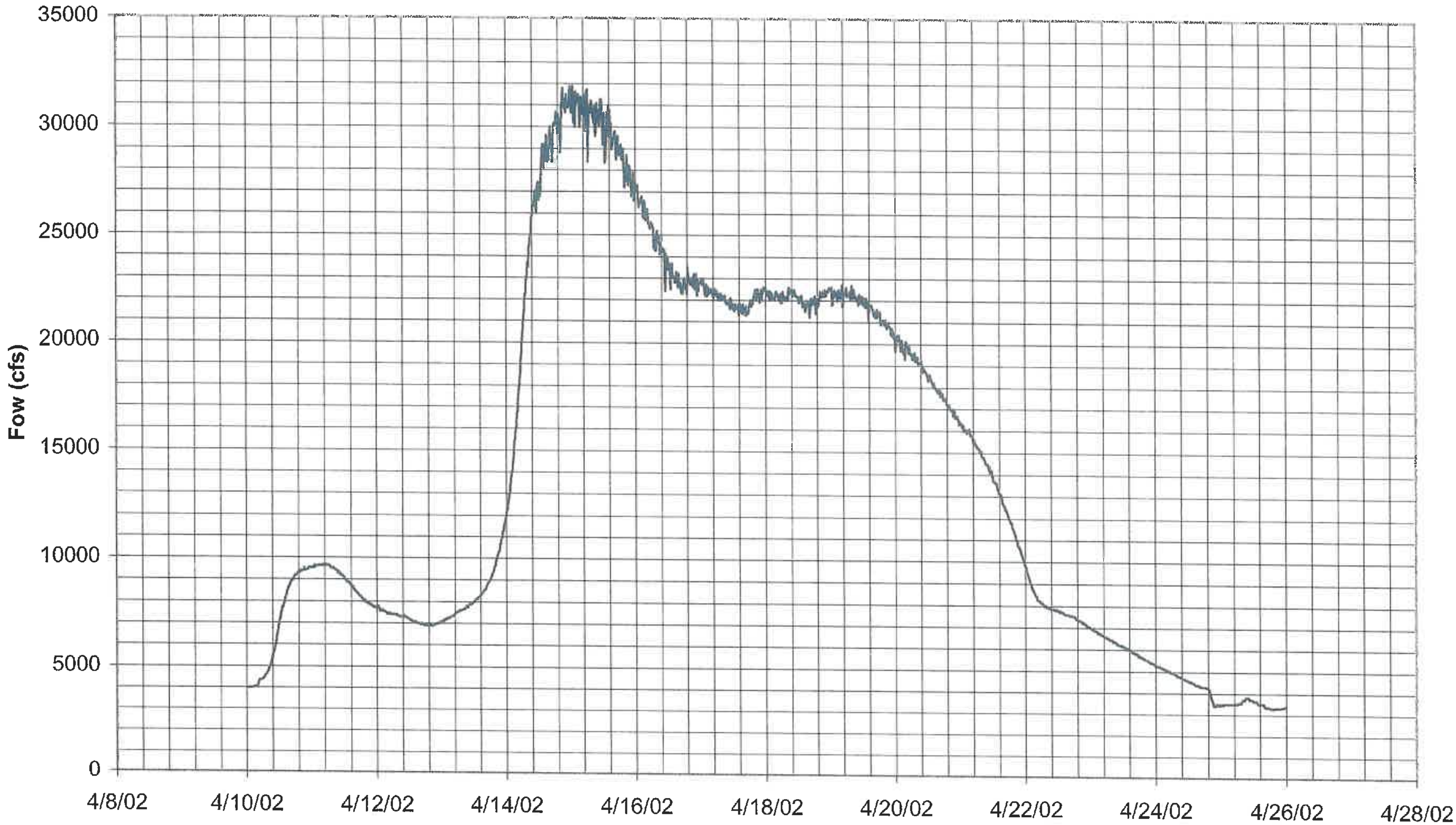
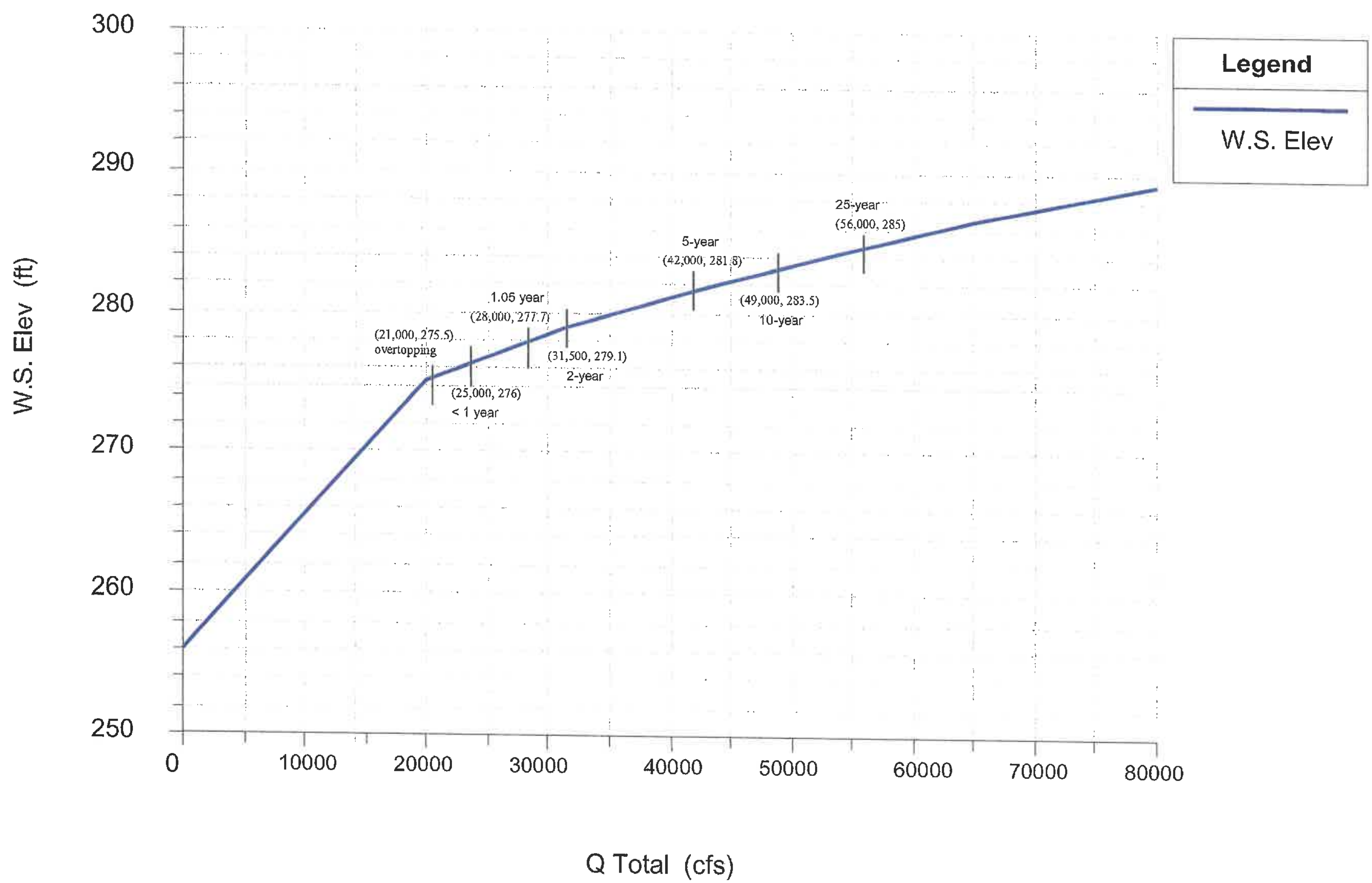


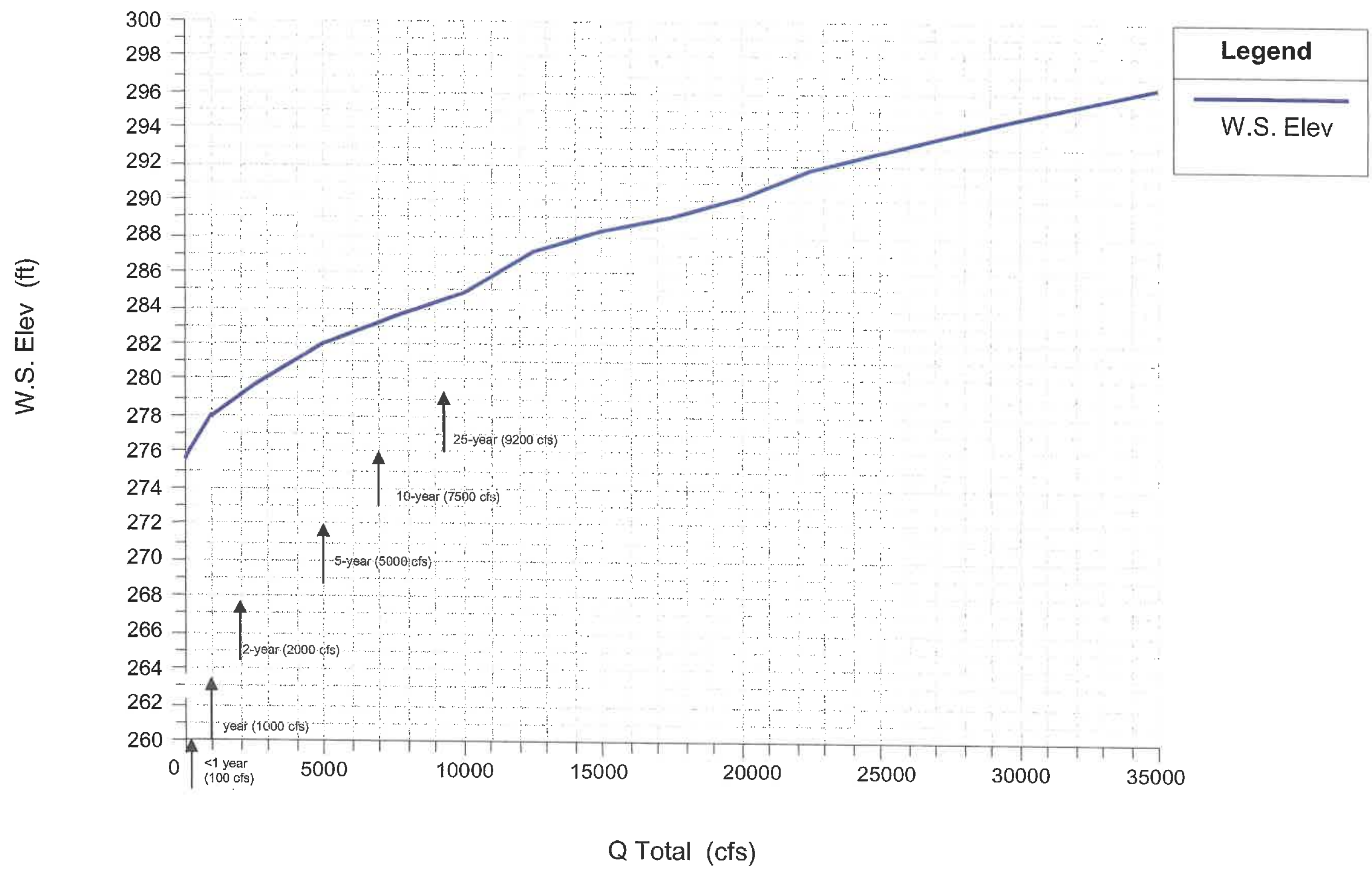
Figure 3
Androscoggin River Flow
at Rumford Gage



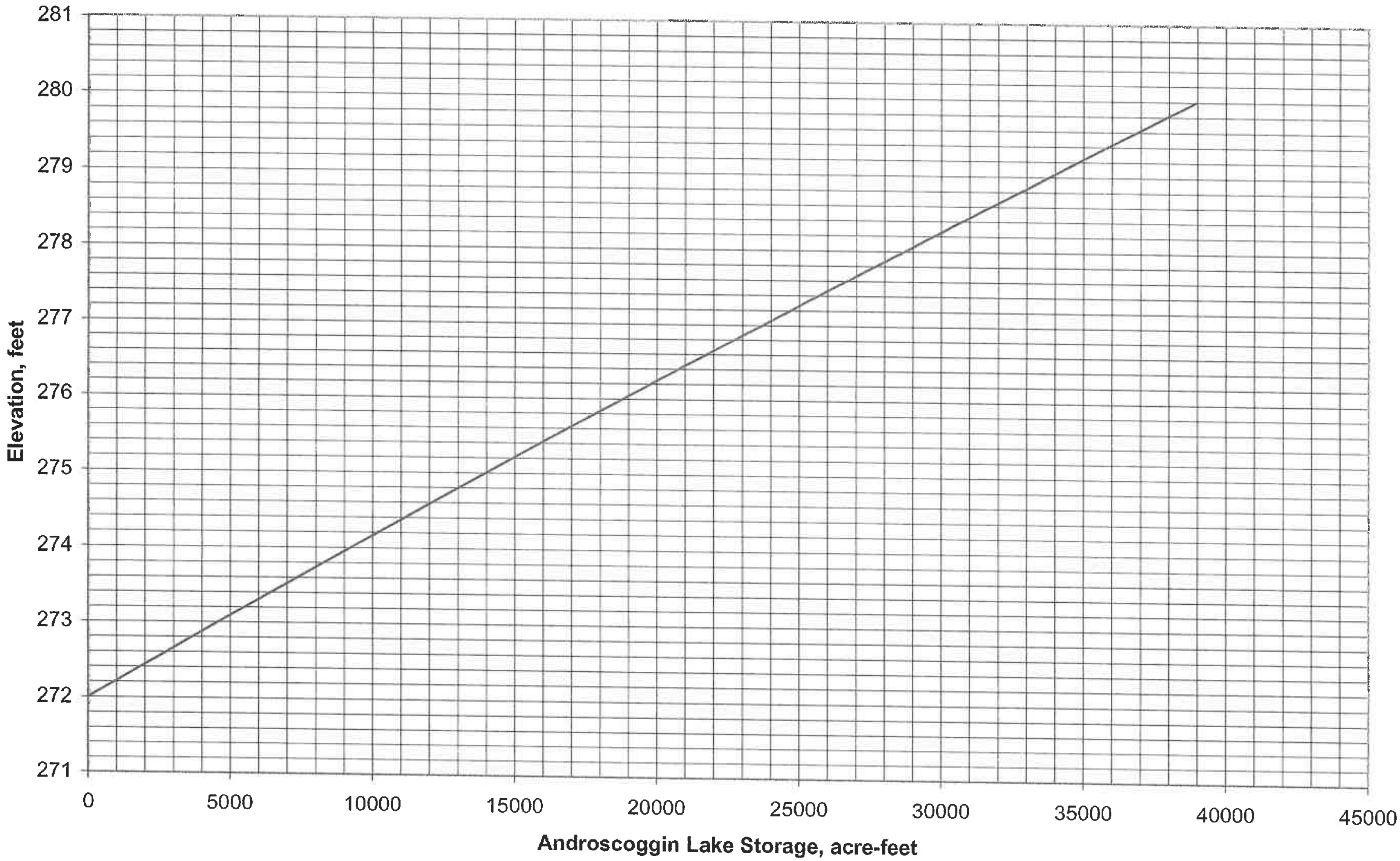
# Figure 4
# Androscoggin River - Dead River Junction



# Figure 5
## Dead River - River to Lake, 2' bds, Half Crest

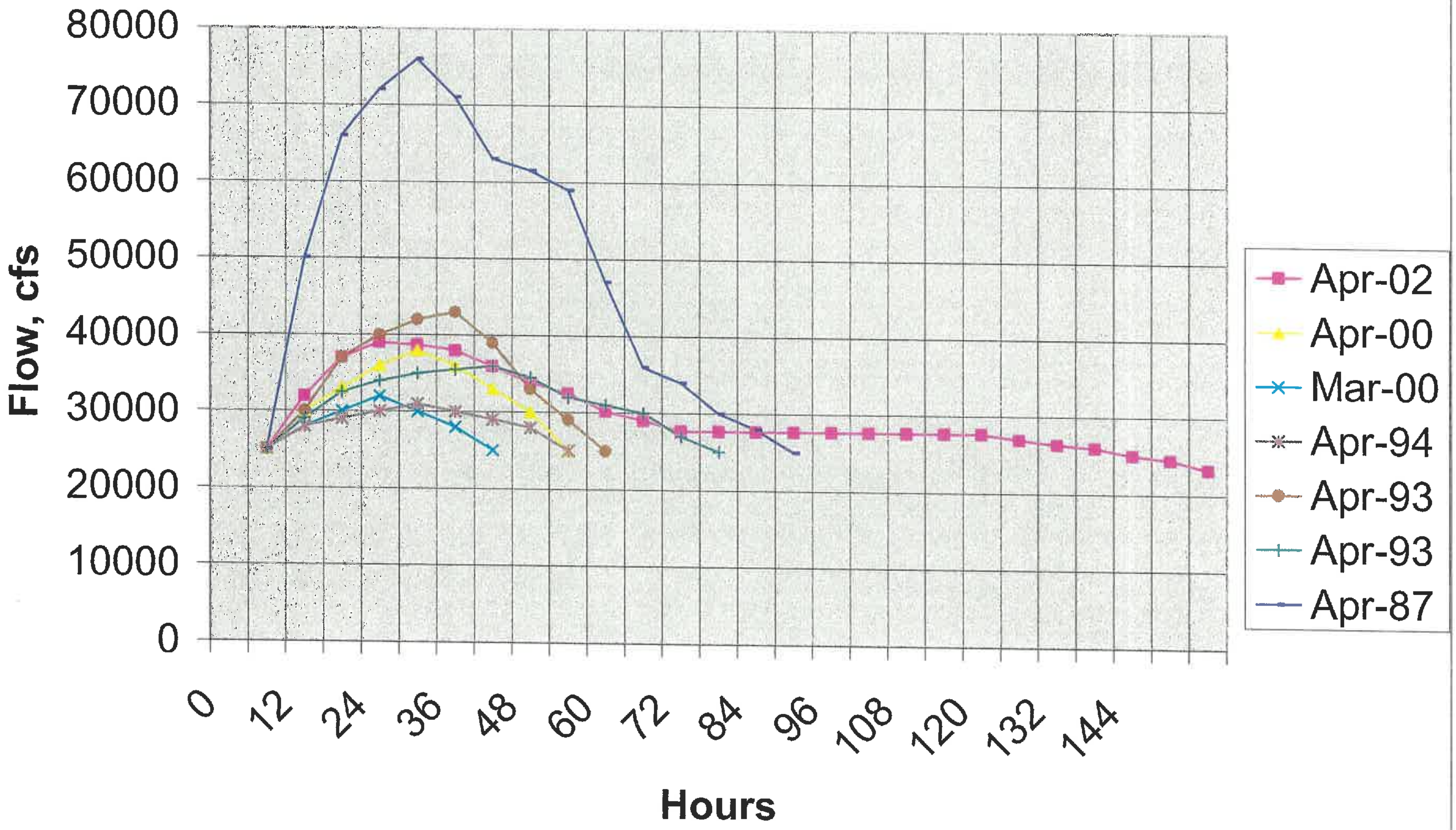


## Figure 6



281
280
279
278
277
276
275
274
273
272
271
Elevation, feet
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Androscoggin Lake Storage, acre-feet

## Figure 7 Androscoggin River Recorded Flows



## Figure 8  Androscoggin River Flow at Dead River

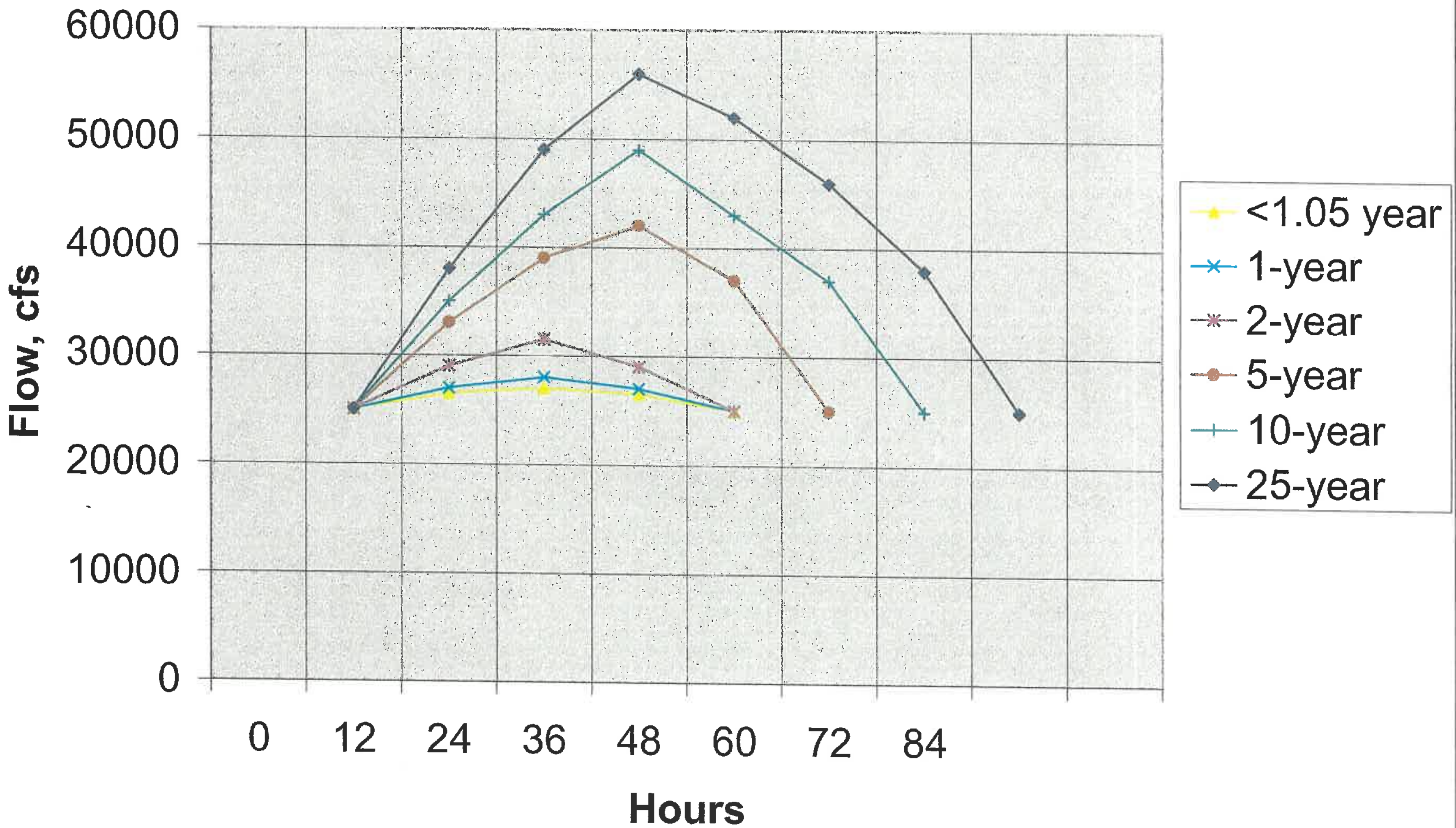


Figure 9
Dead River - River to Lake, 2' bds, Half Crest

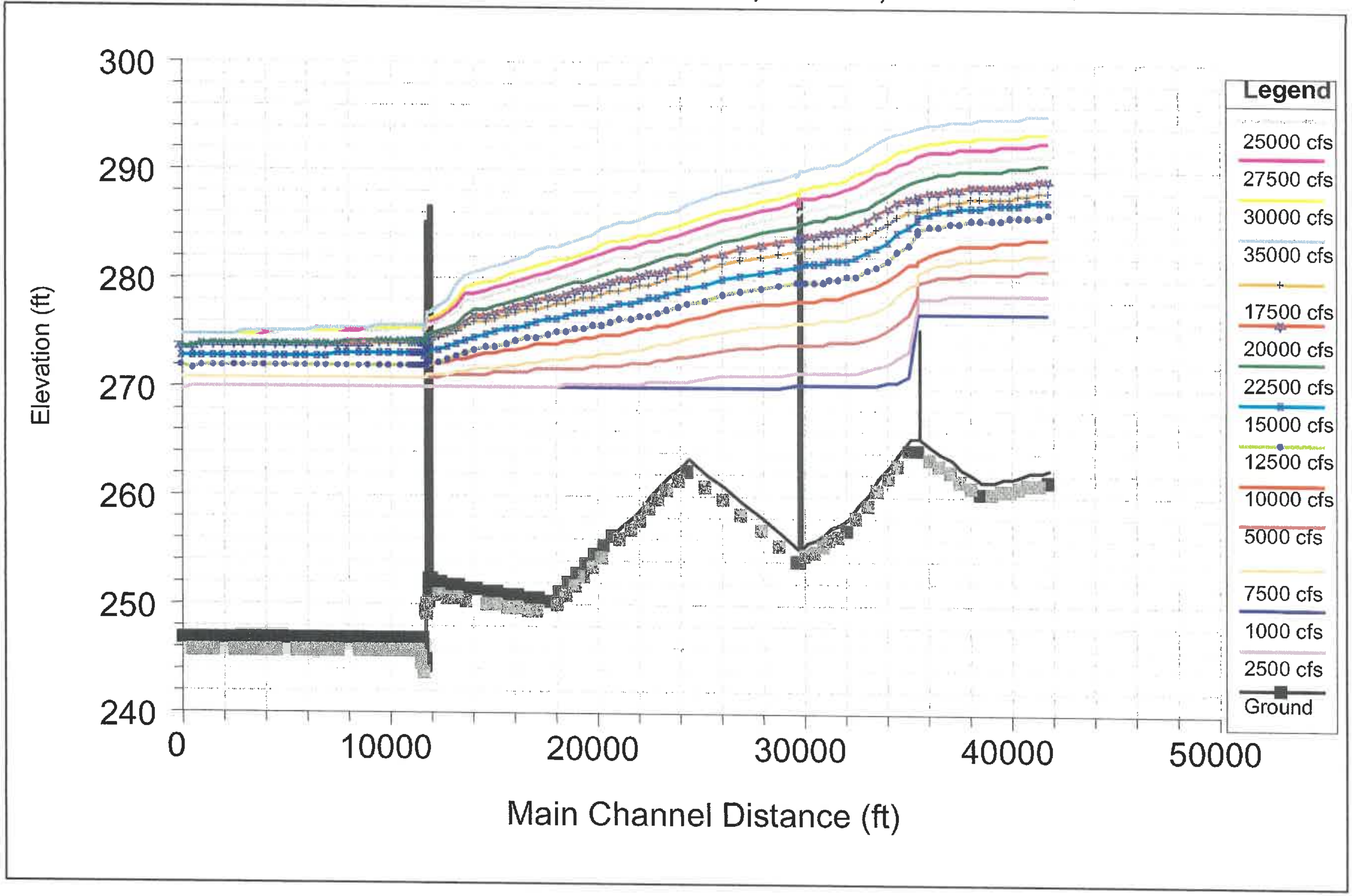
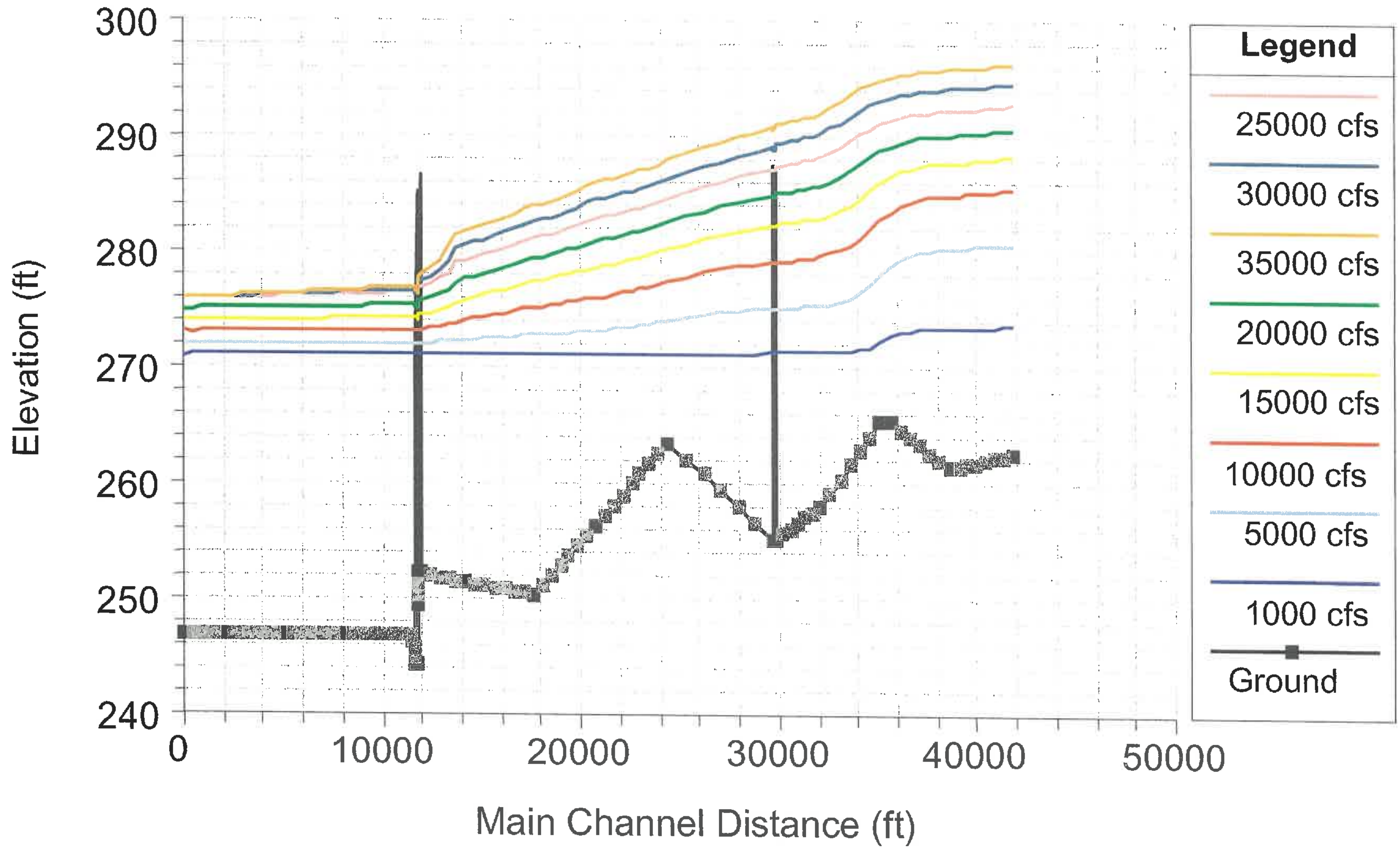
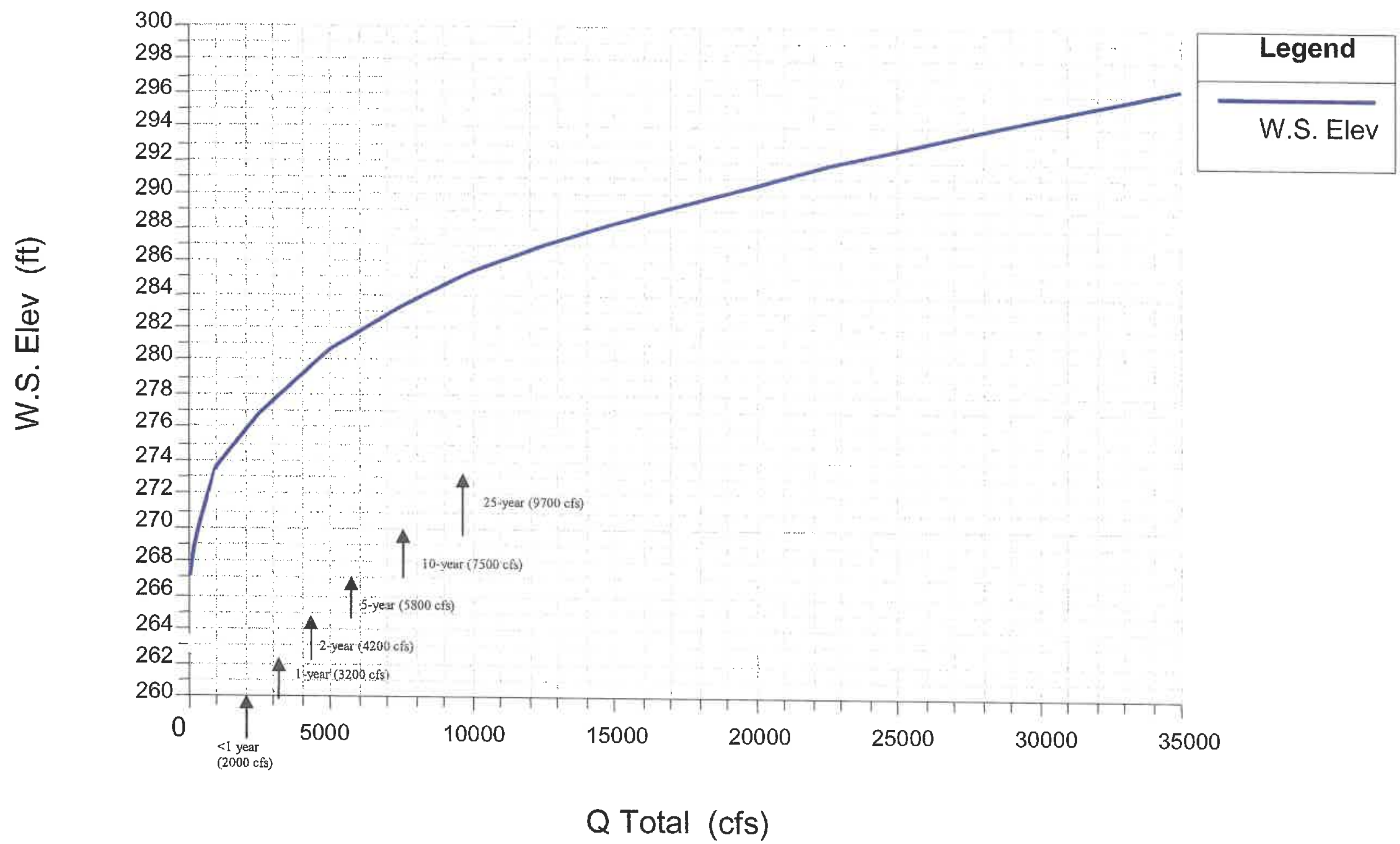


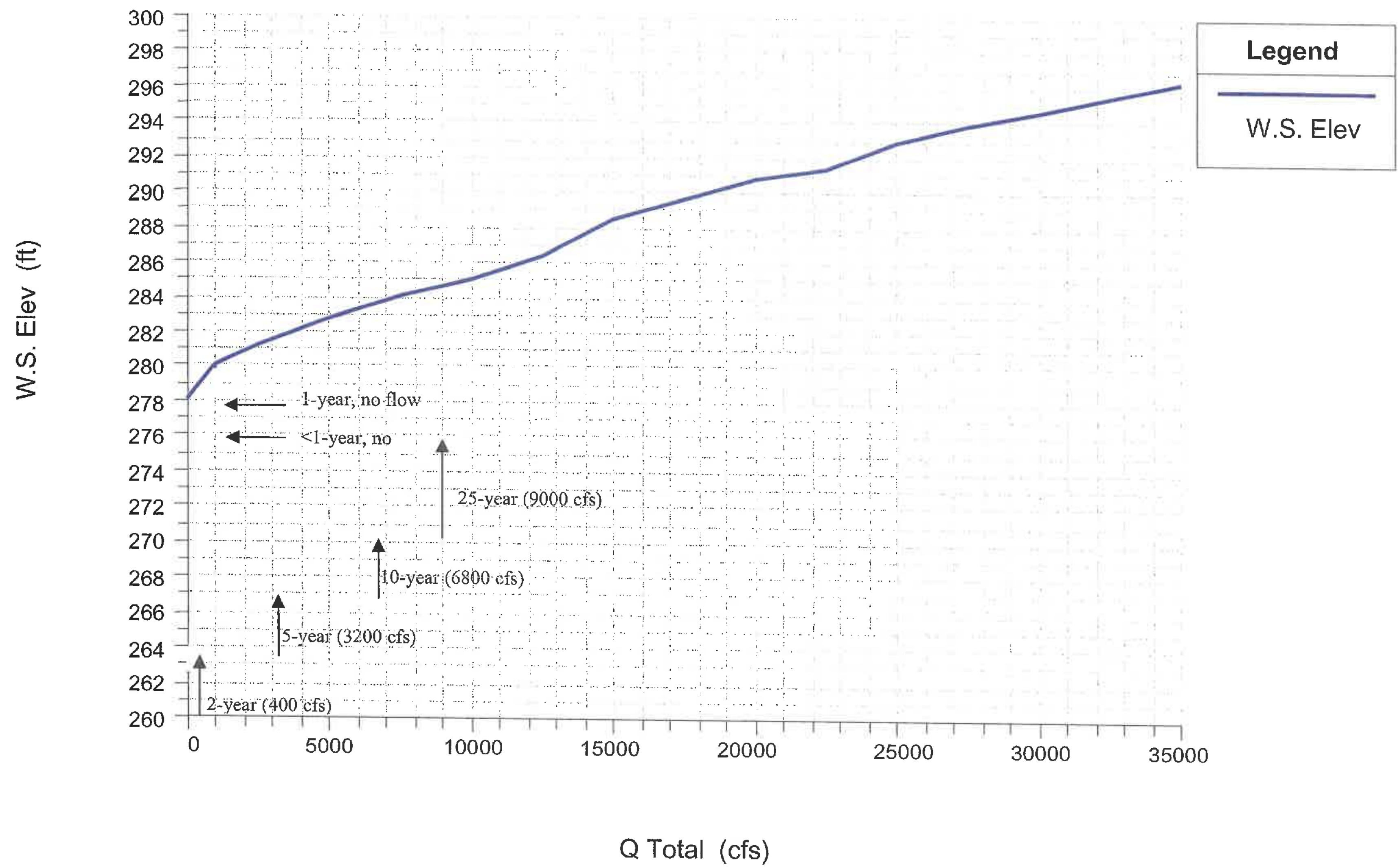
Figure 9a
Dead River - River to Lake, no dam



# Figure 10
## Dead River - River to Lake, No Dam



# Figure 11
## Dead River - River to Lake, 3'/3.5' bds



## Figure 12
## Dead River - River to Lake, 282' Crest

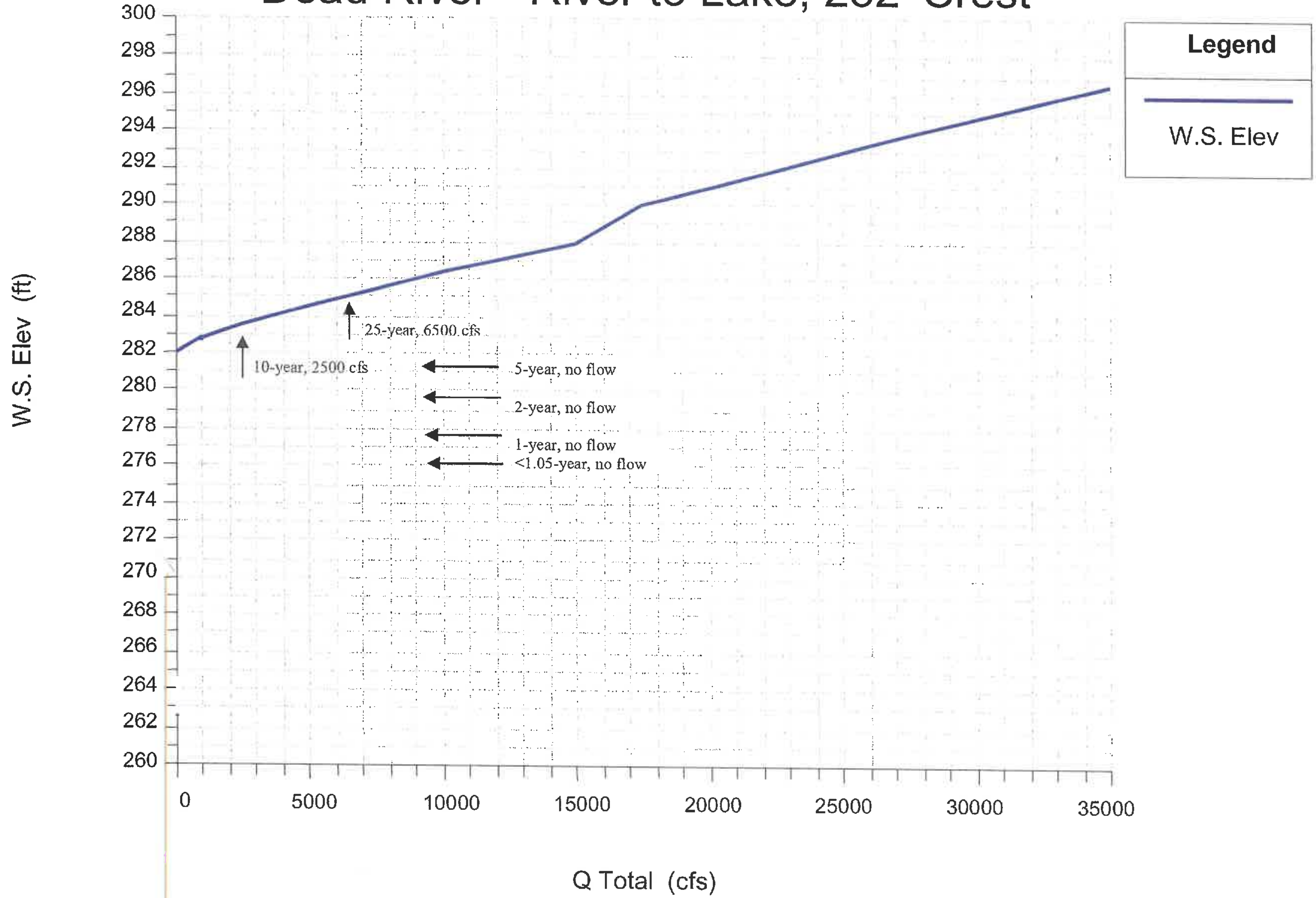


Figure 13
Dead River - Lake to River, No Dam

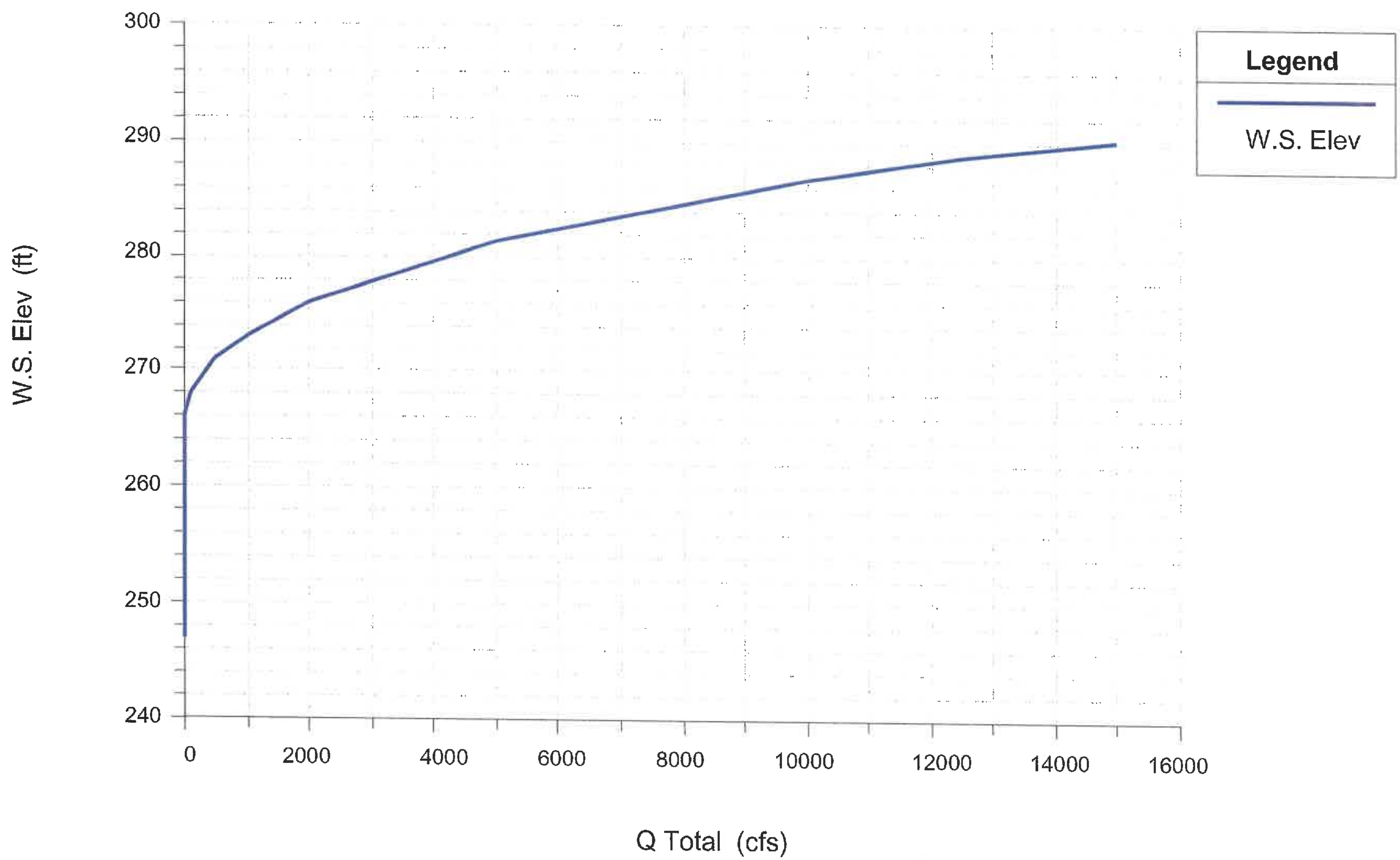
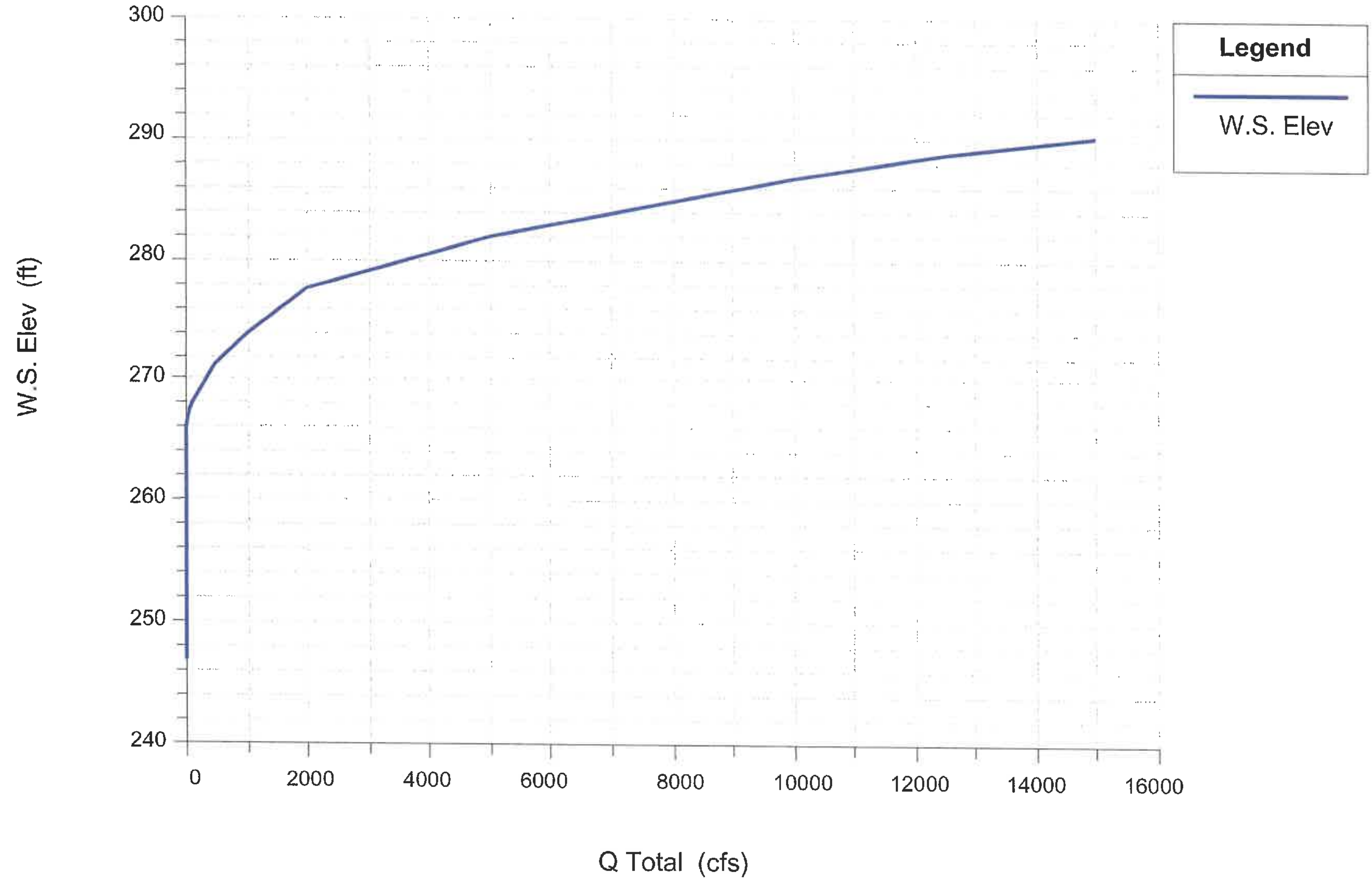
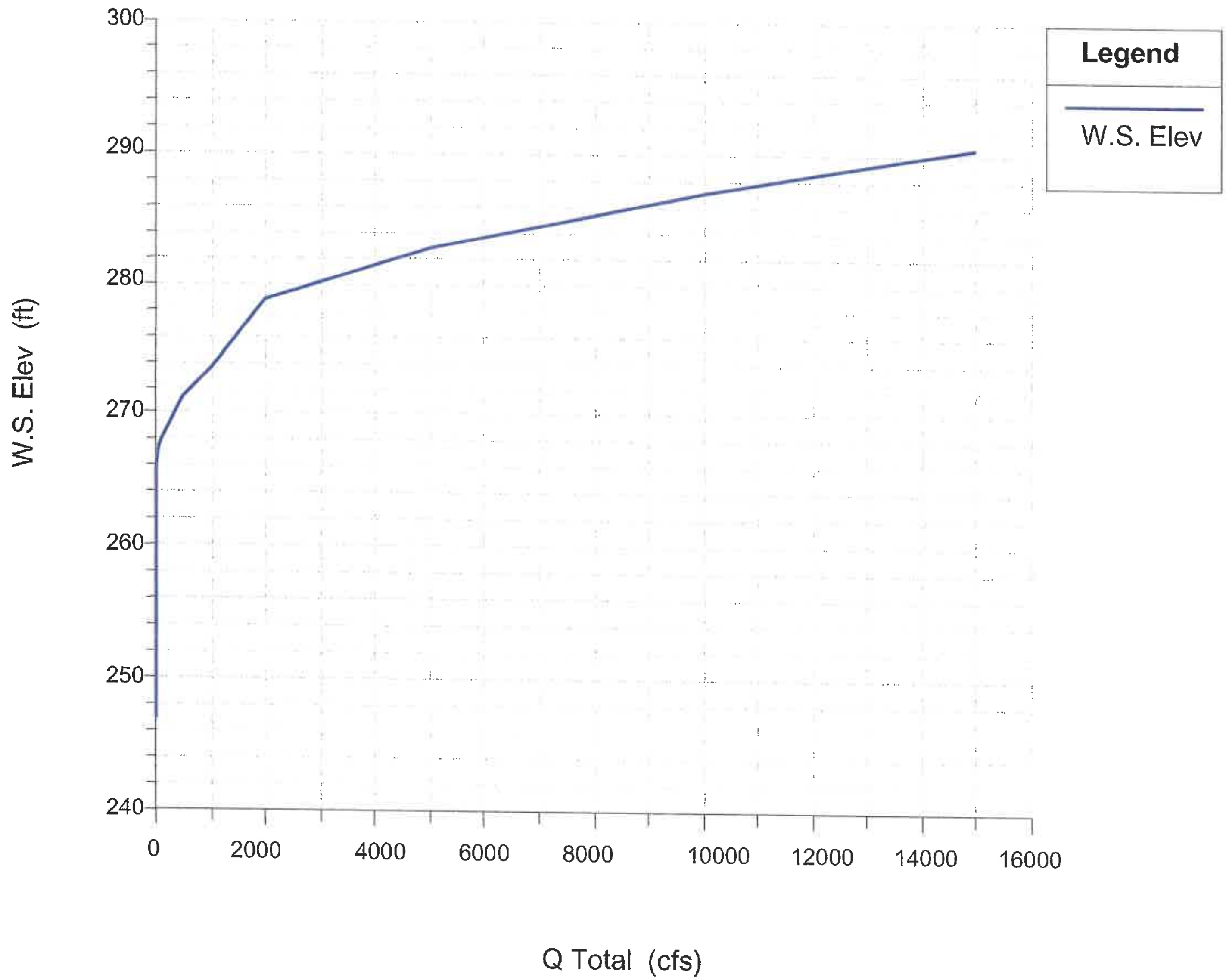


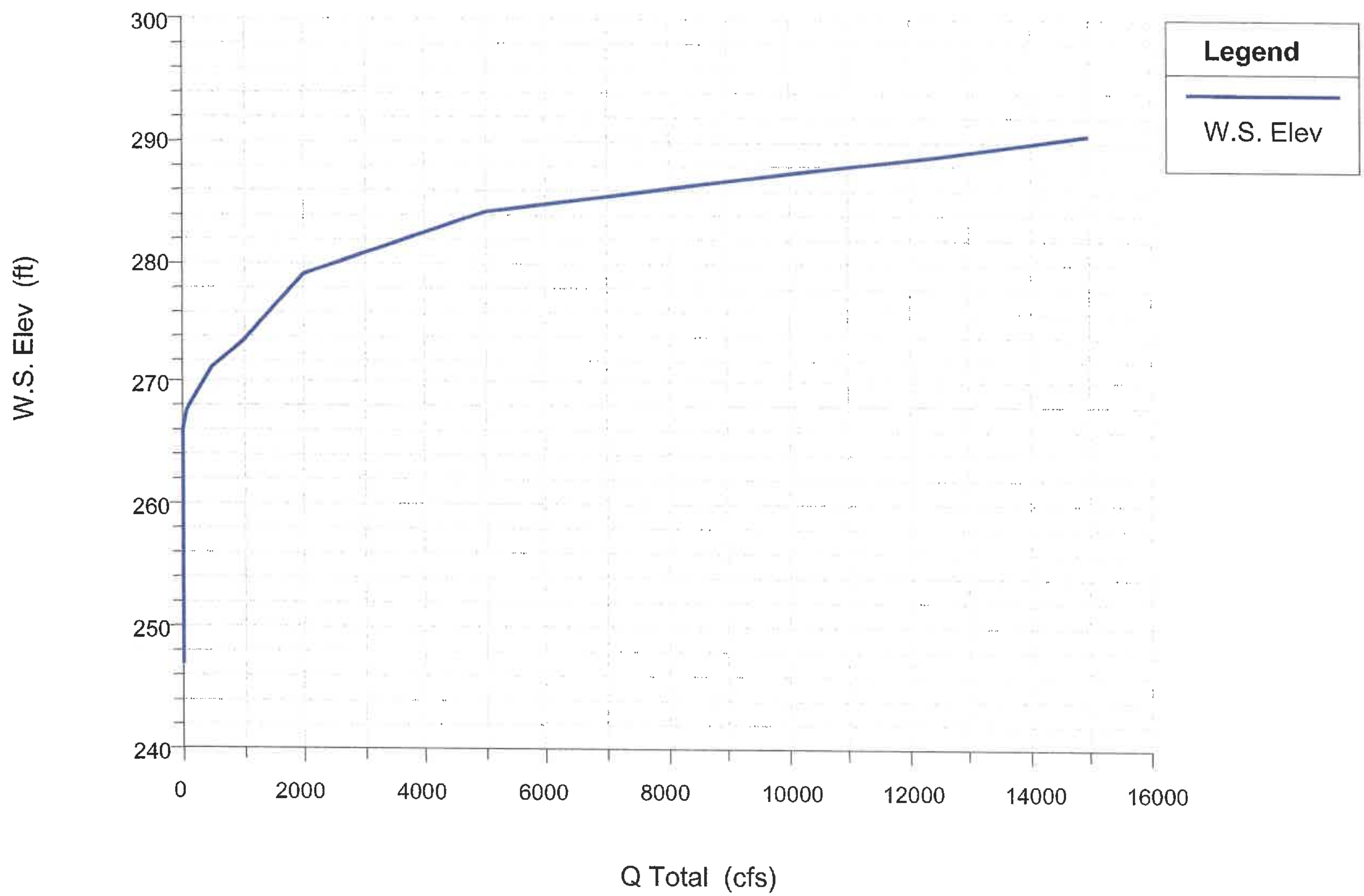
Figure 14
Dead River - Lake to River, 2' bds, Half Crest



# Figure 15
## Dead River, Lake to River, 3'/3.5' bds



# Figure 16
## Dead River, Lake to River, Crest 282'



## Figure 17
## Dead River, Lake to River, No Dam

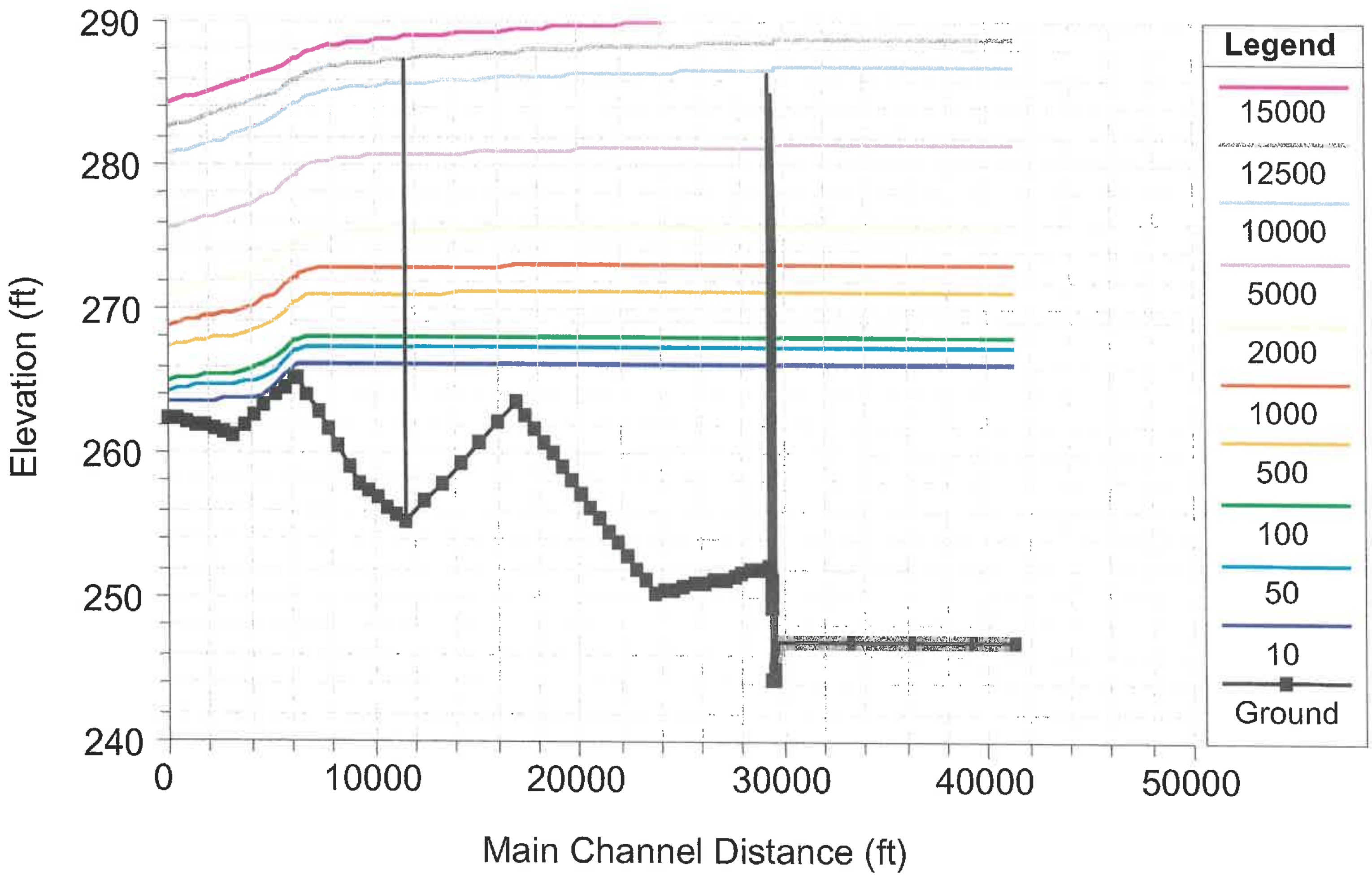


Figure 18
Dead River, Lake to River, 2' bds, Half Crest