For classroom exercise only, not all data is factual

Sumner Dam, New Mexico

Problem: Design a sediment management strategy to maximize reservoir life and allow for continued hydropower and irrigation water supply. The plan should include:

1. Method of sediment management
2. Necessary changes to dam and outlets
3. Frequency and approximate timing of the activity
4. Estimated impacts to water supply, hydropower, and other reservoir uses. If drawdown flushing is used, example impacts include how long hydropower will be off line, how long the reservoir will be drawdown, and how much water is used in the flush.
5. Qualitative description of other downstream impacts or other ancillary impacts.
6. Estimate of costs and benefits of sediment management activities, and
7. Description of impacts associated with not performing sediment management

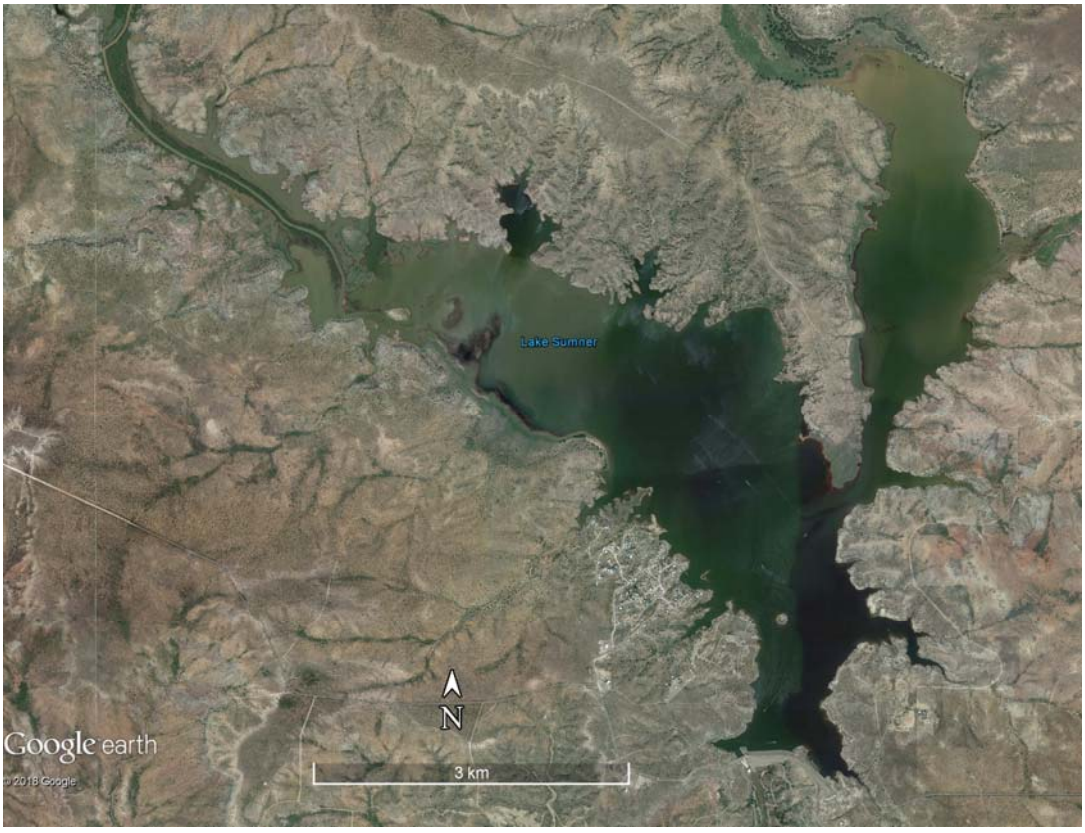

Figure 1. Sumner Dam and Lake (Aerial Photo Courtesy Google, 2014).

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Figure 2. Intake tower in Lake Sumner and reservoir sediment deposit.

Background: Lake Sumner and Sumner Dam are located on the Pecos River about 270 kilometers southeast of Albuquerque, New Mexico. Lake Sumner and Sumner Dam operate as principal features of the Carlsbad Project that supplies irrigation water for about 100 square kilometers within the Carlsbad Irrigation District. Along with irrigation water, the lake and dam provide flood control, river regulation, and recreational benefits. Sumner Dam is a zoned earthfill and rockfill embankment structure with a structural height of 50 meters. The original capacity of Sumner Reservoir was 193 million cubic meters, but 68 million cubic meters (35%) was lost to sediment deposition in the 38 years after storage began (1935-1973).

Purpose:

- Primarily – irrigation
- Secondary – flood control, river regulation, and recreation

Watershed: The watershed has an area of 11,380 square kilometers, a mean annual precipitation of 40 centimeters, and a mean elevation of 1,875 meters. Approximately 9,710 square kilometers (85%) of the reservoir is considered to be sediment contributing (producing sediment potentially delivered to Sumner Reservoir).

Sedimentation Rate: Mean annual sedimentation rates in the active conservation pool below elevation 1298.8 meters have steadily declined since dam closure: varying from 3,953,000 m^3/yr between 1935 and 1944; to 1,200,000 m^3/yr between 1944 and 1964; to only 480,000 m^3/yr between 1964 and 1973. The sediment deposited in the reservoir is about 31% sand and 69% silt and clay (D50 = 0.054 mm). The Sumner Reservoir active conservation pool (elevation 1298.8 meters) was 22 kilometers long and 0.64 kilometers (640 meters) wide as originally constructed. The width of the natural bank full channel is approximately 45 meters and the slope of the pre-dam river is approximately 0.0022.

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Operations: Once the reservoir fills to prescribed levels, an average flow of 3.4 m^3/s is diverted between November 1 and April 30, while 8.5 m^3/s is diverted between May 1 and October 31. The capacity of the outlet works is 50 m^3/s.

Transport Rates: For the purposes of this class, the rate of sediment transport from the reservoir will be greatly simplified and can be estimated as suggested by Atkins (1996):

$$Q_s = K \frac{Q^{1.6} S^{1.2}}{W^{0.6}}$$

Q_s = sediment transport capacity during drawdown flushing (metric tons/s)
Q = flow during drawdown flushing (m^3/s)
S = Slope of reservoir water surface for drawdown condition (-), use hydraulic height of dam divided by the length of the reservoir
W = erosion width (m), use average channel width upstream of the dam.
K = constant, which is a function of sediment grain size and erodibility; assumed 100 for this study

Costs: For the purposes of the class, following unit cost in US Dollar amounts are assumed.

Table 1. Unit costs for Lake Sumner in US dollars

Item	Unit Cost or Revenue
Sediment Removal by Hydraulic Dredging	\$ 10/m^3
Mechanical Sediment Removal	\$ 7/m^3
Irrigation Water	\$ 0.16/m^3
Recreation Revenue	\$ 2,000/day
Treatment of Watershed	\$ 200,000/km^2

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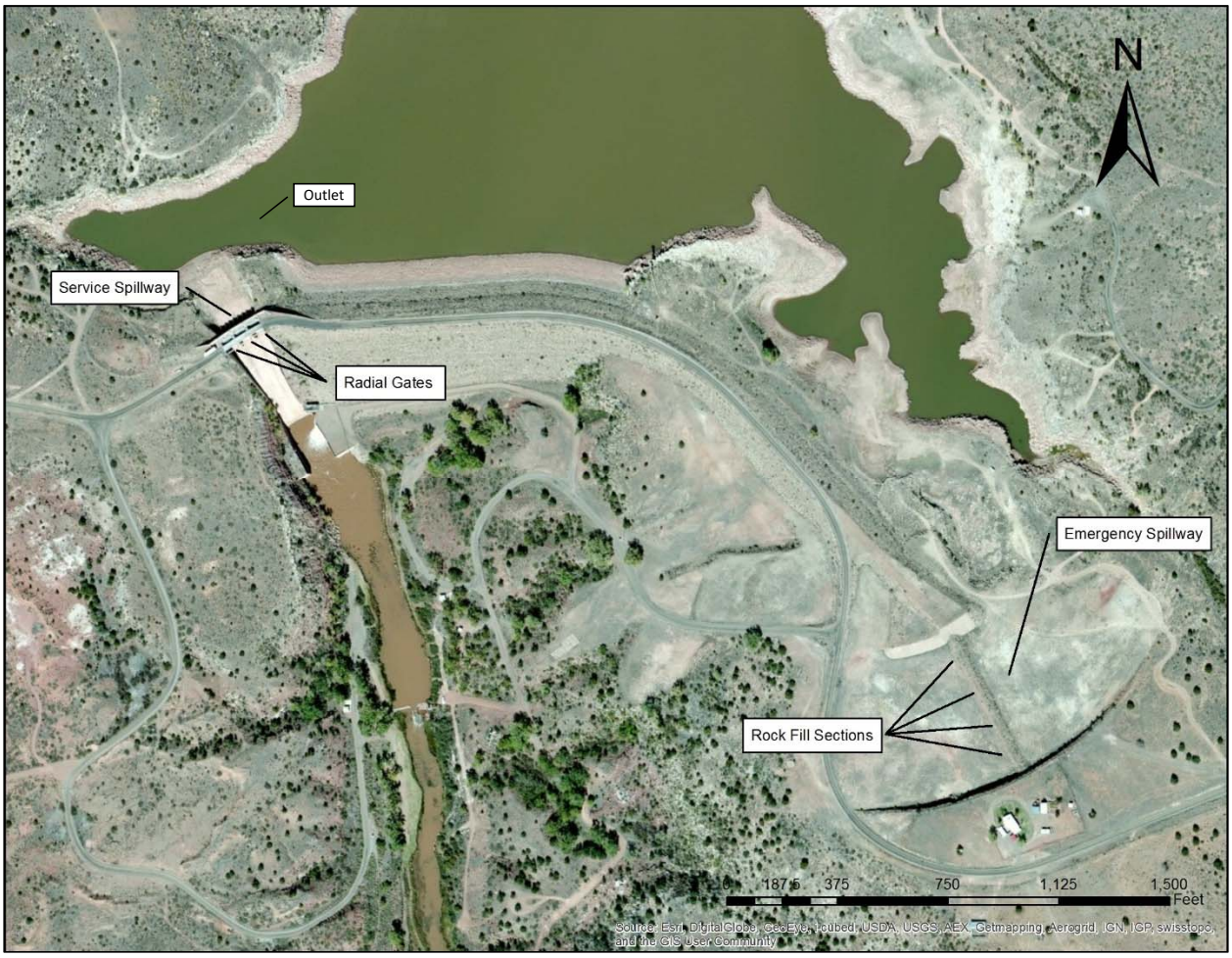

Figure 3. Sumner dam showing spillways and outlets

Table 2. Sumner Dam and outlet dimensions

Parameter	Value
Dam Crest Elevation	1311.0 m
Emergency Spillway Elevation	1303.0 m
Service Spillway Elevation	1298.1 m
Upper Intake Sill Elevation	1280.2 m
Lower Intake Sill Elevation	1266.1 m
Original Reservoir Bottom Elevation	1266.1 m
1973 Sediment Elevation at Dam	1280.2 m
Upper Level Outlet Capacity	50.1 m^3/s
Lower Level Outlet Capacity	45.6 m^3/s

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Table 3. Storage versus elevation data for Lake Sumner

Elevation (m)	Active Storage Volume (m^3)			
	1935	1944	1964	1973
1264.9	0	--	--	--
1268.0	308,372	--	--	--
1271.0	1,233,489	--	--	--
1274.1	3,083,723	--	--	--
1277.1	6,167,446	0	0	--
1280.2	10,793,031	345,377	8,357	0
1281.7	11,500,000	1,000,000	19,685	2,467
1283.2	17,577,222	4,724,264	69,069	14,802
1284.7	20,000,000	8,500,000	750,000	246,698
1286.3	27,136,763	12,211,543	1,810,762	1,191,551
1287.8	32,000,000	21,000,000	4,000,000	2,996,145
1289.3	40,396,773	22,967,570	8,607,288	5,844,272
1290.8	50,000,000	30,000,000	14,000,000	9,999,897
1292.4	58,899,111	38,460,194	20,847,202	15,286,632
1293.9	71,500,000	50,500,000	30,000,000	22,299,018
1295.4	84,802,385	60,983,708	40,393,072	32,050,984
1298.1	116,163,849	90,013,877	66,567,960	63,955,098
1298.5	119,648,456	93,239,452	69,476,281	67,500,000
1298.8	124,150,692	97,572,699	73,566,532	69,250,000

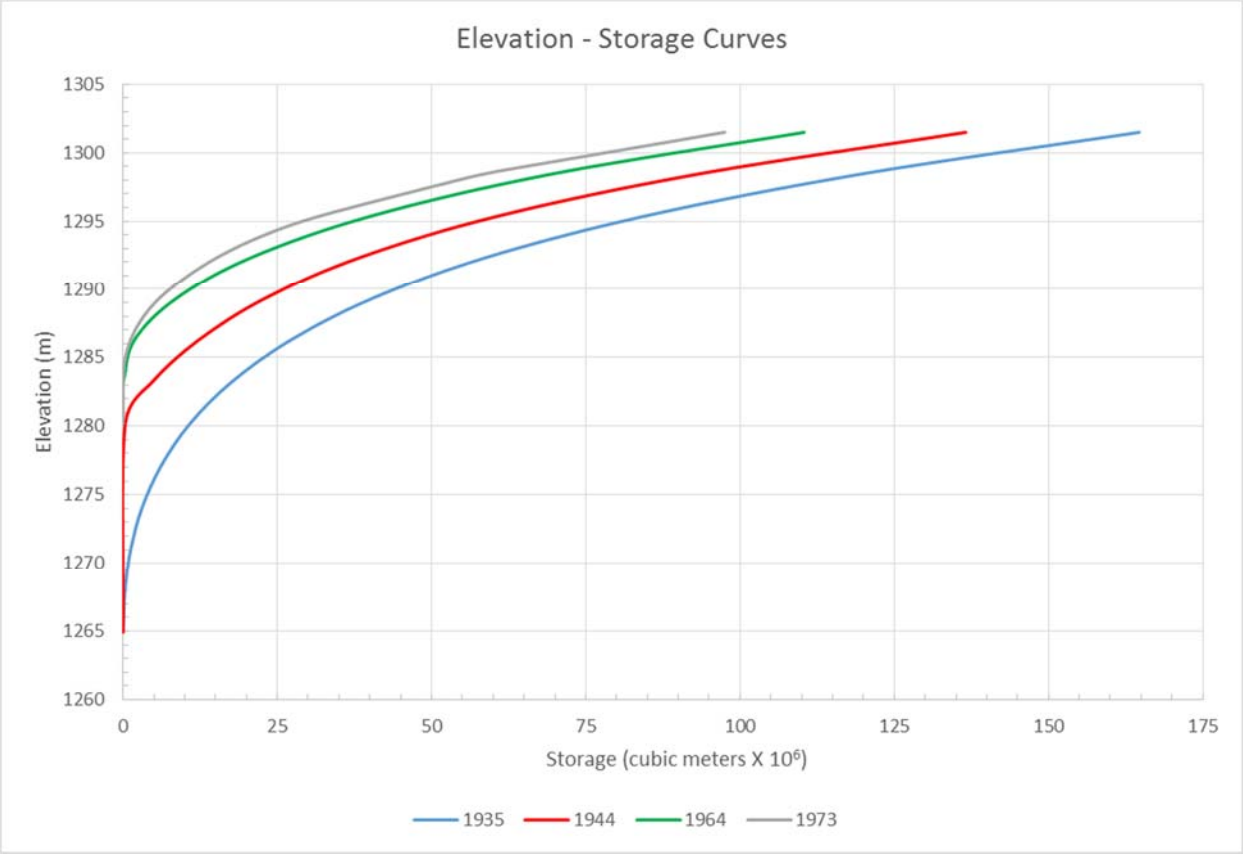

Figure 4. Storage versus elevation curves for Lake Sumner

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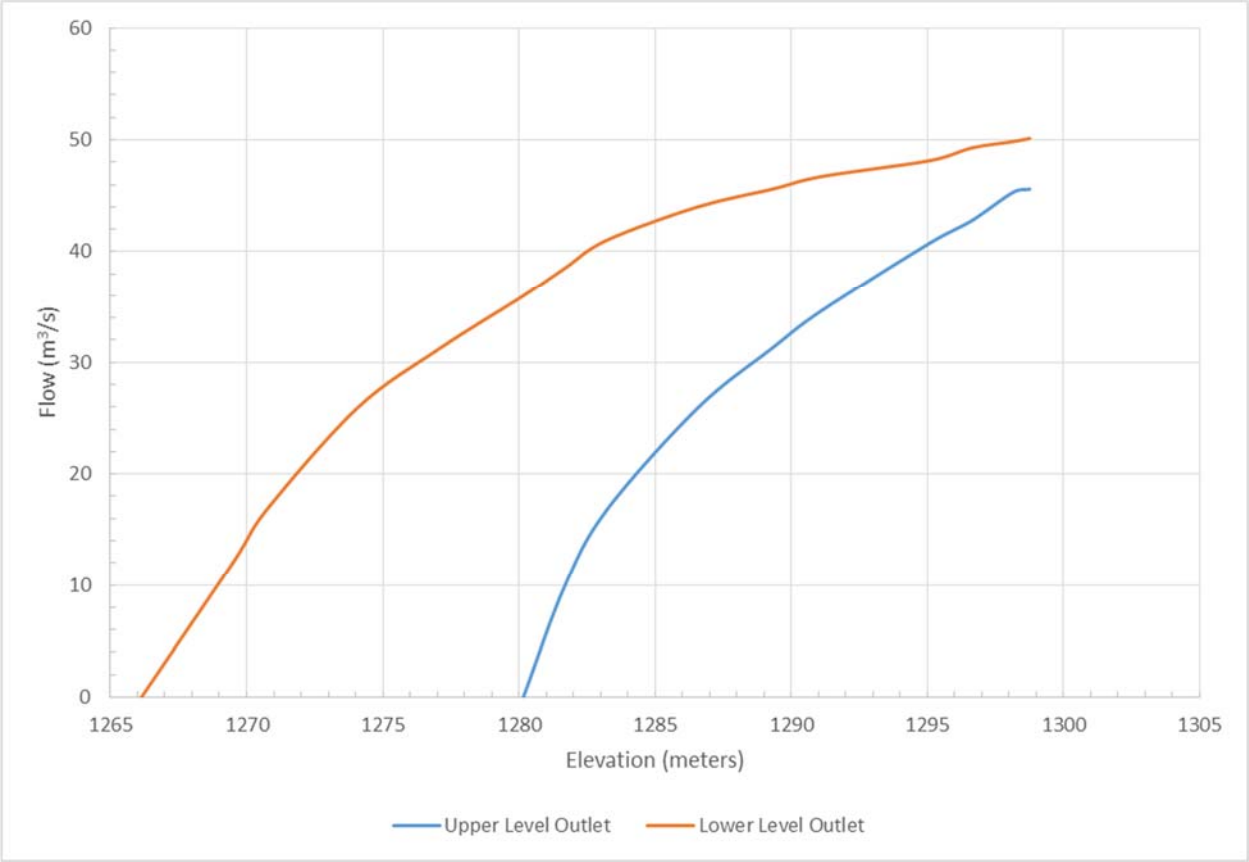

Figure 5. Elevation versus discharge rating curves for upper and lower level outlets at Sumner Dam

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Table 4. Table of average monthly inflows for Lake Sumner

Month	Average Flow (m^3/s)	Average Flow Volume (m^3)
Jan	2.9	7,812,000
Feb	2.9	6,981,000
Mar	2.9	7,888,000
Apr	5.5	14,166,000
May	9.5	25,559,000
Jun	8.4	21,799,000
Jul	8.4	22,450,000
Aug	10.4	27,759,000
Sep	8.8	22,753,000
Oct	5.3	14,183,000
Nov	3.3	8,441,000
Dec	3.0	8,039,000
Annual	**5.9**	**187,829,000**

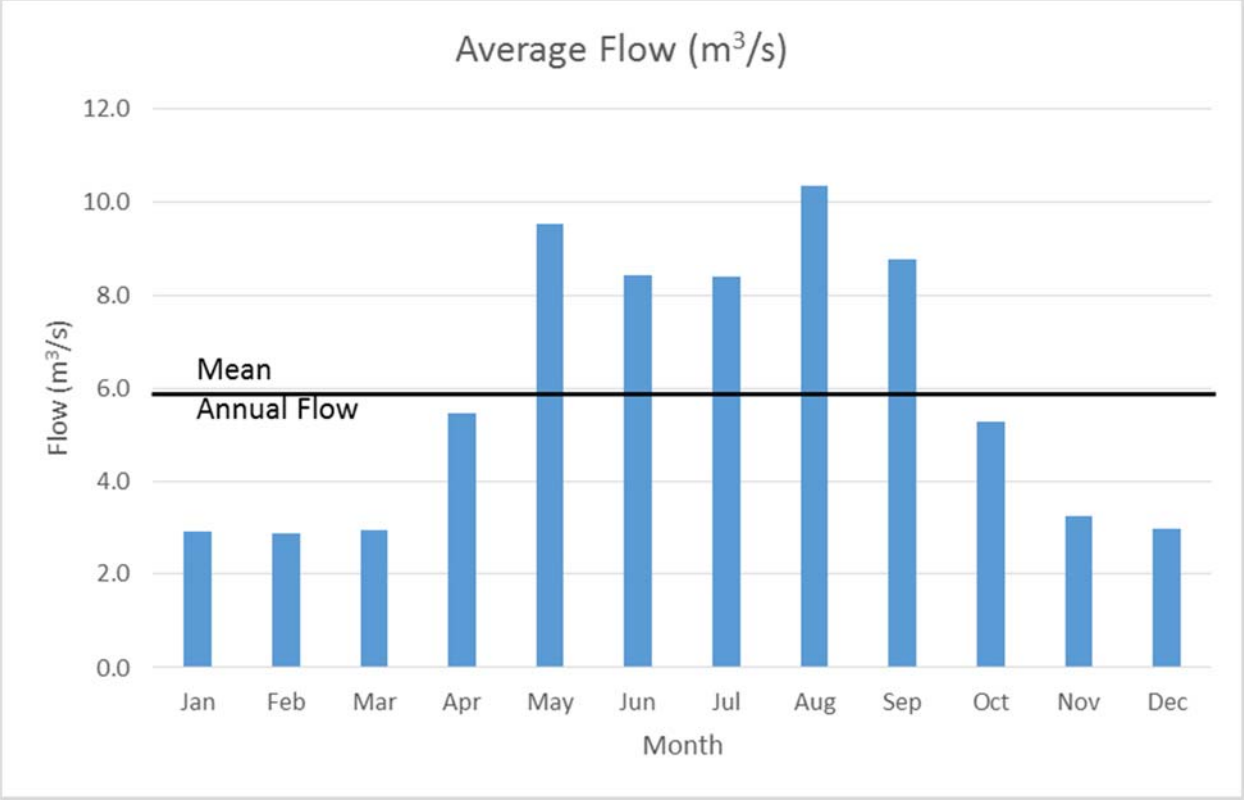

Figure 6. Graph of average monthly inflows for Lake Sumner

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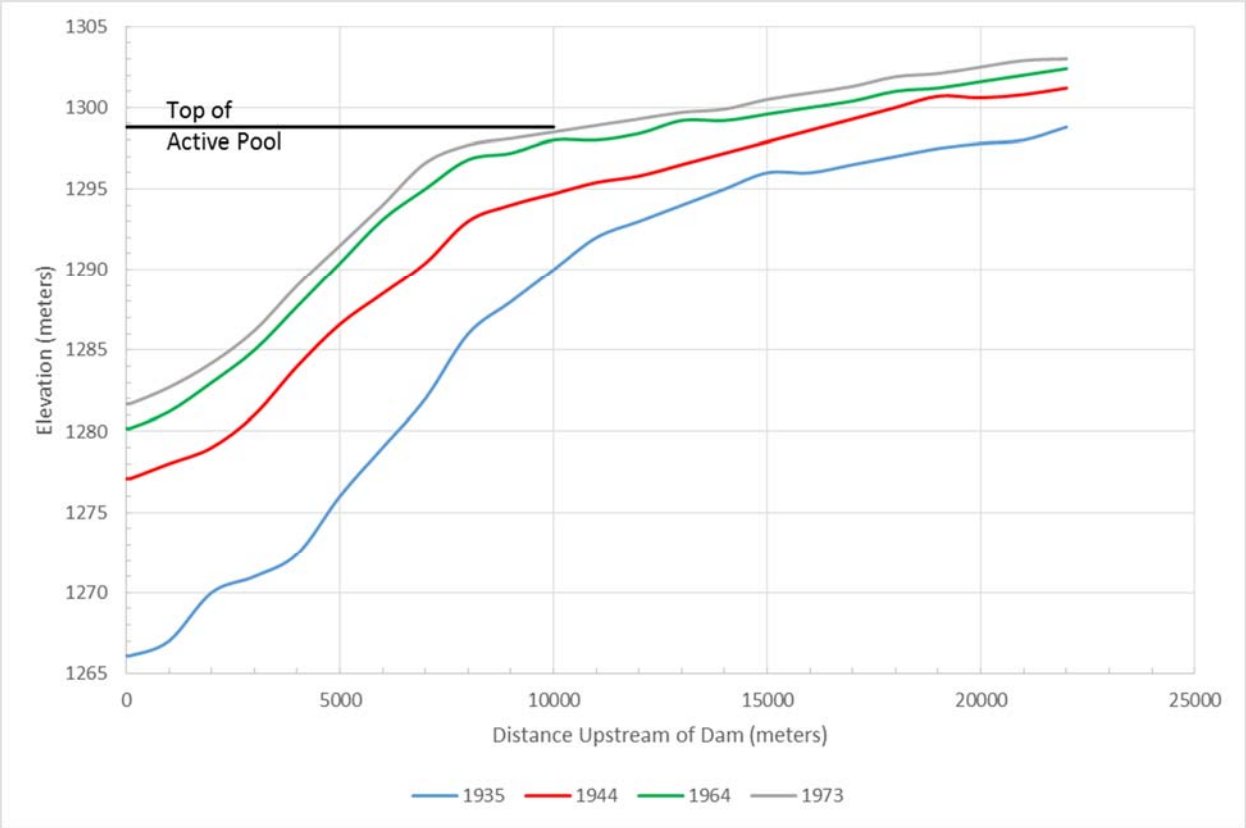

Figure 7. Longitudinal profile plots of Lake Sumner bed elevation over time