A SURVEY OF THE EFFECTS OF *Castor Canadensis* DAMS ON THE EAST BRANCH OF THE MAPLE RIVER

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ABSTRACT

Beaver dams have major impacts on stream morphology, including riparian zone loss, a reduction in plant and forest biomass, an increase in upstream sedimentation, and the creation of wetland conditions upstream. This study examines a number of physical and water quality measurements at twelve dams on a portion of the east branch of the Maple River, and looks to observe and analyze any potential implications, such as macroinvertebrate diversity, stream flow alteration, and the creation of denitrifying anaerobic zones. The purpose of this study is to construct a general survey of beaver dams in this area and their effects.

INTRODUCTION

The North American beaver (*Castor canadensis*) alters stream morphology and hydrology by building dams and lodges from wood cut in the surrounding areas (Naiman et al., 1988). To further understand stream alteration by beavers, one must consider the potential implications of these alterations. The rise in water level upstream of beaver dams, and the reduction in water level downstream have a significant effect on the riparian zone; in areas affected by beavers, the roots of trees are typically flooded, and it is common to find dead trees and vegetation upstream of dams (Cole et. al, 1991). In addition, beaver dams can change the flow of the river itself, and how materials move downstream and sediment deposition. Much of the makeup of dams is build up of sediment and other materials that get trapped on the upstream side of beaver dams (Pringle, 1988). Dams can also alter the biodiversity of flora and fauna in the wetland region near the dam (Naiman et al., 1986). As beavers both use woody material for food and dam construction, the placement of a dam in an area can directly reduce forest biomass from herbivorous foraging (Johnston and Naiman, 1990).

In northern Michigan, beavers have exploited the unsorted glacial tills that create the region's many streams and rivers. This study examines the effects of dam construction by *C. canadensis* on the east branch of the Maple River, a third to fourth order stream in Emmet County, MI. It is likely that beaver dams on this selected section of the Maple River alter a number of stream characteristics, including water level, water discharge, temperature, pH and dissolved oxygen, both on the upstream and downstream sides of the dams.

MATERIALS AND METHODS

Twelve beaver dams and five lodges were surveyed on a segment of the east branch of the Maple River, originating in Maple Bay on the southeast side Douglas Lake, and ending at the intersection of the river and Robinson Road (Figures 1 & 2; Table 3). It is primarily fed by Douglas Lake surface water, with an observed temperature no lower than 26^{o} C when temperature measurements were taken for the purpose of this study. The river has a number of third to fourth order stream characteristics, such as shallow riffles and deep pools, and a variety of substrate types, such as cobble, sand, and silt. Flora is diverse; the surrounding forest is second-growth, and riparian vegetation includes emergent, submergent and floating aquatic plants such as *Chamaedaphne calyculata*, *Sparganium*, and *Potamogeton crispus* (White, 1990).

The criteria by which dams were selected for measurement included whether the dam significantly obstructed surface water flow and if it emerged from the water. Dams that were fully submerged or were not altering flow were not surveyed for this study. It should be noted that other sources of flow obstruction, such as fallen trees, and the subsequent effects were not taken into account.

The surveying method in this study involved using the Hydrolab to determine the temperature, conductivity, pH, and dissolved oxygen concentrations upstream and downstream of each dam. In addition, flow (using a Flowmeter) and depth were determined at each meter along the length of both sides of the dam. Dam height and width, and elevation change from upstream to downstream of the dam were also measured. Comparative profiles were made for each dam, which included the depths at each meter for the lengths of both sides of the dam.

RESULTS

Between Douglas Lake and Douglas Lake Road

Excluding the parameters of water quality differences in the River Continuum Concept (Vannote et. al, 1980), the average dam input discharge was 0.577308 (± 0.304023) m^3/s, while the average output was 0.451381 (± 0.323991) m^3/s. The average temperature upstream of the dam was 27.25667 (± 1.199467) ºC, while the average temperature downstream of the dam was 27.43167 (± 1.0803) ºC. The average conductivity upstream of the dam was 0.235333 (± 0.0017) mS/cm, while the average conductivity downstream of the dam was 0.2355 (± 0.0015) mS/cm. The average dissolved oxygen upstream of the dam was 7.47 (± 0.432396) mg/L, while the dissolved oxygen downstream of the dam had an average of 7.663333 (± 0.34228) mg/L. The average pH upstream of the dam was 9.071667 (± 0.172184), while the average pH downstream of the dam was 9.106667 (± 0.146515). The average decline in stream water level after a dam was 0.073333 (± 0.044121) m. The corresponding profiles for this section of the river are Figures 6-11, and the corresponding figures are 1-3.

Between Douglas Lake Road and Robinson Road

The average dam input discharge was 0.661683 (± 0.113528) m^3/s, while the average output was 0.719847 (± 0.323991) m^3/s. The average decline in stream water level after a dam was 0.215 (± 0.197358) m. It should be noted that the Hydrolab used to take the water quality measurements in the first section of the river, between Douglas Lake and Douglas Lake Road, was not functional for measurements in the second section, and so no reports of pH, dissolved oxygen, conductivity, or temperature were available. The corresponding profiles for this section are Figures 7-12; the corresponding figures are 1-3.

DISCUSSION

The effects of beaver dams on the east branch of the Maple River were primarily physical in nature; there was little to no change in dissolved oxygen or pH between the upstream and downstream sides of each dam, nor was there a gradual change as the survey continued downriver. Changes of this nature perpetuated by dams have been observed before, however; a study conducted by Naiman et. al (1986) observed the creation of anaerobic zones as sediment buildup increased on the upstream side of dams, thus reducing oxygen availability to the deeply buried sediment. These anoxic conditions could potentially be a site of denitification. As the water flows through aerobic, to anaerobic conditions in the sediment, and back to aerobic conditions downstream of the dam, and continues the cycle as it reaches another dam downstream, denitrification is a likely result (Klotz, 2010). In addition, it should be noted that a temperature decrease was observed downriver; this may have to do primarily with the increase in colder groundwater inflow downstream, while upstream is primarily composed of warm surface water from Douglas Lake. (White, 1990). It should be noted that groundwater temperatures were not measured in this study, but past studies have observed colder temperatures in groundwater and underwater streams than in aquatic environments with considerable sunlight exposure and warming, such as Douglas Lake (Schultz, 1985).

Most dams did have a significant effect on water elevation, which can have rather pronounced effects. For instance, though it was not examined in this study, an upstream reduction in the emergence of aquatic insects was observed in a 40 centimeter change in water level; the maximum water level change observed in this study was 56 centimeters (Pringle, 1988; Table 2). In addition, Mantel et. al (2009) observed that in dams on both the Maple River and Carp Creek, macroinvertebrate diversity was much higher downstream than upstream of the dams.

Finally, although results vary based on dam length, height and water level change, many dams saw a change in discharge upstream and downstream of the dam. Other studies more extensively focused on flow velocity observed marked differences in upstream and downstream discharge (Kuo & Feldmann, 1991), although the results in this study were more variable. It should be noted that flow measures can also be influenced by preexisting stream morphology. Based on the results of this study, the most pronounced effects beaver dams had on the morphology of the Maple River were in the decrease in the water level upstream and downstream of each dam.

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FIGURES AND TABLES

Figure 1. Six dams and 2 lodges surveyed on the East Branch of the Maple River between Douglas Lake and Douglas Lake Road. Total approximate distance: 4 km.

Figure 2. Six dams and 3 lodges surveyed on the East Branch of the Maple River between Douglas Lake Road and Robinson road. Total approximate distance: 4.4 km.

Between Douglas Lake Road and Robinson Road

	Dam 1	Dam 2	Dam 3	Dam 4	Dam 5	Dam 6
Height of dam from downstream water level (m)	0.25	0.41	0.55	0.63	0.37	0.42
Width across dam (m)	3.2	3.5	2.9	3.6	4.2	3.3
Width upstream (m)	4.9	12	22.5	11	11.3	8.8
Width downstream (m)	3.9	6	22.5	9.4	9	7.7
Inflow discharge (m^3/s)	0.0019	0.79135	0.43833	0.867	0.521	0.844265
Outflow discharge (m^3/s)	-0.03344	0.455145	0.304855	1.04	0.585	0.356725
Temperature upstream (ºC)	28.23	28.41	28.69	26.22	26.14	25.85
Temperature downstream (ºC)	28.25	28.5	28.65	26.52	26.82	25.85
Conductivity upstream (mS/cm)	0.233	0.234	0.235	0.237	0.235	0.238
Conductivity downstream (mS/cm)	0.235	0.235	0.236	0.236	0.233	0.238
Dissolved oxygen upstream (mg/L)	7.67	8.07	6.65	7.53	7.6	7.3
Dissolved oxygen downstream (mg/L)	7.16	8.14	7.88	7.76	7.77	7.27
pH upstream (units)	9.04	9.1	9.11	9.21	9.25	8.72
pH downstream (units)	8.96	9.12	9.09	9.29	9.25	8.93
Water level increase (m)	0.01	0.04	0.13	0.07	0.11	0.08

Table 1. Physical measurements, discharge, water quality and water level increase from downstream to upstream side of the dam.

Between Douglas Lake Road and Robinson Road

Dam	7	8	9	10	11	12
Height of dam from downstream water level (m)	0.158	0.75	0.43	1.01	0.34	1.13
Width across dam (m)	3.1	5	3	4.3	2.3	2.9
Width upstream (m)	14	23.8	11	22	11.4	20.3
Width downstream (m)	10.6	14.7	10	15.3	8.25	12.8
Inflow discharge (m^3/s)	0.57456	0.61028	0.529055	0.748458	0.83163	0.676115
Outflow discharge (m^3/s)	0.62377	0.68856	0.68704	0.90668	0.776435	0.636595
Temperature upstream (ºC)	N/A	N/A	N/A	N/A	N/A	N/A
Temperature downstream (ºC)	N/A	N/A	N/A	N/A	N/A	N/A
Conductivity upstream (mS/cm)	N/A	N/A	N/A	N/A	N/A	N/A
Conductivity downstream (mS/cm)	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved oxygen upstream (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved oxygen downstream (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A
pH upstream (units)	N/A	N/A	N/A	N/A	N/A	N/A
pH downstream (units)	N/A	N/A	N/A	N/A	N/A	N/A
Water level increase (m)	0.06	0.26	0.05	0.56	0.08	0.28

Table 2. Physical measurements, discharge, water quality and water level increase from downstream to upstream side of the dam.

Dam	Latitude	Longitude
1	45°34'54.19"N	84°44'14.28"W
2	45°34'51.89"N	84°44'17.88"W
3	45°34'51.41"N	84°44'19.31"W
4	45°34'51.74"N	84°44'20.76"W
5	45°34'50.74"N	84°44'24.00"W
6	45°34'22.60"N	84°44'43.63"W
7	45°33'52.74"N	84°45'2.52"W
8	45°33'52.20"N	84°45'4.68"W
9	45°33'51.23"N	84°45'6.48"W
10	45°33'43.88"N	84°45'16.20"W
11	45°33'38.88"N	84°45'9.72"W
12	45°33'10.76"N	84°45'1.44"W

Table 3. Locations of dams 1-12 between Douglas Lake and Robinson Road.

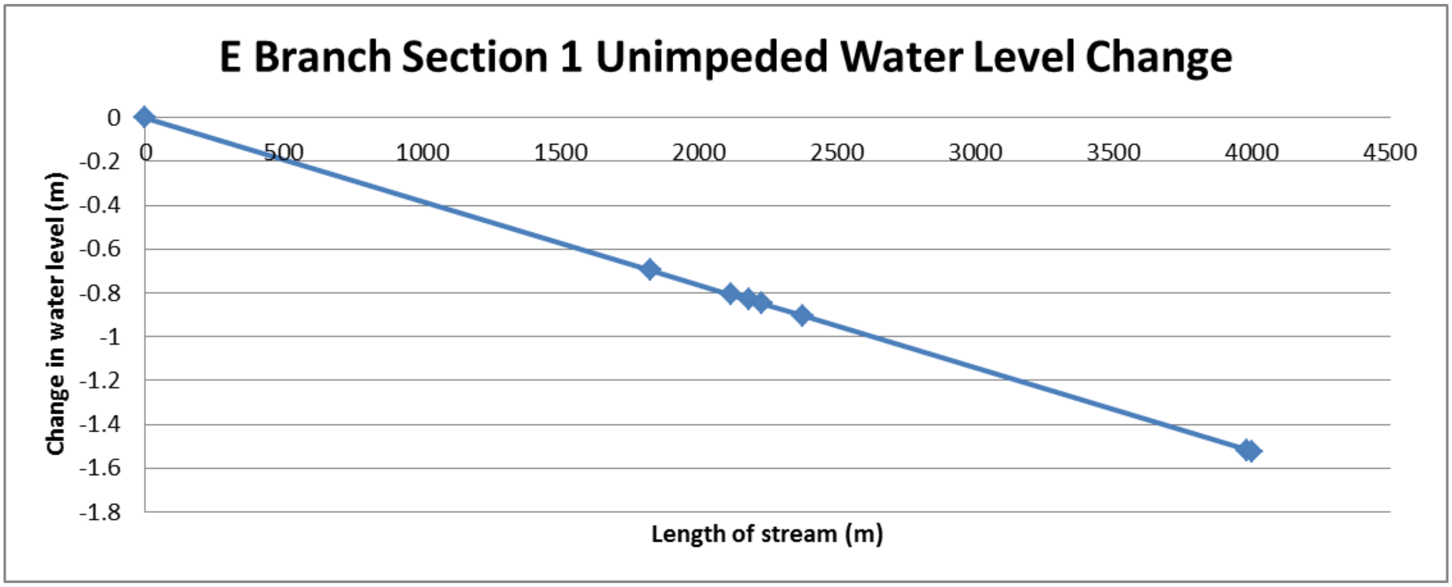

Figure 3. The decrease of water level in relation to length of stream.

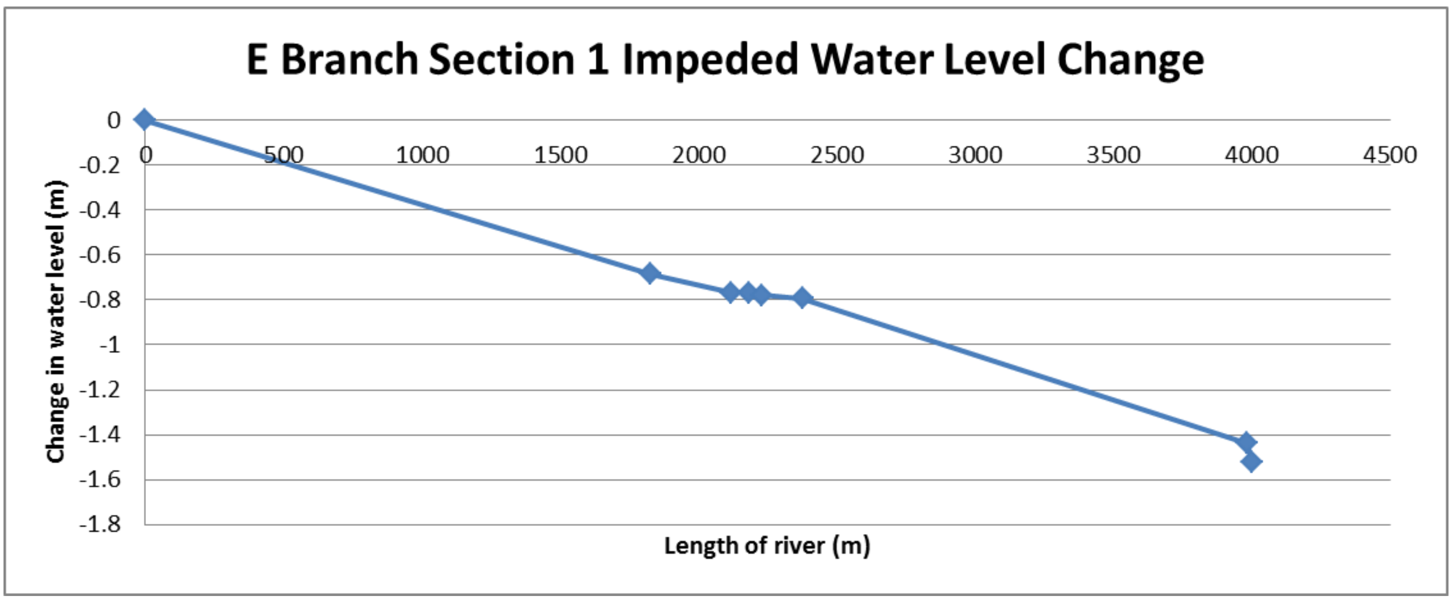

Figure 4. The decrease of water level, impeded by beaver dams, in relation to the length of the stream.

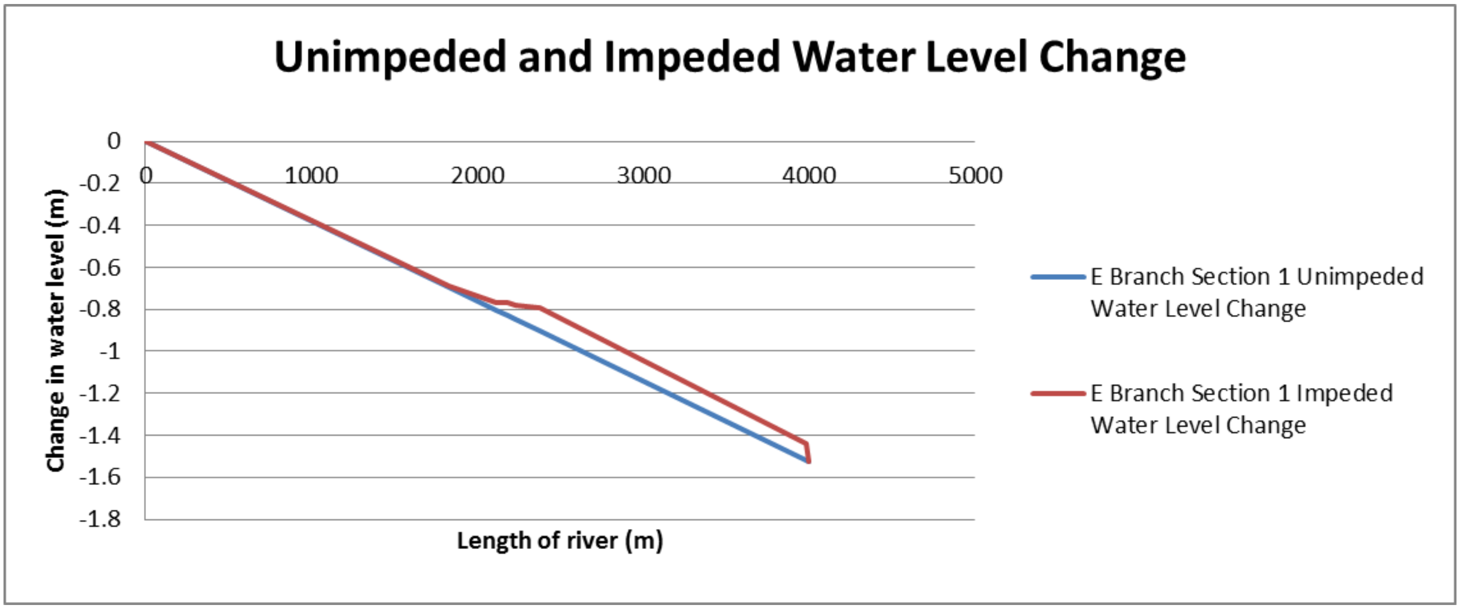

Figure 5. The decrease of water level, unimpeded and impeded by beaver dams, in relation to the length of the stream.

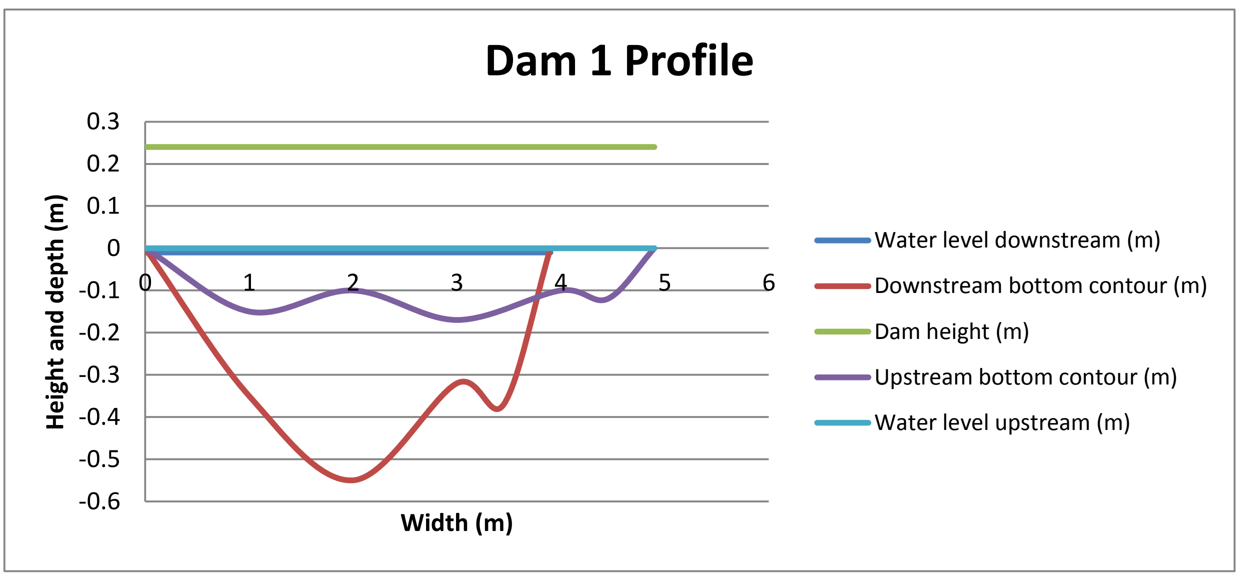

Figure 6. Profile of Dam 1.

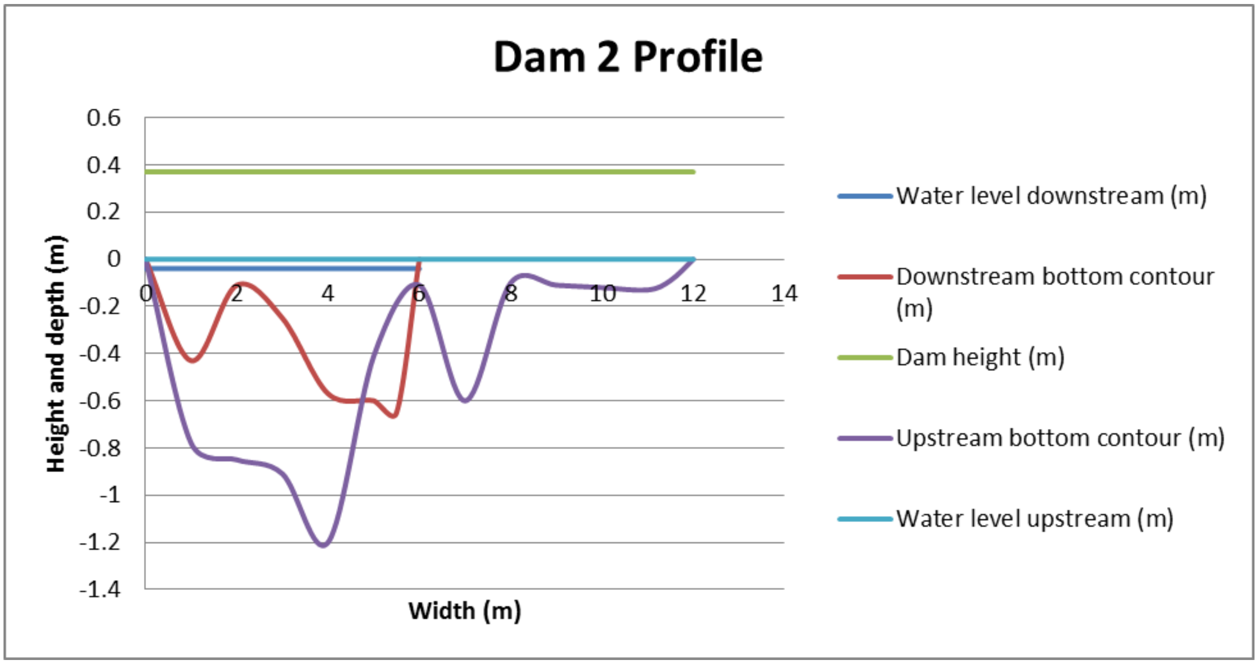

Figure 7. Profile of Dam 2.

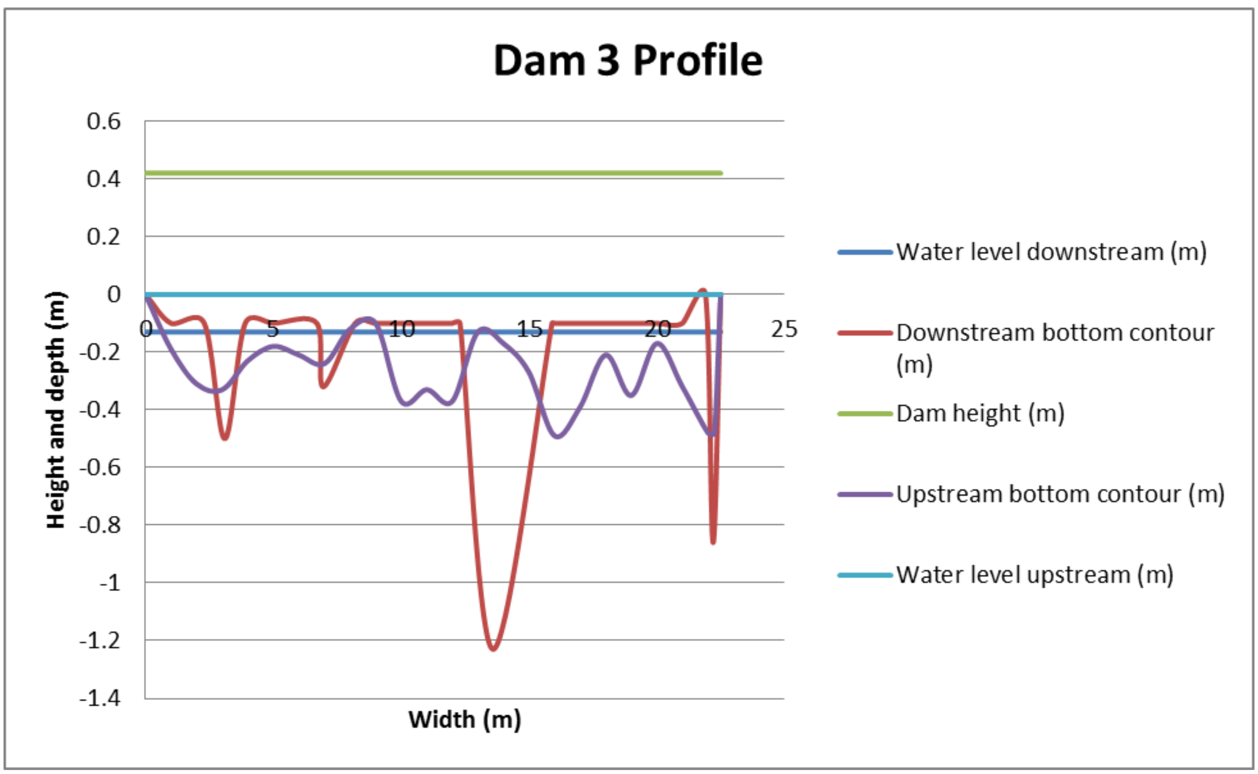

Figure 8. Profile of Dam 3.

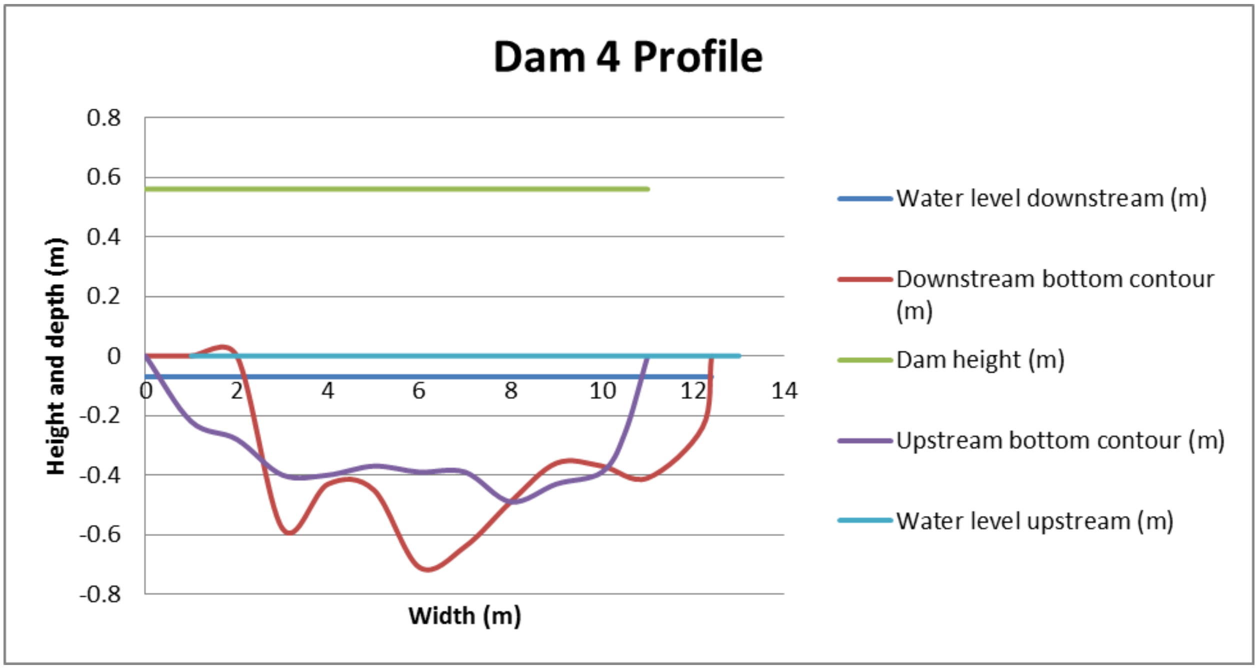

Figure 9. Profile of Dam 4.

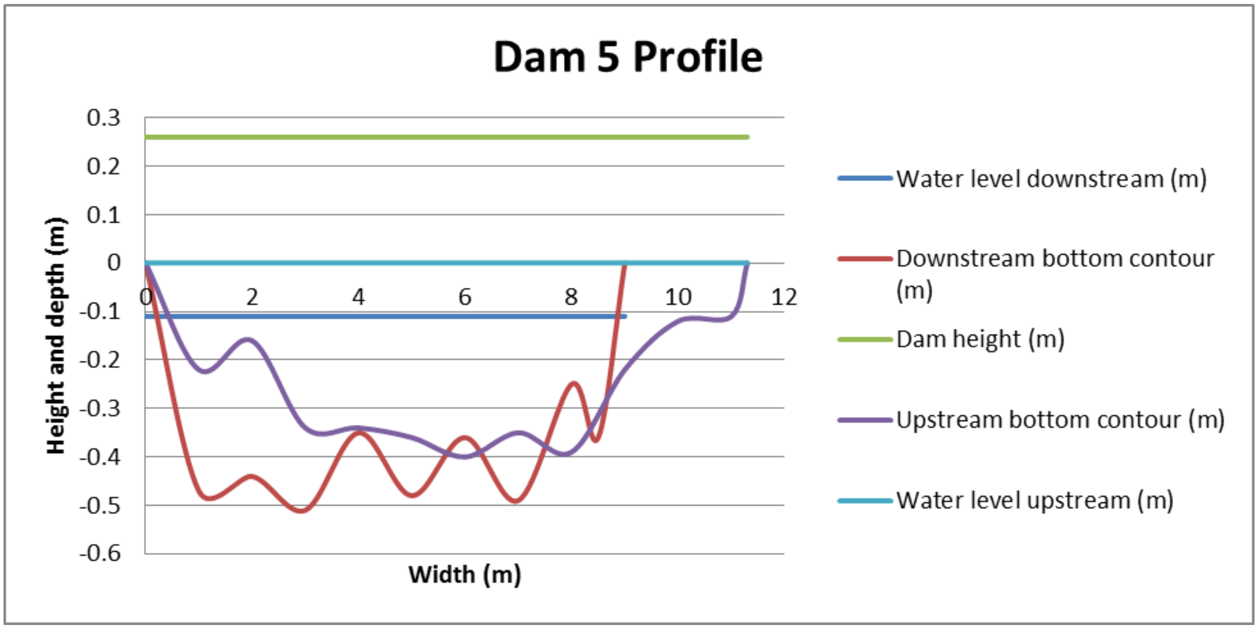

Figure 10. Profile of Dam 5.

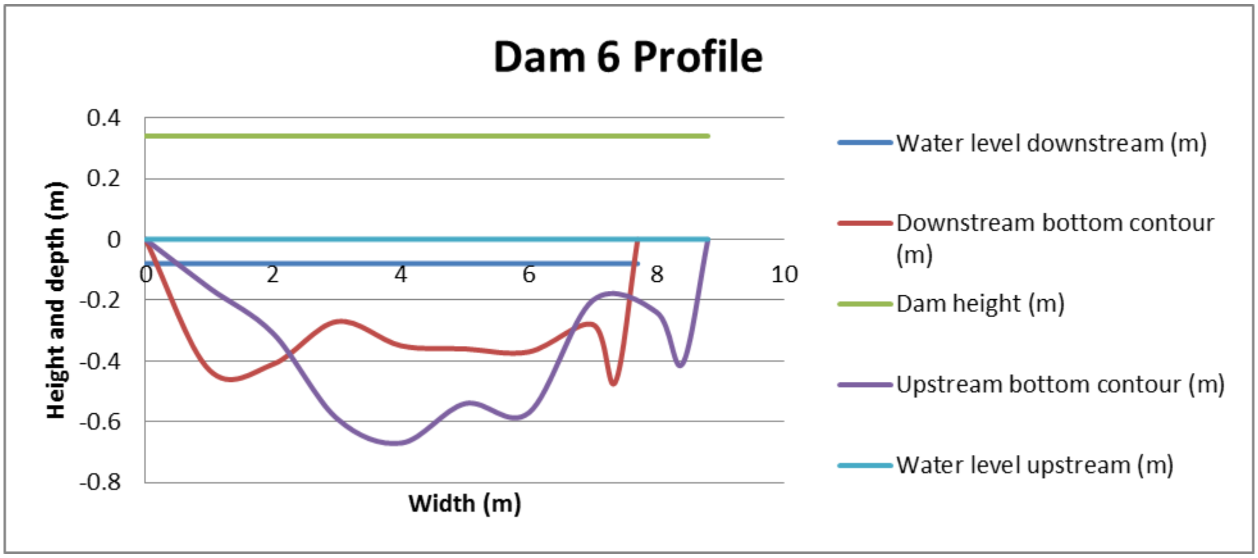

Figure 11. Profile of Dam 6.

Between Douglas Lake Road and Robinson Road

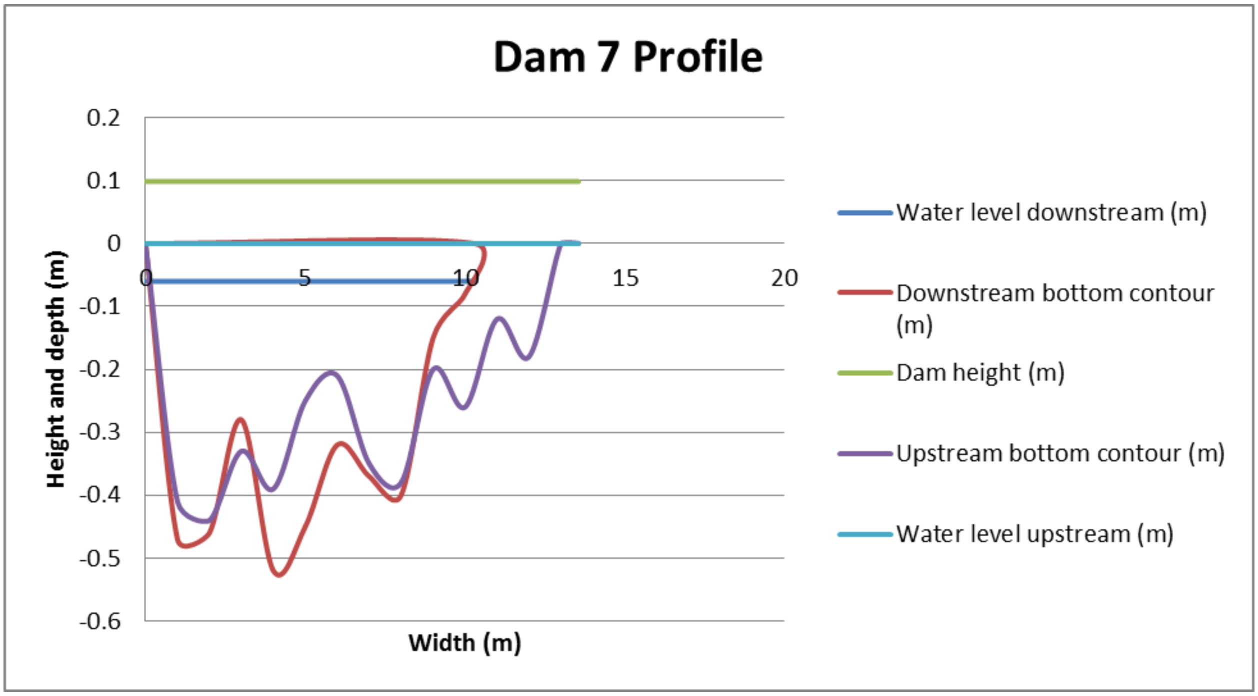

Figure 12. Profile of Dam 7.

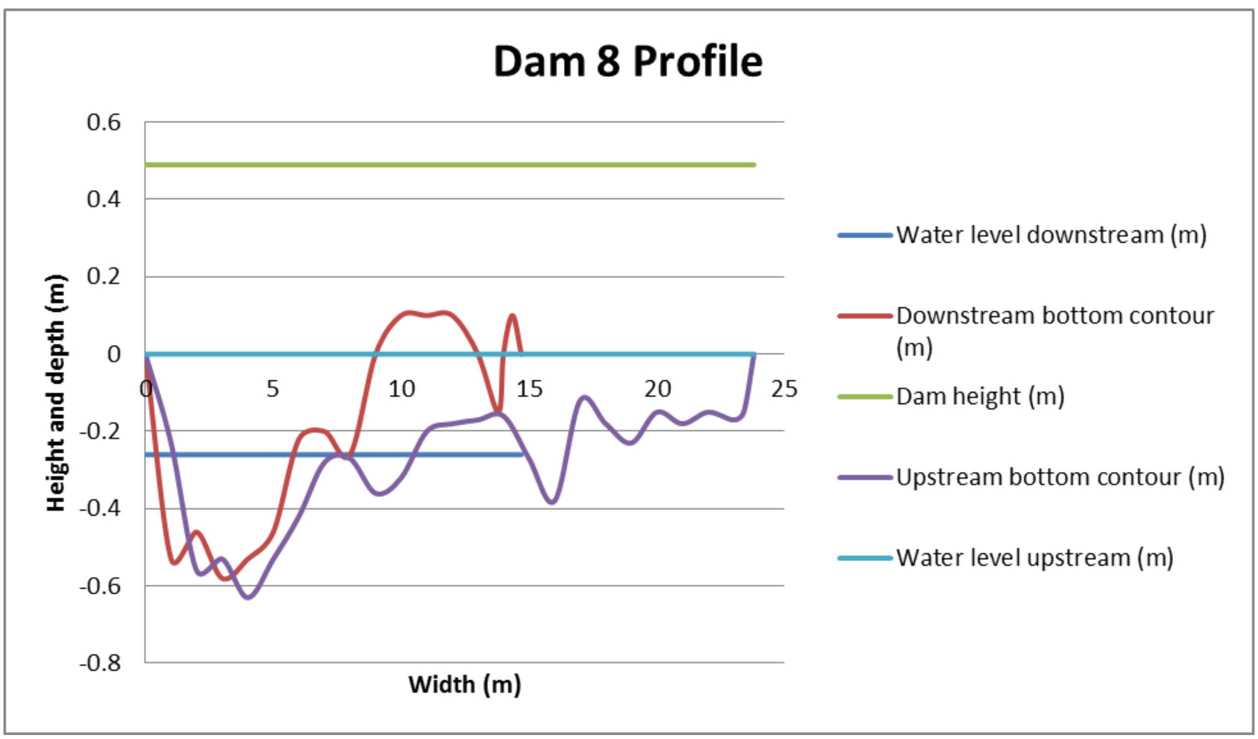

Figure 13. Profile of Dam 8.

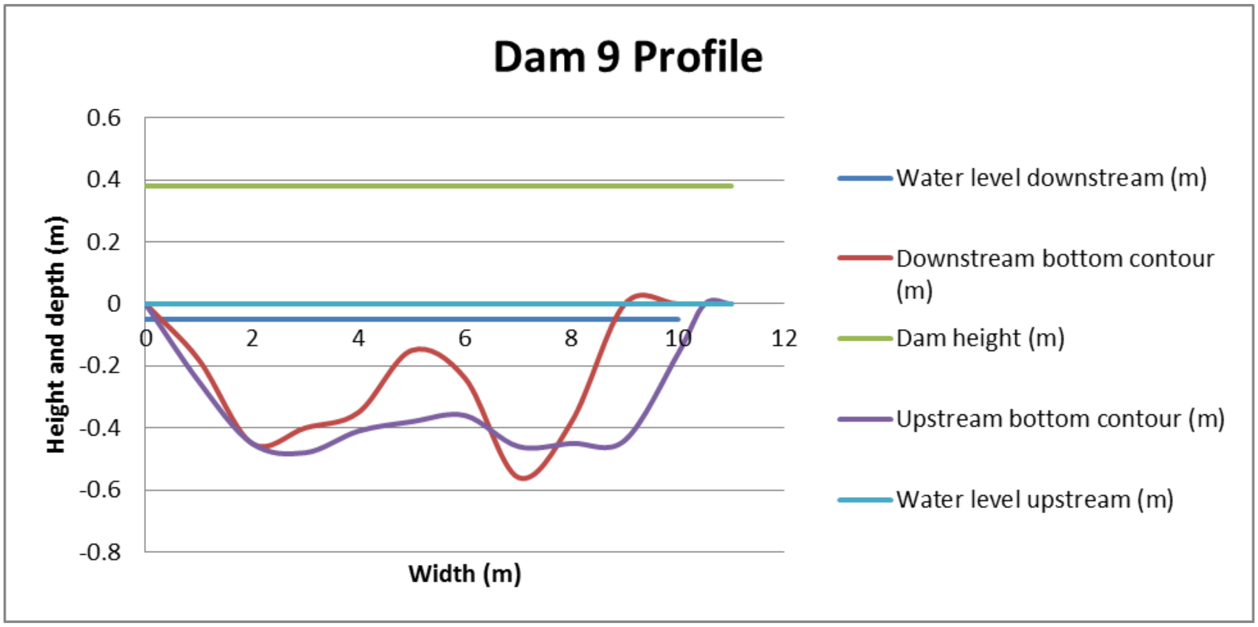

Figure 14. Profile of Dam 9.

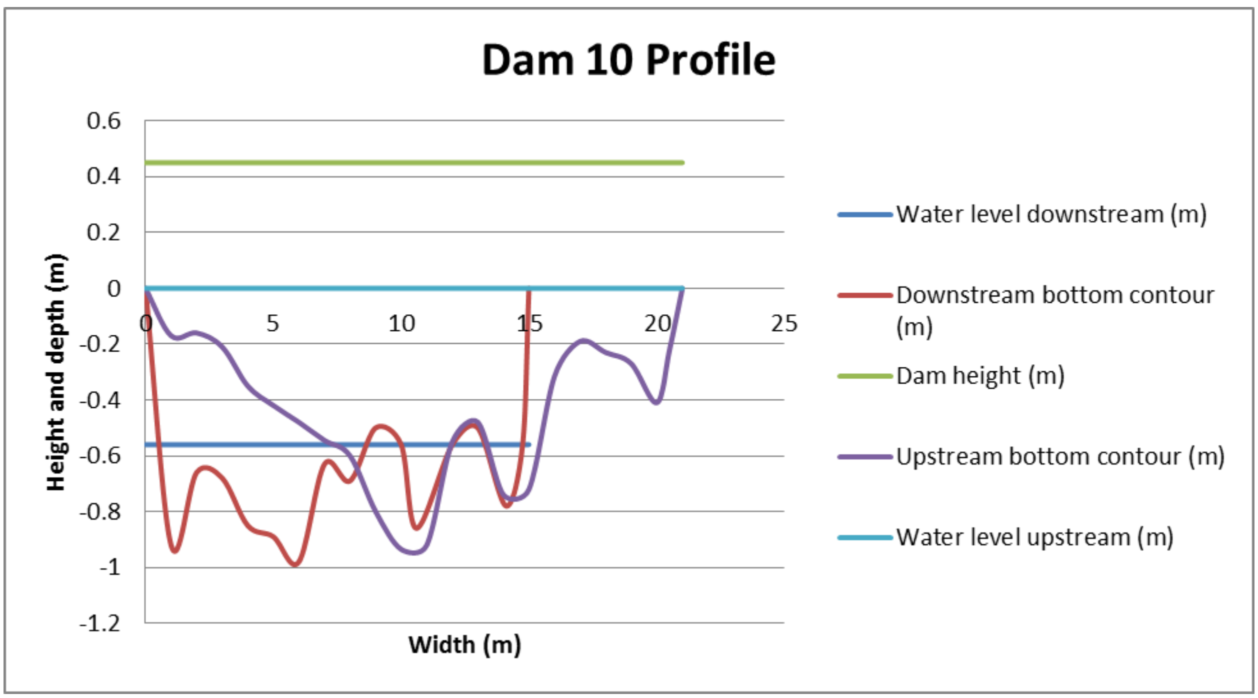

Figure 15. Profile of Dam 10.

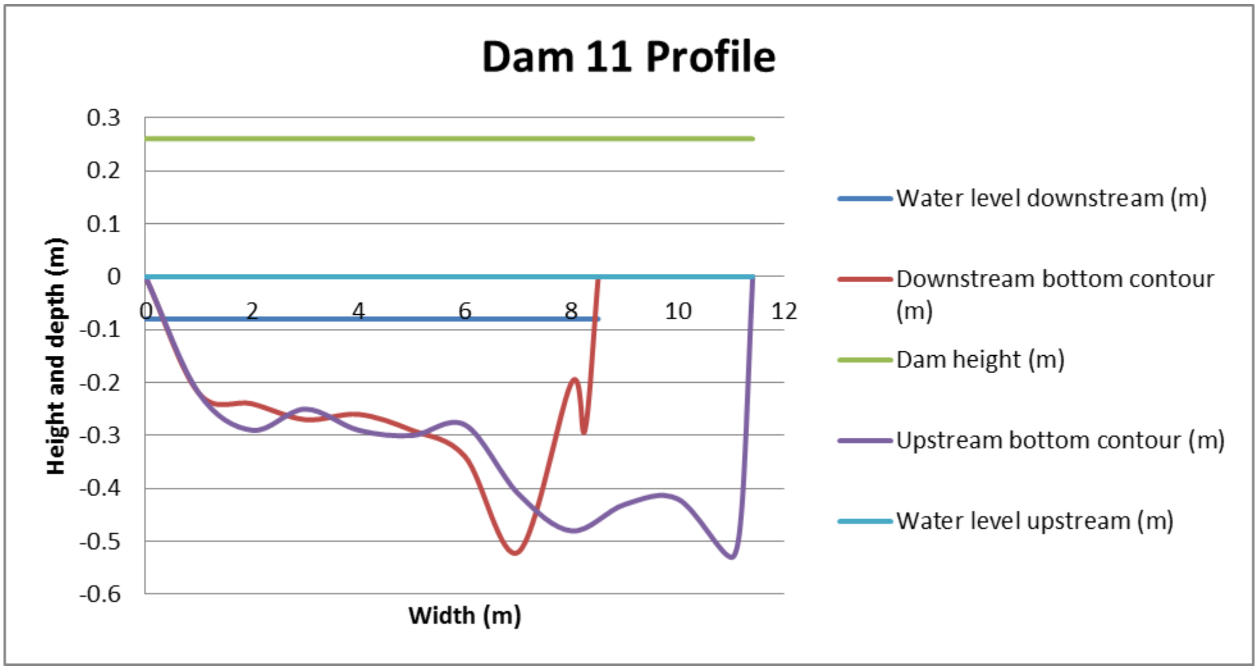

Figure 16. Profile of Dam 11.

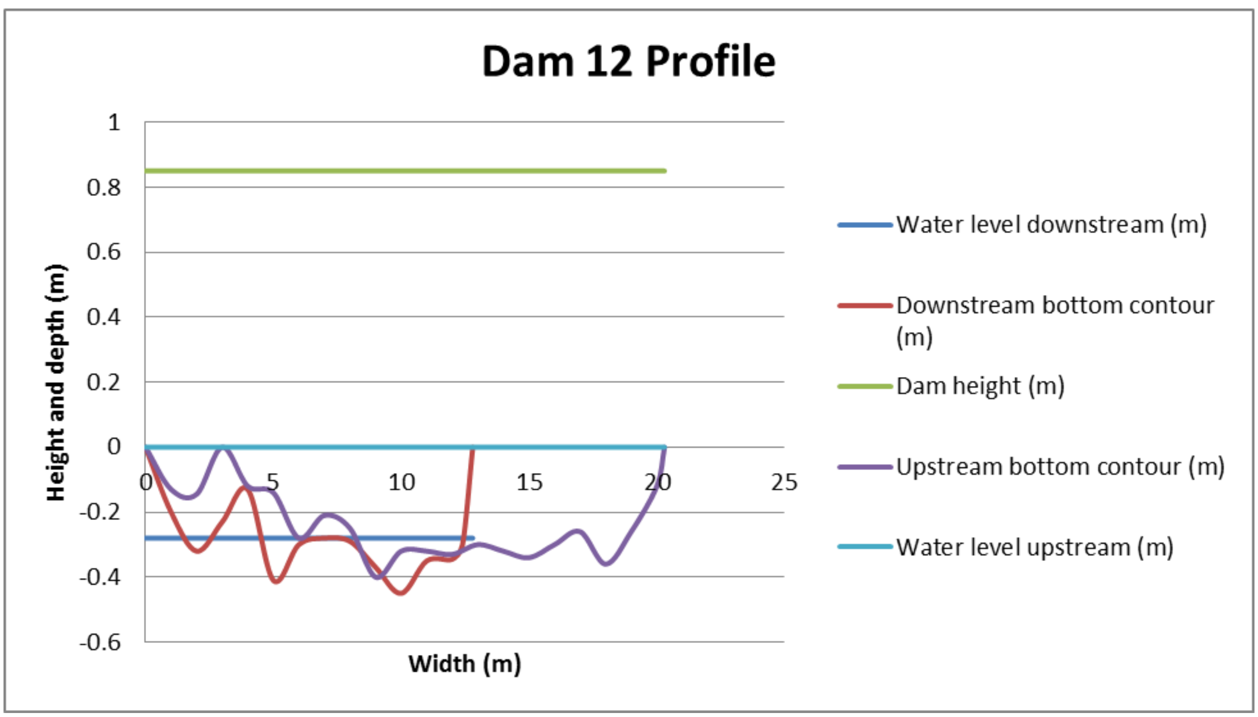

Figure 17. Profile of Dam 12.