Apple Canyon Lake
Preliminary Design Report
Jo Daviess County Illinois

January 2022

CMT
Crawford, Murphy & Tilly
Engineers and Consultants

Table of Contents

Executive Summary

The report provides responses to questions raised by the Property Owners Association following the completion of the Planning Report in 2020. Summary of the questions:

1) Should the channel downstream of the waterfall be widened?
2) What are regulatory requirements related to increased downstream flooding?
3) Can rock removal for the new spillway be done without impact on the dam?
4) What is the estimated cost of adding fill to level the crest of the dam?

The proposed labyrinth spillway will result in increased discharge in comparison to the existing spillway for the same storm event across the watershed. For the 100-year flood, the channel will have a peak water level 3 feet higher. For Alternative No. 1 (30% PMF flood event) in the Planning Report, the peak water level will be 9 feet below the bridge deck. For Alternative No. 2 (60% PMF flood event), the peak water level will be 2 feet below the bridge deck.

The channel downstream of the waterfall does not need to be widened. The bridge downstream of the waterfall will not be overtopped by the design flood required by IDNR. The rock walls of the channel can withstand higher velocities of the increased discharge. The three design floods discuss in the report are rare events. Bridges and county roads are typically designed for flood events of 100-year or less.

The proposed labyrinth spillway will require a construction permit from IDNR and Jo Daviess County. IDNR will not object to the increased discharges from the new spillway which afford better protection of the dam from being overtopped. Jo Daviess County will issue a construction permit if IDNR issues a construction permit.

Rock removal for the labyrinth spillway can be done without impacting the existing dam. Alternative techniques of rock removal such as rock excavating equipment, hydraulic rams and controlled blasting can be specified. Requirements for each technique can be tailored to minimize vibration and other impacts outside the spillway vicinity. Creation of seepage paths through rock not removed is to be considered during design. Soil borings of the dam embankment may be recommended during design.

The estimated cost to raise the dam crest with compacted clay is $44,000. The estimated cost to raise the dam crest with general fill is $33,000.

An additional item was noted in the site visit. The lake depth upstream of the spillway is relatively shallow - 1 to 2 feet deep near spillway and gradually sloping down toward the lake. Rock removal in this area is recommended for increased flow over the labyrinth spillway. Rock removal can be done while the lake is lowered for construction.

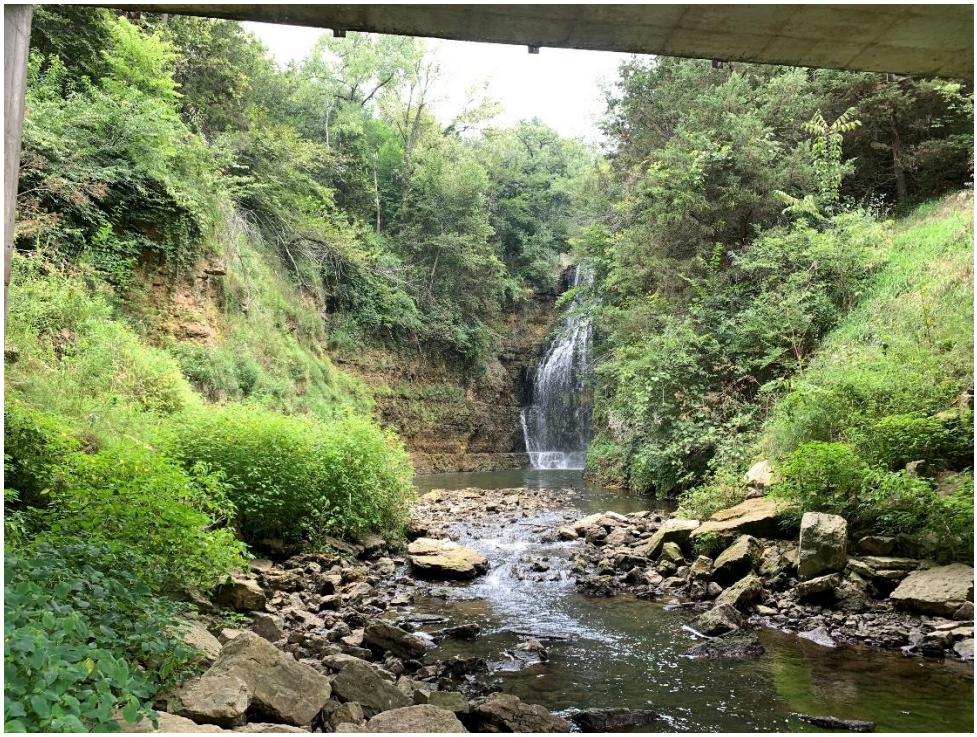
1. Introduction

Following the completion of the Planning Report for the Apple Canyon Lake spillway, the Property Owners Association (POA) authorized further investigation into the proposed project to construct a new labyrinth spillway. The areas of investigation are as follows.

- Evaluation of the flow in the channel downstream of the waterfall
- County and State regulatory requirements for spillway replacement
- Removal of rock for the spillway (Report by Rubino Engineering included)
  - Impact of rock removal methods on the dam
  - Recommendations on rock removal methods
  - Geotechnical aspects of the rock removal for the proposed spillway
- Cost Opinion to raise the crest of the dam to be level

2. Hydraulic Analysis of Downstream Channel

The proposed labyrinth spillway will release water from Apple Canyon Lake at a higher rate than the existing spillway will for the same rainfall event across the watershed. The concern is whether the channel downstream of the waterfall has adequate flow capacity or if additional rock removal from the channel will be needed.



View upstream of bridge on South Apple Canyon Lake Road

Channel downstream of bridge on South Apple Canyon Road

The channel downstream of the waterfall was analyzed hydraulically from the waterfall to 300 feet downstream of the bridge. The channel was field surveyed to develop cross sections. The HEC-RAS hydraulic software developed by the U.S. Army Corps of Engineers was utilized for calculations. The following information was input to the computer model:

- Ten cross sections of the channel
- Dimensions of the bridge opening under South Apple Canyon Road
- Peak flow rates for four storm events taken from the Planning Report
  - 100-year flood with existing spillway – Flow 2,827 cfs
  - 100-year flood with proposed labyrinth spillway - Flow 5,026 cfs
  - 30% of the Probable Maximum Flood (PMF) – Flow 6,926 cfs
  - 60% of the Probable Maximum Flood – Flow 14,407 cfs
- Estimation of the channel roughness factor (n value)

The Planning Report prepared in June 2020 includes two alternatives for the proposed spillway. Alternative No. 1 is a labyrinth spillway and channel capable of handling a flood of 30% of the PMF without overtopping the dam. Alternative No. 2 is a labyrinth spillway and channel capable of handling a flood of 60% of the PMF without overtopping the dam. The 60% PMF flood is the current requirement of the IDNR regulations for existing dams with High Hazard downstream .

The results of the hydraulic analysis are summarized as follows.

- For the 100-year flood, the water level under the South Apple Canyon Road bridge will be 3 feet higher with the labyrinth spillway than with the existing spillway.

- For Alternative No. 1 with the 30% PMF flood, the peak water level will be 9 feet below the underside of the bridge deck. The bridge will not be overtopped in this flood scenario.

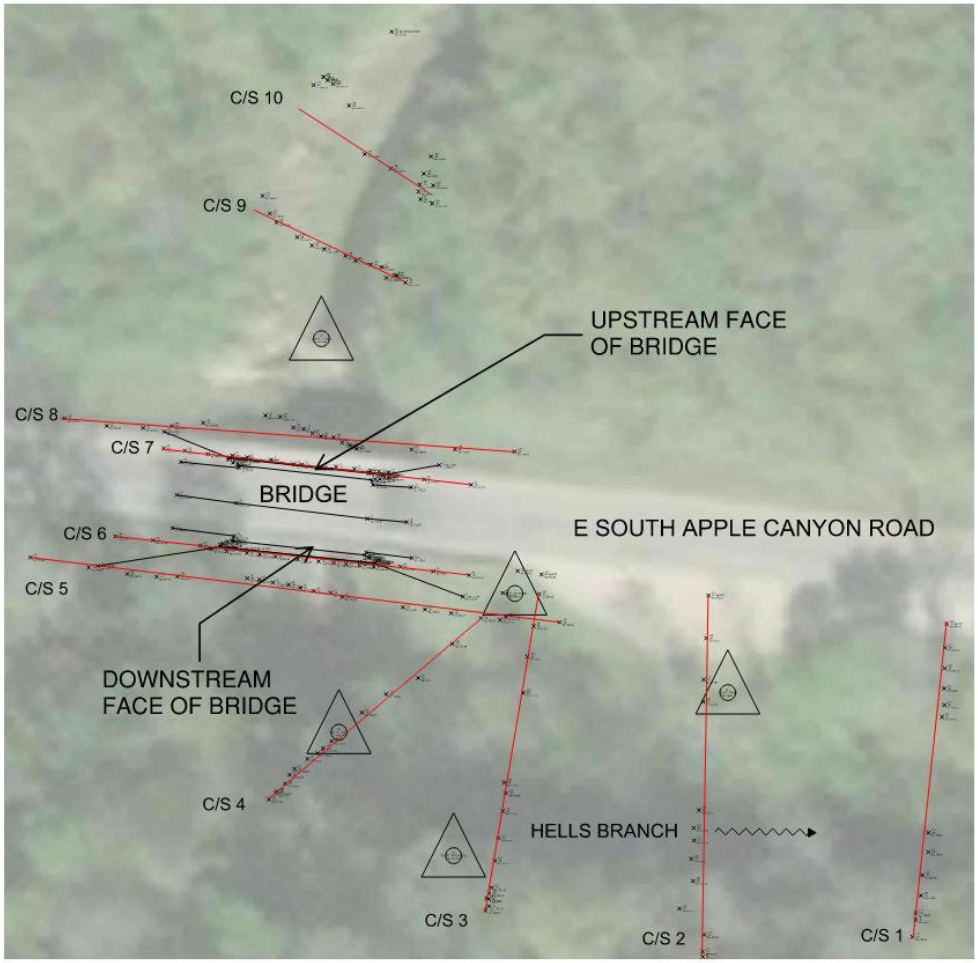
- For Alternative No. 2 with the 60% PMF flood, the peak water level will be 2 feet below the underside of the bridge deck. The bridge will not be overtopped in this flood scenario.

The results of the hydraulic analysis are presented in Exhibits 1 – 5. Exhibit 1 shows the location of the cross sections of the downstream channel. Exhibit 2 shows the peak water surface profile of the four flood events. The peak water surface is defined as the highest water level predicted during the flood event. Exhibits 3 – 5 show the peak water levels in the downstream channel at three cross sections: between the bridge and the waterfall; at the upstream side of the bridge; and 200 feet downstream of the bridge.

The flow in the downstream channel between the waterfall and 300 feet downstream of the bridge will not be backed up by flooding in Hells Branch Creek which is 700 feet east of the bridge. The conclusion was determined as follows. First, the flow through the downstream channel is in critical flow stage at the end which means that the water surface profile is not affected by the downstream water levels based on principles of open channel hydraulics.

Second, the report prepared by IDOT in November 1983 (Hydrologic, Hydraulic and Dam Breach Analysis for Apple Canyon Lake Dam Jo Daviess County) shows a peak water level of El. 728 in Hells Branch Creek on the downstream side of the dam for the 100% PMF flood with no dam breach. The water level El. 728 is 7 feet lower than the water level in the downstream channel analyzed for this report for the 60% PMF. Therefore, the water level in Hells Branch Creek will not cause a backwater effect on the flow in the downstream channel.

The higher flow rates from the labyrinth spillway may result in overtopping of South Apple Canyon Road for a certain range of flood events which would not have overtopped the road with the existing spillway.



NORTH

CMT

APPLE CANYON LAKE PROPERTY OWNERS ASSOCIATION

Apple Canyon Lake

APPLE RIVER, ILLINOIS

MARK	DATE	DESCRIPTION

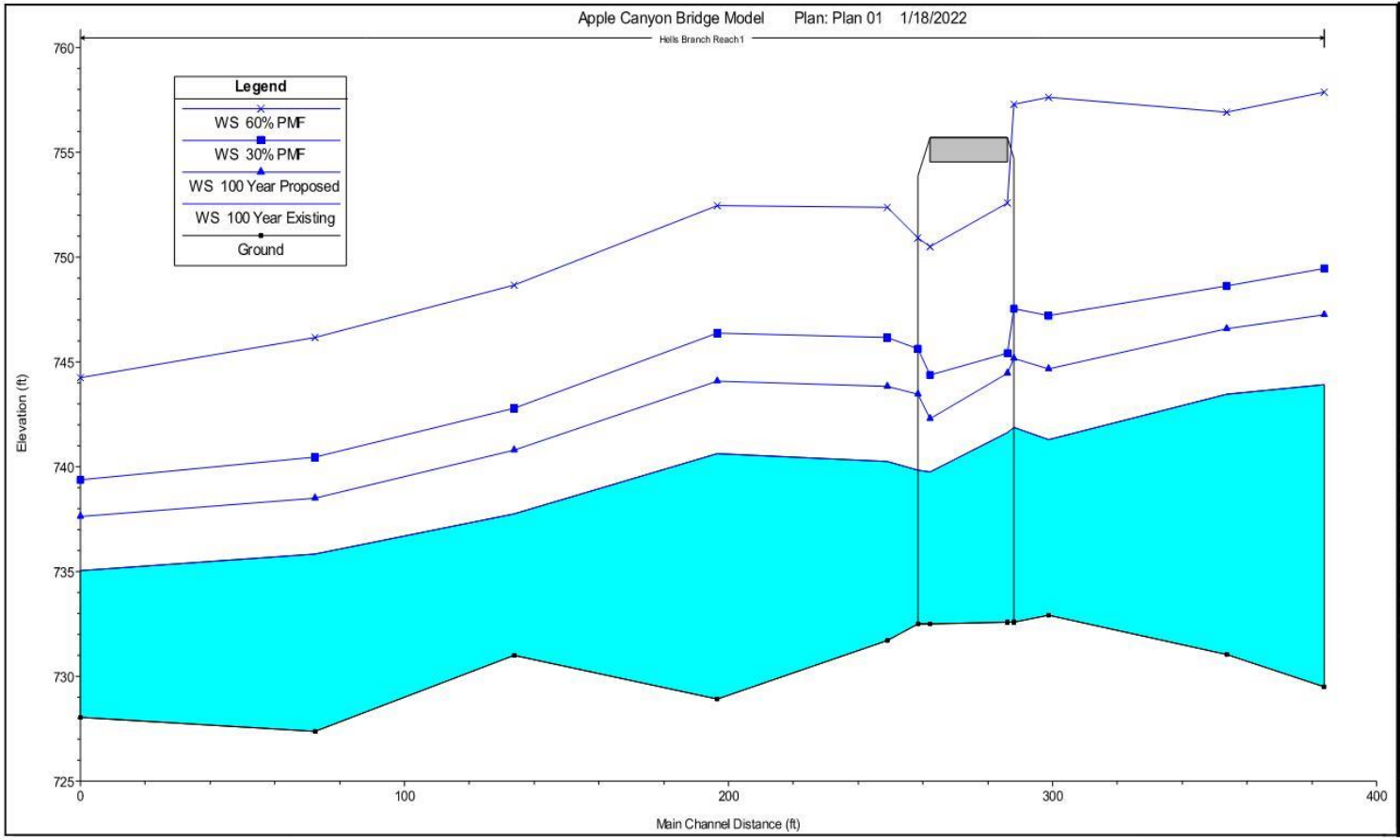
PROJECT NO:	19000144-01
CAD DWG FILE:	
DESIGNED BY:	
DRAWN BY:	--
CHECKED BY:	--
APPROVED BY:	--
COPYRIGHT:	CRAWFORD, MURPHY & TILLY, INC. 2022

SHEET TITLE

AERIAL WITH CROSS SECTIONS

EXHIBIT 1

SHEET -- OF --



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APPLE CANYON LAKE PROPERTY OWNERS ASSOCIATION

Apple Canyon Lake

APPLE RIVER, ILLINOIS

MARK	DATE	DESCRIPTION

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SHEET TITLE

PROFILE PLOT

EXHIBIT 2

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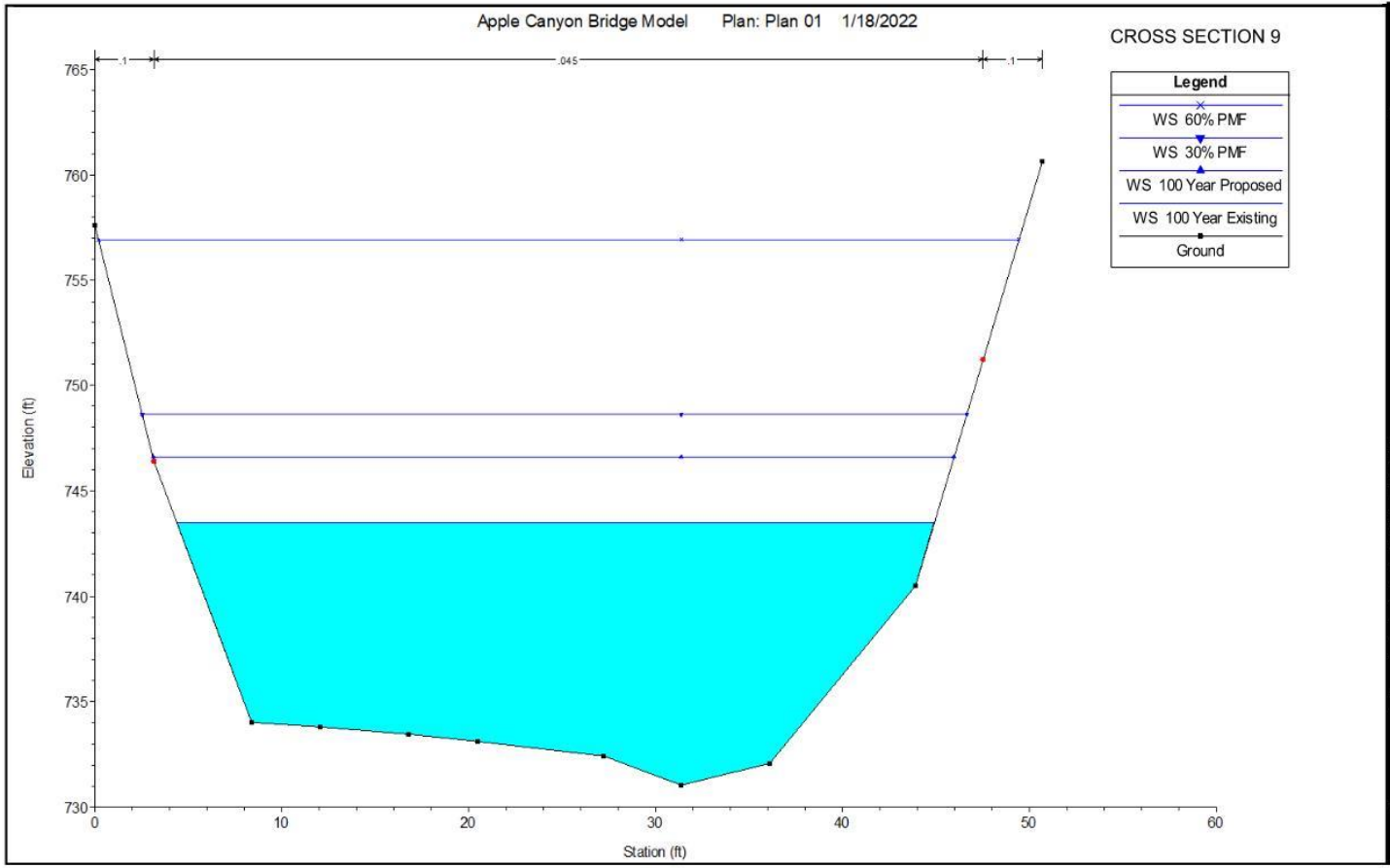

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APPLE CANYON LAKE PROPERTY OWNERS ASSOCIATION

Apple Canyon Lake

APPLE RIVER, ILLINOIS

MARK	DATE	DESCRIPTION

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UPSTREAM CROSS SECTION

EXHIBIT 3

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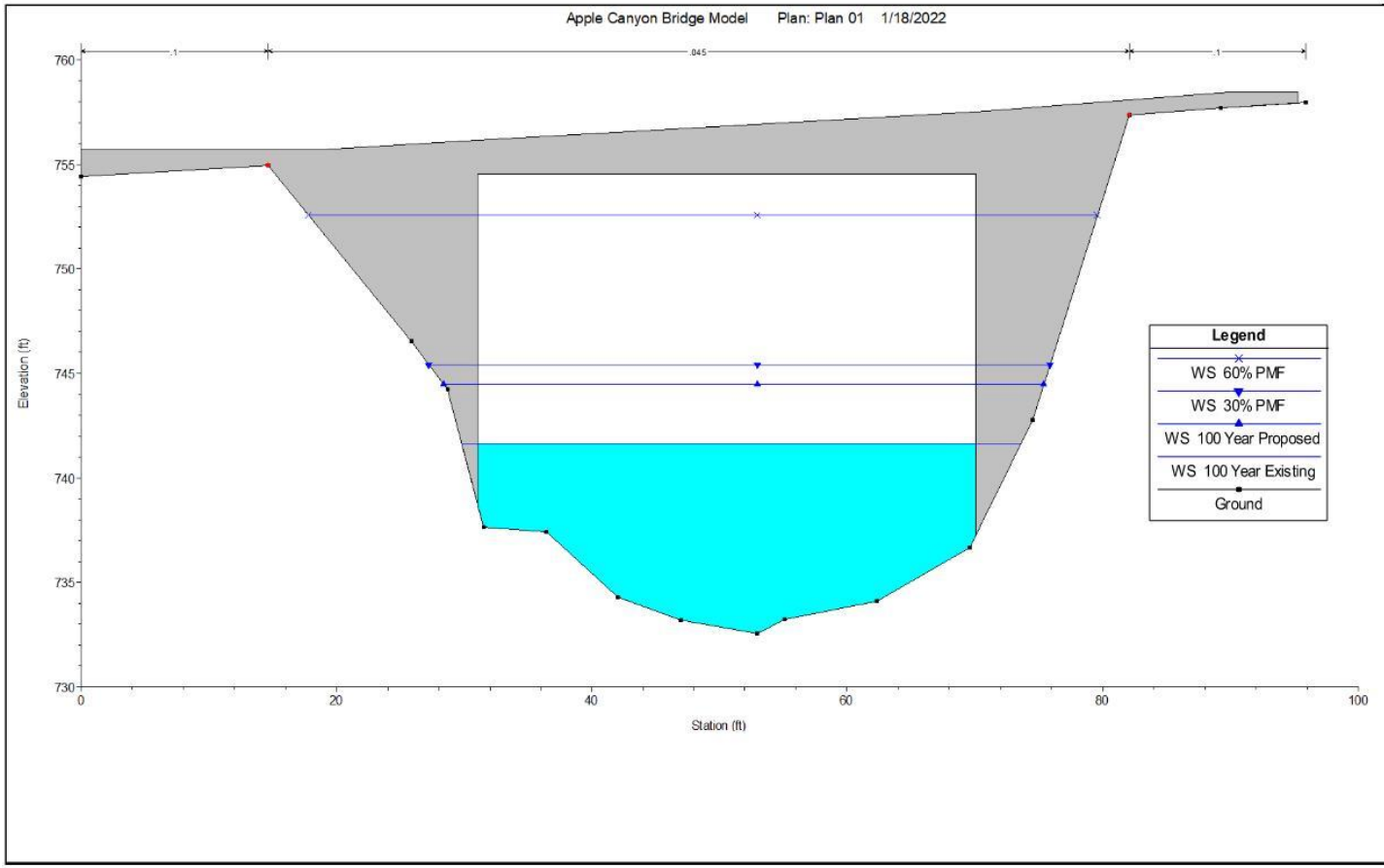

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APPLE CANYON LAKE PROPERTY OWNERS ASSOCIATION

Apple Canyon Lake

APPLE RIVER, ILLINOIS

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BRIDGE UPSTREAM CROSS SECTION

EXHIBIT 4

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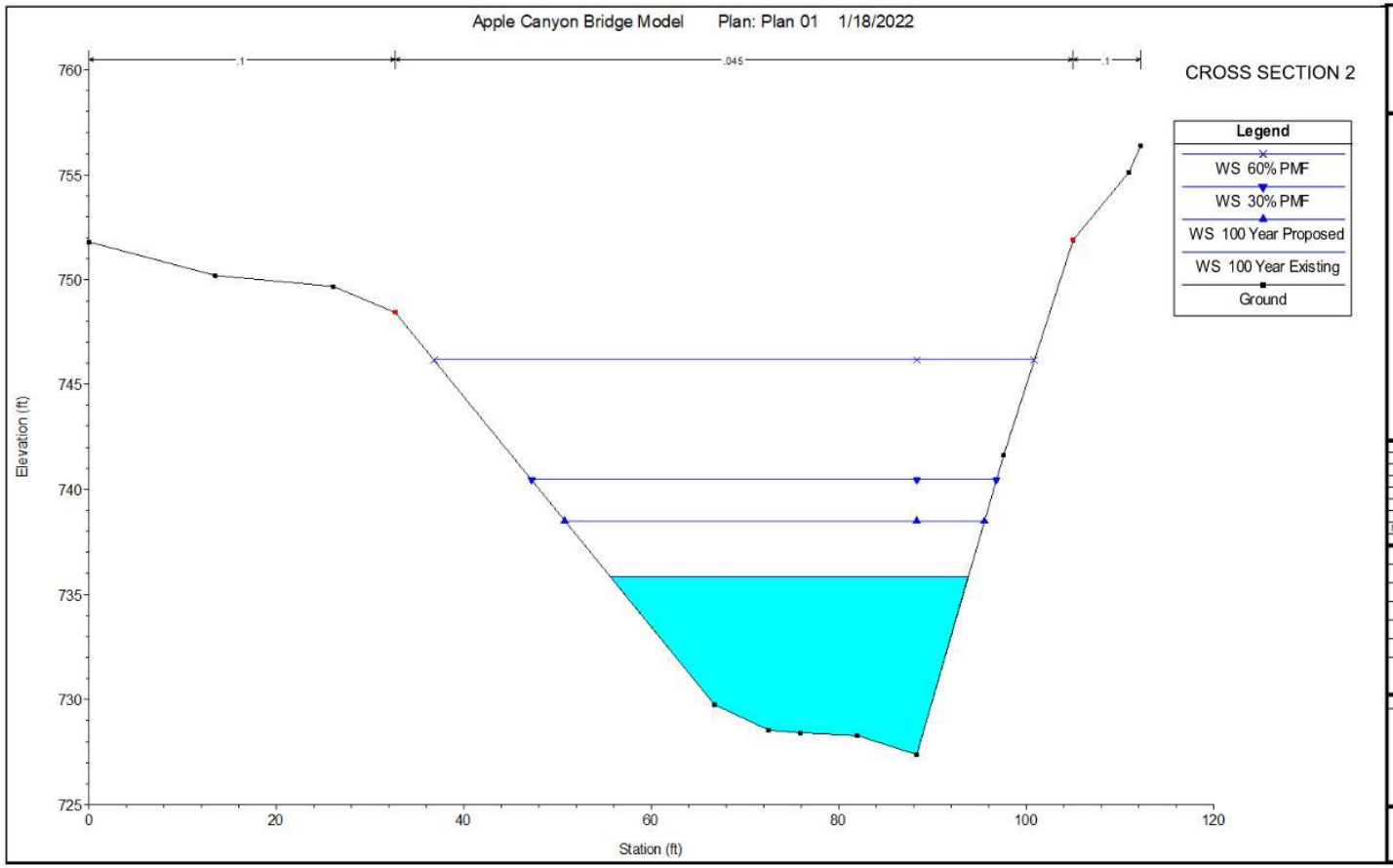

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APPLE CANYON LAKE PROPERTY OWNERS ASSOCIATION

Apple Canyon Lake

APPLE RIVER, ILLINOIS

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SHEET TITLE

DOWNSTREAM CROSS SECTION

EXHIBIT 5

SHEET -- OF --

Rock Removal in Downstream Channel

The increased flow rates in the downstream channel raise the question of whether the downstream channel should be widened by removal of rock along the channel. The higher flow rates will result in higher velocities under the bridge and in the channel.

The hydraulic analysis shows that the velocities through the bridge opening will be between 13 and 16 feet per second (fps) for the 100-year flood. The velocities will be between 21 and 23 fps for the design flood of 60% PMF. The velocities in the channel upstream and downstream of the bridge are lower because the channel is wider than the bridge.

The rock surfaces of the channel will be able to withstand the higher velocities. The higher velocities may result in movement of the loose rocks on the bottom of the channel and erosion of the earth banks of the channel downstream of the bridge.

The channel and bridge do not need to be widened in our opinion because they are capable of passing the discharge flows without overtopping the bridge. Furthermore, the flood events analyzed herein are extremely rare events. Roadway bridges and drainage channels for counties and townships in Illinois are typically designed for floods equal to or smaller than the 100-year frequency flood.

The bridge plans dated 1969 show that the bridge foundation is in a trench excavated into the native rock. The bottom of the foundation is 2 to 4 feet below the creek bottom. The condition around the bridge foundation should be checked after major flood events for undermining of the bridge.

During the site visit on August 6, 2021, a Thompson Township employee mentioned that the riprap on the upstream side of the bridge base has been replenished following a few high flow events in the past. It is recommended that larger riprap pieces be placed at the base of the bridge to prevent scour during future floods.

3. Downstream Flooding Hazard - Regulatory Requirements

The replacement of the existing spillway with a labyrinth spillway will require governmental permits from Illinois Department of Natural Resources (IDNR) and from Jo Daviess County. One concern raised about the new spillway is that the discharges downstream will be greater than the existing spillway for the same storm across the watershed.

The question of increased discharge was presented to IDNR Division of Water Resource Management who issues the construction permits for dams. IDNR stated that increased discharge does not violate any provision of the regulations that apply to the project. IDNR regulations have a primary intent to protect the dam from overtopping and being breached. The dam does not meet current IDNR regulations because the dam was constructed before the regulations were enacted. The proposed

spillway Alternative No. 2 would bring the dam into compliance with current state regulations which have changed since the dam was constructed. IDNR commented that local floodplain regulations would apply also.

Although the flow in Hell's Branch Creek will increase if the spillway is replaced, the peak flow rate from the new spillway will be less than would occur if the dam did not exist. The lake detains the natural flooding surge which reduces peak flows and water levels downstream of the dam.

The spillway project construction will be regulated by Jo Daviess County ordinance Title 10 Flood Control, Section 10-1-6: Preventing Increased Flood Heights and Resulting Damages. The Jo Daviess County Engineer stated that a county construction permit would be issued if the IDNR issues a construction permit. The response agrees with the wording in Paragraph B.1 of the county ordinance.

4. Raising the Dam Crest

It is recommended to add earth fill to make the crest of the dam level at El. 807.81. The raising of the crest will increase the freeboard above the lake level for all flood scenarios because freeboard is defined as the vertical difference between the water level and the lowest point on the crest of the dam. The east end of the dam crest is 1.05 feet lower in elevation than the west end of the dam based on the survey of the four control points on the crest. It is not known why the crest of the dam is not level from end to end.

There are two options to raising the crest of the dam.

Option 1
Remove vegetation and roots. Place compacted clay fill up to El. 807.81 for the full length of the dam. The dam will be considered capable of retaining water to the crest elevation if the fill is placed in accordance with IDNR requirements for an earthen dam. The estimate includes adding riprap to the upstream side of the fill. A construction permit will be required from IDNR for Option 1.

The total project cost opinion for Option 1 is $44,000 in Table 1. The delivery cost of the clay fill in Option 1 is based on a quotation from Stagecoach Trails Limestone quarry located northeasterly of Apple Canyon Lake.

Option 2
Remove vegetation and roots. Place lightly compacted general dirt fill up to El. 807.81. The material would not be considered capable of retaining water. The top of dam will be considered to be the lowest point of the existing crest at El. 806.76. The estimate includes adding riprap to the upstream side of the fill. It is unknown at this time if IDNR will require a construction permit for Option 2 based on communication with IDNR about the matter.

The total project cost opinion for Option 2 is $33,000 in Table 2. The delivery cost of the general dirt fill in Option 2 earth is based on a quotation from the Helm Group quarry located southwest of the Apple Canyon Lake.

Option 1 is recommended because the peak water level of Apple Canyon Lake for the design flood of 60% PMF is El. 807.7 which is 0.1 foot below the crest in Option 1. The dam will have less freeboard than recommended by IDNR but would be capable of retaining the peak water level of the design flood.

Table 1
Apple Canyon Lake Dam
Option 1 - Raise the Dam Crest with Compacted Clay

OPINION OF PROJECT COST

	Quantity	Unit	Unit Price	Amount
Mobilization				$ 3,000
Strip 3" topsoil & vegetation	111	C.Y.	11.90	$ 1,320
Haul away topsoil	111	C.Y.	5.44	$ 603
Loosen soil disk	1685	S.Y.	1.15	$ 1,938
Clay fill delivered to site	380	C.Y.	$16.50	$ 6,272
Spread soil	380	C.Y.	11.90	$ 4,525
Compact soil	380	C.Y.	2.15	$ 817
Soil testing in lab		L.S.		$ 1,000
Soil testing on site		L.S.		$ 1,500
Filter Fabric	140	S.Y.	2.30	$ 323
Riprap on upstream face	140	S.Y.	36.23	$ 5,087
Fetilize & seed	0.35	acre	1,810	$ 630
Total Construction Cost				$ 25,000
Geotechnical Engineering				$ 1,500
Field Survey				$ 4,000
Prepare Request for Construction Proposal				$ 5,000
IDNR Permit Application & Response				$ 2,000
Construction Observation (3 days part time)				$ 3,000
Reset Four Survey Monuments on Crest				$ 3,000
Total Non-construction Cost				$ 18,500
Total Project Cost				**$ 44,000**

Table 2
Apple Canyon Lake Dam
Option 2 - Raise the Dam Crest with General Fill

OPINION OF PROJECT COST

	Quantity	Unit	Unit Price	Amount
Mobilization				$ 3,000
Strip 3" topsoil & vegetation	0	C.Y.	-	$ -
Haul away topsoil	0	C.Y.	-	$ -
Loosen soil disk	1685	S.Y.	1.15	$ 1,938
General fill delivered to site	269	C.Y.	13.61	$ 3,665
Spread soil	269	C.Y.	11.90	$ 3,205
Compact soil		C.Y.		$ -
Soil testing in lab		L.S.		$ -
Soil testing on site		L.S.		$ -
Filter Fabric	140	S.Y.	2.30	$ 323
Riprap on upstream face	140	S.Y.	36.23	$ 5,087
Fetilize & seed	0.35	acre	1,810.12	$ 630
Total Construction Cost				$ 15,000
Geotechnical Engineering				$ 1,500
Field Survey				$ 4,000
Prepare Request for Construction Proposal				$ 5,000
IDNR Permit Application & Response				$ 2,000
Construction Observation (2 days part time)				$ 2,000
Reset Four Sruvey Monuments on Crest				$ 3,000
Total Non-construction Cost				$ 17,500
Total Project Cost				**$ 33,000**

GEOTECHNICAL ENGINEERING REPORT BY RUBINO ENGINEERING IS ON THE FOLLOWING PAGES

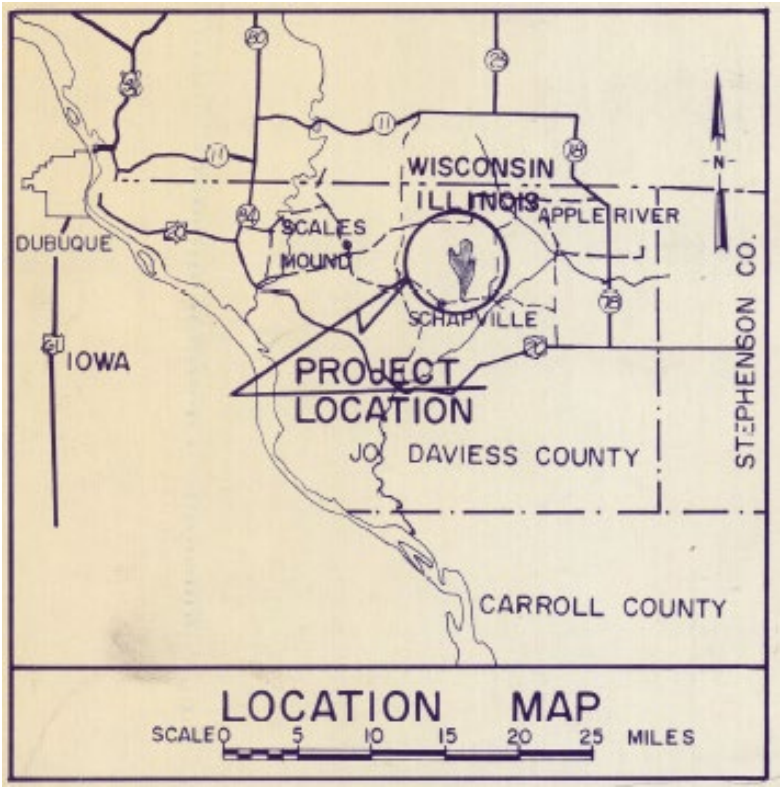
PROJECT UNDERSTANDING - DAM HISTORY

The purpose of this geotechnical report is to discuss rock removal for the spillway channel, raising the Dam crest, and potential impacts on the Dam itself.

Mr. Ted LaBelle, P.E. with Crawford Murphy & Tilly (CMT) provided the project information to PSI through multiple emails from December 15, 2020 through January 27, 2021. Attached to the emails, PSI received the following documents which were then passed on to Rubino.

- Apple Canyon Lake Dam and Spillway Planning Report by CMT dated June 2020
- Apple Canyon Lake Dam and Spillway Construction Plans with completed soil borings at the Dam and Lake site, prepared by Bauer Engineering, Inc. dated April 1969
- Army Corp of Engineering Inspection Report dated July 1978
- Apple Canyon Lake Dam and Spillway Phase-II investigation Report by Hanson Engineering Inc. dated 10/1/1982

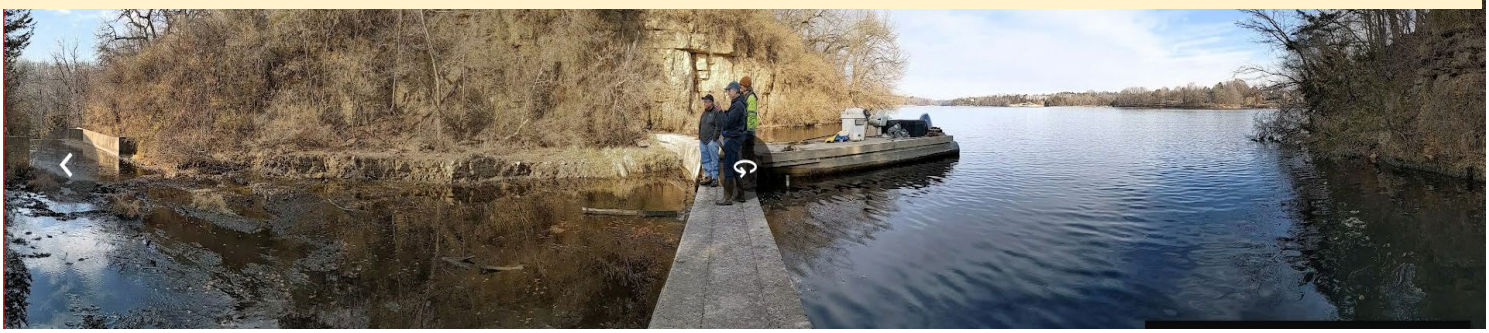
Based on the provided information, Rubino and PSI Intertek understand that the Apple Canyon Lake Dam is an 80-feet high and 1,100 feet in length, earth and rock fill Dam. The Dam was constructed during 1969 and was classified as the "high hazard potential", intermediate size Dam under Illinois Department of Natural Resources (IDNR) regulations.



The Dam is owned by Apple Canyon Lake Property Owner's Association and the reservoir is used by the Association members for recreational purposes. The appurtenant work consists of a concrete broad-crested weir chute spillway cut in rock and discharging into a vertical drop plunge pool located at the right abutment and a steel-lined concrete conduit outlet works located at the approximate midpoint of the Dam. The weir is a concrete wall with overall length of 95.7 feet long and height of 4 feet. The crest of the wall has an elevation 800.00 for a length of 82 feet and a low flow notch at elevation 799.42 for a length of 13.7 feet long. The spillway channel is a combination of natural rock floor and walls, followed by concrete floor and walls.

Apple Canyon Lake has reportedly experienced three unusually high flood levels since 2010 with the highest level occurring in July 2017. The peak water level was within 1 to 2 feet of the top of the Dam according to information from Apple Canyon Lake Property Owners Association (ACLPOA).

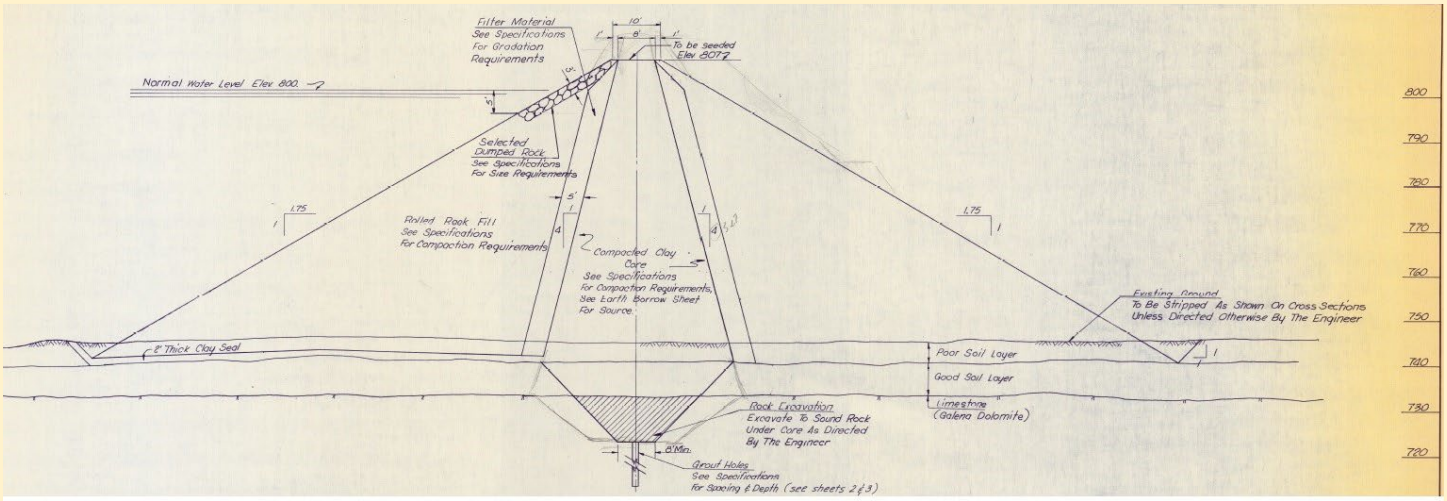
Photo: Panoramic View



Based on recently completed planning report by CMT, it was discussed that if water had over topped the Dam, erosion of the Dam could have occurred with the risk of washing out and breaching the Dam. Such an occurrence would have been more detrimental than the property damage which occurred around the lake. A report titled Flood Mitigation Investigation Summary was prepared in June 2019 with options to reduce peak lake levels during flood events. This Planning Report provides additional alternatives to consider which will result in lower peak lake levels for the same flood events. The results of flood modeling of the existing spillway and proposed changes to the spillway are presented in the June 2019 report to demonstrate the changes that would occur for various degrees of flooding.

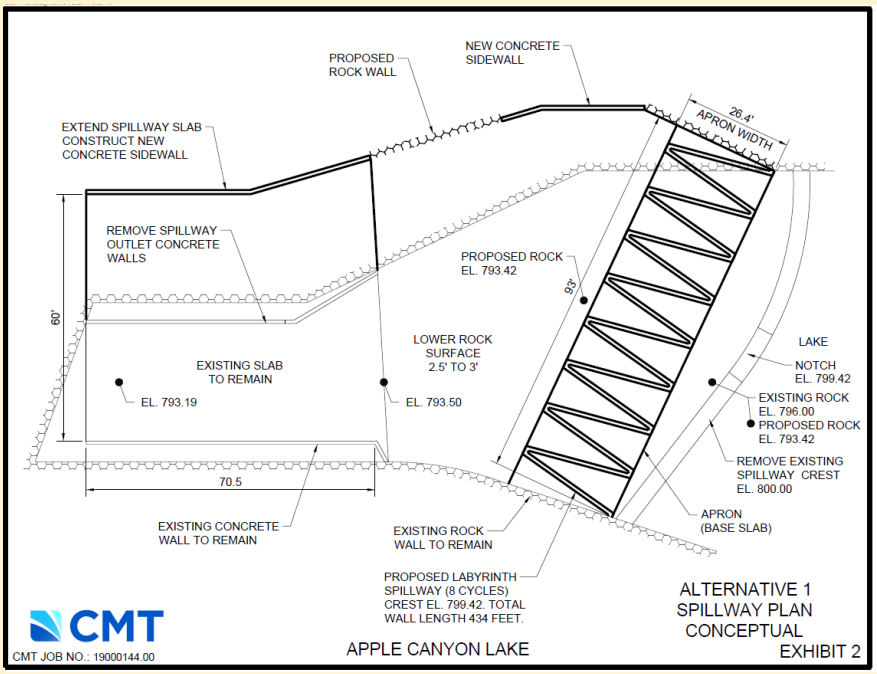
PROJECT UNDERSTANDING - PLANNING PHASE

Rubino and PSI Intertek understand that CMT is in the planning phase and proposing two spillway alternatives to increase the discharge capacity, and these alternatives are discussed below:



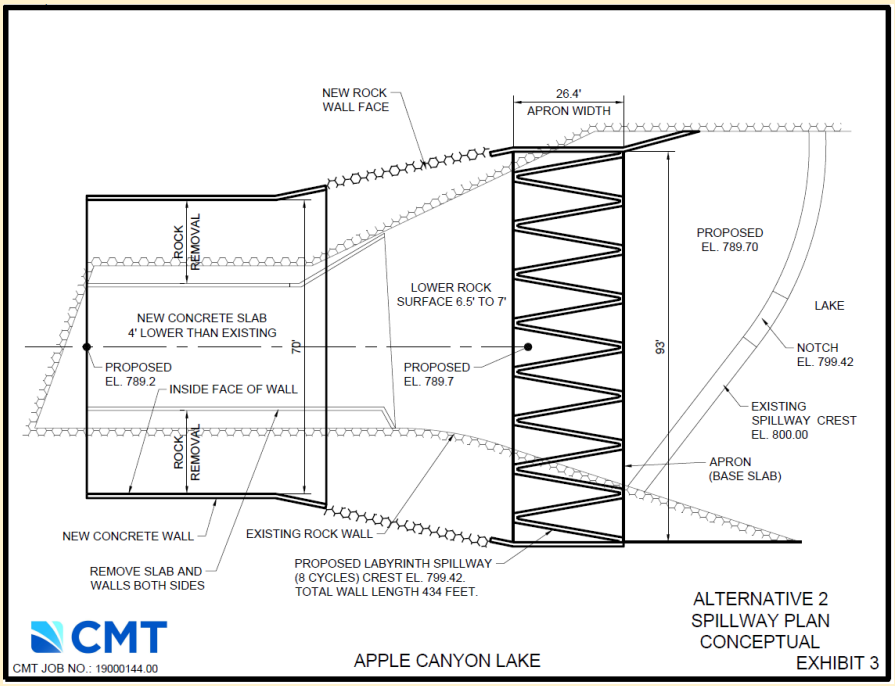
↑ **Typical Section of Dam** ↑

Alternative No. 1 is a labyrinth spillway with a total wall length of 434 feet, overall length of 93 feet and height of 6 feet. The existing spillway channel will be widened from 28 feet to 60 feet and extending primarily into the north-western bank of the existing rock cut. The channel floor would potentially remain at the same elevation.



↑ **Alternative 1, Proposed by CMT** ↑

Alternative No. 2 is a labyrinth spillway with a total wall length of 434 feet, overall length of 93 feet and height of 10 feet. The spillway channel will be widened from 28 feet to 70 feet on both the south-eastern and north-western sides of the existing channel and lowered by 4 feet.



↑ **Alternative 2, Proposed by CMT** ↑

SITE VISIT SUMMARY – DECEMBER 3, 2021

On December 3, 2021, Michelle Lipinski of Rubino Engineering and Kevin Miller of PSI Intertek met with Ted LaBelle of CMT and Sean Nordlie of the Apple Canyon Dam POA at the Apple Canyon Dam site in Jo Daviess County near Woodbine, Illinois.

The purpose of the meeting was to visually observe the dam and spillway to make geotechnical recommendations to aid in future improvements to the dam. Future improvements could include:

- Adding fill to restore the original design elevations of the dam
- Widening the concrete mouth of the spillway to increase the hydraulic flow capacity of the existing spillway.

Soil was sampled at the crest of the dam and taken back to Rubino's laboratory with the following results:

Rubino Project No. G21.236			
Apple Canyon Lake Dam – Jo Daviess County, Illinois			
Sample Location	West End	Middle	East End
Atterberg Results	LL: 41 PL: 25 PI: 16	---	---
Loss on Ignition (Organic Content)	3 %	3 %	3 %
Moisture Content	13 %	19 %	21 %
Visual Classification	Brown Clayey Sand with gravel	Brown Silty Clay	Brown Silty Clay

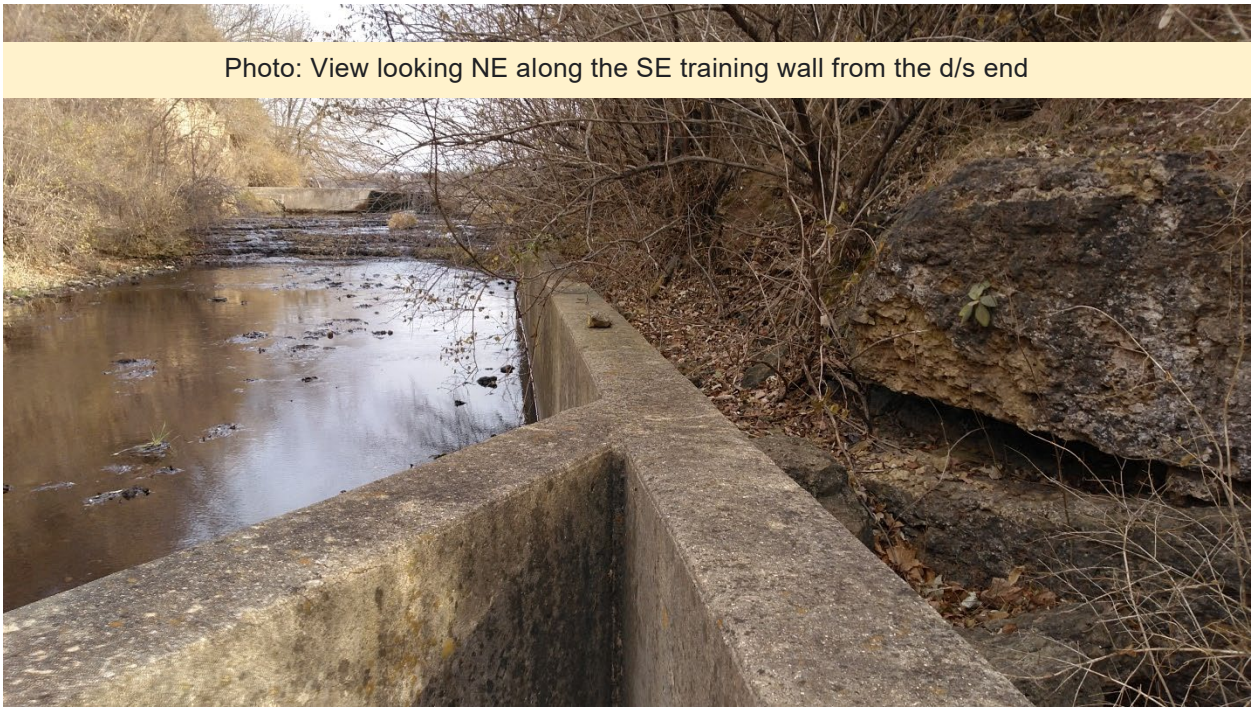
Photo: Downstream Face of Dam looking NW

Spillway Wall Options and on-site discussions:

- Widening the existing spillway channel at least an additional 10 feet is anticipated.
- Lowering the channel floor by 0 - 3 feet (Alternative #1) or by 4 to 7 feet (Alternative #2)
- Freeze/Thaw cycles as well as roots that are growing through natural jointing and layering of the existing rock wall may have resulted in the loosening up of the surficial rock. Weathering of the rock should make first 2-3 feet of rock excavation easier.

Photo: View of d/s channel of spillway showing rock base and existing training walls

Photo: View looking NE along the SE training wall from the d/s end



The POA Board members have voiced concern for the potential degradation of the integrity of the Dam as a result of rock removal in the spillway. Removal of rock in the existing spillway could potentially impact the Dam in the following ways:

- The excavation processes could fragment the rock in the vicinity of the rock/dam embankment contact area, increasing potential seepage
- The excavation process could induce vibraton which could result in additional settlement of the existing dam embankment
- The excavation of rock could reduce overburden on the rock in the spillway channel which could cause existing fractures and layers to open up and cause an increase in seepage.

Typically, rock excavation is executed with equipment that has sufficient power to bend and break rock material. Hydraulic Rams can be used to break rock with high impact point loads. Rock Excavators can be used to break rock with their high strength teeth, shovels, and hydraulic breakout pressures. Controlled Blasting is a viable alternative to using an excavator.

With either the machine excavator or blasting method, the embankment of the existing dam can be isolated from vibrations and expanding fractures by using a technique known as pre-splitting. This technique involves a straight row of tightly spaced holes (typically 2 feet on center) located between the embankment dam and the rock excavation work. If the option is selected to widen the rock face to the Southeast, the presplit line may be shot with a light load to create a crack along the pre-split alignment. This produces a smoother rock face, but also creates a plane fracture that mitigates fractures and vibrations from being transmitted through the pre-split zone. The same pre-split zone can be used to mitigate machine-induced vibrations to avoid impacting the embankment dam.

As discussed later in this report, in blasting, the primary control will be in limiting the amount of explosive per delay. Controlled blastings will require planned drilling depths, spacing of holes, and planning sequences of delays to successfully remove the rock with limited overbreaking and minimal ground vibrations. The blast or rock excavtion plan can include ground vibration monitoring to document actual motion in the dam embankment and pipe structures. Therefore, the rock excavaton should be able to be completed with minimal and controlled ground vibration and fracture control.

Photo: View of Plunge Pool below existing spillway discharge point

- Removal or repair of existing concrete training walls appears to be needed (Distress on the southeastern training wall needs some repair (see photo above)
- Shot Crete can be applied on the exposed rock walls instead of constructing a higher concrete training wall to create a combination of formed training walls and higher anchored shotcrete walls
- Fixing cracks in the rock face down stream of the waterfall is not necessary. Noted in the on-site meeting is that there is desire by the residents to retain the drop high wall at the downstream end of the rock cut spillway.

Photo: View of Plunge Pool below existing spillway discharge point

- CMT is considering a Labyrinth spillway to lengthen the weir length of the spillway to increase the outflow and reduce the head fluctuation in the pool during storm events. NOTE: shallow water depth within the reservoir upstream of the proposed labyrinth spillway can cause some in-efficiencies in the spillway.

- During transport to the spillway, it was observed that the rock in front of the spillway was very shallow. It may be necessary to excavate a sloping channel into the approach to the spillway control section to improve the hydraulic characteristic of the spillway. A shallow approach could substantially reduce the flow capacity of the spillway.

- Rock removal in the approach channel can be considered in the design phase in order to improve the hydraulic deficiency.

Photo: Entrance to Spillway weir from reservoir – Very shallow leading up to weir

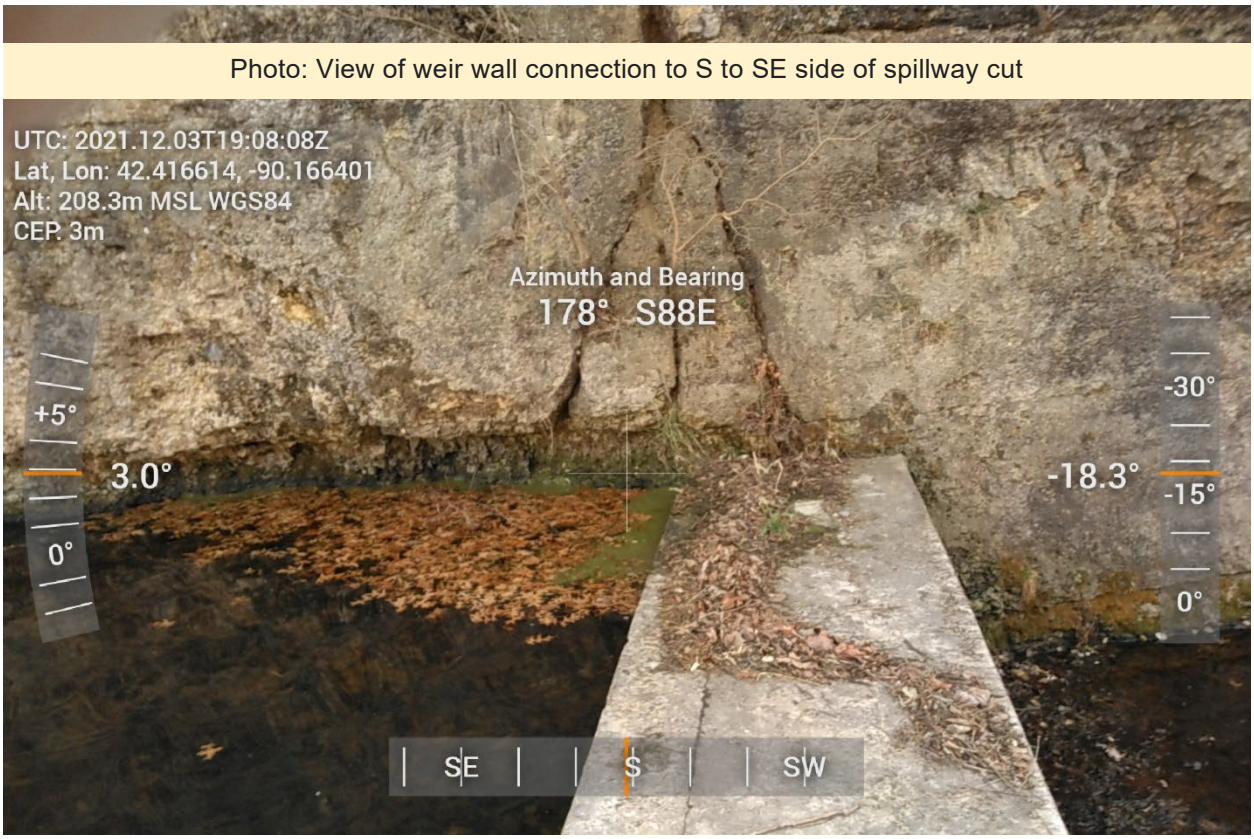


Photo: View of weir wall connection to S to SE side of spillway cut

Photo: View of N-NW connection of weir wall with NW rock cut

- The current lake drain, which consists of a pressurized, lined, cylinder concrete pipe, has a valve on the downstream end that maintains a full reservoir head pressure throughout the pipe penetrating the earthen embankment. It is anticipated that this pressure head in the lake drain may be as high as 35 to 40 psi.

Estimate of how the spillway was constructed:

It appears that the rock channel was excavated to its current configuration with either conventional rock excavation equipment or may have been blasted. Once the channel was excavated it appears that a concrete weir was installed near the upstream edge of the spillway to control the pool of the reservoir with a notch to control low flow conditions. The weir wall was reported to have been widened at some later time. The water down stream of the concrete weir wall traverses a rock channel until it engages wing wall and training walls downstream of the control weir. The wing walls are connected to the highwalls at different lengths from the weir wall. The training walls then appear to focus the discharge through a concrete lined pathway that ends with pinch walls before dumping into the overflow high wall. It was reported by Shaun Nordlie, General Manager, that extreme flows during historical events had overtopped the training walls in the spillway. Evidence of erosion above the wall and along the outside edges of the spillway appeared to confirm the overtopping. A HEC-RAS analysis run by CMT has demonstrated the need for a wider and possible deeper channel to route the currently required design storm event safely through the spillway channel.

Photo: NW view of spillway discharge and overtopping erosion

Photo: View rough rock surface of spillway channel and stop log weir

Estimate of Spillway adjustment / Hydraulic needs

Discussions on the adjustment to improve the flow capacity of the spillway included the following items:

- Determine the extent of widening the spillway channel.
- Creating training walls at a wider width that would convey up to a specific storm (such as the 100-year storm or greater) within the training walls and provide erosion protection above that level with an anchored shotcrete wall on the exposed rock surface to an elevation required to route the maximum design storm.
- Limited discussion was held on staging the size of the spillway and whether or not there was a possibility of utilizing the existing walls and adding wider wall widths above that. These options would likely require widening in both directions.
- The current spillway configuration has multiple convergence points that are not particularly symmetric, which can be improved upon to increase the flow of water throughout the channel.
- During future construction excess excavated rock can be "placed" in the pool area of the highwall below the current discharge point of the spillway.
- Discussions were held concerning the labyrinth spillway having secondary gates in for drawdown, but having a lake drain likely negates the need for that.

ROCK BLASTING DISCUSSION

Discussions were held on the potential methods of rock excavations. It is believed that much of the excavation can be performed with conventional rock removal equipment such as a backhoe with a rock ram attachment. Blasting was discussed and that also is a viable excavation technique. Ground vibrations will be controlled by how much blasting agent is set off per delay with breakage controlled by spacing of blastholes, depth of overdrilling, and pre-drilling/pre-splitting defined limits to the spillway expansion in the rock. Blast monitoring would be performed to document actual vibrations experienced by the dam and other defined structures.

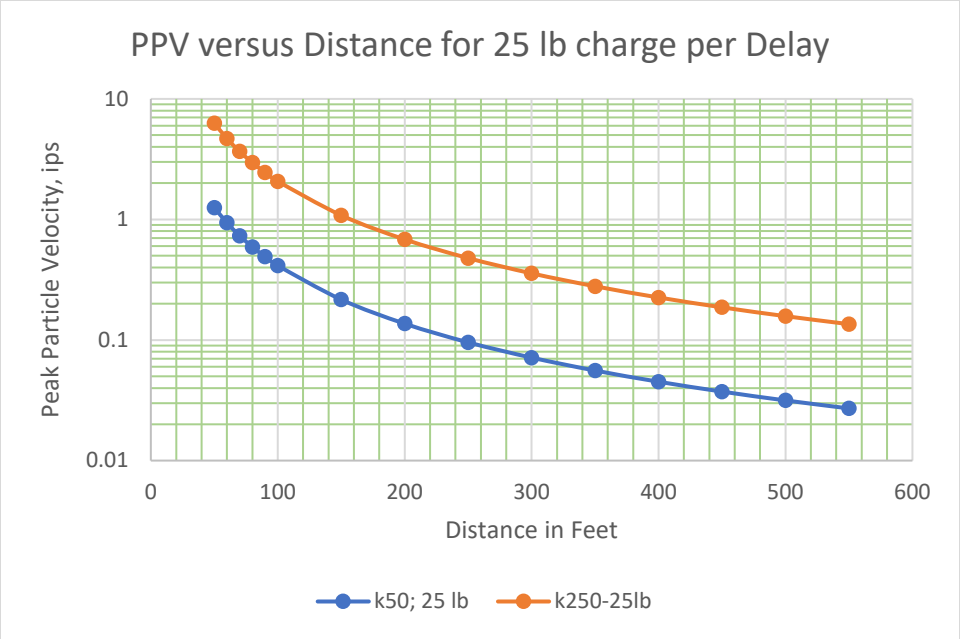
Based on the CalTrans Manual on transportation and construction generated ground vibrations, the prediction of blast vibrations uses a scaling method that is based on the energy released, the distance to the blast and the relationship between then variables at a specific site. Square-root scaled distance is a scale that divides the distance from the point of interest to the blast by the square root of the largest charge weight detonated on one delay period. Explosives detonating within any given 8-millisecond time period are typically counted as having been detonated on the same delay. One of the more commonly accepted blast vibration prediction curves in use today were developed by Lewis L. Oriard and are based on data collected from a large number of blasts in various geological settings.

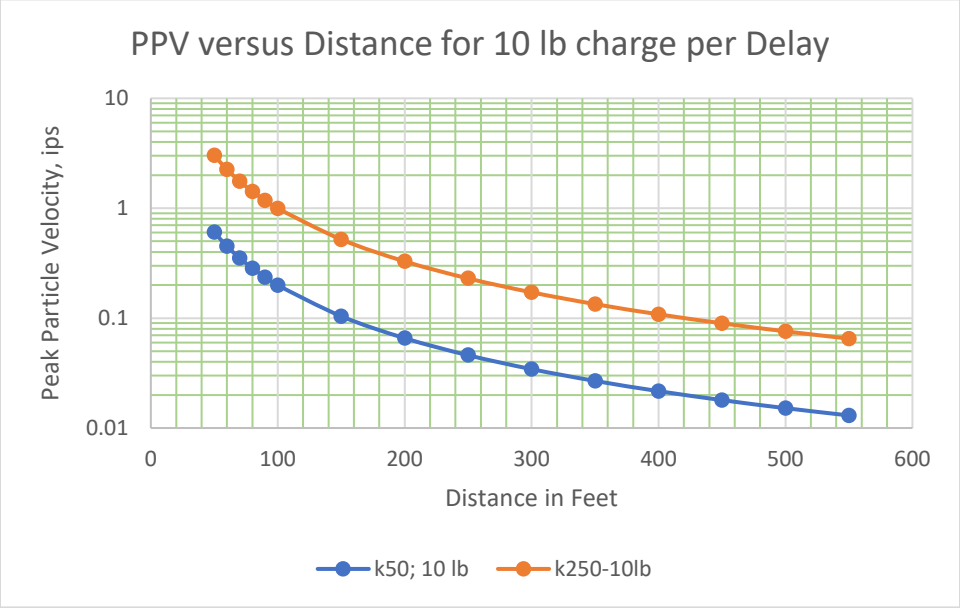
Using Oriard's basic formula for calculating peak particle velocity (PPV) attenuation with distance:

$$PPV = K * (D_s)^{-1.6}$$

$$where\ D_s = (distance\ from\ blast)/\sqrt{charge\ weight\ in\ pounds}$$

K would be developed for this site based on the physical information obtained for the rock units, but would be expected to be in a range between 50 and 250. Typically, we would target to keep the PPV below 0.5 inch per second. Using these relationships the following curves show what the expect range of Peak Particle Velocity (PPV) would be expected per delayed blast of a specific weight of charge over a distance from the charge:





The blasting contractor would then determine the depth of rock to be removed and prepare a blast spacing based on the depth and diameter of the blasthole. Typically, these blastholes will be drilled 30 to 50% deeper than the desired depth of removal with the charge initiated at the depth of removal. Based on the pattern of the blasthole and loading factors, this would determine how many blastholes could be placed on a delay and have the anticipated vibration PPV shown on the above charts.

This work could also be performed with rock excavation equipment. Rock excavators with buckets designed for rock excavation combined with hydraulic rock breaking rams can be used in this type of rock excavation. As in the blasting option, Rubino would likely recommend a pre-splitting technique to limit the extent of the rock breakage and give a more defined surface to the rock excavation. The technique chosen is typically part of the contract bidding process and allows the contractor to bid with the technique that they are most comfortable with and thereby the more economical choice.

To provide contractors with the information for them to provide an economical rock excavation estimate, Rubino would need to explore the rock unit near the spillway channel. A rock core on the northern side of the channel, if accessible, could provide a continuous core of the units that would need to be excavated. If

slope is too large for vehicle access, a rock core maybe taken adjacent to the removal area in an area with the same or similar surface elevation. The type, density, RQD and unconfined compressive strength would provide the contractors with the information they need to develop an excavation plan. It may also be possible to perform a core on the southern side of the spillway which would be closer to the dam structure, but it may not extend high enough to define the rock units on the northern side to be excavated. Based on the option chosen for the shape of the dam and accessibility, the northern side may be the best side to explore. Furthermore, Alternative #2 would involve the widening of both sides of the channel so if this option is desired, Rubino recommends that two borings/rock cores are taken (one on the south and one on the north side of the spillway).

RECOMMENDATIONS FOR ADDITIONAL TESTING / CONSTRUCTION PHASE

Rubino also plans to explore the existing dam to assist in the leveling of the crest of the dam to the design elevation. Additional exploration borings would be performed to evaluate the embankment's ability to resist rock removal for the spillway and to gather data for a slope stability analysis (if IDNR requires one or if the Owner requests one). Rubino plans to perform conventional geotechnical exploration borings with SPT testing and Shelby tube samples combined with CPT probes of the clay core materials. The CPT will provide an insitu shear strength measurement of the in-place soils and allow our geotechnical evaluation of proposed configuration changes to the shell of the dam. Both the conventional and CPT probes will be used in the evaluation of the dam. It should be noted that during the exploration of the dam embankment, it would be a good time to place instrumentation in the dam to measure the phreatic (water) surface that exists in the dam. This type of instrumentation can be installed in a conventional exploration borehole if desired by the Owner or State Agency.

Possible Contractors: Contractors to perform this work will likely come out of eastern Iowa. Rubino and PSI can be of assistance in the location of potential bidders for this work if needed.