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Conceptual Design Basis Report
Rehabilitation of Secord Dam

Gladwin County, Michigan

Submitted to:
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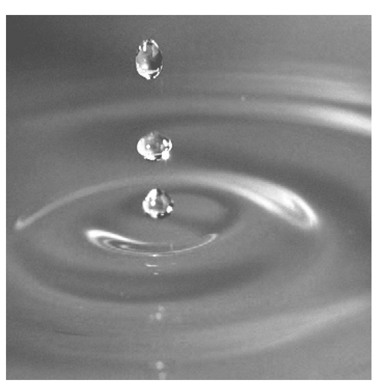

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1. Introduction

1.1 Background

Following the May 19, 2020, storm event that resulted in resulted in minor downstream erosion damage to Secord Dam, severe downstream erosion damage to the Smallwood Dam and a catastrophic failure (breach) of the Edenville and Sanford Dams, the Four Lakes Task Force (FLTF) requested GEI Consultants of Michigan, P.C. (GEI) to provide “planning-level” opinions of probable construction costs to reconstruct and/or rehabilitate the four dams without hydroelectric power formerly owned by Boyce Hydro, LLC (Boyce) and licensed by the Federal Energy and Regulatory Commission (FERC).

As documented in the July 2020 Post Failure Reconstruction Cost Analysis prepared by GEI (Ref. GEI, 2020a), we developed engineer’s opinion of construction cost estimates assuming repair or reconstruction of the dams without hydropower generation and increasing spillway capacity to pass the ½ Probable Maximum Flood (PMF) in accordance with the Michigan Department of Environment, Great Lakes and Energy (EGLE) requirement for high hazard dams. The FLTF also requested that GEI develop cost estimates for dam rehabilitation improvements to pass the full PMF in the event the State of Michigan EGLE, at a future date, increases the high hazard dam minimum spillway capacity requirement above the ½ PMF, or if the probable maximum precipitation (PMP) estimates for a Michigan site-specific region increase. These high-level cost estimates were used to begin budgetary planning for the reconstruction / rehabilitation of the four projects.

As follow-up to our Post Failure Reconstruction Cost Study, the FLTF requested two additional engineering studies be undertaken. The first (Task Order No. 3) is a Tobacco and Tittabawassee River watershed hydrologic and hydraulic flood study to update and finalize the design storms at each of the four dams and determine the additional minimum spillway capacity required to safely pass the ½ PMF. This study is a collaborative effort being performed by GEI, Ayres Associates (Ayers) and the Spicer Group, Inc. (SGI). The results of this Task Order No. 3 study are being provided in a separate report titled, “GEI Flood Study of the Tittabawassee River from Secord to Sanford Dam” (Ref. GEI, 2021).

The second engineering study (Task Order No. 4), the subject of this Report for Secord Dam, provides the study results, which involved “value engineering” and further development of the concept designs, construction sequencing and cost estimates, presented in the July 2020 Post Failure Reconstruction Cost Analysis (Ref. GEI, 2020a).

Based on previous FERC orders to Boyce that pre-dated the May 2020 flood, the initial results of GEI’s (Task Order No. 3) flood study (still in progress), visual inspection of the four dams during October 2020 (Task Order No. 5) and follow-on discussions with FLTF, SGI, Essex

Partnership (Essex), the FERC and EGLE, the following dam safety-related issues were identified:

- The dam in its current condition can pass approximately 7,700 cubic feet per second (cfs) of flow before water begins spilling over the east (left) abutment and east reservoir rim with many residential structures. According to the latest flood analysis, a total spillway capacity of approximately 18,075 cfs is needed to safely pass the ½ PMF as currently required by the Michigan EGLE without overtopping the dam structures or left abutment and east reservoir rim areas.
- The gated spillways and single powerhouse are reinforced concrete hollow, buttress-type structures constructed on glacial till soil foundations that were more common pre-1940s when materials were expensive and labor inexpensive. This style of dam does not currently meet industry standards of design practice in terms of long-term durability and ductility. Furthermore, the dams were constructed of non-air entrained concrete and exhibit extensive deterioration along water lines were exposed to freeze-thaw conditions.
- The existing Tainter gates are likely beyond the end of their design life and exhibit signs of age and corrosion. The Tainter gate hoisting mechanisms are insufficiently sized for the range of design service loads including ice and do not meet current industry design standards for wire rope cable and reel hoists and gate operators.
- Without hydro operation, there is no low-level outlet to draw down or drain the impoundment below the invert of the spillway sill. Passing flow over the spillway crest during winter of 2021 has also led to significant ice-buildup on the spillway walls and reinforced concrete cross struts.
- The embankment dams are overly steep, have insufficient slope stability, and leak excessively along the toe of both left and right earth fill embankments. They are homogeneous earthfill structures with no impervious core or seepage cutoff, and no internal filters or drains to protect against seepage-induced internal erosion.
- The downstream riprap erosion protection is inadequate to prevent erosion during high flows.
- The projects do not include sufficient downstream energy dissipation structures or armor stone to protect against high tailwater and velocities that can scour un-zoned earthen embankments and spillway abutments that do not have sufficient riprap or armor stone.

The conceptual designs and reconstructions cost estimates presented in this Report assume the following for the rehabilitation of Secord Dam:

- Provide an updated earth and concrete structure that will have a 75 (+) year design service life.

- Provide temporary cofferdams and diversion structures to have the ability to safely pass base river flows plus flood flows (assumed 100-year storm event) without failing during construction.
- Rehabilitation designs to meet current industry standards of engineering practice and the design standards for high hazard dams in accordance with the State of Michigan EGLE.
- Restoring hydropower generation will not be part of the rehabilitation plans and was not included in our costs.
- Upgrade the total spillway capacity to pass at a minimum the ½ PMF in accordance with State of Michigan EGLE requirements.
- Transform the powerhouse to a gated low level outlet structure using the intake, scroll case, a fixed Francis wheel and draft tube to release 100 to 200 cfs baseflows during low flow winter months.

1.2 Project Purpose

The purposes of this Design Basis Report include the following:

- A descriptive narrative of the proposed spillway capacity improvements to pass the design flood (1/2 PMF).
- A description of the proposed improvements to the embankments to reduce seepage, provide protective measures against seepage-induced internal erosion, and improve slope stability.
- Document project hydrology and geology, establish hydraulic, structural concrete and earth fill embankment design for dam foundation, slope, and seepage stability criteria.
- Discuss construction considerations including anticipated construction sequencing and cofferdam requirements.
- Develop design drawings to an approximate 30% level of development and prepare an engineer's opinions of probable construction cost.

1.3 Authorization

The work was authorized by the FLTF under Task Order No. 4 dated September 19, 2020, in accordance with the Master Services Agreement dated May 29, 2020.

1.4 Project Personnel

The following GEI personnel were primarily responsible for performing the hydrology and hydraulics analyses for this report:

Project Manager:	Paul D. Drew, P.E., CFM
Staff Engineer:	Alexa Sampson, E.I.T
Staff Engineer:	Alex Michaud, E.I.T.
Project Principal:	Richard J. Anderson, P.E.
Engineer of Record:	William H. Walton, P.E.(MI), S.E.

This work was coordinated with Mr. Dave Kepler from the FLTF and Mr. Ron Hansen, P.E., P.S. from SGI.

1.5 Elevation Datum

Elevations listed herein are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Vertical datum conversions to the site datum and North American Vertical Datum of 1988 (NAVD88) are included in **Table 1**.

Table 1: Vertical Datum Conversions

Project	Summer Lake Level (Site Datum)[1]	Summer Lake Level (NGVD29)	Winter Lake Level (NGVD29)	VertCon[2] Conversion	Summer Lake Level (NAVD88)	Winter Lake Level (NAVD88)
Secord	745.0	**750.8**	**747.8**	-0.5	750.3	747.3
Smallwood	699.0	**704.8**	**701.8**	-0.5	704.3	701.3
Edenville	670.0	**675.8**	**672.8**	-0.6	675.2	672.2
Sanford	625.0	**630.8**	**627.8**	-0.6	630.2	627.2

1: Datum conversion Site Datum to NGVD29 = +5.8 feet.
2: National Geodetic Survey Height Conversion: https://geodesy.noaa.gov/TOOLS/Vertcon/vertcon.html

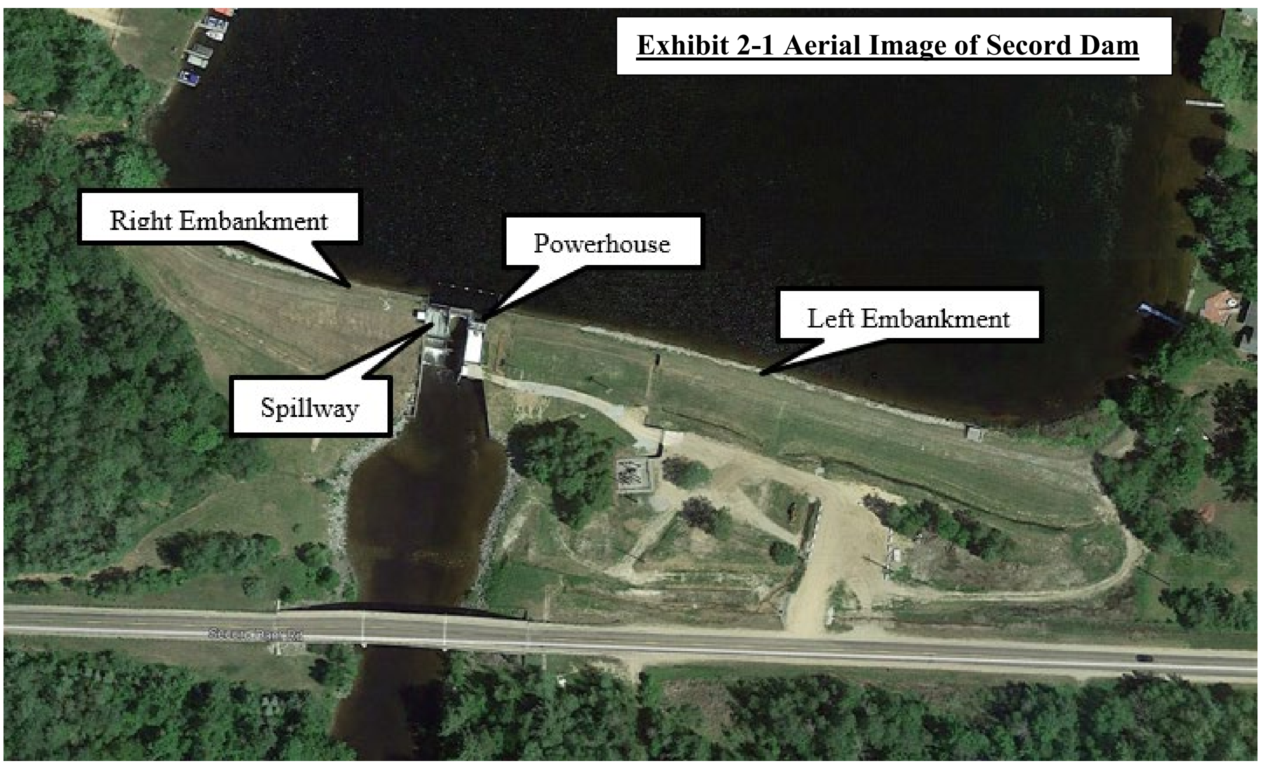
1.6 Limitation of Liability

The professional services completed in preparing this Conceptual Design Basis Report were performed in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or any other instrument of service.

2. Description of Project Structures

2.1 General Project Descriptions

The Secord Dam is located on the Tittabawassee River, a tributary of the Saginaw River, and is approximately 41 river miles upstream of the City of Midland in Midland County, Michigan (see **Figure 1**). The facility is owned and operated by the FLTF and the FERC License is currently maintained by Boyce. Construction of the dam was completed in 1925 to provide storage and headwater level control for the purpose of hydroelectric power generation. The FERC issued an original license for the Project in 1998. From left to right[1], the project consists of a 650-foot-long left embankment with a minimum dam crest elevation of 757.8[2] feet; a 25-foot-wide powerhouse containing one turbine generating unit with a rated capacity of 1.2 MW with an operating head of 46.5 feet, a 46.3-foot-wide gated spillway with two Tainter gates, and an approximately 350-foot-long right embankment. Normal headwater and tailwater pools at the dam are El. 750.8 and 704.3, respectively. The Exhibit F Drawings from the FERC license, illustrating the typical plan and sections for each of the existing project structures, are included in **Appendix A**. The Secord Hydroelectric Project is classified as having a high hazard potential



[1] All references to left and right herein are with respect to looking in a downstream direction.

[2] All references to elevation herein are with respect to National Geodetic Vertical Datum of 1929 (NGVD29) unless otherwise noted.

based on estimated downstream impacts in the event of a failure. An aerial image illustrating the project structures is included in **Exhibit 2-1**.

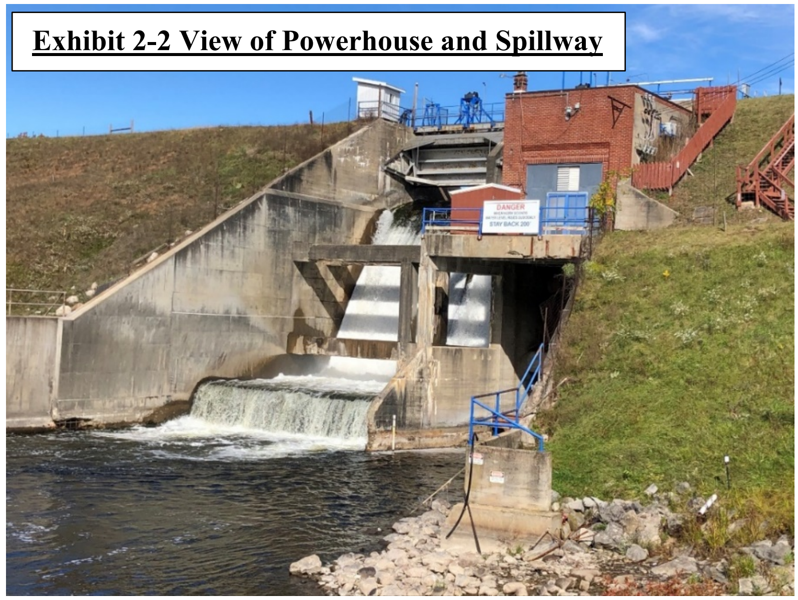


Exhibit 2-2 View of Powerhouse and Spillway

The powerhouse consists of a reinforced concrete substructure and brick superstructure with one vertical Francis unit. The powerhouse is 25-feet wide (left to right) and 36.5-feet long (upstream to downstream). The reinforced concrete spillway structure is a hollow reinforced concrete barrel arch and ogee shaped rollway spanning to buttress pier supported structure with two Tainter gate bays. The left Tainter gate is 20.5-feet-wide by 10-feet-high and the right Tainter gate is 23.8-feet-wide by 10-feet-high separated by a 2-foot-wide center pier. The spillway ogee crest is at El. 742.8 feet. The gates are operated by hydraulic hoist with the operators located directly adjacent to the hoist above each gate on an elevated platform. The hydraulic gate chain and single cable hoist system was installed in 2019, replacing the original electric hoist and trolley system. The powerhouse and Tainter gate spillway are illustrated in **Exhibit 2-2**.


Exhibit 2-3 View of Left Embankment

The left and right embankments are approximately 650 feet and 350 feet long, respectively, with maximum structural height of 56 feet near the powerhouse and spillway. The original embankments were reportedly constructed of a mix of clay and poorly graded sand, and are founded on native soils consisting of interbedded layers of clay and silty sand with some gravel overlying glacial till. The upstream and downstream slopes were constructed at 2.5H:1V and 2H:1V, respectively. In 2005, the embankment crest was re-established to the design elevation of 757.8 feet. Portions of both embankments immediately adjacent to the powerhouse and spillway contain an upstream seepage cutoff wall consisting of hot-rolled, ball and socket interlocked steel sheeting installed into foundation soils with a reinforced concrete cap. The seepage cutoff wall has a top elevation of 753.8 feet and extends approximately 96 feet left of the powerhouse and 82 feet right of the spillway. In 2008, leakage along the abutment/sheeting contact was repaired. Both embankments also contain lateral finger drains that extend under the downstream embankment shell at the embankment / foundation contact and discharge into a drainage ditch located at the downstream toe. A toe berm was reportedly constructed on the left embankment downstream slope to improve stability and address seepage. No record of these repairs was found. There is no record of improvements or repairs made to the right embankment. The left embankment looking right towards the powerhouse is illustrated in **Exhibit 2-3**. Key project data for the Secord Dam are provided in **Table 2**.

Table 2: Key Existing Project Data

Parameter	Secord Project
Min. Design Dam Crest El. (feet) (left embankment)	757.8
Normal Operating Headwater Pool El. (feet)	750.8
Normal Operating Tailwater El. (feet)	704.3
Spillway Ogee Sill (Gate Invert) El. (feet)	742.8
# Tainter Gates	2
Gate Numbering (left to right looking downstream)	1 to 2
Gate 1 Width (feet)	20.5
Gate 1 Max Opening (feet) (as of February 2021)	10.0
Gate 2 Width (feet)	23.8
Gate 2 Max Opening (feet) (as of February 2021)	10.0
Auxiliary Spillway Type	None
Auxiliary Spillway El. (ft)	N/A
Auxiliary Spillway Length (feet)	N/A
Left Embankment Length (feet)	650.0
Left Embankment Design Dam Crest El. (feet)	757.8
Left Embankment Upstream / Downstream Slopes (H:V)	2.5:1 / 2:1
Right Embankment Length (feet)	350.0
Right Embankment Dam Design Crest El. (feet)	757.8
Right Embankment Upstream / Downstream Slopes (H:V)	2.5:1 / 2:1

2.2 Reservoir Operations

The project is operated as a “modified peaking plant.” Per the FERC license, the reservoir is to be operated at a summer and winter elevation. The summer headwater level is maintained between elevation 750.4 and 751.1 feet with the normal summer level at elevation 750.8 feet.

The winter headwater level is maintained with the normal winter level at elevation 747.8 feet so that the daily fluctuation in reservoir elevation does not exceed 0.7 foot. Currently, the Tainter gates are in the fully open position (10-feet) and Secord Lake is maintained approximately 1-foot above the spillway sill at El. 743.8 feet in accordance with the FERC July 2020 drawdown order.

3. Hydrology and Hydraulics

3.1 Introduction

The purpose of this report section is to establish and document the hydrology and hydraulics to upgrade the total spillway capacity to pass at a minimum the ½ PMF in accordance with State of Michigan EGLE requirements. GEI reviewed the following information to assess the hydrology and hydraulics for the Secord Dam project:

- Secord Hydropower Plant Design Drawings, 1924
- Secord Dam Flood Routing, Secord Hydroelectric Project, Mead & Hunt, February 2004
- Supporting Technical Information Document (STID), 2006
- 2D Analysis of Eastern Ridgeline Along Secord Lake, Purkeypile Consulting, LLC, 2016
- Secord Gate Test Notes, Spicer Group Inc., December 2019
- Secord Dam Improvement Project Drawings, Spicer Group Inc., 2020
- Hydraulic Report for Secord Hydroelectric Project, Spicer Group Inc., February 2020
- PMF Report by Ayres Associates, Inc., May 2020
- GEI Flood Study of the Tittabawassee River from Secord to Sanford Dam, March 2021

3.2 Hydrology

GEI has reviewed the May 2020, PMF Report by Ayres Associates, Inc. (Ref. Ayres, 2020) prepared for Secord, Smallwood, Edenville and Sanford Dams. This report was prepared before the May 2020 flood and only used data available prior to that event. Following the May 2020 event, modifications were made to the analysis. These modifications are discussed below but are still under technical and regulatory review. As of this writing, no formal report on the post-May 2020 PMF updates exists. GEI has reviewed the current 2020 Ayres Report and the associated HEC-HMS model and generally agree with the methodology and results of the study.

Current modeling results by Ayres for the ½ PMF and PMF are summarized in **Table 3** and represent the results of the most recent provisional model, as revised to account for observations noted during the May 2020 flood. During the ½ PMF, the reservoir surcharges above the Secord Lake Ridgeline at El. 755.0 and significantly floods the eastern shoreline residential properties, yards, and streets. Note also that the "½ PMF" is not half of the PMF value. Verbal consultation with EGLE personnel clarified that "½ PMF" in the context of State of Michigan EGLE standards refers to the flood calculated to result from one-half of the Probable Maximum Precipitation (PMP).

Table 3: Secord Dam Flood Routing Results – Existing Conditions

Parameter or Modeling Result	½ PMF	PMF
Peak Inflow (cfs)	18,075	43,020
Peak Outflow Spillway (cfs)	7,700	8,125
Peak Outflow Tea Creek Ridgeline	4,885	25,200
Embankment Overtopping	0	7,750
Total Outflow	12,585	41,075
Maximum Reservoir El. (feet)	757.8	759.7
Freeboard (Dam Crest El. 757.8)	0.0	-1.9

Previous studies have been performed to assess the flood hydrology and spillway hydraulics for the Secord, Smallwood, Edenville and Sanford Dams. The PMF was originally computed by Mead and Hunt, Inc., using the 1993 EPRI Wisconsin-Michigan PMP Study. The 1994 PMF Study (Ref. Mead & Hunt, 1994) was performed as part of an evaluation of the PMF throughout the Tittabawassee River Basin. In 2011, Mill Road Engineering concluded that the 1994 model misrepresented the offset in timing between the Tittabawassee River and Tobacco River contributions to Lake Wixom. The two branches of the reservoir were re-analyzed using a HEC-RAS model, resulting in lower peak inflow at Edenville Dam. **Table 4** summarizes the results of the available PMF studies for the Secord, Smallwood, Edenville and Sanford Projects.

Table 4: Summary of Previous PMF Studies

Date	Author	Secord	Smallwood	Edenville	Sanford
1994	Mead & Hunt, Inc.	27,200	41,000	74,400	75,500
2011	Mill Road Engineering	N/A	N/A	62,000	N/A
2020	Ayres Associates (Model calibrated using 2014, 2017 floods only)	29,400	41,200	80,900	80,600
2020	Ayres Associates (Model recalibrated after May 2020 flood [provisional])	43,020	58,640	116,525	116,065
% PMF Increase since 1994 using provisional Ayers 2020 recalibrated model		*58%*	*43%*	*88%*	*54%*

As shown in **Table 4**, the 2020 PMF Study, after incorporating the May 2020 flood data, significantly increased the PMF estimates at each of the FLTF projects. The 2020 studies were the first to include calibration to observations of actual flood events and associated precipitation. The May 2020 Ayres report attributes the increase primarily to the use of more conservative hydrologic loss rates derived from the calibration efforts. Considering the significant increase in the PMF, the FLTF currently has Applied Weather Associates (AWA) under contract to compute a site-specific PMP and probability assessment of various rainfall depths for the Tittabawassee River Basin. The FLTF recognizes that PMP and PMF studies typically use the most common sources of the PMP information (such as the regional HMRs or EPRI 1993), and that the generalized rainfall values are not site-specific and tend to represent the largest PMP values across a broad region. A site-specific study of the PMP and PMF can result in a lower and more appropriate estimate of the ½ PMF and PMF. The AWA will provide the updated rainfall depths and distributions to Ayres to develop site specific ½ PMF and PMF inflow hydrographs. The updated PMP and PMF study by AWA and Ayres is expected to be completed in the second quarter of 2021.

See the 2021 GEI Flood Study of the Tittabawassee River from Secord to Sanford Dam report for more information (Ref. GEI, 2021).

3.3 Spillway Design Storm Flood Selection

In June 2020, Gladwin and Midland Counties signed a resolution to have the four projects (Secord, Smallwood, Edenville and Sanford) condemned in accordance with Part 307 of the Michigan Natural Resources and Environmental Protection Act (NREPA). The FLTF approached the Michigan bankruptcy court and worked through an agreement to have the ownership of all the projects transferred to the FLTF, while Boyce will temporarily maintain the FERC licenses. We understand that the FERC licenses at each of the FLTF projects will likely be abandoned and the dams will be ultimately regulated by the State of Michigan EGLE. In accordance with Part 315 Dam Safety of the Michigan State Statutes, GEI understands that the FLTF projects will be classified as high hazard dams and shall be capable of passing the ½ PMF.

Following the Edenville and Sanford Dam failures, the Michigan Dam Safety Task Force evaluated the statutory structure, budget, and program design of the Water Resources Division Dam Safety Program, the adequacy of Michigan's dam safety standards, and the level of investment needed in Michigan's dam infrastructure. Their work culminated in a report to Governor Whitmer and the state legislature dated February 25, 2021, summarizing its findings, and recommending regulatory, financial, and programmatic improvements to help ensure Michigan's dams are appropriately maintained, operated, and overseen to protect Michigan residents and aquatic resources.

We understand that the current spillway capacity requirement (1/2 PMF) will likely change as a result of the Dam Safety Task Force recommendation to follow the current Federal Emergency Management Agency (FEMA) Model Dam Safety Program (MDSP) for recommendations for design floods including FEMA P-94 – *Selecting and Accommodating Inflow Design Floods for Dams* (Ref. FEMA, P-94). According to the FEMA P-24 document, the goal of selecting the

Inflow Design Flood (IDF) should be to balance the risks of a hydrologic failure of a dam with the potential downstream consequences and the benefits derived from the dam. Selection of the IDF can involve tradeoffs in trying to satisfy multiple objectives including the following:

1. Providing acceptable safety to the public;
2. Effectively applying the resources of the dam owner;
3. Maintaining the credibility of the regulator in representing the interest of the public; and
4. Assessing the desire of the public for the benefits of a dam in exchange for the inherent risks that come from living downstream of a dam.

FEMA acknowledges that no single approach to the selection of an IDF is adequate for all existing or planned dams. FEMA identifies the following approaches to defining the IDF to accommodate the wide variety of situations, resources, and conditions.

- Prescriptive Approach – Evaluate the dam based on hazard potential classification of the dam. This approach is intended to be conservative to allow for efficiency of resource allocation while providing reasonable assurance of the public safety.

    This approach is similar to the current state of Michigan EGLE prescriptive requirement of the ½ PMF.

- Site Specific PMP – This approach requires a site specific Probable Maximum Precipitation PMP study.

    The FLTF currently has AWA under contract to calculate a site specific PMP and probability assessment of various rainfall depths for the Tittabawassee River Basin. The AWA will provide the updated rainfall depths and distributions to Ayers to develop site specific ½ PMF and PMF inflow hydrographs.

- Incremental Consequence Analysis – IDF established by identifying the flood for which the downstream consequences with and without failure are not significantly different. This process is already accepted by the State of Michigan EGLE as the ½ PMF; criteria may be reduced to not less than the 200-year flood with proper documentation, evidencing a failure of a dam under ½ PMF conditions will not cause additional flood damage or loss of life.

    An incremental consequence analysis may be the preferred way to select the IDF; however, we recommend not completing an incremental consequence analysis until the site specific PMP and PMF analysis is completed by AWA and Ayres.

- Risk Informed Decision Making (RIDM) – In this method, the IDF is selected as the design flood, which assures that a given level of "tolerable risk" is not exceeded. The benefit of RIDM is providing dam owner and regulators the ability to cooperatively assess the marginal value of increasing levels of flood protection, balancing capital investment in risk reduction across multiple potential failure modes (PFM), and prioritizing risk reductions across a portfolio of dams. RIDM requires a site-specific evaluation of probability of hydrologic events and performance of the dam during those events and evaluates in detail the social, economic, and environmental consequences of failure.

  As discussed above, AWA will derive the Annual Exceedance Probability (AEP) of the rainfall up to and including the PMP. This will provide the recurrence interval of rainfall depths for critical durations and can be used for the RIDM process for dam design and selection of the IDF.

Considering the schedule of the site specific PMP and PMF study by AWA and Ayres, an interim IDF was selected for the purposes of the flood study and developing 30% design plans and budgetary costs for the FLTF projects. The current state of Michigan EGLE spillway requirement for high hazard dams is the ½ PMF; however, the project team (GEI, SGI, Essex and the FLTF) collaboratively selected a more conservative design criteria, considering the uncertainty of the state of Michigan EGLE spillway capacity requirements and the upcoming site specific PMP and PMF study. For the purposes of the 30% design phase, the selected IDF is the ½ PMF plus a 15% to 30% increase in peak inflow (i.e., 1/2 PMF + design storm). Once the site specific PMP, PMF, and AEP studies are complete, the IDF will be re-evaluated using the techniques prescribed in FEMA P-94. The selected IDF is the ½ PMF + design storm with peak inflows are summarized in **Table 5**.

Table 5: Summary of Inflow Design Flood (1/2 PMF + Design Storm)

Dam	½ PMF	PMF	½ PMF +[1]	IDF Design Storm Notes	Annual Exceedance Probability (AEP)
Secord Dam	18,075	43,020	**21,150**	½ PMF + 17% Peak Inflow	1/5,000 or 0.0002
Smallwood Dam	19,065	58,640	**24,550**	½ PMF + 28% Peak Inflow	1/5,000 or 0.0002
Edenville Total	41,260	116,525	**52,275**	½ PMF + 26% Peak Inflow	TBD
Sanford Dam	37,695	116,065	**47,470**	½ PMF + 26% Peak Inflow	TBD

1. The current IDF for the FLTF Projects is the ½ PMF + design storm.

See the 2021 GEI Flood Study of the Tittabawassee River from Secord to Sanford Dam report for more information (Ref. GEI, 2021).

3.4 Hydraulic Design

GEI performed hydraulic analysis to evaluate the proposed spillway upgrades at each of the FLTF projects during the ½ PMF + design storm. Based on the existing conditions of the FLTF projects, GEI has developed new conceptual spillway and dam configurations, which would allow the FLTF dams to safely pass the ½ PMF + design storm with residual freeboard. The proposed configurations consist of reconstruction or rehabilitation of earthen embankments, demolition, and replacement of the primary Tainter gate spillways with deeper hydraulic crest gates, decommissioning and selective demolition of the powerhouse and conversion of the water passages to a gated low-level outlet, and construction of a new passive overflow auxiliary spillway. The proposed dam repairs and flood capacity upgrades are described in further detail in Section 4 below.

See the 2021 GEI Flood Study of the Tittabawassee River from Secord to Sanford Dam report for more information (Ref. GEI, 2021).

3.4.1 Hydraulic Design Criteria

GEI performed hydraulic analysis and modeling to appropriately size the proposed primary and auxiliary spillways for each of the FLTF projects. The proposed spillways were designed to achieve the following design goals:

- The reconstruction / rehabilitation of the FLTF projects will provide a 75+ year design service life.
- The reconstruction / rehabilitation of the FLTF projects will be designed to meet the current industry standards of engineering practice and design standards for high hazard dams in accordance with State of Michigan EGLE.
- The proposed primary spillway when combined with the auxiliary spillway should have sufficient capacity to pass the ½ PMF + design storm without overtopping the embankments and provide sufficient freeboard below the dam crest.
- The target routed ½ PMF + headwater is El. 755.0 with 3.0 feet of freeboard below the dam crest.
- Pass the ½ PMF + without surcharging the reservoir above the Secord Lake Ridgeline at El. 755.0 and reduce flood impacts to the eastern shoreline residential structures, properties, yards, and streets.
- The structural integrity of the earthen dam and its foundation should not be jeopardized by auxiliary spillway operations.
- Operation of the crest control gates will be the primary means for regulated releases to the Tittabawassee River under both normal and flood conditions.
- Auxiliary spillways will have passive steel (pipe) pin-flashboard or un-gated concrete fixed weir overflow crest to assist in safely passing the ½ PMF + design storm without human intervention. The steel pipe fold over when reservoir rise to water level hydraulic

loads exceed the ultimate strength of the pipes. These passive systems have been used for more than 100 years to pass flow when needed.

- The proposed auxiliary spillway and stilling basin should fit within the footprint of the existing embankments to minimize the impact to downstream wetlands.
- The impoundments will be drawn down 3 feet in winter in accordance with the current lake operating level standards (see **Table 1** in Section 1.4) to minimize static ice loading on the auxiliary spillway. This winter drawdown will keep ice off the passive steel (pipe) pin-flashboards.

3.5 Empirical Equations Analysis

Prior to developing the hydraulic computer models, GEI evaluated proposed crest gates and auxiliary spillways using traditional empirically-based equations. This provides an initial evaluation of the hydraulic performance of the proposed spillway structures for each of the FLTF projects up to the ½ PMF + design storm. Conceptual-level proposed spillway rating curves were developed using the methods prescribed in the United States Bureau of Reclamation Design of Small Dams (Ref. USBR, 1987).

3.5.1 Crest Gate Spillways

In accordance with the *Design of Small Dams* (Ref. USBR, 1987), the crest gate spillway calculations were computed using the weir equation: $\mathbf{Q = CLH_e^{3/2}}$, where:

Q = discharge, cfs
C = discharge coefficient
L = effective crest length, feet
H_e = energy head on crest, feet

We adopted a standard Steel-Fab, Inc. (Steel-Fab) hydraulically operated crest gate profile, which closely approximates that of the lower nappe of sharp crested weir discharging at the design head of the crest gate. This ideal shape has been modified to provide positive pressure at all heads up to the design head. According to Steel-Fab (crest gate manufacturer in Fitchburg, MA), the discharge coefficient of the standard Steel-Fab crest gate at design head is estimated to be a minimum of 3.5 when the crest gate is fully down, and the water level is at the design head equal to height of the gate. At water levels less than the design head, the discharge coefficient decreases. At water levels greater than the design head, the discharge coefficient increases.

The effective length **L** of a spillway crest used in spillway discharge computations is expressed by the equation: $\mathbf{L = L' - 2(NK_p + K_a)\, H_e}$, where:

L = effective length, ft
L' = net length of crest, ft
N= number of piers
K_p = pier contraction coefficient
K_a = abutment contraction coefficient
H_e = energy head on crest, ft

3.5.2 Auxiliary Overflow Spillways

In accordance with the *Design of Small Dams* (Ref. USBR, 1987), the pin flashboard spillway calculations were computed using the weir equation: $\mathbf{Q = CLH_e^{3/2}}$, where:

Q = discharge, cfs
C = discharge coefficient
L = effective crest length, ft
H_e = energy head on crest, ft

The discharge coefficient was computed using the nomographs provided in Chapter A5 of the USGS *Measurement of Peak Discharge at Dams by Indirect Method (*USGS 1968) assuming an upstream slope of 2.5H:1V and downstream slope equal to 2.5H:1V. The supporting rating curve calculations are provided in **Appendix B**.

3.6 Proposed Conditions HEC-RAS Model

Once the initial evaluation of the hydraulic performance of the proposed spillways structures for each of the FLTF projects was completed, GEI developed a more detailed hydraulic model using the United States Army Corps of Engineers (USACE) HEC-RAS, Version 5.0.7. computer model (Ref. USACE, 2019) to further evaluate the proposed spillway capacity of the FLTF crest gates and auxiliary spillways. The HEC-RAS model and flood inundation mapping extended from Secord Lake to approximately 2-miles downstream of Sanford Dam. The HEC-RAS computer model can perform one-dimensional (1D) and two-dimensional (2D) unsteady flow modeling. The 2D unsteady flow modeling capabilities are useful for estimating the considerable amount of lateral flow that occurs in the Tea Creek floodplain, developed areas adjacent to Secord Lake and the relatively flat downstream topographic features. The 2D hydraulic calculations were performed in the HEC-RAS model using unsteady flow simulations with a variable time step based on the courant number calculated for cells within the computation mesh. This allows for longer time steps during intervals of lower velocities and shorter time steps during intervals with higher velocities. This is ideal for spillway flood studies as it allows for the time step to decrease as flow rates and velocities through the spillway increase. HEC-RAS 2D can solve full momentum equations or a simplified version of the equations (known as the diffusion wave equations). The full momentum equations were used in the 2D model calculations.

See the 2021 GEI Flood Study of the Tittabawassee River from Secord to Sanford Dam report for more information (Ref. GEI, 2021).

3.7 Secord Dam Flood Routing Results

The proposed spillway rating curves developed using the 2D HEC-RAS model were input into the HEC-HMS model as the primary spillway to determine the final flood routing results. Based on the proposed spillway configuration for Secord Dam, the ½ PMF + design storm results in a peak inflow of 21,150 cfs, a maximum reservoir water surface at El. 755.2, a peak discharge of 17,230 cfs, and a minimum of 2.8-feet of dam crest freeboard and minor overtopping of 0.2 feet of the Secord Lake ridgeline at El. 755.0. The Secord Dam ½ PMF + design storm inflow, outflow, and stage hydrographs are shown on **Figure 2**. Based on the configuration described above, the proposed Secord Dam spillway configuration would have sufficient discharge capacity to safely pass the ½ PMF + design storm with over 2.5 feet of freeboard.

The existing conditions model results indicate that during the ½ PMF + design storm, Secord Lake surcharges above the Secord Lake Ridgeline and left abutment at El. 755.0 (2.8 feet of overtopping) before reaching the dam, resulting in severe flooding to the eastern shoreline residential properties, yards, and roads. The overflow is routed east into the Tea Creek and then eventually into the Tittabawassee River approximately 2.5 miles downstream of Secord Dam. The proposed spillway upgrades result in nearly 3 feet of flood reduction in Secord Lake and limits the overtopping of the Secord Lake Ridgeline to 0.2 feet.

The proposed Secord Dam spillway discharge rating curves calculated by the 2D HEC-RAS model are compared to the empirical equation-based rating curves in **Figure 3**. In general, the empirical rating curves align well with the rating curves calculated by the 2D model up to the ½ PMF + design storm headwater El. 755.2, meaning that downstream submergence has little impact on the discharge capacity of the spillway. During the ½ PMF + design storm, the downstream tailwater rises to El. 726.6, which is approximately 8.2 feet lower than the spillway crest El. 734.8; therefore, the tailwater submergence ratio is not high enough to cause an increase in the upstream headwater elevation during the ½ PMF + design storm. Output data from the HEC-HMS model are summarized in **Table 6**.

Table 6: Secord Dam Flood Routing Results – Proposed Conditions

Parameter or Modeling Result	½ PMF + design storm
Initial Water Surface El. (feet)	750.8
Peak Inflow (cfs)	21,150
Peak Outflow (cfs)	17,230
Maximum Reservoir El. (feet)	755.2
Freeboard (Tea Creek E. 755.0)	-0.2
Freeboard (Dam Crest El. 758.0)	2.8

See the 2021 GEI Flood Study of the Tittabawassee River from Secord to Sanford Dam report for more information (Ref. GEI, 2021).

4. Summary of Dam Repairs and Flood Capacity Upgrades

4.1 Primary Spillway Modifications

The existing Tainter gate spillway will be partially demolished and the two (2) Tainter gates will be replaced with hydraulically operated crest gates at sill El. 734.8 to increase the spillway capacity. The left crest gate (Bay No.1) will be 18-feet-wide by 16-feet-high and the right crest gate (Bay No. 2) will be 21-feet-wide by 16-feet-high. The automated hydraulically operated crest gates will be designed to open and close with minimal human intervention during normal operation or during flood events. In the event of loss of power or control the gates can be depressurized and they will automatically lower to full discharge condition. The hydraulic gate operators will be supported on a new, reinforced concrete center pier. The upstream portions of the barrel arches below El. 734.8 will remain and the crest gates and their anchorage embedment's will be founded on mass concrete. A reinforced concrete stepped chute will convey water that discharges over the crest gates down to a new reinforced concrete stilling basin. Both the left and right spillway walls will be extended downstream and raised to provide adequate flow clearance and accommodate flattening of the flanking embankments. The proposed design drawings for the spillway improvements are provided in **Appendix C**.

4.2 Auxiliary Spillway

A new 130-foot-wide pin flashboard overflow spillway will be constructed across the top of the left embankment at El. 748.5 with steel pipe pins embedded in concrete holding timber flashboards that extend up to El. 752.0 to maintain the normal summer pool at El. 750.8. The pin-flashboards will be designed to fail when overflow greater than 1.5 feet water head over the top of the boards reaches El. 753.5. This release will provide additional spillway capacity during the ½ PMF + design storm. The overflow spillway will discharge into a concrete chute and 130-foot wide USBR Type III stilling basin to dissipate and transfer flow into the downstream discharge channel. Downstream of the stilling basin, flows will be conveyed downstream of the left embankment, approximately 600 feet back into the Tittabawassee River just upstream of Secord Dam Road via a riprap-lined discharge channel. A concrete-lined stepped drop structure will be constructed at the terminus of the discharge channel at the riverbank of Tittabawassee River. Steel sheet piling will be provided along the upstream side of the auxiliary discharge channel from the end of the stilling basin downstream to the stepped drop structure as an added measure to protect the left embankment toe from possible erosion and undermining in the event of high flows within the auxiliary discharge channel. The proposed auxiliary spillway design drawings are provided in **Appendix C**.

4.3 Powerhouse Modifications to Provide Low Level Outlet

Photo 4-1 View of 2021 Ice Management

As highlighted by the ongoing ice issues experienced at Secord Dam during the winter of 2020 / 2021, it is crucial to develop a reliable low-level outlet to pass base flows in the winter at Secord Dam to minimize active daily ice management. For the long-term reconstruction, we are proposing to retrofit the existing powerhouse to pass base flows (100 to 200 cfs) through the powerhouse in accordance with the 95% exceedance base flows estimated by the State of Michigan Department of Environmental Quality (DEQ) Flood discharge database. This will be accomplished by removing the existing generator, turbine shaft, wicket gates and ancillary mechanical and electrical equipment, installing a bulkhead over the runner pit and fixing the runner into place. By lowering the concrete sill upstream of the existing head gate and installing an upstream vertical slide gate to control in-flow, the powerhouse water passages will be converted into a low-level outlet to pass base flows. The low-level outlet conceptual design was developed by GEI, Essex and SGI.

Ice accumulation on the concrete downstream piers, walls and cross-struts and ice removal activities in January 2021 are illustrated in **Exhibit 4-1**. The proposed low-level outlet design consists of the following elements:

- Cut down the barrel arch upstream of the powerhouse intake to El. 723.8 and fill the hollow structure below the barrel arch with mass concrete.
- Construct a new reinforced concrete cap at the intake elevation just upstream of the existing head gate. The total impoundment drawdown potential is from El. 750.8 to El. 723.8.
- Remove the existing trash rack and provide a replacement trash rack upstream of its current location.
- Construct a new vertical slide gate(s), gate (bulkhead) guide slots, operating deck, and hoist system at spillway operator deck level upstream of the existing head gate.
- Remove and upgrade the existing steel head gate.
- Remove generator, turbine shaft and wicket gates.
- Construct a new bulkhead over the top of the runner pit in the powerhouse floor slab.

- Leave the runner in place and affix (weld) to the new bulkhead to provide horizontal to vertical flow energy dissipation.
- Construct a new tailrace weir wall to maintain higher tailwater immediately downstream of the draft tube bays.
- The new upstream slide gates will be used to throttle base flows to pass approximately 100 to 200 cfs of flow.
- The upstream bulkhead and head gate will allow for full de-watering for maintenance and inspections of the downstream water passages.

The conceptual design for the powerhouse modifications is illustrated on Drawing C-07 included in **Appendix C.**

4.4 Embankment Modifications

The upstream and downstream slopes will be flattened, and the crest widened to a minimum width of 15 feet to provide adequate stability in accordance with EGLE requirements under normal and flood pool loading criteria. A new permanent hot rolled steel sheet pile cutoff wall with interlock sealants will be constructed along the upstream edge of the dam crest and extend through the embankment fill and foundation overburden soils and be founded into the clayey glacial till to provide a seepage cutoff. A reverse filter and toe drain, comprised of filter sand and drainage stone, will be incorporated into the downstream fills to provide improved internal drainage and filter protection against internal erosion in the event of seepage through the sheet pile cutoff. General site plans and cross sections for the Secord Dam rehabilitation are provided in **Appendix C**.

4.4.1 Embankment Fill

New embankment fill placed on maximum 2.5H:1V slopes will be used to reconstruct the embankment sections upstream and downstream of the newly constructed concrete core wall between each end of the new auxiliary spillway and the existing buried barrel arch spillway abutment walls. The embankment fill will consist of material either salvaged from on-site excavations or imported from approved off-site sources, as required. All cobbles greater than 4 inches in diameter will be screened out. New embankment fill material will be comprised of semi-pervious granular material (Unified Soil Classification System soil types: SP-SM, SM, and SC-SM) and will be compatible with the remaining, existing embankment fill in terms of filter criteria. Embankment fill will be placed in loose horizontal lifts not exceeding 12 inches and compacted in a controlled manner to a minimum of 95 percent of maximum dry density determined by the standard Proctor (ASTM D698) with appropriate moisture control measures.

4.4.2 Reverse Filter and Toe Drain

A reverse filter toe drain consisting of filter sand and drainage stone will be constructed at downstream slope and toe of the left and right embankments to mitigate against seepage and internal erosion of the embankment and foundation soils. The reverse filter and drain will generally consist of 18 inches of fine filter (MDOT 2NS natural sand) and 24 inches of coarse filter (MDOT 29A stone). Depending upon their condition upon excavation, the existing finger drains will either be extended and conveyed downstream to daylight at the toe or be terminated within and seepage collected in the drainage stone layer. The seepage will be collected in a minimum 8-inch diameter slotted drainpipe surrounded by coarse filter material. The purposes are: 1) to provide an outlet to convey seepage toward the outlet to keep the phreatic surface from rising within the reverse filter, and 2) to collect and direct seepage flow entering the reverse filter to the downstream weir box so the flow rate and potential fines movement can be collected and monitored.

4.4.3 Riprap and Bedding

Riprap placed on the upstream side of the auxiliary spillway approach apron, and upstream and downstream embankment slopes will consist of a hard, durable, non-weathered, angular stone in accordance with Michigan Department of Transportation (MDOT) standard specifications. Riprap placed downstream of the stilling basin and in the auxiliary spillway discharge channel will consist of MDOT heavy riprap. Bedding material will consist of imported granular material in accordance with MDOT specifications placed over MDOT 29A crushed stone. The 29A stone should be placed on natural 2NS sand placed over native soil subgrades. For accessible riprap and bedding subgrades, the bedding material can be placed on non-woven geotextile.

5. Structural Design Criteria

5.1 General

The existing and proposed concrete spillways, water retaining, or water conveyance structures described in this Report are the primary gated spillway (comprised of side walls, center piers, rollway, stilling basin and crest gates), powerhouse (side walls, intake, scroll case, draft bay, stilling basin), auxiliary spillway (side walls, base slab, chute stilling basin, flashboard, and stanchion pins) and auxiliary spillway stepped terminal structure. The structural design criteria applicable to these structures are described in the following sections.

Geotechnical explorations, standard penetration and pressuremeter testing and soil-structure analyses will be performed at Secord Dam to quantify bearing capacity, subgrade moduli and estimate settlement of glacial till foundation settlement under new dams loads to assess dam performance when the hollow sections of the existing spillway and powerhouse dam are filled in with concrete and steel crest gates and operators are installed. Based on Fisher measurements at lowered Tobacco Spillway weir, the 15.5 feet of new mass concrete cause the two piers and training walls to settle 0.3 inches with no observed distress to the wall and piers. Our design approach will be model new normal or lightweight concrete on the existing spillway mat with and without grouted 100 to 200 ton battered drilled and grouted steel micro-piles under the heavily loaded piers and gate operators. We will run finite element stress and deformations using pressuremeter data to compute settlement with and without underpinning piles.

Special attention will be made to work with the existing counterfort walls to ensure the walls remain stable as the rollway, barrel arches and cross lot struts are removed and replaced with mass concrete that support the gates and buttress the walls. Installation of supplemental temporary and higher bracing and steel or concrete struts may be required to brace right spillway and powerhouse counterfort walls. Concrete wall overlays and use of lightweight fill may be required on the embankment side of the existing wall to reduce lateral earth pressures. The counterforts are narrow on the right side of the spillway that will require special attention.

5.1.1 Stability Analyses

Stability analyses of the training wall, spillway overflow section, piers and powerhouse concrete structures will be based on FERC Dam Safety Guidelines Chapter 3 *Gravity Dams* and Chapter 10 *Other Dams* and USACE EM-1110-2-2100 – *Stability Analysis of Concrete Structures* (Ref. USACE, 2005).

5.1.2 Reinforced Concrete Design

Reinforced concrete design will be in accordance with applicable provisions of Building Code Requirements for Structural Concrete (ACI 318-14) and USACE EM-1110-2-2104 – *Strength Design for Reinforced-Concrete Hydraulic Structures* (Ref. USACE, 2016). For design of hydraulic structures, ACI 318-14 will be supplemented by the provisions of the American Society of Civil Engineer's *Strength Design of Reinforced-Concrete Hydraulic Structures* (Ref. ASCE, 1993). Concrete temperature and shrinkage steel will meet USACE requirements.

5.2 Material Properties

The following material properties will be used to calculate the compression and flexural design strength and shear capacity for reinforced concrete structures.

Compressive Strength:

- For Exterior Exposed Structural Concrete components: Specified 28-day compressive strength of concrete cylinders of f`c = 4,000 psi. Air entrainment in normal concrete should be 5 to 7 percent. Water to cement ratio for normal weight concrete should be no higher than 0.4. Concrete should meet ACI 318-14 and the latest MDOT standards.
- For Internal Mass Lightweight Concrete (flowable, self-leveling): Specified 28-day compressive strength of concrete cylinders of f`c = 3,000 psi. Air entrainment in concrete should be 5 to 7 percent. Water to cement ratio for the lightweight concrete should be no higher than 0.45. Lightweight concrete should meet ACI 318-14 standards.

Unit Weight: normal weight reinforced concrete was selected with a unit weight of 140 to 150 pounds per cubic foot (pcf). Lightweight concrete shall have a unit weight of 90 to 115 pcf.

Steel Reinforcing: ASTM A615, Grade 60 reinforcing steel, uncoated, with yield strength fy = 60,000 psi.

5.2.1 Load Cases and Required Factors of Safety Against Sliding

The stability of the primary and auxiliary spillway and outlet works will be analyzed as a rigid 2-dimensional block using the shear friction factor (SFF) of safety method; conducted in accordance with Chapters 3 and 10 of the current FERC Guidelines. The FERC Guidelines require that stability versus sliding be computed for the following load cases and corresponding recommended factors of safety presented in **Table 7**:

Table 7: Applicable Loading Conditions and FERC Recommended Minimum Factors of Safety

FERC Required Loading Condition	FS with Cohesion (High or Significant Hazard)	FS without Cohesion
Case I (Usual Loading Combination) – Normal Operating Condition	3.0	1.5
Case II (Unusual Loading Combination) – Flood Discharge Loading	2.0	1.5 (1)
Case IIA (Unusual Loading Combination) – Normal Operating Condition plus Ice Loading	2.0	1.5

Notes: (1) Can be reduced to 1.3 flood load case if flood is equal to PMF.
(2) Stability under seismic loading (Case III) is not anticipated as a requirement as Central Michigan USGS defined design earthquake having 2% probability in 50-year event (2,500-year return period) has reported Peak Ground Acceleration (PGA) less than 0.05g.

5.2.2 Limits on Resultant Force Location

In accordance with USACE EM 1110-2-2100 (Ref. USACE, 2005), limits on the location of the resultant of applied forces acting on the base of the structure are specified for each load condition category. We will use existing piezometers to assess hydrostatic uplift under the gravity spillway dam. The existing mat has an effective upstream concrete seepage cutoff wall in hardpan glacial till. The location of the resultant can be determined by static analysis. The rotational behavior of the structure must comply with the limits given in **Table 8**.

Table 8: Requirements for Loading of Resultant – All Structures

Site Information Category	Load Condition Categories		
	Usual	Unusual	Extreme
All Categories	100% of Base in Compression	75% of Base in Compression	Resultant Within Base

5.2.3 Factors of Safety versus Floatation

The required factors of safety for uplift (flotation) stability (FERC Load Case IA) in accordance with FERC Dam Safety Guidelines Chapter 10 are shown in **Table 9**.

Table 9: Required Factors of Safety for Low-Level Outlet (Retrofitted Powerhouse) Flotation

Site Information Category	Load Condition Categories		
	Normal	Scheduled Maintenance	Construction
All Categories	1.5	1.3	1.1

6. Embankment Design Criteria

6.1 Existing Subsurface Information

Soil borings were performed on the right and left embankments in 1924, 1996, 2001 and 2005. There is no record of prior borings and no record of new or additional borings since 2005.

In 1996, four (4) borings (P-96-01, P-96-02, SB-03 and SB-04) were completed on the left embankment by Stearns Drilling. The borings were each advanced through the embankment fill and foundation soil to the underlying hardpan clayey glacial till layer. Boring P-96-01 and P-96-02 were converted to monitoring wells MW#3 and MW#4. The boring logs were developed by Barr Engineering.

In 2001, two (2) borings were performed by RC Associates, Inc. (Ref. RC, 2001). Boring B-1 was performed on the left embankment crest and boring B-2 on the right embankment crest. The borings were advanced to depths of 52 to 54 feet, respectively, below the crest and into the underlying clayey till.

In 2005, three (3) borings were performed by McDowell & Associates (Ref. McDowell, 2005). Boring B-5 was performed on the left embankment crest and borings B-6 and B-7 on the right embankment crest. Boring B-5 was advanced to a depth of 57 feet below the crest and into the underlying clayey till. Borings B-6 and B-7 were advanced through the embankment fill to depths of 32.5 to 33 feet, respectively, into the underlying native clay foundation soil. The three borings were converted to monitoring wells (MW#5, MW#6 and MW#7).

Boring locations are shown on the Monitor Well Plan and Section Drawings from the DSSMP included in Appendix D of this Report. The results of the borings were used to develop the interpreted subsurface profile included in **Appendix D**.

6.2 Existing Stability Analyses

Available stability analysis results for the embankments were performed as part of the 1991 Consultants Safety Inspection Report (CSIR) and Addendum No. 1. The analysis reportedly utilized the computer program TSTAB to evaluate stability of circular failure surfaces using Bishop's simplified method of analysis which satisfies vertical force and moment equilibrium. The analysis evaluated the left embankment section for the following loading conditions:

1. Normal Pool
2. Earthquake
3. Maximum Pool
4. Rapid Drawdown

Output from the analysis was provided in the project's Supporting Technical Information Document (STID), but the original analysis and report were not available for review. The analyses show factors of safety summarized in **Table 10**.

Table 10: Summary of Embankment Stability

Loading Condition	Computed FS	FERC Required FS
Downstream Normal Pool	1.85	1.5
Downstream Earthquake at Normal Pool	1.57	1.0
Downstream Maximum Pool	1.55	1.5
Upstream Rapid Drawdown	1.12	1.2

6.3 Review of Existing Subsurface Information and Stability Analyses

Further review of the individual boring logs confirms the embankment materials near the spillway and powerhouse are a mix of sand and clay. The underlying hardpan glacial till layer is 50 to 70 feet below the crest near the spillway and powerhouse. However, there is no subsurface information beyond approximately 100 feet right and 50 feet left of the spillway and powerhouse. Additional information is required to adequately analyze the embankment stability. Therefore, we recommend additional soil borings on both the left and right embankments to further define these conditions.

Additional subsurface information is needed to inform the designs for the new auxiliary spillway and embankment repairs presented in the 30% design drawings. Improvements to the existing spillway are also planned that include adding mass concrete inside the existing barrel arches. The additional concrete will increase loads on the underlying till foundation soil. To evaluate the bearing capacity and settlement from this additional load, we recommend performing in-situ pressuremeter tests (PMT) in the till foundation soils below elevation 700 feet. The PMT can be performed within the additional recommended soil borings.

The record stability analysis for the left embankment was completed in 1991. The method of analysis is outdated and only satisfies vertical force and moment equilibrium. There is no record analysis for the right embankment. There is no information about how the material properties assumed in the stability analysis were developed. The phreatic surface was estimated from two piezometers as shown on the cross section. Although the modeled cross section contains a toe berm and is likely the critical section of the left embankment, there is limited information about how the embankment cross section geometry was developed.

For these reasons, we recommend that the record stability analysis for both the left and right embankments be updated using the results of the additional recommended soil borings. For both right and left embankments, the updated stability analyses should consider the current slope geometry and the proposed new slope geometry presented in the GEI conceptual drawings. Additional subsurface investigations at Secord Dam are currently planned for Spring 2021.

See the GEI Subsurface Exploration Work Plan, February 2021 for more information (Ref, GEI 2021b).

6.4 Proposed Embankment Seepage and Stability Analysis Approach

Upstream and downstream embankment and foundation stability analyses will be performed in accordance with the current Chapter 4 of the FERC Engineering Guidelines using the Slope/W and Seep/W modules of the GeoStudio software package (Ref. GEOSLOPE International Ltd). Section geometry will be based on survey data. Section lithology will be based on subsurface exploration results. Phreatic surface will be based on the observed subsurface conditions or the SEEP/W parent model results.

For each section analyzed for stability, a critical surface search routine will be performed using the SLOPE/W program. As appropriate, GEI will use SEEP/W to predict piezometric pressures distribution for use in the Slope/W slope stability model. Surfaces considered critical may vary by structure, but in general are required to either breach the embankment crest, or intercept the phreatic surface in a manner that would lead to breaching of the embankment crest by progressive slope failure. Shallow failure surfaces, which do not meet the critical criteria are not typically considered. Factors of safety in SLOPE/W will be computed by using Spencer and the Morgenstern-Price method applied to a method of slices, limit equilibrium approach. Circular or block failure surfaces will be considered in the analyses, as considered appropriate, based on the geotechnical characteristics of the section analyzed.

6.5 Loading Conditions

The following FERC-required loading conditions will be evaluated:

- Steady Seepage with Maximum Storage Pool – Upstream and Downstream Slopes
- Steady Seepage, End of Construction Conditions – Upstream and Downstream Slopes
- Rapid Drawdown – Upstream Slope
- Steady Seepage with Surcharge Pool – Downstream slope

Because the dam is located in an area of low seismic activity and the peak ground acceleration at the dam site is less than 0.05g for a 2,500 year period of return (Ref. USGS, 2014), evaluation of liquefaction potential, post-earthquake seismic stability, and seismic-induced permanent deformation are not required per the FERC Engineer Guidelines.

6.6 Material Properties

Unit weights and shear strengths for the foundation and embankment fill material will be developed from the subsurface exploration program results and laboratory testing of recovered samples, available information from previous work on the project, and published correlations based on SPT blow counts for similar materials.

6.7 Phreatic Surface Assumptions

The steady-state phreatic surface used in the stability model will be computed using the integrated SEEP/W file results or informed by the subsurface exploration program results.

6.8 Results

To be completed as part of final design scheduled for late 2021 to early 2022.

7. Construction Considerations

7.1 Erosion Control

All construction work on site will be completed in accordance with the State of Michigan EGLE construction activity permit and the Stormwater Pollution Prevention Plan (SWPPP) that will be prepared for this project. All other federal, state, and local permit requirements should be adhered to during construction. Work should be planned to minimize soil erosion from the construction area. Soil erosion and sediment control measures should be in place prior to any earthwork operation and will be used to prevent construction related degradation of the natural water quality. Erosion and sediment control best management practices (BMPs) should be used for all site erosion and sediment control.

To minimize soil erosion, all work should be planned, conducted, and controlled to reduce the areas disturbed by the new construction. Precipitation runoff should be directed to retention basins and infiltration areas. Disturbed areas should be promptly stabilized. Effective use and maintenance of erosion and sediment control measures such as silt fences, seeding and erosion control blankets for soil slopes should be used throughout the construction period and maintained until the permanent drainage and erosion control measures are installed.

To protect the water quality in natural water bodies, set-back criteria should be established for equipment traffic. Siltation of the water should be prevented by dispersing any flows to infiltration areas and retention basins. Gravel pads should be used to prevent spillage or tracking soils or other construction material on roads used for site access. Exposed soil slopes should be seeded and covered with erosion control blankets. For long slopes, earth berms and ditches should be constructed across the slopes to intercept and convey surface water to stable outlets at non-erosive velocities.

7.2 Upstream and Downstream Cofferdams

The proposed upstream and downstream cofferdam design consists of internally braced, hot rolled steel sheet pile (SSP) with interlock sealants. The cofferdam cells can be constructed in three (III) phases at the powerhouse and each bay. Phase I is constructed at the powerhouse to allow construction of the low-level outlet while the Tainter gate spillway bays remain open to pass base river flow. Phase I requires an upstream cofferdam only. Phase II requires both an upstream and downstream cofferdam and would occur at Spillway Bay No. 2 while the newly constructed low-level outlet and spillway bay No. 1 pass base river flow. Phase II construction includes the Spillway Bay No. 2 demolition of the concrete barrel arch and downstream rollway, concrete repairs, construction of the new concrete rollway and crest gates. Finally, Phase III would occur at the spillway bay No. 1 and like Phase II, while Spillway Bay No. 2 and the low-level outlet would remain open to pass base river flow. The upstream cofferdams will consist of steel sheet piles braced internally with three levels of walers and struts. The Phase II and III upstream cofferdam will require three levels of internal waler, cross-lot and corner bracing to be installed prior to dewatering, which will require some underwater diver assisted installation. The Phase II and III downstream cofferdam new two levels of internal bracing, Steel sheet piles running upstream and downstream will be cut within the barrel arch and require a closure connection using divers between the steel sheet pile and concrete barrel arch to create a "watertight" seal. The internal bracing will react against the end walls, the powerhouse, or the internal pier. The conceptual design is illustrated in **Exhibits 7-1** through **7-3** and included in **Appendix E**.

Exhibit 7-1 Phase I Cofferdam Design

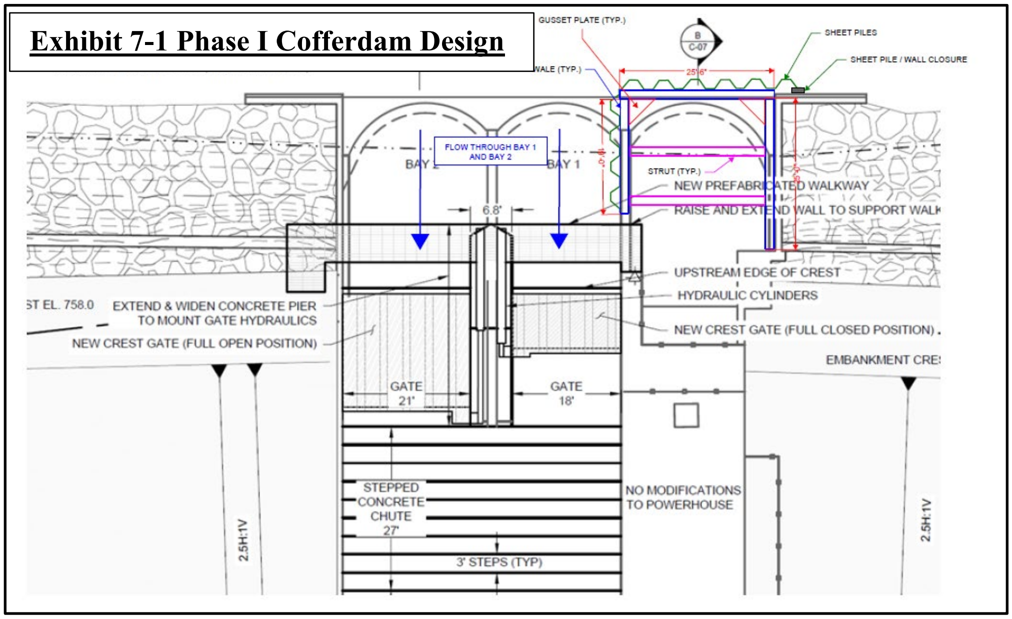


Exhibit 7-2 Phase II Cofferdam Design

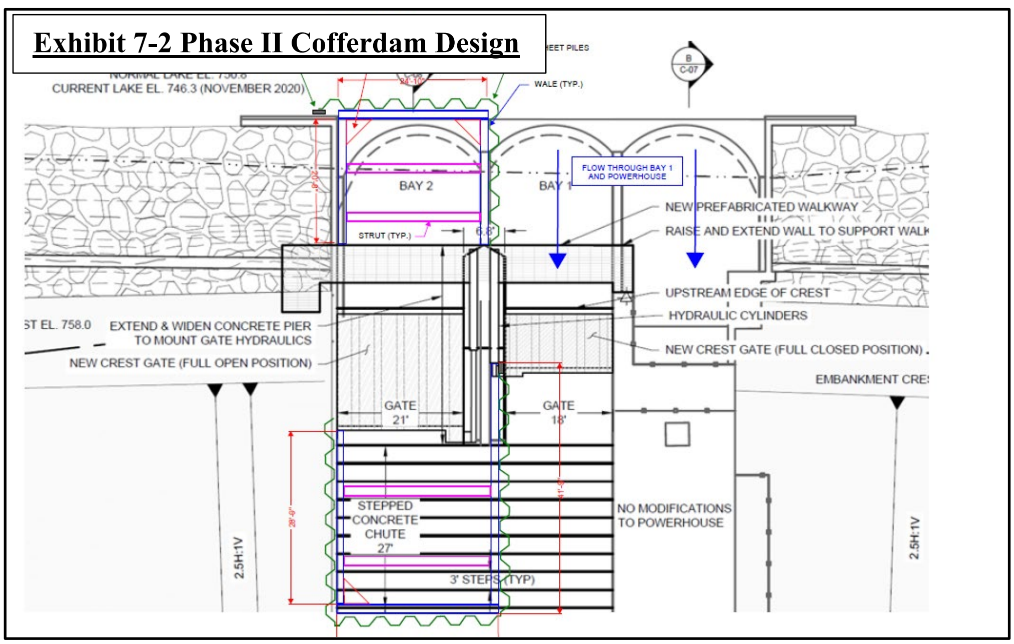
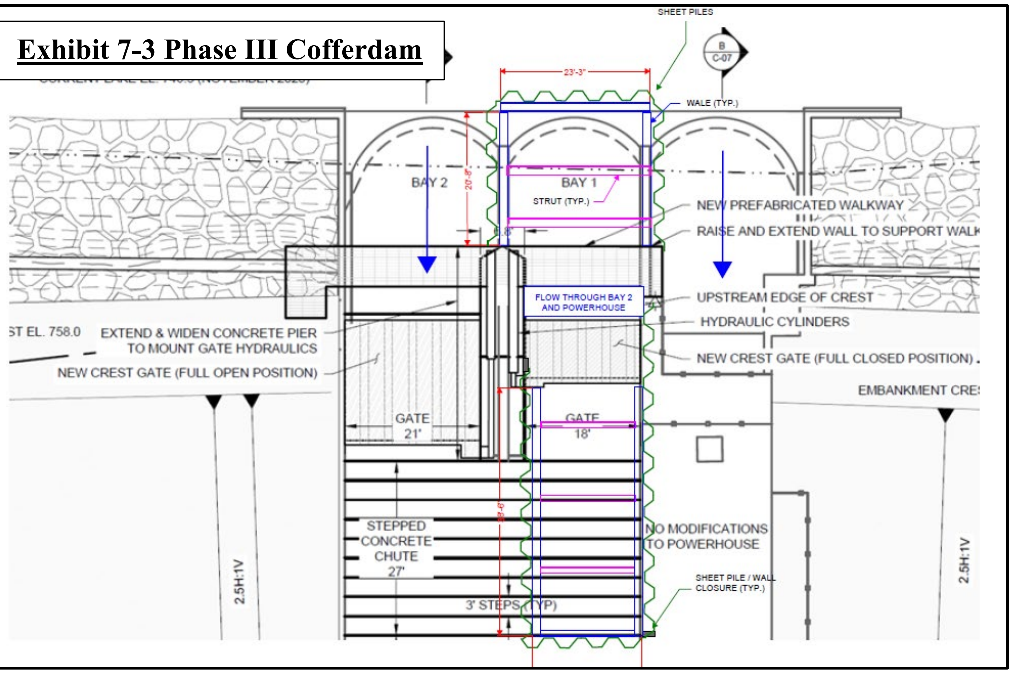


Exhibit 7-3 Phase III Cofferdam



7.3 Reservoir Operations During Construction

The reservoir is currently drawn down to approximately El. 743.8 +/- or within one foot above the ogee shaped spillway sill crest (El. 742.8) with the Tainter gates fully open (10-feet) and dogged off. The reservoir will remain drawn down during construction and the headwater will fluctuate based on seasonal Tittabawassee River flow.

7.4 Dewatering and Diversion Needs

The Tittabawassee River will be conveyed through the new low-level outlet constructed within the existing powerhouse and through the current Tainter gate spillway bays in the following three phases:

- Phase I – Pass base river flow through open Tainter Gate Bay No. 1 and No. 2 while constructing the low-level outlet in the powerhouse.
- Phase II – Pass base river flow through the low-level outlet and Tainter Gate Bay No. 1 while demolishing Tainter Gate Bay No. 2 and constructing the new right crest gate and concrete rollway.
- Phase III – Pass base river flow through the low-level outlet and Tainter gate Bay No. 2 while demolishing Tainter Gate Bay No. 1 and constructing the new left crest gate and concrete rollway.

Additional flow during extreme flood events will be passed through the new auxiliary spillway constructed near the left abutment.

7.5 Anticipated Construction Sequence

The anticipated construction sequence for the Secord Dam rehabilitation is as follows:

1. Contractor mobilization and develop crane access pads, material laydown and work areas.

2. Install the new seepage sheet pile cutoff along the upstream edge of the left and right embankment crests, along the upstream edge, sides, and downstream end of the proposed auxiliary spillway, as shown on the drawings.

3. Install a temporary braced cofferdam upstream of the powerhouse intake and downstream in the powerhouse tailrace area. Remove the turbine shaft, generator set and associated appurtenant mechanical and electrical equipment from within the powerhouse. Install a bulkhead over the runner pit and fix the runner into place.

4. Cut down the barrel arch concrete upstream of the powerhouse intake to El. 723.8 feet, fill the hollow structure with mass concrete, and install a new reinforced cast-in-place cap at the intake elevation upstream of the existing headgate.

5. Construct a new slide frame, slide gate and steel hoist frame structure upstream of the powerhouse intake and trash racks. Construct repairs to the powerhouse intake and outlet walls, penstock inlet, and draft tube outlet concrete, as needed. Raise and extend the left outlet works retaining wall.

6. Test and commission the new low-level outlet gate at the powerhouse. Remove the upstream and downstream cofferdams from the powerhouse intake and outlet areas.

7. Construct the new flashboard auxiliary spillway, outlet channel, and stepped terminal structure over new seepage sheet pile cutoff along the upstream edge of the left embankment crest. Do not yet install the flashboards.

8. Concurrent with Step 7, construct rehabilitation repairs to the left and right embankments, including installation of filter sand, drainage stone, toe drains and additional embankment fill. Excavation from the overflow spillway and outlet channel can be used as embankment fill if suitable.

9. Install the braced upstream and downstream cofferdams to isolate the right Spillway Bay No. 2, rollway, and center pier.

10. Remove the right Tainter gate and hoist. Cut down and demolish the upstream barrel arch concrete to El. 734.8 feet and demolish the rollway ogee crest, downstream rollway

and cross struts as designated on the drawings down to the stilling basin within the right Spillway Bay No. 2.

11. Fill the barrel arch bay with mass concrete, and install the new hydraulic crest gate steel anchor embedment. Construct the reinforced concrete stepped chute, ogee crest, stilling basin overlay and new downstream stilling basin end sill. Install reinforcement and construct the widened center pier. Raise and extend the right spillway wall. Install the right crest gate, hydraulic operator, and controls.

12. Test and commission the right crest gate.

13. Remove the upstream and downstream cofferdams from the right spillway bay and relocate to the left spillway bay. Repeat steps 10 and 11 and test and commission the new crest gate in the left Spillway Bay No. 1. Remove the upstream and downstream cofferdams.

14. Install the new pre-engineered spillway operator's deck.

15. Install site instrumentation (piezometers, settlement monitoring points, etc.).

16. Site restoration and contractor demobilization.

17. Refill Secord Lake and monitor and record instrumentation and deformation monitoring point performance on routine basis.

8. Engineer's Opinion of Probable Construction Cost

8.1 30% Design Cost Analysis

An engineer's Opinion of probable construction cost (OPCC) were developed for the Secord Dam to pass the ½ PMF+ design storm based on the proposed project facilities and construction approaches presented in this Report. The level of detail for this type of estimate is assumed to provide construction costs within the range of ± 25%, typically used for the 30% design phase. The OPCC includes 25% contingency for all construction items and includes an allowance for site investigations, engineering design, permitting and construction engineering / management costs. The total OPCC for the Secord Dam to pass the ½ PMF + design storm is approximately **$25 million**. A summary of the ½ PMF + OPPC for the Secord project is summarized in **Table 11** and cost estimate worksheets are provided as **Appendix F**.

Table 11: Summary of Opinion of Probable Construction Costs

Item	Description	Estimated Cost
0.00	General Conditions	$ 1,236,000
1.00	Site Preparation and Cofferdams	$ 1,470,000
2.00	Site Demolition (Spillway and Powerhouse)	$ 826,000
3.00	Left Embankment Repair and Stabilization	$ 2,723,000
4.00	Right Embankment Repair and Stabilization	$ 1,648,000
5.00	New Crest Gate Spillway and Outlet Works	$ 4,542,000
6.00	Powerhouse Rehabilitation	$ 1,000,000
7.00	Auxiliary Spillway Structure	$ 1,415,000
8.00	Discharge Channel	$ 3,739,000
9.00	Site Restoration	$ 150,000
	Subtotal	$ 18,749,000
	Contingency (25%, possible micropile underpinning)	$ 4,687,000
	Construction Subtotal	$ 23,436,000
	Site Investigations, Engineering, Permitting and Construction Management	$ 1,700,000
	Total Estimated Cost	**$ 25,136,000**

8.2 Closing

Our opinions of probable design and construction costs should be considered rough budgetary estimates based on conceptual level designs, costs for similar projects and engineering judgment. Detailed designs and quantities have not yet been prepared. Actual bids and total project costs may vary based on contractor's perceived risk, site access, season, market conditions, etc. No warranties concerning the accuracy of costs presented herein are expressed or implied.

9. References

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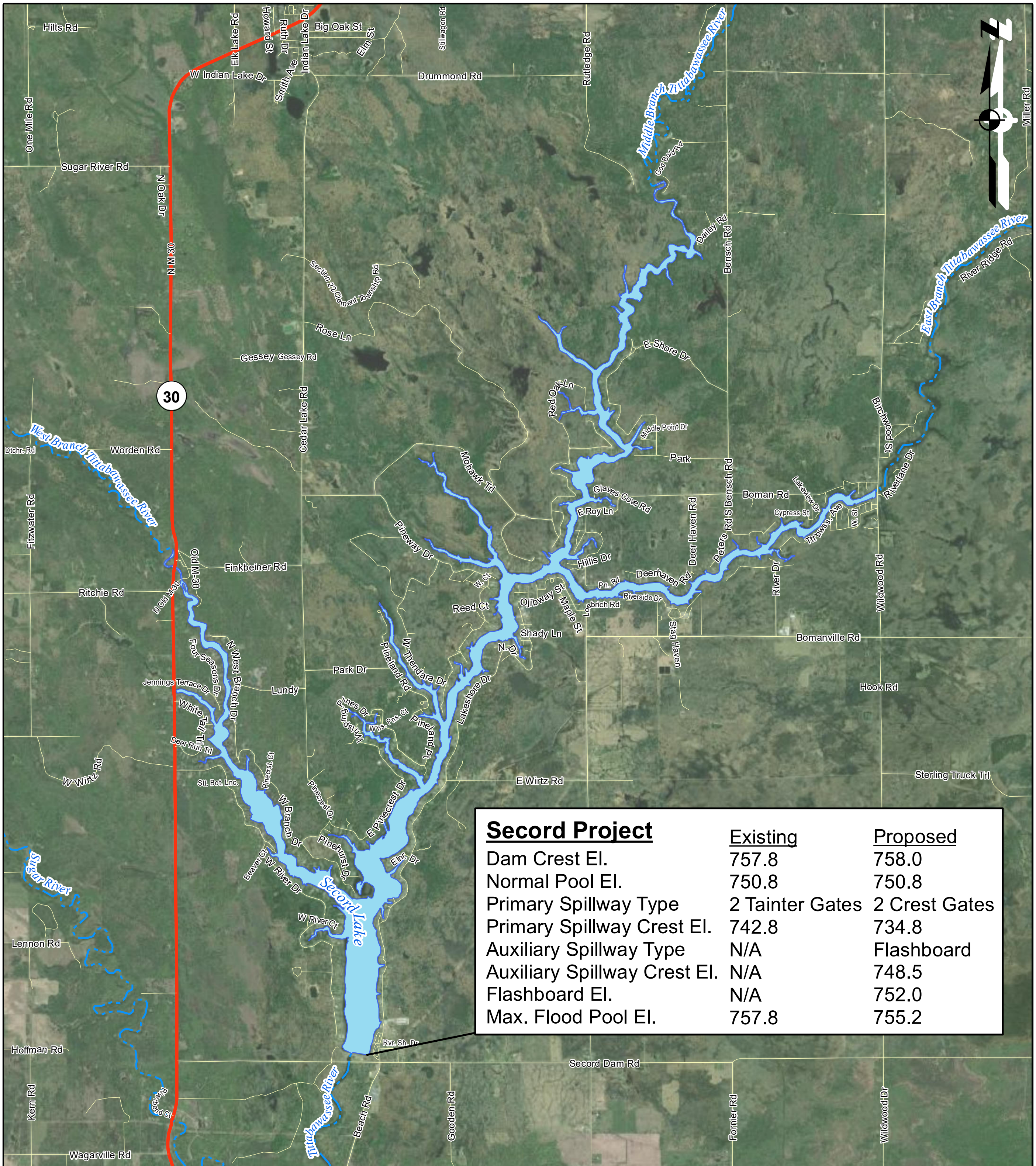
Figures



Secord Project	Existing	Proposed
Dam Crest El.	757.8	758.0
Normal Pool El.	750.8	750.8
Primary Spillway Type	2 Tainter Gates	2 Crest Gates
Primary Spillway Crest El.	742.8	734.8
Auxiliary Spillway Type	N/A	Flashboard
Auxiliary Spillway Crest El.	N/A	748.5
Flashboard El.	N/A	752.0
Max. Flood Pool El.	757.8	755.2

0 1 2

Scale, Miles

Note: All elevations referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). The acronym "El." represents Elevation.

Conceptual Design Basis Report
Secord Dam

Four Lakes Task Force
Gladwin and Midland County, Michigan

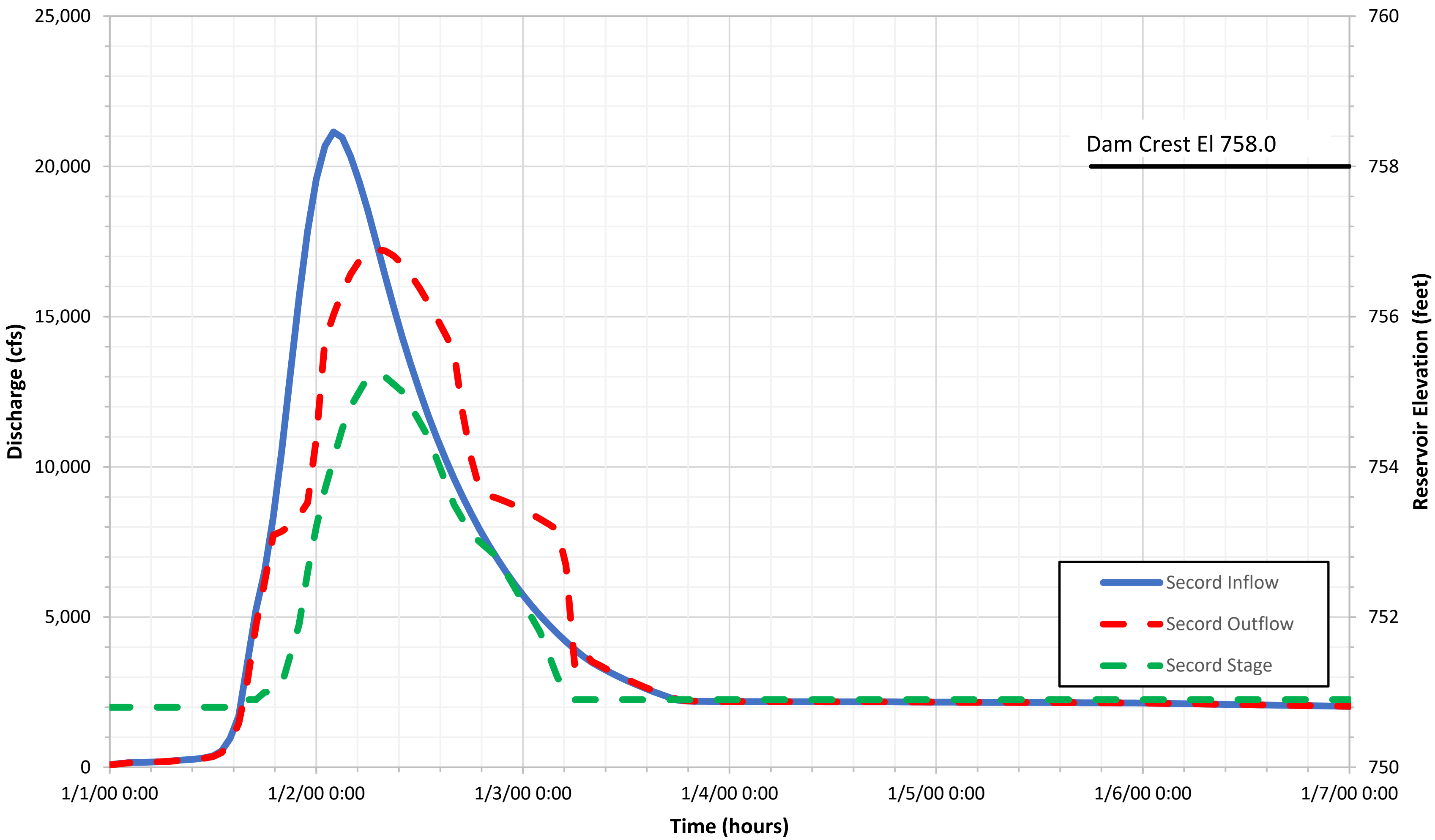
GEI Consultants

Project 2002879

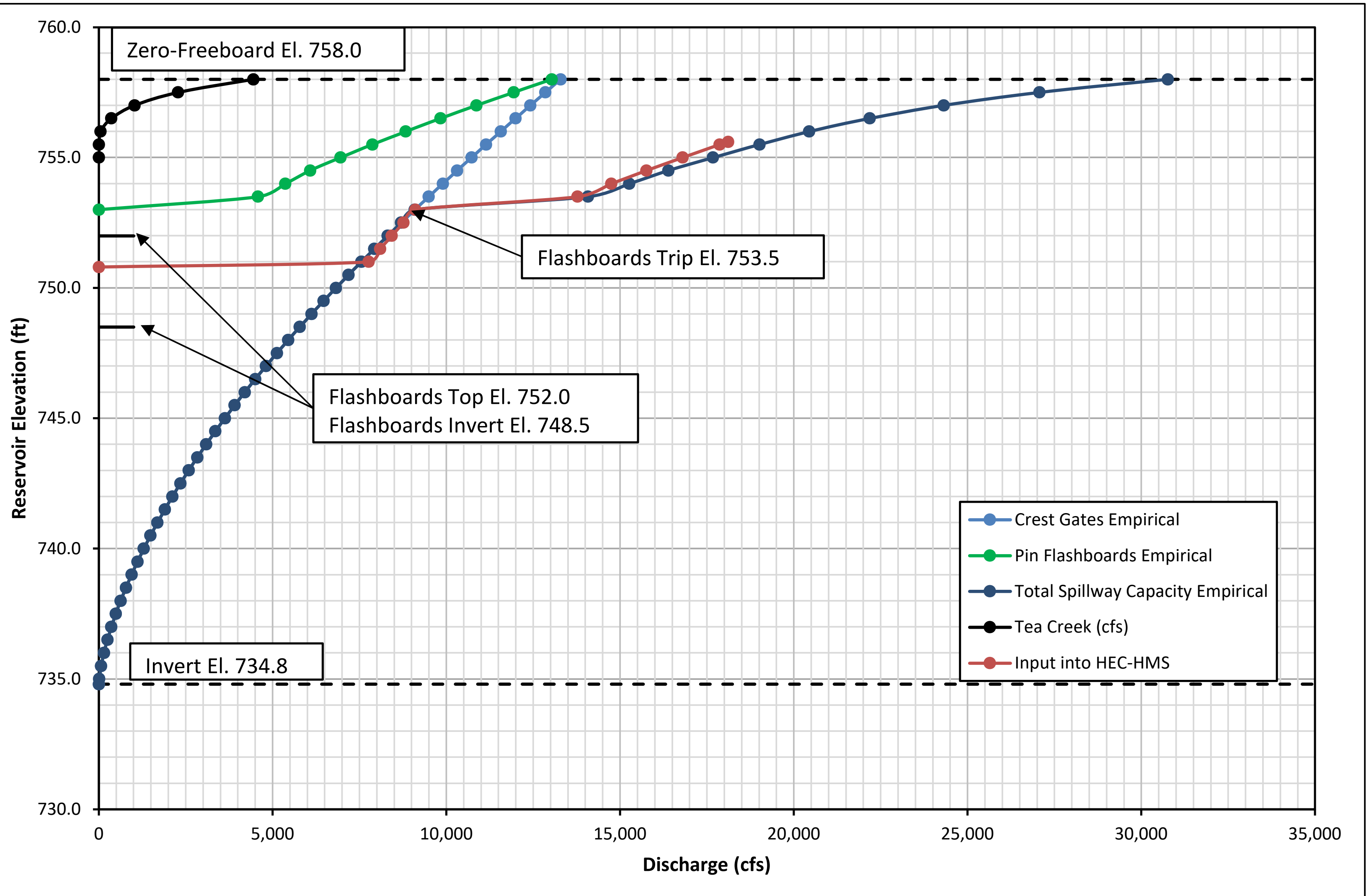
SECORD DAM
SITE LOCATION MAP

March 2021

Figure 1



Secord Dam **Client: Four Lakes Task Force** **Location: Gladwin County, Michigan**	GEI Consultants	**Proposed Conditions 1/2 PMF + Flood Routing Results**
	Project 2002879	**March 2021** **Figure 2**



Secord Dam
Client: Four Lakes Task Force
Location: Gladwin County, Michigan

GEI Consultants

Secord Dam 1/2 PMF + Spillway Rating Curves

Project 2002879

March 2021

Figure 3

Appendix A

Exhibit F Drawings

drawn using HAH 1923 survey

THIS DRAWING IS A PART OF THE
APPLICATION FOR LICENSE MADE
BY WOLVERINE POWER CORPORATION
THIS DATE

PC 11/86

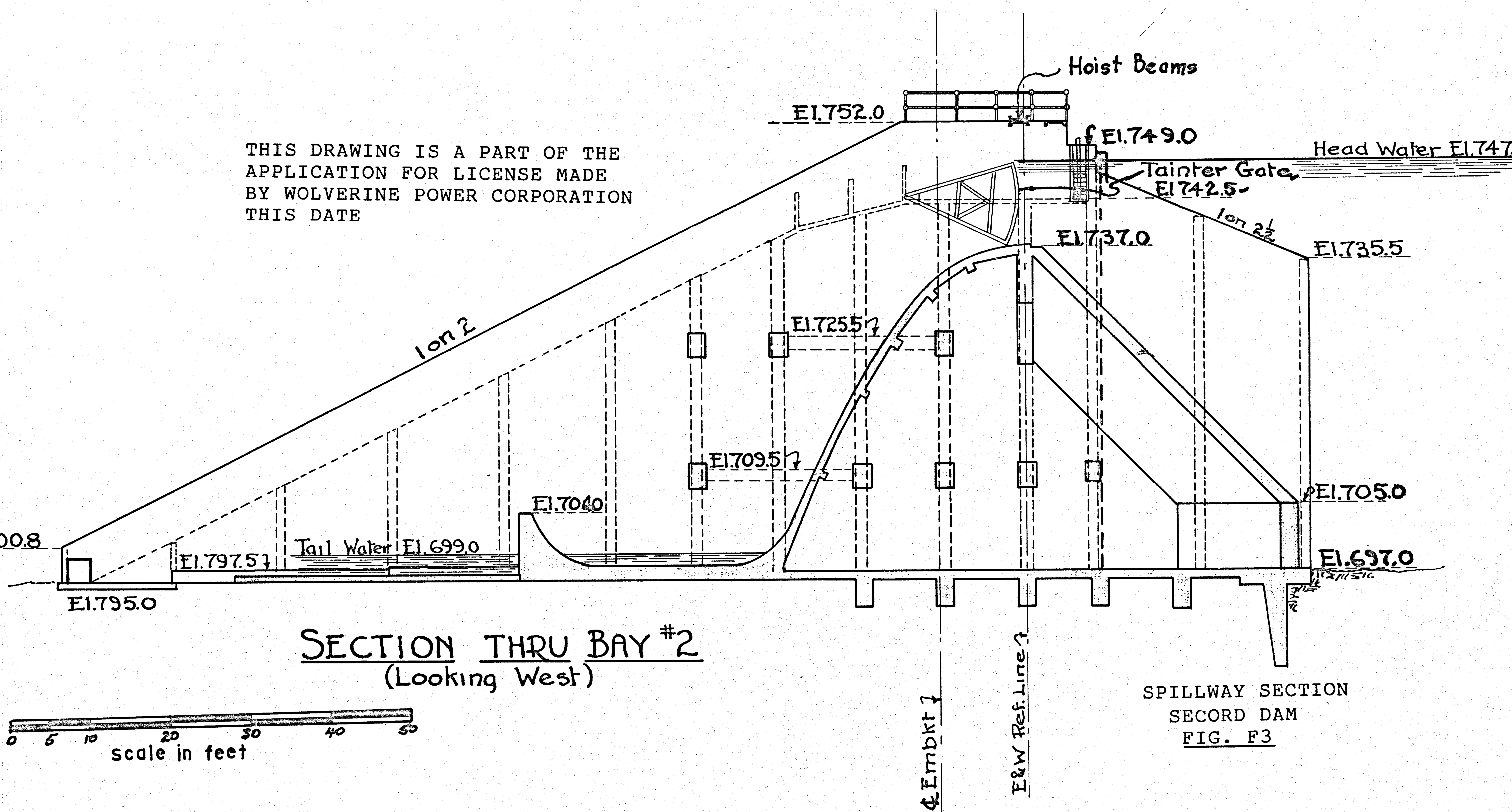
WOLVERINE POWER CORP
SECORD DAM
SURVEY PLAN

FIG. F1

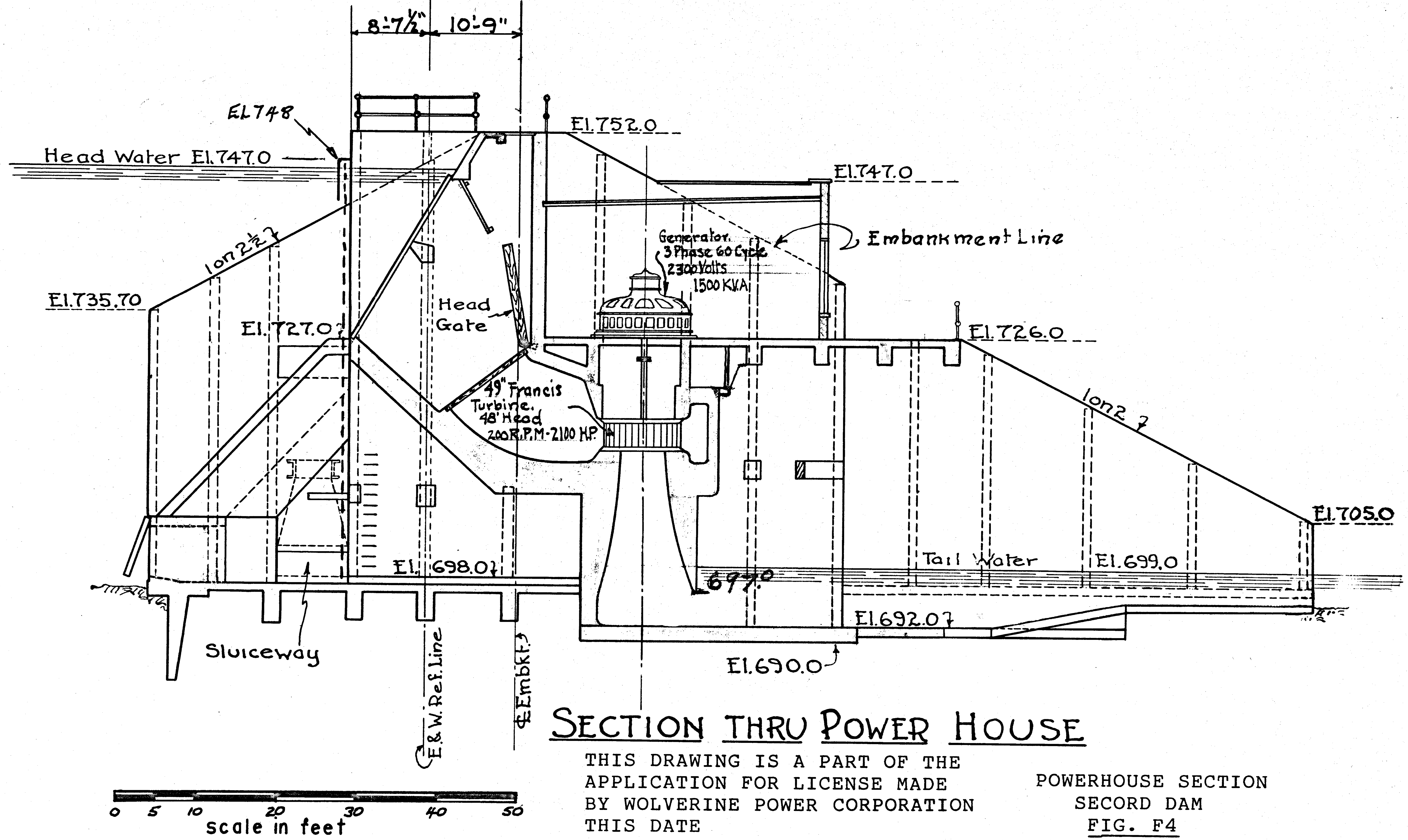
THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY WOLVERINE POWER CORPORATION THIS DATE

PLAN VIEW
SECORD DAM
FIG. F2

THIS DRAWING IS A PART OF THE
APPLICATION FOR LICENSE MADE
BY WOLVERINE POWER CORPORATION
THIS DATE



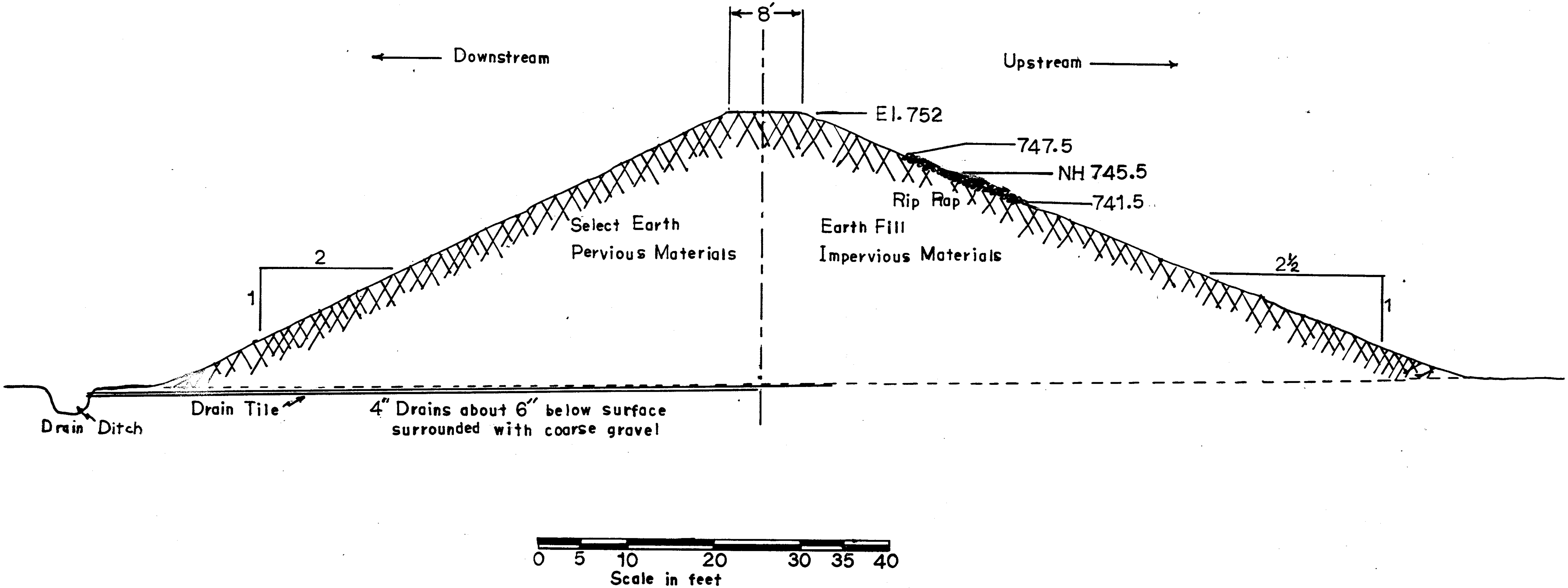
SPILLWAY SECTION
SECORD DAM
FIG. F3



SECTION THRU POWER HOUSE

THIS DRAWING IS A PART OF THE
APPLICATION FOR LICENSE MADE
BY WOLVERINE POWER CORPORATION
THIS DATE

POWERHOUSE SECTION
SECORD DAM
FIG. F4



Embankment Section
Secord Dam
Fig. F5

Appendix B

Spillway Rating Curve Calculations

GEI Consultants

CLIENT:	Four Lakes Task Force		
PROJECT:	Secord Dam	Project: 2002879	Pages:
SUBJECT:	1/2 PMF + Spillway Design (Crest Gates)	Date: 11/12/2020	By: P. Drew
		Checked:	By:
		Approved:	By:

Purpose: Develop a spillway discharge rating curve for the proposed spillway

Procedure: Follow design steps presented in *Discharge Characterisitics of Broad-Crested Weirs*

References: USBR (1987). Design of Small Dams
USGS (1957). Geological Survey Circular 397 Discharge Characteristics of Broad-Crested Weirs, J.H. Tracy
USGS (1968). Measurement of Peak Discharge at Dams by Indirect Method, Harry Hulsing

Input Variables:

Weir Crest El.	734.8	ft	L, Width Along Dam Axis	16.00	ft
Average Gate Weir Crest Width, b	19.5	ft	Number of Piers, N	1.0	-
Upstream Slope	1H:1V	Hor:Ver	Pier Contraction Coeff., Kp	0.01	-
Upstream Slope factor, Kr	Varies	-	Abutment Shape	45 Degree	-
Downstream Slope	1H:1V	Hor:Ver	Contraction Coeff., Ka	0.1	-
Downstream Slope Factor	Varies	-			
Number of Gates	2				

Step 1: Develop Spillway Discharge Rating Curve

Eq. (1-1) $Q=CbH^{3/2}$ USBR (1987) - Equation 3 pg. 365 (Discharge over uncontrolled crest)

where:

Q = Flow Rate (cfs)

C = Discharge Coefficient (USGS 1957), Figure 11 -- Discharge Coefficieints for broad-crested weirs with upstream face slope of 1:1

b = L' - 2(NKp + Ka)H (width of weir normal to flow)

H= Total Energy Head

Reservoir El. (ft)	Head, H (ft)	H/L	Weir Coeff.,C	D/S Slope Adjust[1].	Adjusted Weir Coeff.,C[2]	Effective Length (1 Gate) (ft), L'	Crest Gate Discharge (1 Gate) (cfs)	Crest Gate Discharge (Total) (cfs)	Comments
734.8	0.0	0.0	2.88	1.00	2.88	19.5	0	0	Spillway Invert
735.0	0.2	0.0	2.88	1.00	2.88	19.5	5	10	
735.5	0.7	0.0	2.87	1.00	2.87	19.5	33	65	
736.0	1.2	0.1	2.86	1.00	2.86	19.4	73	146	
736.5	1.7	0.1	2.86	1.00	2.86	19.3	122	245	
737.0	2.2	0.1	2.85	1.00	2.85	19.3	180	359	
737.5	2.7	0.2	2.85	1.00	2.85	19.2	243	487	
738.0	3.2	0.2	2.86	1.00	2.86	19.2	313	627	
738.5	3.7	0.2	2.86	1.00	2.86	19.1	389	778	
739.0	4.2	0.3	2.87	1.00	2.87	19.0	470	939	
739.5	4.7	0.3	2.87	1.00	2.87	19.0	556	1,111	
740.0	5.2	0.3	2.88	1.00	2.88	18.9	647	1,293	
740.5	5.7	0.4	2.89	1.00	2.89	18.9	742	1,485	
741.0	6.2	0.4	2.91	1.00	2.91	18.8	843	1,686	
741.5	6.7	0.4	2.92	1.00	2.92	18.7	948	1,897	
742.0	7.2	0.5	2.93	1.00	2.93	18.7	1,058	2,116	
742.5	7.7	0.5	2.95	1.00	2.95	18.6	1,173	2,345	
743.0	8.2	0.5	2.96	1.00	2.96	18.6	1,292	2,583	
743.5	8.7	0.5	2.98	1.00	2.98	18.5	1,415	2,830	
744.0	9.2	0.6	3.00	1.00	3.00	18.4	1,543	3,087	
744.5	9.7	0.6	3.02	1.00	3.02	18.4	1,676	3,351	
745.0	10.2	0.6	3.04	1.00	3.04	18.3	1,813	3,625	
745.5	10.7	0.7	3.06	1.00	3.06	18.3	1,954	3,908	
746.0	11.2	0.7	3.08	1.00	3.08	18.2	2,099	4,199	
746.5	11.7	0.7	3.10	1.00	3.10	18.1	2,249	4,498	
747.0	12.2	0.8	3.12	1.00	3.12	18.1	2,403	4,806	
747.5	12.7	0.8	3.14	1.00	3.14	18.0	2,561	5,123	
748.0	13.2	0.8	3.16	1.00	3.16	18.0	2,724	5,447	
748.5	13.7	0.9	3.18	1.00	3.18	17.9	2,890	5,779	
749.0	14.2	0.9	3.21	1.00	3.21	17.8	3,060	6,120	
749.5	14.7	0.9	3.23	1.00	3.23	17.8	3,234	6,467	
750.0	15.2	1.0	3.25	1.00	3.25	17.7	3,411	6,823	
750.5	15.7	1.0	3.27	1.00	3.27	17.7	3,592	7,185	
751.0	16.2	1.0	3.29	1.00	3.29	17.6	3,777	7,554	Normal Pool
751.5	16.7	1.0	3.31	1.00	3.31	17.5	3,965	7,930	
752.0	17.2	1.1	3.33	1.00	3.33	17.5	4,156	8,312	
752.5	17.7	1.1	3.35	1.00	3.35	17.4	4,350	8,700	
753.0	18.2	1.1	3.37	1.00	3.37	17.4	4,547	9,095	
753.5	18.7	1.2	3.39	1.00	3.39	17.3	4,747	9,494	
754.0	19.2	1.2	3.41	1.00	3.41	17.2	4,950	9,899	
754.5	19.7	1.2	3.43	1.00	3.43	17.2	5,154	10,309	
755.0	20.2	1.3	3.45	1.00	3.45	17.1	5,362	10,723	Tea Creek
755.5	20.7	1.3	3.47	1.00	3.47	17.1	5,571	11,142	
756.0	21.2	1.3	3.49	1.00	3.49	17.0	5,782	11,564	
756.5	21.7	1.4	3.50	1.00	3.50	16.9	5,995	11,990	
757.0	22.2	1.4	3.52	1.00	3.52	16.9	6,210	12,420	
757.5	22.7	1.4	3.53	1.00	3.53	16.8	6,426	12,852	
758.0	23.2	1.5	3.55	1.00	3.55	16.8	6,643	13,286	Zero Freeboard

GEI Consultants

CLIENT:	Four Lakes Task Force		
PROJECT:	Secord Dam	Project: 2002879	Pages:
SUBJECT:	1/2 PMF + Spillway Design (Auxiliary Flashboards)	Date: 11/12/2020	By: P. Drew
		Checked:	By:
		Approved:	By:

Purpose: Develop a spillway discharge rating curve for the proposed spillway

Procedure: Follow design steps presented in *Discharge Characterisitics of Broad-Crested Weirs*

References: USBR (1987). Design of Small Dams
USGS (1957). Geological Survey Circular 397 Discharge Characteristics of Broad-Crested Weirs, J.H. Tracy
USGS (1968). Measurement of Peak Discharge at Dams by Indirect Method, Harry Hulsing

Input Variables:

Weir Crest El.	748.5	ft	L, Width Along Dam Axis	6.00	ft
Weir Crest Width, b	130.0	ft	Number of Piers, N	1.0	-
Upstream Slope	2H:1V	Hor:Ver	Pier Contraction Coeff., Kp	0.0	-
Upstream Slope factor, Kr	Varies	-	Abutment Shape	45 Degree	-
Downstream Slope	2H:1V	Hor:Ver	Contraction Coeff., Ka	0.1	-
Downstream Slope Factor	Varies	-			

Step 1: Develop Spillway Discharge Rating Curve

Eq. (1-1) $Q=CbH^{3/2}$ USBR (1987) - Equation 3 pg. 365 (Discharge over uncontrolled crest)

where:

Q = Flow Rate (cfs)

C = Discharge Coefficient (USGS 1957), Figure 11 -- Discharge Coefficieints for broad-crested weirs with upstream face slope of 2:1

b = L' - 2(NKp + Ka)H (width of weir normal to flow)

H= Total Energy Head

Reservoir El. (ft)	Head, H (ft)	H/L	Weir Coeff.,C	D/S Slope Adjust[1].	Adjusted Weir Coeff.,C[2]	Effective Length (Gate 1) (ft), L'	Discharge (cfs)	Comments
748.5	0.0	0.0	2.89	1.00	2.89	130.0	0	Spillway Invert
749.0	0.5	0.1	2.89	1.00	2.89	129.9	0	
749.5	1.0	0.2	2.90	1.00	2.90	129.8	0	
750.0	1.5	0.3	2.92	1.00	2.92	129.7	0	
750.5	2.0	0.3	2.95	1.00	2.95	129.6	0	
751.0	2.5	0.4	2.99	1.00	2.99	129.5	0	Normal Pool
751.5	3.0	0.5	3.04	0.98	2.97	129.4	0	
752.0	3.5	0.6	3.08	0.98	3.02	129.3	0	
752.5	4.0	0.7	3.13	0.98	3.07	129.2	0	
753.0	4.5	0.8	3.19	0.98	3.12	129.1	0	
753.5	5.0	0.8	3.24	0.98	3.18	129.0	4,580	
754.0	5.5	0.9	3.29	0.98	3.23	128.9	5,366	
754.5	6.0	1.0	3.34	0.96	3.21	128.8	6,079	
755.0	6.5	1.1	3.39	0.96	3.26	128.7	6,950	Tea Creek
755.5	7.0	1.2	3.44	0.96	3.30	128.6	7,869	
756.0	7.5	1.3	3.48	0.96	3.35	128.5	8,830	
756.5	8.0	1.3	3.52	0.96	3.38	128.4	9,831	
757.0	8.5	1.4	3.56	0.96	3.42	128.3	10,868	
757.5	9.0	1.5	3.59	0.96	3.45	128.2	11,936	
758.0	9.5	1.6	3.62	0.96	3.47	128.1	13,032	Zero Freeboard

CLIENT:	Four Lakes Task Force		
PROJECT:	Secord Dam	Project: 2002879	Pages:
SUBJECT:	1/2 PMF + Spillway Design (Total)	Date: 11/12/2020	By: P. Drew
		Checked:	By:
		Approved:	By:

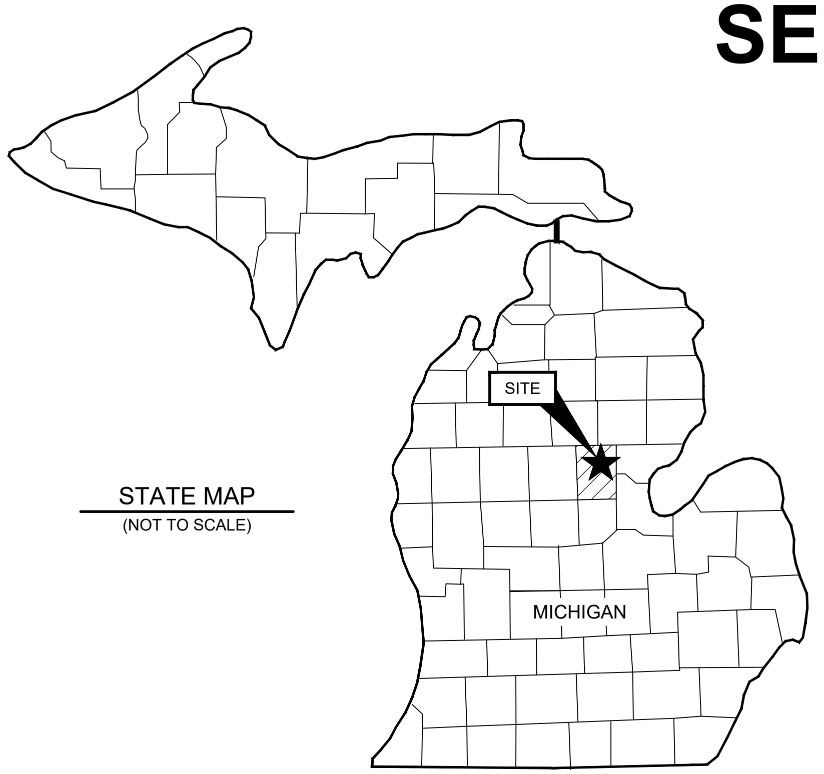
Reservoir El. (ft)	Gated Spillway (cfs)	Auxiliary Spillway (cfs)	Tea Creek (cfs)	Total Spillway Capacity (cfs)	Comments
734.8	0	0	0	0	Primary Gated Spillway
735.0	10	0	0	10	
735.5	65	0	0	65	
736.0	146	0	0	146	
736.5	245	0	0	245	
737.0	359	0	0	359	
737.5	487	0	0	487	
738.0	627	0	0	627	
738.5	778	0	0	778	
739.0	939	0	0	939	
739.5	1,111	0	0	1,111	
740.0	1,293	0	0	1,293	
740.5	1,485	0	0	1,485	
741.0	1,686	0	0	1,686	
741.5	1,897	0	0	1,897	
742.0	2,116	0	0	2,116	
742.5	2,345	0	0	2,345	
743.0	2,583	0	0	2,583	
743.5	2,830	0	0	2,830	
744.0	3,087	0	0	3,087	
744.5	3,351	0	0	3,351	
745.0	3,625	0	0	3,625	
745.5	3,908	0	0	3,908	
746.0	4,199	0	0	4,199	
746.5	4,498	0	0	4,498	
747.0	4,806	0	0	4,806	
747.5	5,123	0	0	5,123	
748.0	5,447	0	0	5,447	
748.5	5,779	0	0	5,779	Auxiliary Spillway
749.0	6,120	0	0	6,120	
749.5	6,467	0	0	6,467	
750.0	6,823	0	0	6,823	
750.5	7,185	0	0	7,185	
751.0	7,554	0	0	7,554	Normal Pool
751.5	7,930	0	0	7,930	
752.0	8,312	0	0	8,312	
752.5	8,700	0	0	8,700	
753.0	9,095	0	0	9,095	
753.5	9,494	4,580	0	14,074	
754.0	9,899	5,366	0	15,265	
754.5	10,309	6,079	0	16,387	
755.0	10,723	6,950	0	17,674	
755.5	11,142	7,869	5	19,015	Tea Creek
756.0	11,564	8,830	50	20,444	
756.5	11,990	9,831	360	22,182	
757.0	12,420	10,868	1,030	24,317	
757.5	12,852	11,936	2,280	27,068	
758.0	13,286	13,032	4,445	30,763	Zero-Freeboard

Appendix C

Secord Dam Conceptual Design Drawings

SECORD DAM CONCEPTUAL DESIGN

GLADWIN COUNTY, MICHIGAN
FOUR LAKES TASK FORCE
FERC PROJECT NO. 10809

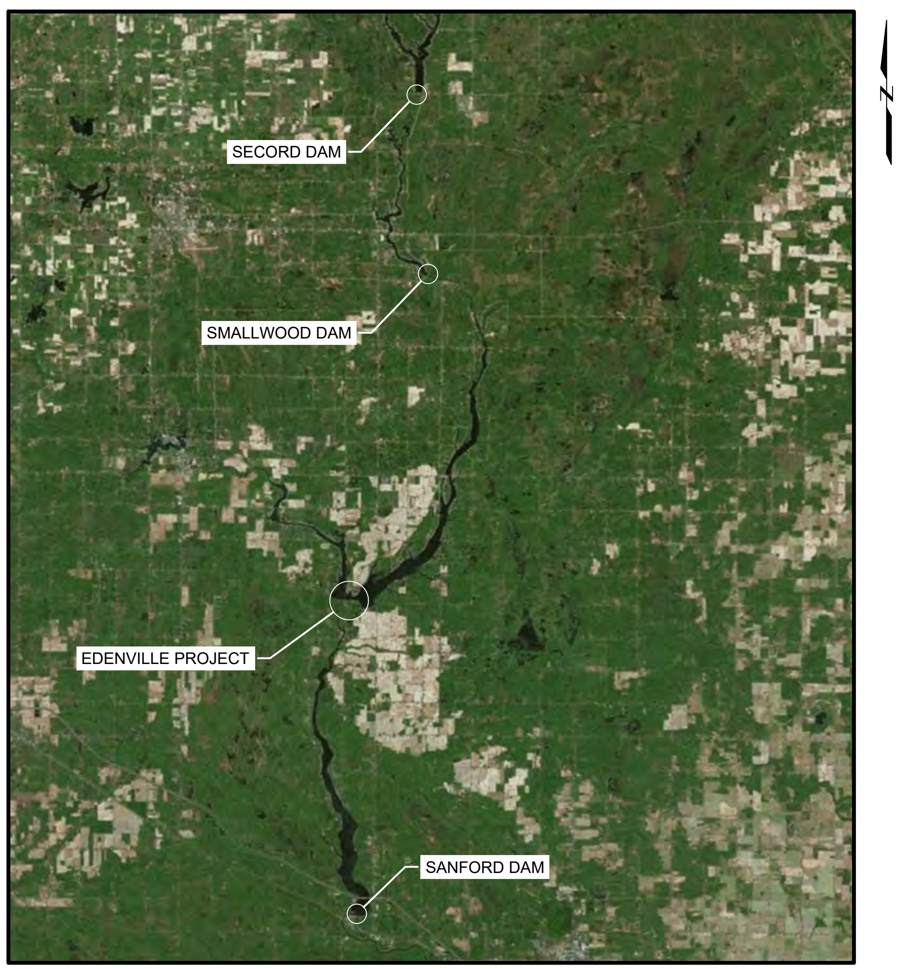


STATE MAP
(NOT TO SCALE)

SITE AERIAL
(NOT TO SCALE)

SHEET INDEX

SHEET NO.	DRAWING NO.	TITLE
1	G-01	COVER SHEET AND SITE LOCATION
2	G-02	GENERAL NOTES AND LEGEND
3	C-01	SITE PLAN - EXISTING CONDITIONS
4	C-02	OUTLET WORKS - EXISTING CONDITIONS PLAN
5	C-03	OUTLET WORKS - TEMPORARY COFFERDAMS PLAN
6	C-04	OUTLET WORKS - DEMOLITION PLAN
7	C-05	OUTLET WORKS - DEMOLITION SECTION
8	C-06	OUTLET WORKS - MODIFICATIONS PLAN VIEW
9	C-07	POWERHOUSE - MODIFICATIONS SECTION
10	C-08	PRIMARY SPILLWAY - MODIFICATIONS SECTION
11	C-09	PRIMARY SPILLWAY - CREST GATE DETAILS
12	C-10	RIGHT EMBANKMENT - EXISTING SITE PLAN AND ELEVATION PROFILE
13	C-11	RIGHT EMBANKMENT - MODIFICATIONS PLAN
14	C-12	LEFT EMBANKMENT - EXISTING SITE PLAN AND ELEVATION PROFILE
15	C-13	LEFT EMBANKMENT - MODIFICATIONS PLAN
16	C-14	RIGHT EMBANKMENT - MODIFIED SECTIONS
17	C-15	LEFT EMBANKMENT - MODIFIED SECTIONS
18	C-16	RIGHT AND LEFT EMBANKMENTS - MODIFICATION DETAILS
19	C-17	AUXILIARY SPILLWAY - PROPOSED PLAN VIEW
20	C-18	AUXILIARY SPILLWAY - PROPOSED SPILLWAY CROSS SECTION
21	C-19	AUXILIARY SPILLWAY TERMINAL STRUCTURE - PROPOSED PLAN AND SECTION



SOURCE:
AERIAL IMAGE TAKEN FROM GOOGLE EARTH

SITE LOCATION
(NOT TO SCALE)

PREPARED FOR:

FOUR LAKES TASK FORCE
233 E. LARKIN
MIDLAND, MI 48640

PREPARED BY:

GEI CONSULTANTS OF MICHIGAN, P.C.
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FAX. (989) 754-4440

GEI PROJECT NO. 2002879

NO.	DATE	ISSUE/REVISION	APP
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DWG. NO. G-01

SHEET NO. 1

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1. GENERAL

SPACIAL DATUM INFORMATION

- VERTICAL: NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29).
- HORIZONTAL: NORTH AMERICAN DATUM OF 1983 (NAD83), MICHIGAN STATE PLANE, CENTRAL ZONE.
- A CONVERSION OF +5.8' IS REQUIRED WHEN CONVERTING VERTICAL DAM DATUM TO NGVD29 (E.G., HEADWATER ELEVATION AT DAM DATUM IS 745.0' AND AT NGVD29 DATUM IS 750.8').
- A CONVERSION OF -0.512' IS REQUIRED WHEN CONVERTING VERTICAL NGVD29 DATUM TO NAVD88 DATUM.
- CONTROL MONUMENTS ON-SITE SHALL BE REFERRED TO CONFIRM HORIZONTAL AND VERTICAL MEASUREMENTS.

BASEMAP DATA

- SITE TOPOGRAPHY AND AERIAL IMAGE OBTAINED DRONE FLIGHT PERFORMED BY SPICER GROUP IN 2020.
- COVER SHEET AERIAL IMAGES OBTAINED FROM GOOGLE EARTH REPRESENT CONDITIONS IN JUNE, 2018.
- OBTAINED FROM BOYCE HYDRO:
  - ORIGINAL CONSTRUCTION DRAWINGS
  - EXHIBIT F LICENSE DRAWINGS

DESIGN PARAMETERS

- NORMAL RESERVOIR ELEVATION 750.8' (+0.3' / -0.4')
- WINTER RESERVOIR OPERATIONS: MINIMUM 747.8' (+0.7')
- ORDINARY HIGH WATER MARK ELEVATION 704.3 (±0.5')

DESIGN REFERENCE STANDARDS

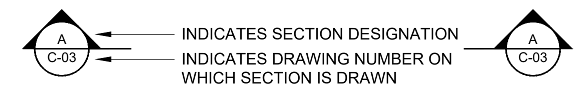
- (USBR, 1987) UNITED STATES DEPARTMENT OF THE INTERIORER, BUREAU OF RECLAMATION, "DESIGN OF SMALL DAMS", 1987.
- (USACE, 1995) UNITED STATES ARMY CORPS OF ENGINEERS, ENGINEERING AND DESIGN, "CONSTRUCTION CONTROL FOR EARTH AND ROCK-FILL DAMS", EM 1110-2-1911, 1995.
- (ACI, 2001) AMERICAN CONCRETE INSTITUTE, "CONTROL OF CRACKING IN CONCRETE STRUCTURES" (ACI 224), 2001.
- (USACE, 2004) UNITED STATES ARMY CORPS OF ENGINEERS, ENGINEERING AND DESIGN, "GENERAL DESIGN AND CONSTRUCTION CONSIDERATIONS FOR EARTH AND ROCK-FILL DAMS", EM 1110-2-2300, 2004.
- (ACI, 2006) AMERICAN CONCRETE INSTITUTE, "CODE REQUIREMENTS FOR ENVIRONMENTAL ENGINEERING CONCRETE STRUCTURES" (ACI 350), 2006.
- (ACI, 2011) AMERICAN CONCRETE INSTITUTE, "BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE" (ACI 318), 2011.
- (FERC, 2016) FEDERAL ENERGY REGULATORY COMMISSION, ENGINEERING GUIDELINES FOR EVALUATION OF HYDROPOWER PROJECTS (MOST RECENT VERSIONS)

ABBREVIATIONS

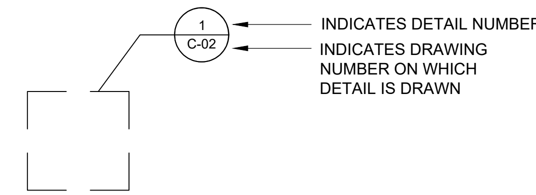
BO = BOTTOM OF
C = CENTER LINE
MM = MOVEMENT MONUMENT
CONC = CONCRETE
CONT = CONTINUOUS
CTRD = CENTERED
D/S = DOWNSTREAM
EO = EDGE OF
EX = EXISTING
EF = EACH FACE
EL = ELEVATION (FEET)
HW = HEADWATER
MAX = MAXIMUM
OC = ON CENTER
OCEW = ON CENTER EACH WAY
OHWM = ORDINARY HIGH WATER MARK
PL = PLATE
PMF = PROBABLE MAXIMUM FLOOD
SDF = SPILLWAY DESIGN FLOOD
SSP = STEEL SHEET PILE
STD = STANDARD
STIFF = STIFFENER
TBD = TO BE DETERMINED
TO = TOP OF
TW = TAILWATER
TYP = TYPICAL
UON = UNLESS OTHERWISE NOTED
U/S = UPSTREAM
VIF = VERIFY IN FIELD
WL = WETLAND
W/ = WITH

SECTION AND DETAIL LEGEND

SECTION



DETAIL



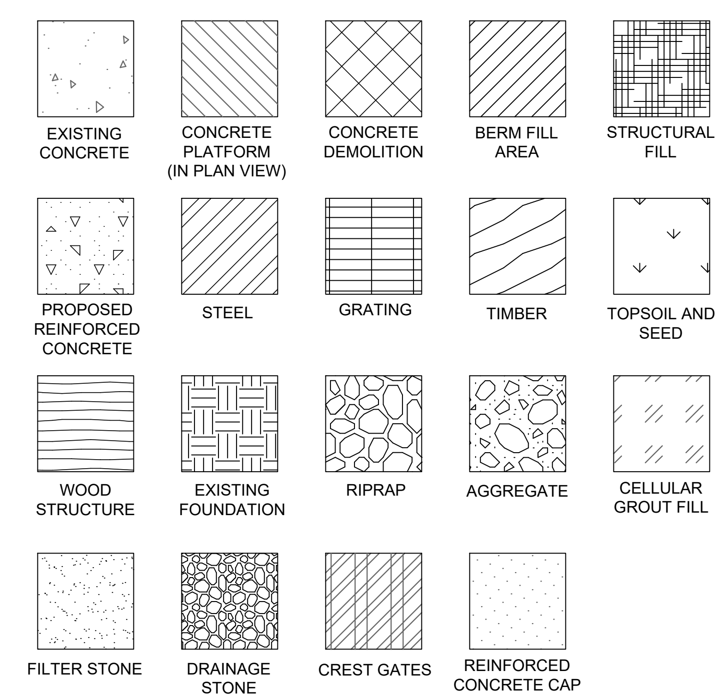
LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- O/E — OVERHEAD ELECTRIC LINES
- X — FENCE LINE (STEEL)
- FENCE LINE (WOOD)
- CATV — UNDERGROUND CABLE
- GAS — GAS LINE
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- SILT FENCE
- 750 — EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS
- 750 — DESIGN MAJOR CONTOURS
- DESIGN MINOR CONTOURS

SYMBOLS LEGEND

- WATER ELEVATION
- FLOW DIRECTION
- 1H:1V — CUT SLOPE
- 1H:1V — FILL SLOPE
- POWER POLE
- SB-1 — SOIL BORING
- MW #1 — MONITORING WELL
- BM #1 — SURVEY REFERENCE MONUMENT (CONTORL POINT / BENCHMARK)
- SURVEY MOVEMENT MONUMENT
- SB-3 — SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
- SB-1 — SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
- SB-5 — SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
- DRAIN TILES

HATCH LEGEND



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Checked:	P. DREW
Drawn:	A. SAMPSON
Approved By:	B. WALTON

Four Lakes Task Force
FERC Project No. 10809

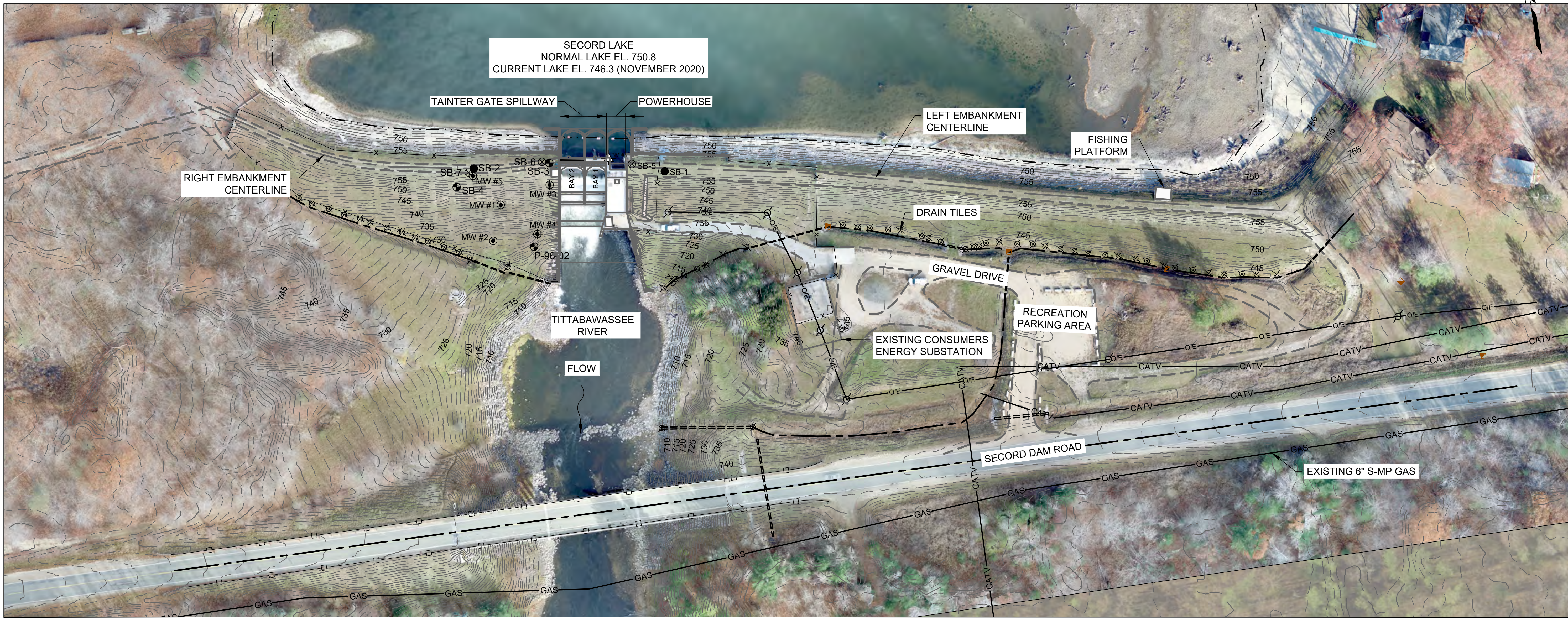
GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

GENERAL NOTES AND LEGEND

DWG. NO. G-02

SHEET NO. 2



EXISTING CONDITIONS SITE PLAN

0 50 100
SCALE, FT

LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- O/E — OVERHEAD ELECTRIC LINES
- X — FENCE LINE (STEEL)
- FENCE LINE (WOOD)
- CATV — UNDERGROUND CABLE
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- GAS — GAS LINE
- 750 — EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS

SYMBOLS LEGEND

- SB-3 — SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
- SB-1 — SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
- SB-5 — SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
- DRAIN TILES
- FLOW DIRECTION
- MW #1 — MONITORING WELL
- BM #1 — SURVEY REFERENCE MONUMENT

SURVEY CONTROL MONUMENT LOCATIONS

ID	ELEVATION	COMMENT
BM #1	758.45	EXISTING BENCHMARK CAP IN NORTHEAST CORNER OF SPILLWAY WALKWAY.

NOTES:
1. Vertical datum: National Geodetic Vertical Datum of 1929 (NGVD29)
2. Spatial datum: North American Datum of 1983 (NAD83), Michigan State Plane, Central Zone

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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SITE PLAN - EXISTING CONDITIONS

DWG. NO. C-01

SHEET NO. 3

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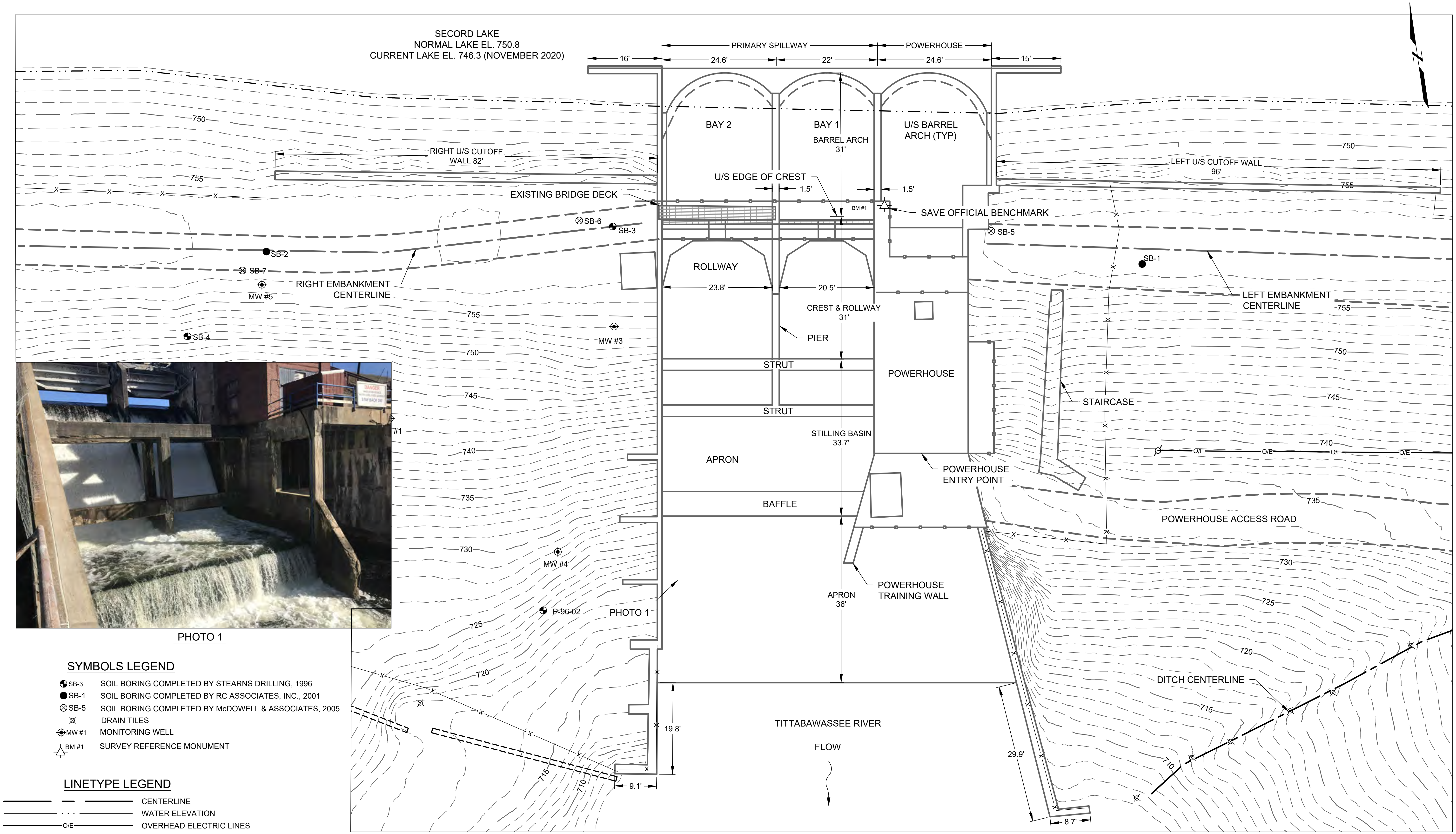

PHOTO 1

SYMBOLS LEGEND

- SB-3 — SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
- SB-1 — SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
- SB-5 — SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
- DRAIN TILES
- MW #1 — MONITORING WELL
- BM #1 — SURVEY REFERENCE MONUMENT

LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- O/E — OVERHEAD ELECTRIC LINES
- X — FENCE LINE (STEEL)
- EDGE OF ROADWAY (UNPAVED)
- BURIED PIPING
- 750 — EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS

OUTLET WORKS - EXISTING PLAN VIEW

0 10 20
SCALE, FT

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

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0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Approved By:	B. WALTON

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Secord Dam Conceptual Design
Gladwin County, Michigan

OUTLET WORKS - EXISTING CONDITIONS PLAN

DWG. NO. C-02

SHEET NO. 4

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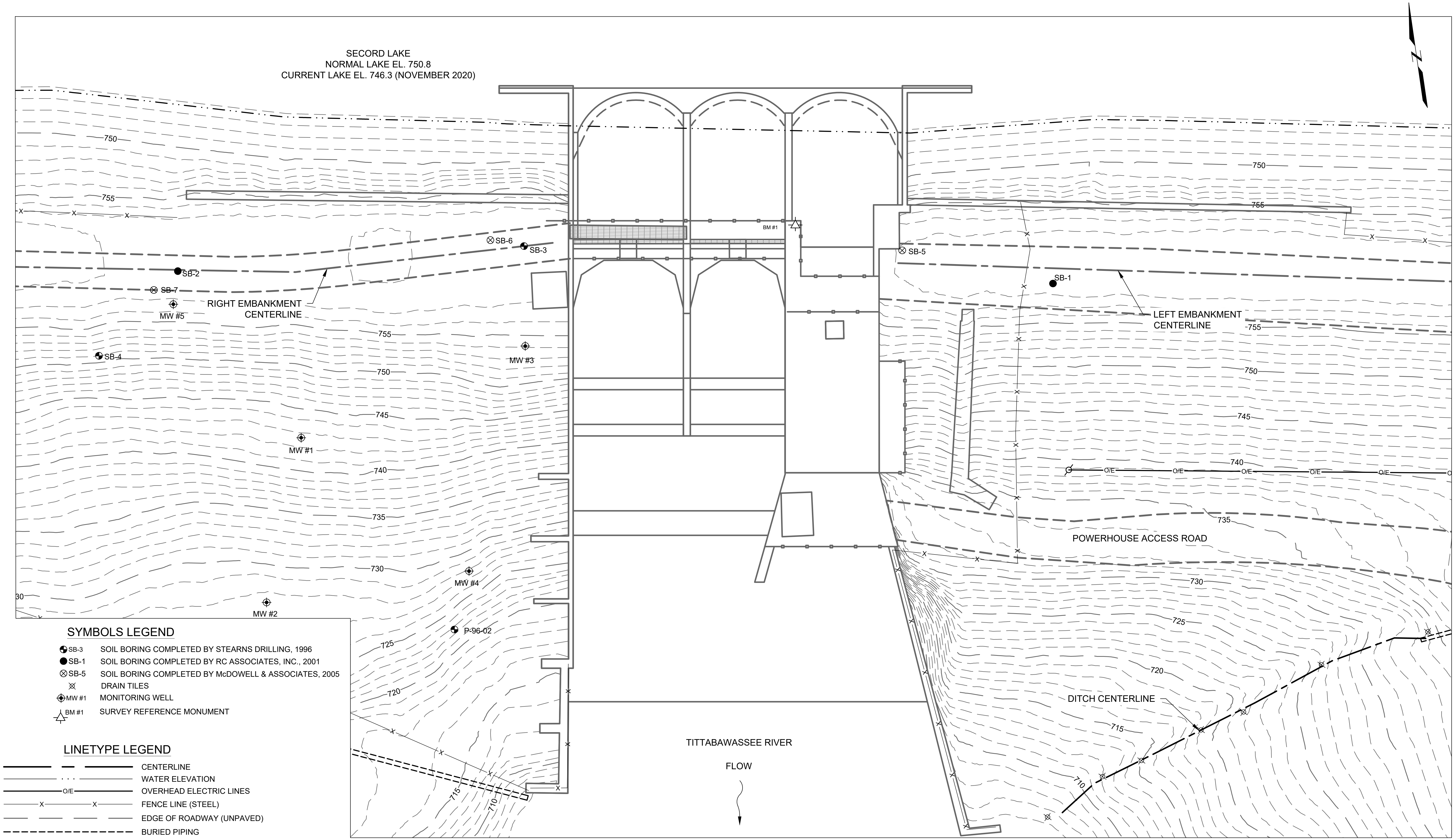

SYMBOLS LEGEND

SB-3	SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
SB-1	SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
SB-5	SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
	DRAIN TILES
MW #1	MONITORING WELL
BM #1	SURVEY REFERENCE MONUMENT

LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- O/E — OVERHEAD ELECTRIC LINES
- X — FENCE LINE (STEEL)
- EDGE OF ROADWAY (UNPAVED)
- BURIED PIPING
- 750 — EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS

OUTLET WORKS - PLAN VIEW

0 10 20
SCALE, FT

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Gladwin County, Michigan

OUTLET WORKS - TEMPORARY COFFERDAMS PLAN

DWG. NO. C-03

SHEET NO. 5

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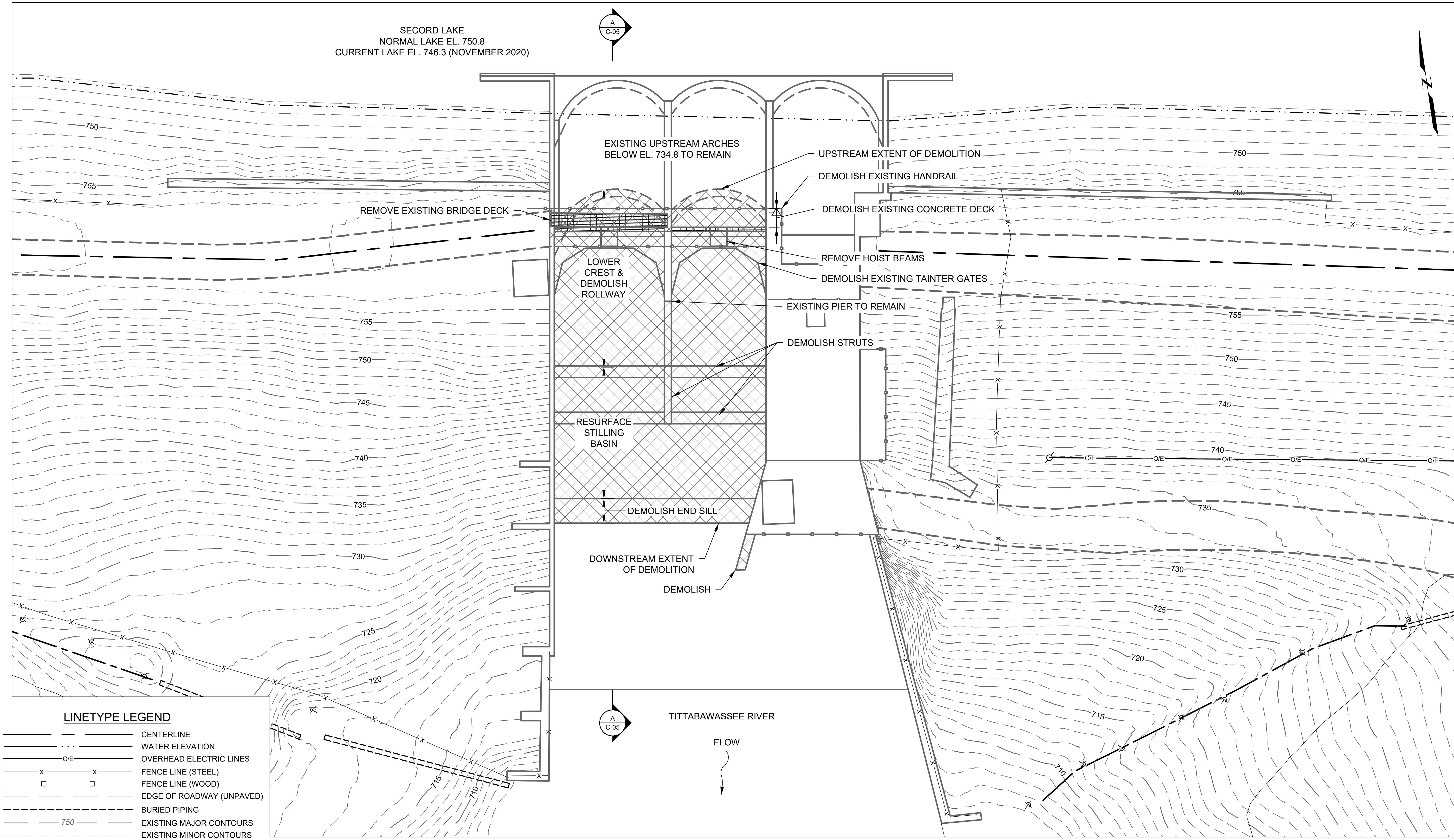

LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- OVERHEAD ELECTRIC LINES (O/E)
- FENCE LINE (STEEL)
- FENCE LINE (WOOD)
- EDGE OF ROADWAY (UNPAVED)
- BURIED PIPING
- EXISTING MAJOR CONTOURS (750)
- EXISTING MINOR CONTOURS

HATCH LEGEND

- GRATING
- CONCRETE DEMOLITION

SYMBOLS LEGEND

- DRAIN TILES
- FLOW DIRECTION

OUTLET WORKS - DEMOLITION PLAN VIEW

0 10 20
SCALE, FT

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

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Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

OUTLET WORKS - DEMOLITION PLAN

DWG. NO.
C-04

SHEET NO.
6

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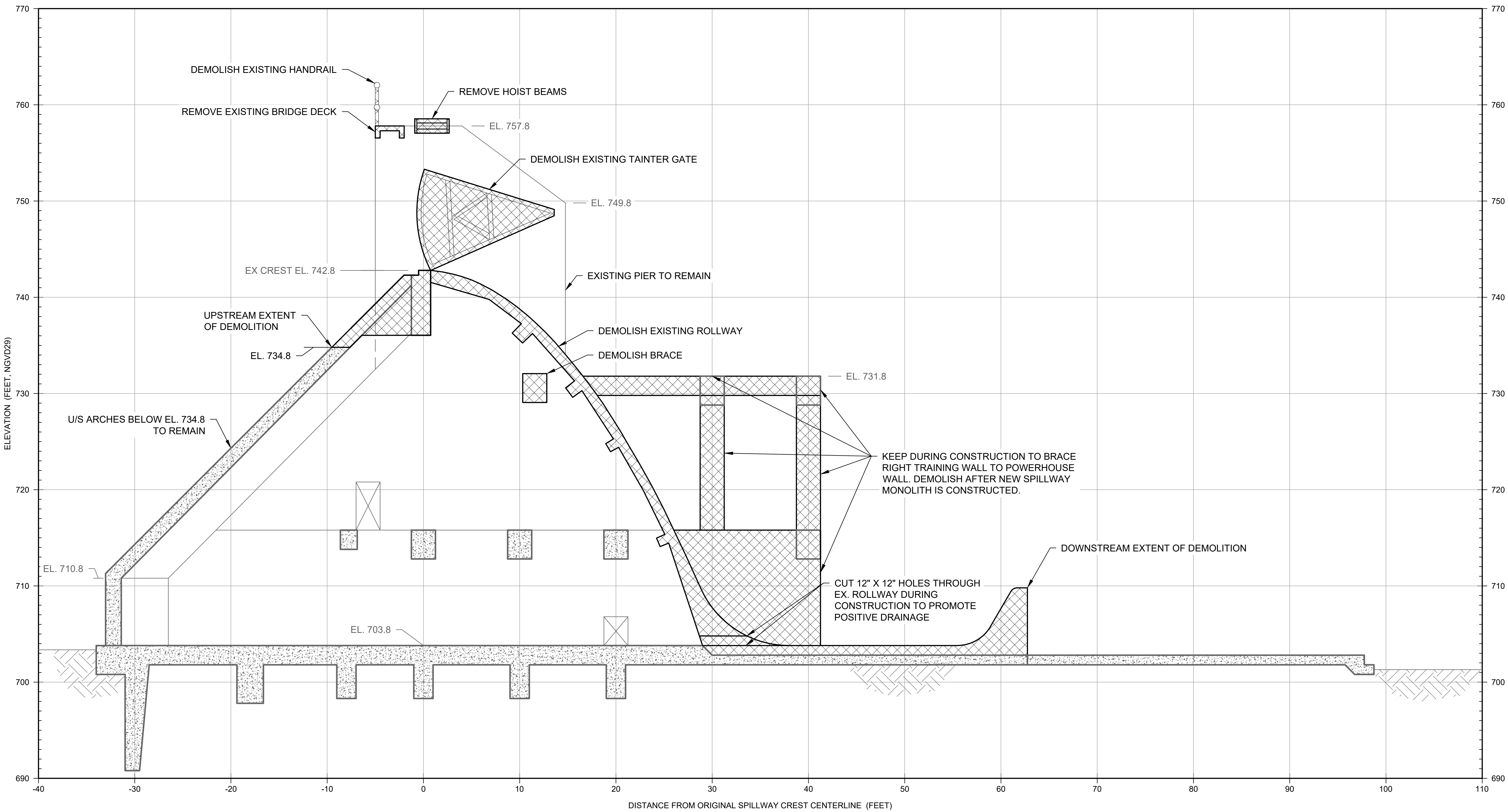

A SECTION
C-04 SPILLWAY DEMOLITION

0 5 10
SCALE, FT

HATCH LEGEND

CONCRETE DEMOLITION | EXISTING CONCRETE | EXISTING FOUNDATION

Attention:				
0 1" If this scale bar does not measure 1" then drawing is not original scale.	0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--
	NO.	DATE	ISSUE/REVISION	APP

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Approved By:	B. WALTON

Four Lakes Task Force
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Secord Dam Conceptual Design
Gladwin County, Michigan

OUTLET WORKS - DEMOLITION SECTION

DWG. NO. C-05

SHEET NO. 7

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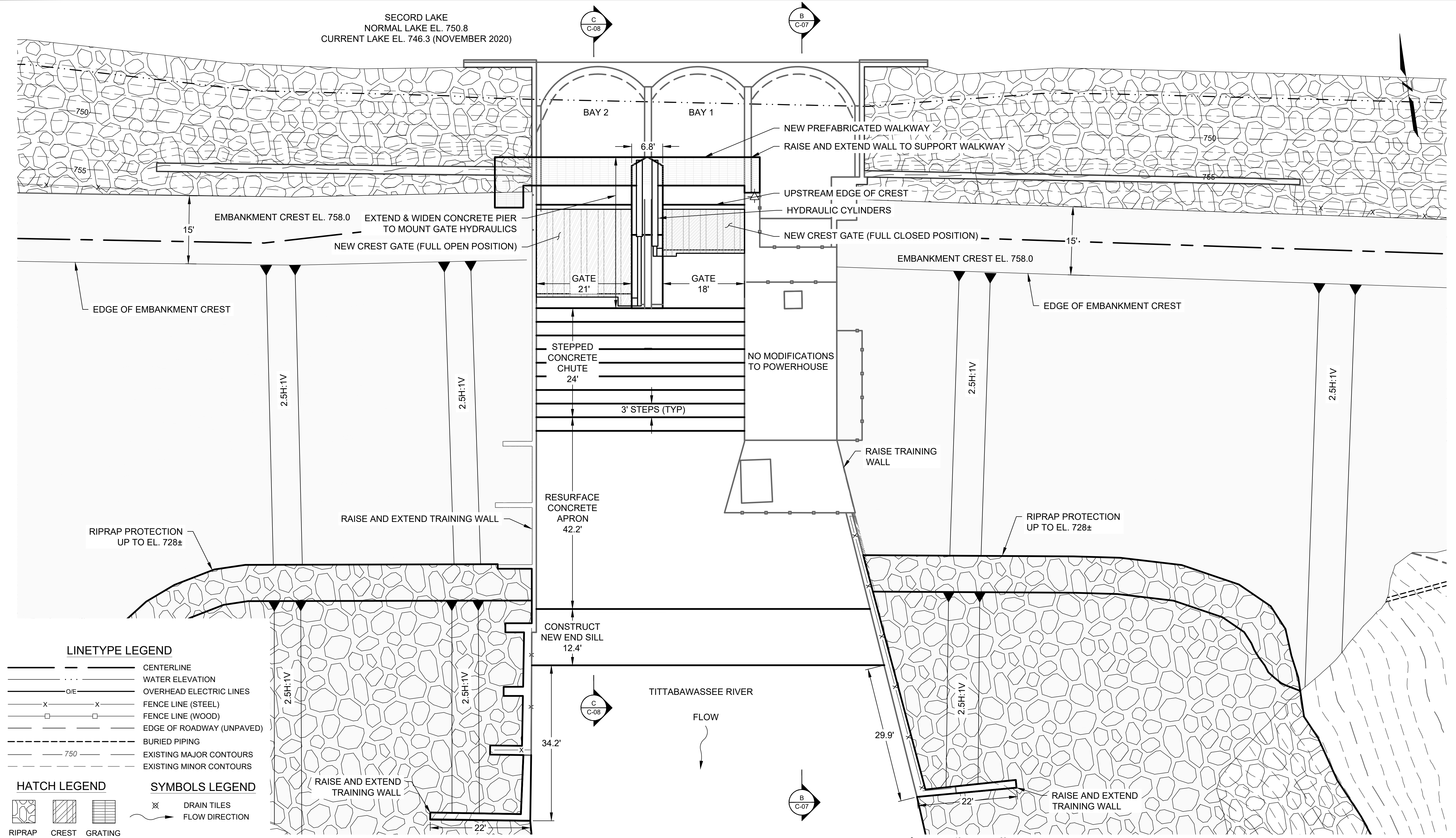

OUTLET WORKS - MODIFICATIONS PLAN VIEW

NO.	DATE	ISSUE/REVISION	APP
0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Drawn: A. SAMPSON
Approved By: B. WALTON

Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

OUTLET WORKS - MODIFICATIONS PLAN VIEW

DWG. NO. C-06
SHEET NO. 8

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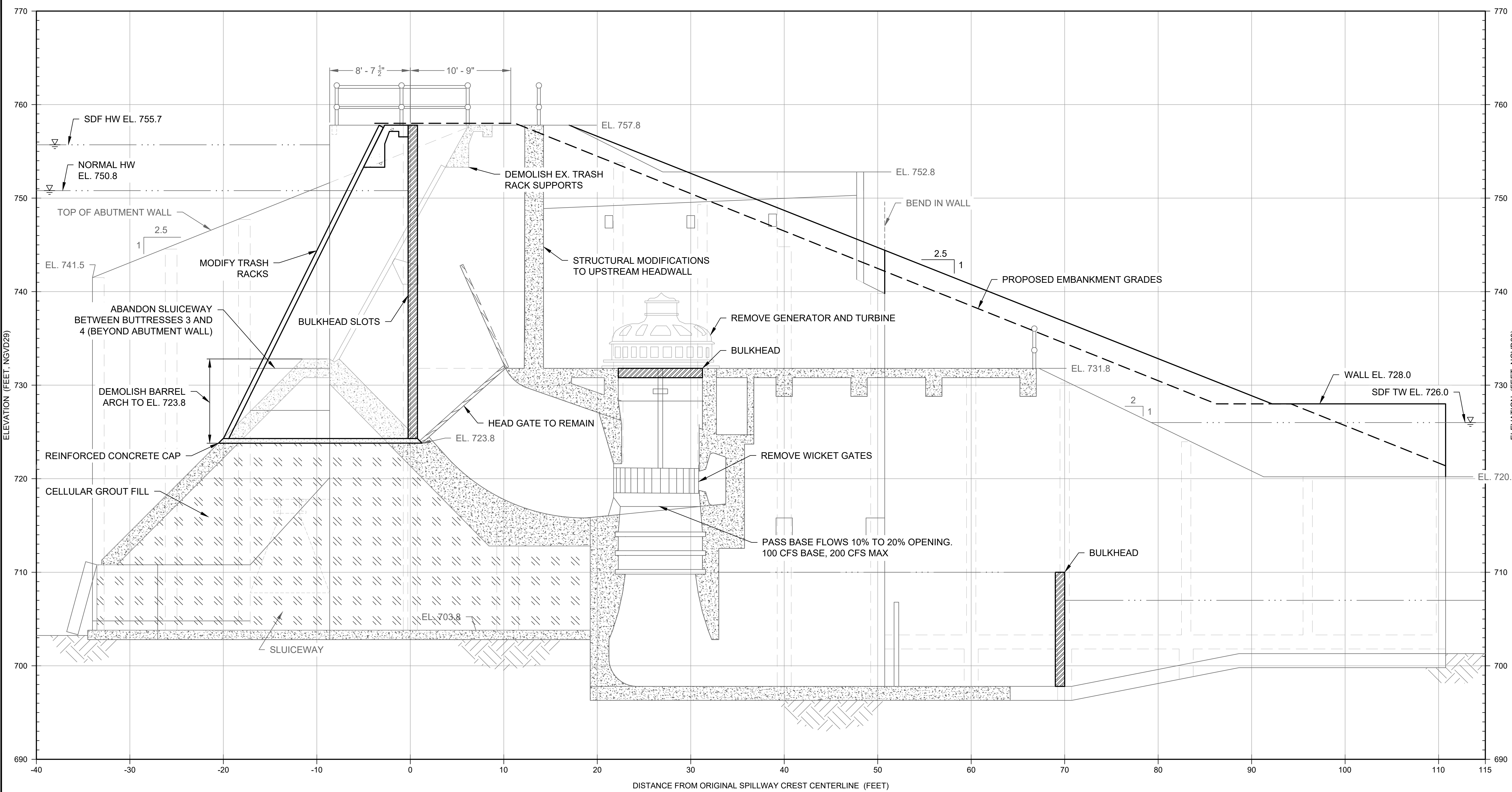

B SECTION
C-06 POWERHOUSE

0 5 10
SCALE, FT

HATCH LEGEND

EXISTING CONCRETE | EXISTING FOUNDATION | REINFORCED CONCRETE CAP | CELLULAR GROUT FILL | TIMBER

Attention: If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Drawn: A. SAMPSON
Approved By: B. WALTON

Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

POWERHOUSE - MODIFICATIONS SECTION

DWG. NO. C-07

SHEET NO. 9

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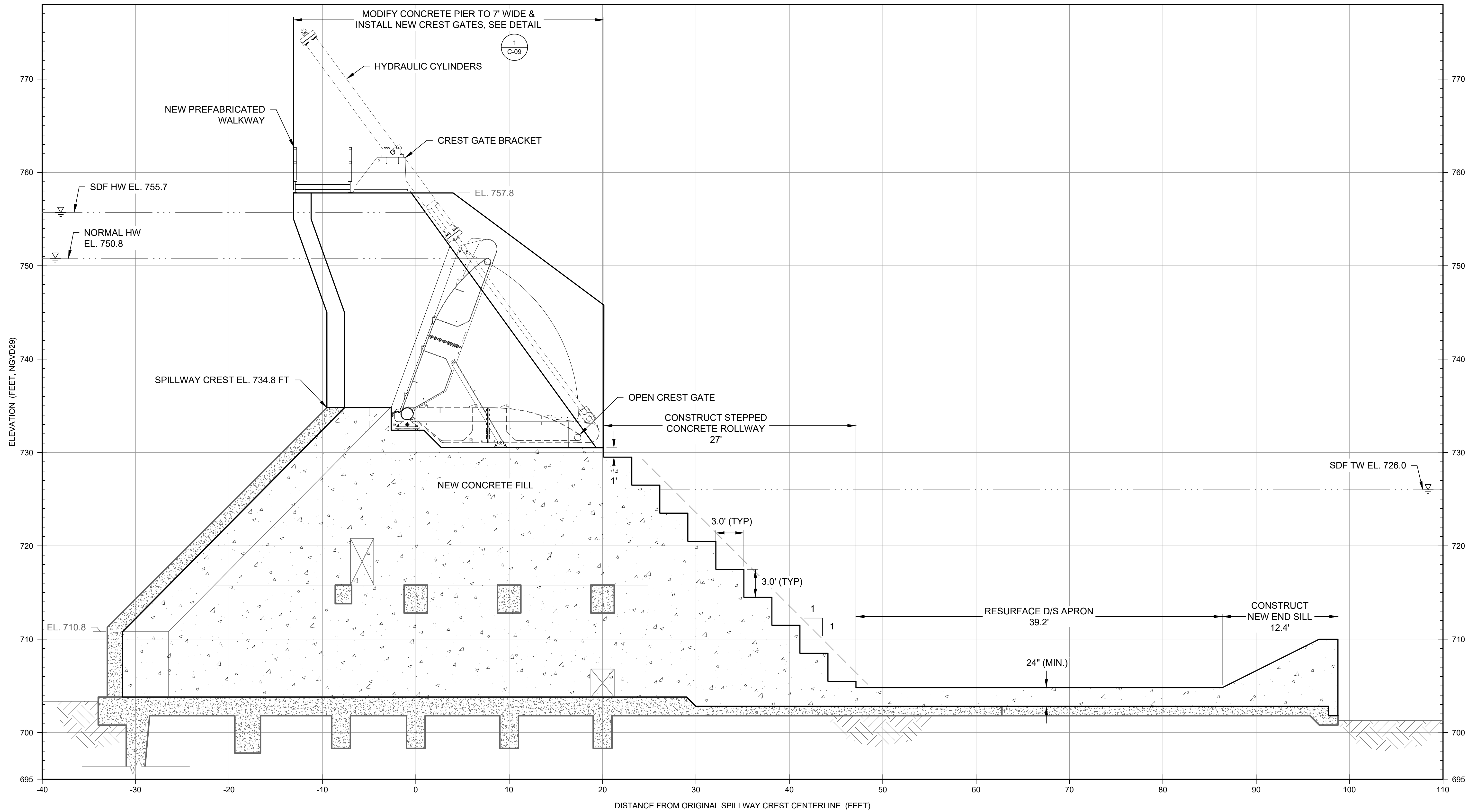

C SECTION
C-06 BAY 2 SPILLWAY

0 5 10
SCALE, FT

HATCH LEGEND

PROPOSED REINFORCED CONCRETE | EXISTING CONCRETE | EXISTING FOUNDATION

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

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Checked: P. DREW
Drawn: A. SAMPSON
Approved By: B. WALTON

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FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

PRIMARY SPILLWAY - MODIFICATIONS SECTION

DWG. NO. C-08

SHEET NO. 10

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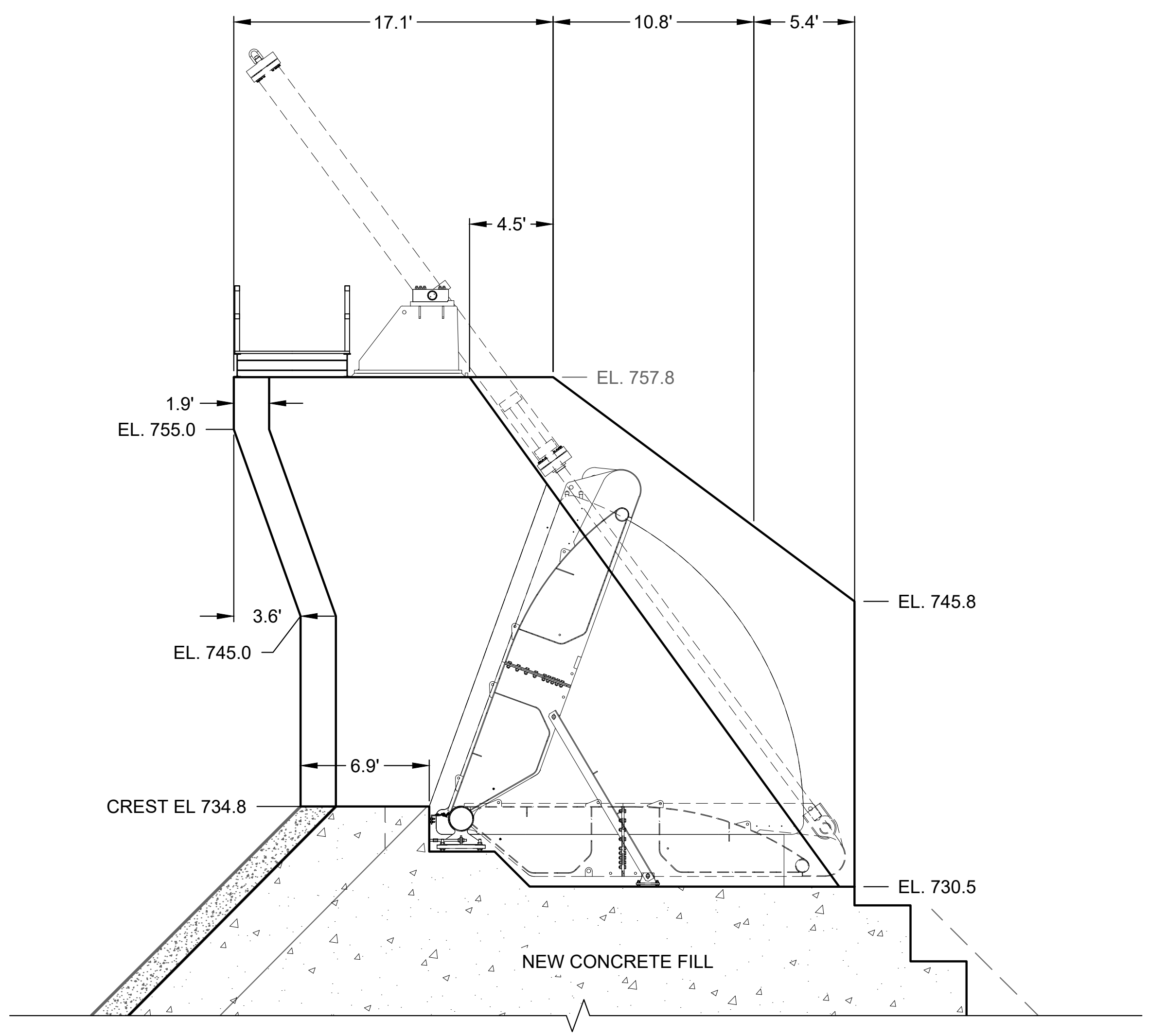
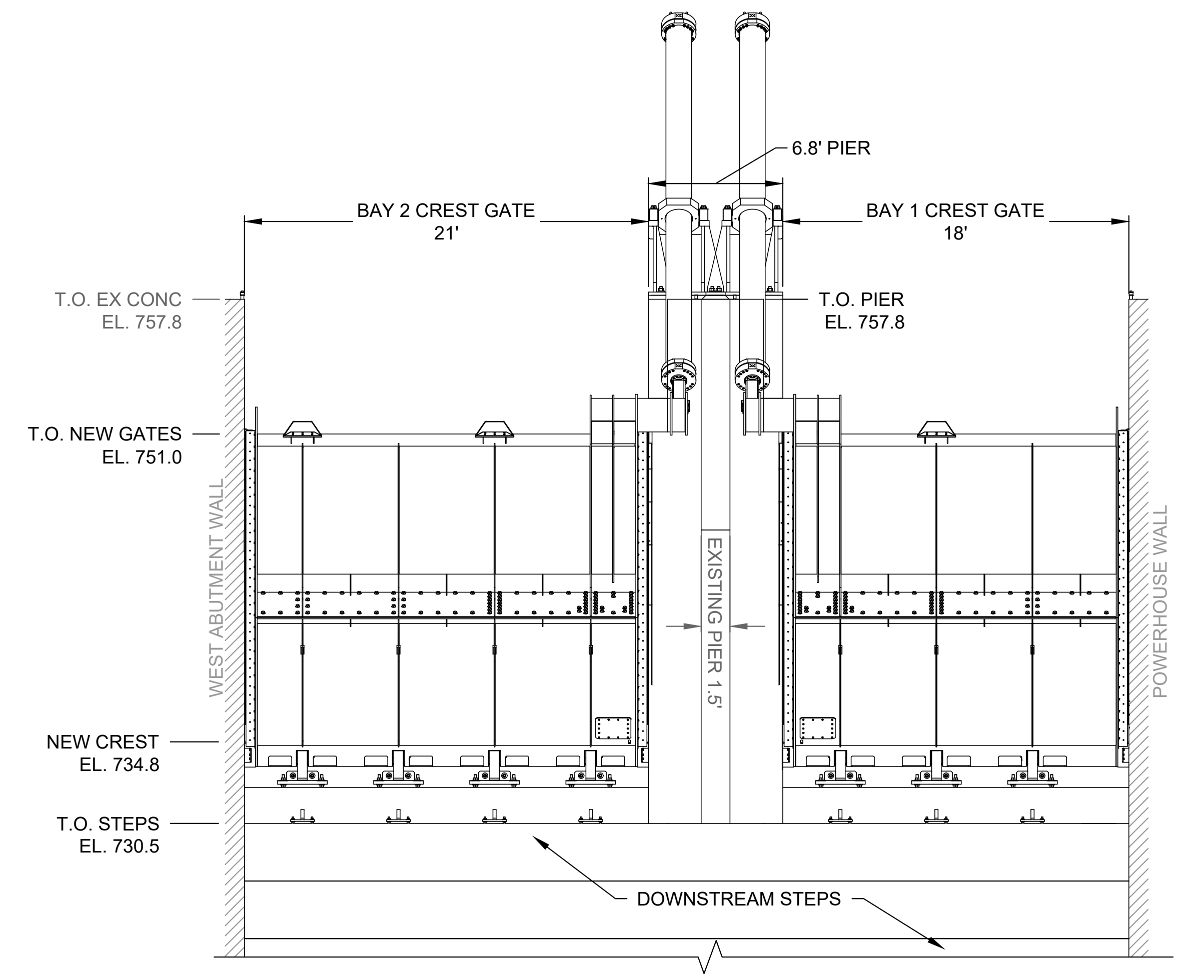


SECTION



DOWNSTREAM ELEVATION
(LOOKING UPSTREAM)

1 / C-08 DETAIL
PIER-MOUNTED CREST GATE

0 5 10
SCALE, FT

HATCH LEGEND

PROPOSED REINFORCED CONCRETE

EXISTING CONCRETE

Attention:
0 1"
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Gladwin County, Michigan

PRIMARY SPILLWAY - CREST GATE DETAILS

DWG. NO.
C-09

SHEET NO.
11

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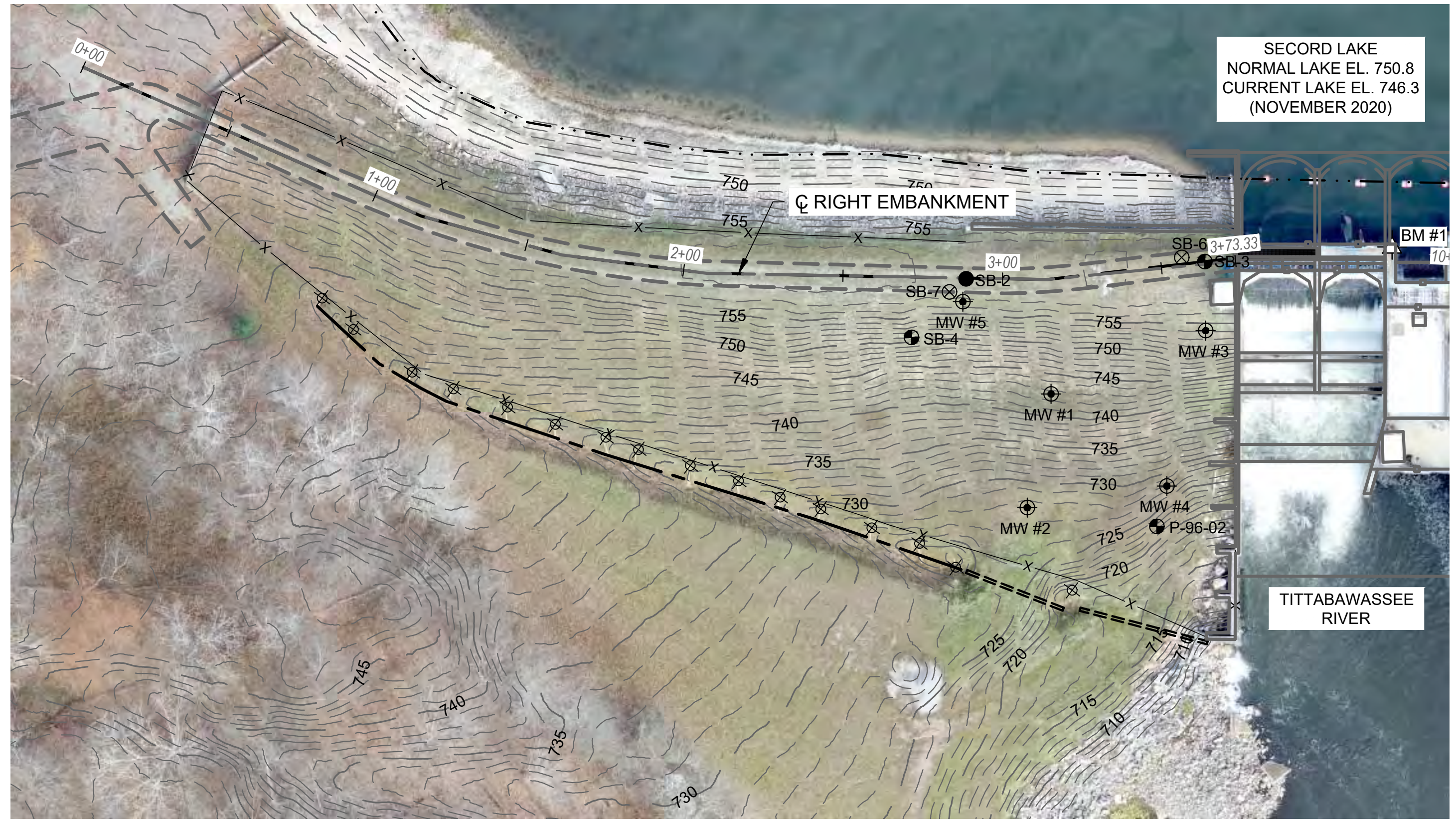
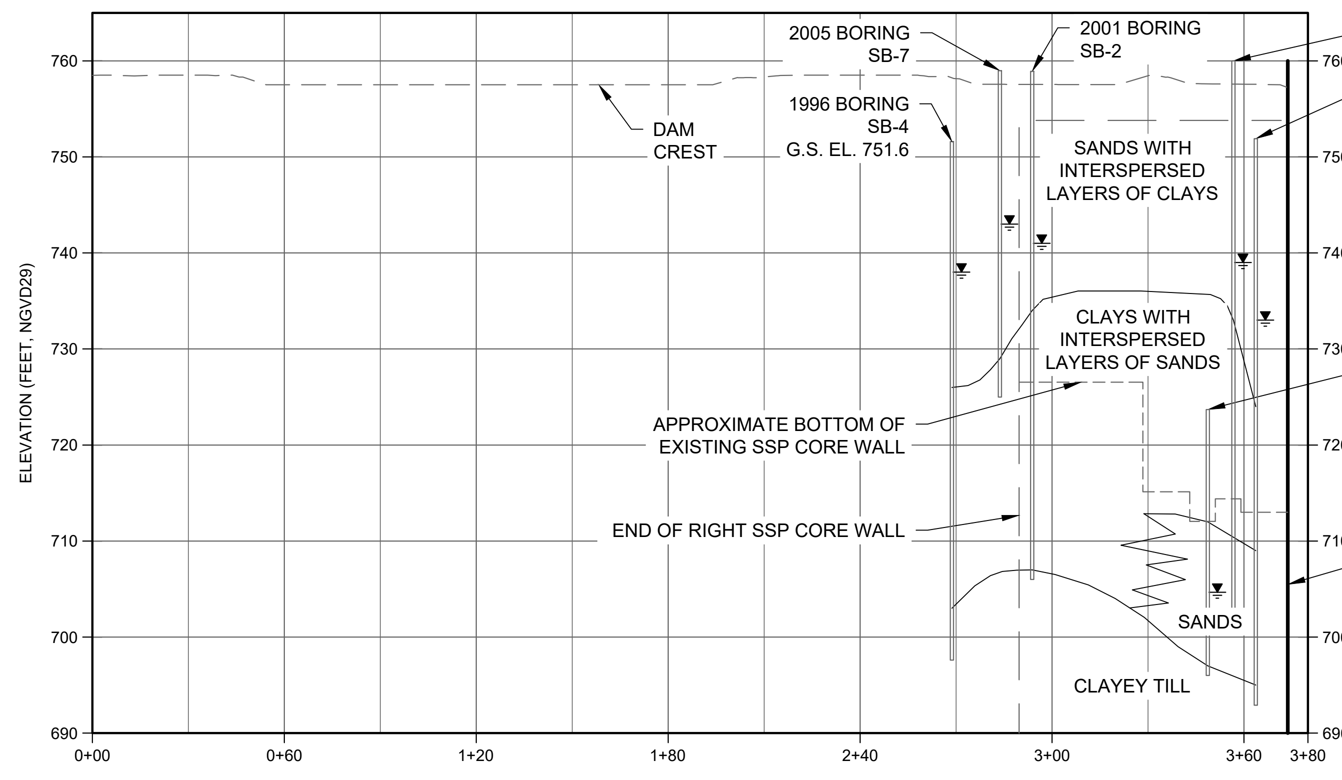


RIGHT EMBANKMENT EXISTING CONDITIONS PLAN

0 30' 60'
SCALE, FT



PROFILE

RIGHT EMBANKMENT

HORIZONTAL SCALE, FEET
0 30 60
0 10 20
VERTICAL SCALE, FEET
NOTE: 3x VERTICAL EXAGGERATION

LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- FENCE LINE (STEEL)
- FENCE LINE (WOOD)
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- EXISTING MAJOR CONTOURS (750)
- EXISTING MINOR CONTOURS
- EXISTING SURFACE ELEVATION
- SSP CORE WALL EXTENTS

SYMBOLS LEGEND

- SB-3 SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
- SB-1 SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
- SB-5 SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
- DRAIN TILES
- MW #1 MONITORING WELL
- BM #1 SURVEY REFERENCE MONUMENT

NOTES:

1. RIGHT EMBANKMENT SOIL PROFILE DEVELOPED FROM SECORD SUPPORTING TECHNICAL INFORMATION DOCUMENT, FEBRUARY 2006.

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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Gladwin County, Michigan

RIGHT EMBANKMENT - EXISTING SITE PLAN AND ELEVATION PROFILE

DWG. NO. C-10

SHEET NO. 12

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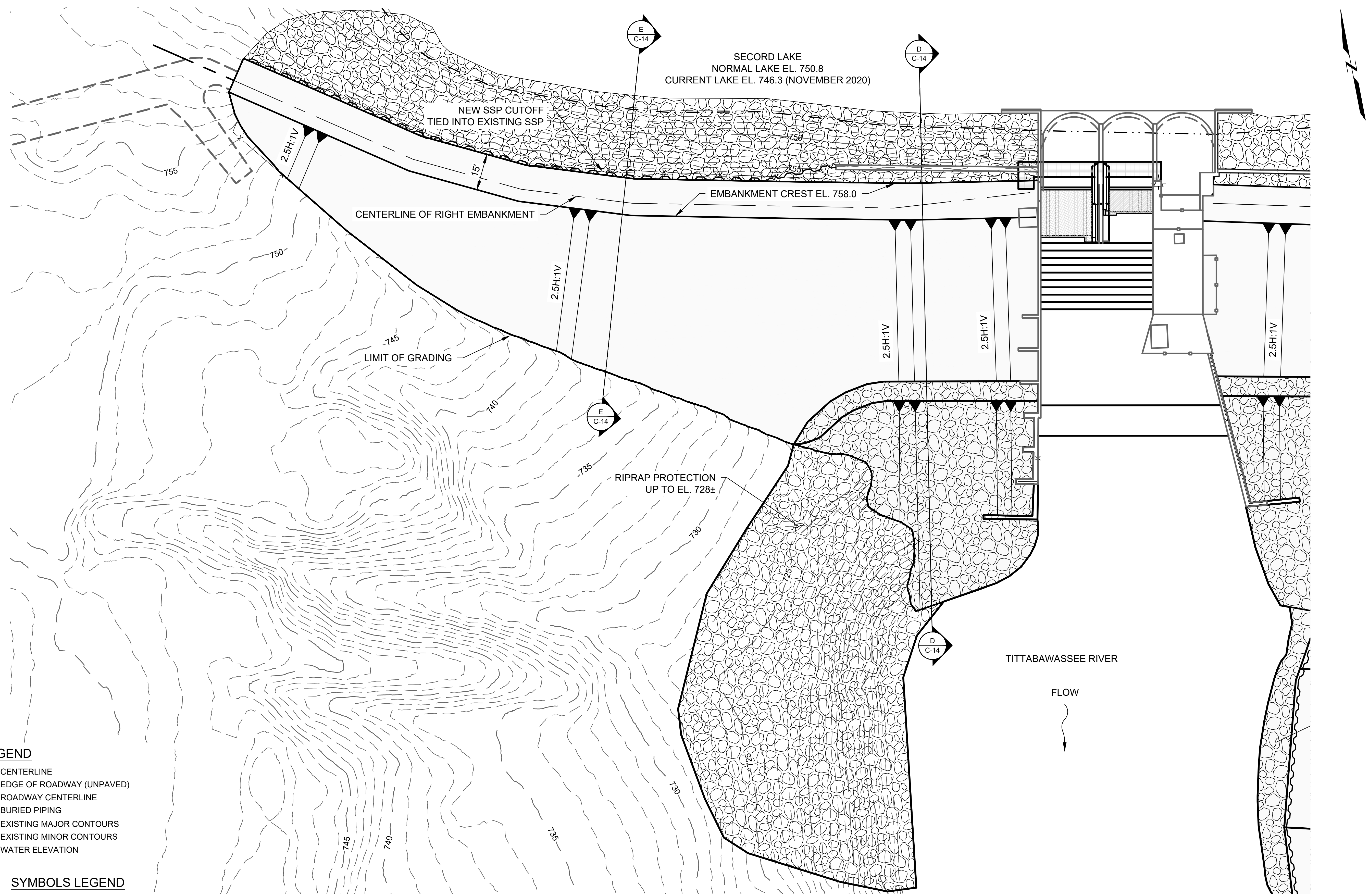

RIGHT EMBANKMENT MODIFICATIONS PLAN

0 20 40
SCALE: 1" = 20'

LINETYPE LEGEND

- CENTERLINE
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- 750 EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS
- WATER ELEVATION

HATCH LEGEND

- RIPRAP
- BERM FILL AREA

SYMBOLS LEGEND

- 1H:1V CUT SLOPE
- 1H:1V FILL SLOPE

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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Gladwin County, Michigan

RIGHT EMBANKMENT - MODIFICATIONS PLAN

DWG. NO. C-11

SHEET NO. 13

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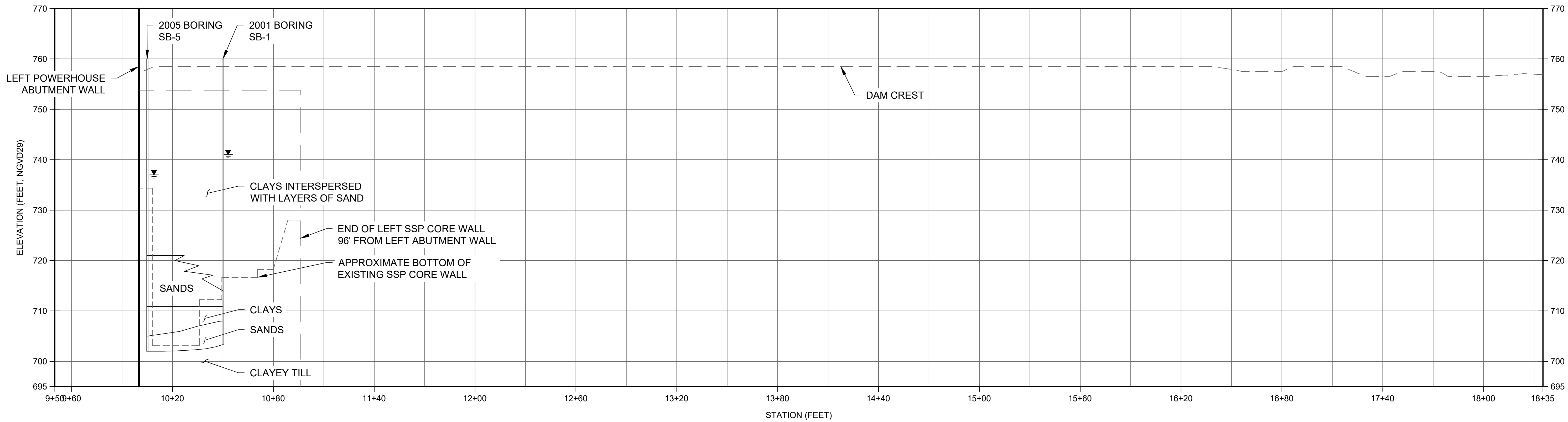
LEFT EMBANKMENT EXISTING CONDITIONS PLAN

0 30' 60'
SCALE, FT



LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- FENCE LINE (STEEL)
- FENCE LINE (WOOD)
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- EXISTING MAJOR CONTOURS (750)
- EXISTING MINOR CONTOURS
- EXISTING SURFACE ELEVATION
- SSP CORE WALL EXTENTS

SYMBOLS LEGEND

- SB-3 SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
- SB-1 SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
- SB-5 SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
- DRAIN TILES
- MW #1 MONITORING WELL
- BM #1 SURVEY REFERENCE MONUMENT

PROFILE
LEFT EMBANKMENT

HORIZONTAL SCALE, FEET 0 30 60
VERTICAL SCALE, FEET 0 10 20
NOTE: 3x VERTICAL EXAGGERATION

NOTES:
1. LEFT EMBANKMENT SOIL PROFILE DEVELOPED FROM SECORD SUPPORTING TECHNICAL INFORMATION DOCUMENT, FEBRUARY 2006.

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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Gladwin County, Michigan

LEFT EMBANKMENT - EXISTING SITE PLAN AND ELEVATION PROFILE

DWG. NO. C-12

SHEET NO. 14

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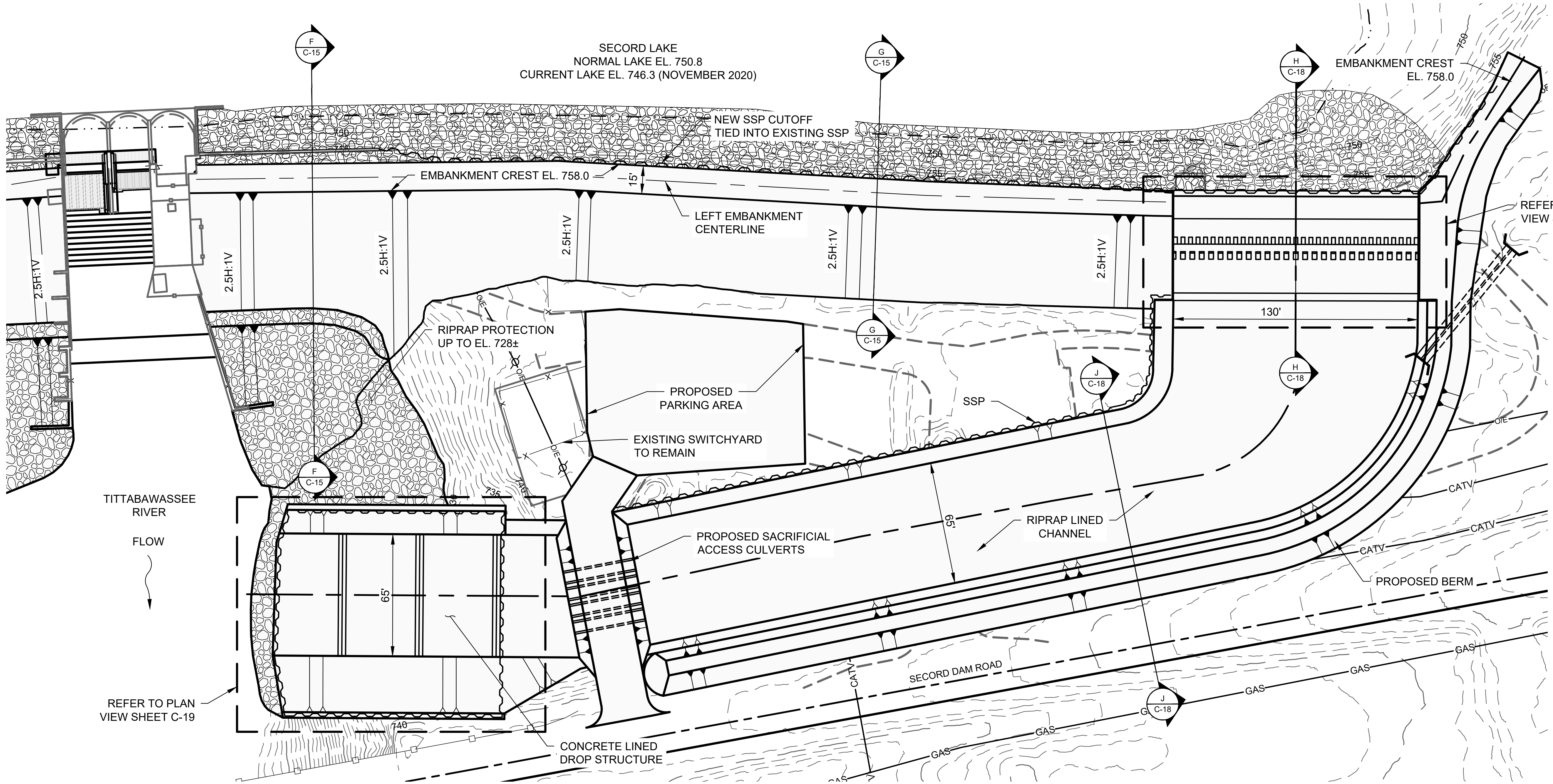

AUXILIARY SPILLWAY PLAN

0 30 60
SCALE, FEET

LINETYPE LEGEND

- CENTERLINE
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- 750 EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS
- WATER ELEVATION

HATCH LEGEND

- RIPRAP
- BERM FILL AREA

SYMBOLS LEGEND

- 1H:1V CUT SLOPE
- 1H:1V FILL SLOPE

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Secord Dam Conceptual Design
Gladwin County, Michigan

LEFT EMBANKMENT - MODIFICATIONS PLAN

DWG. NO. C-13

SHEET NO. 15

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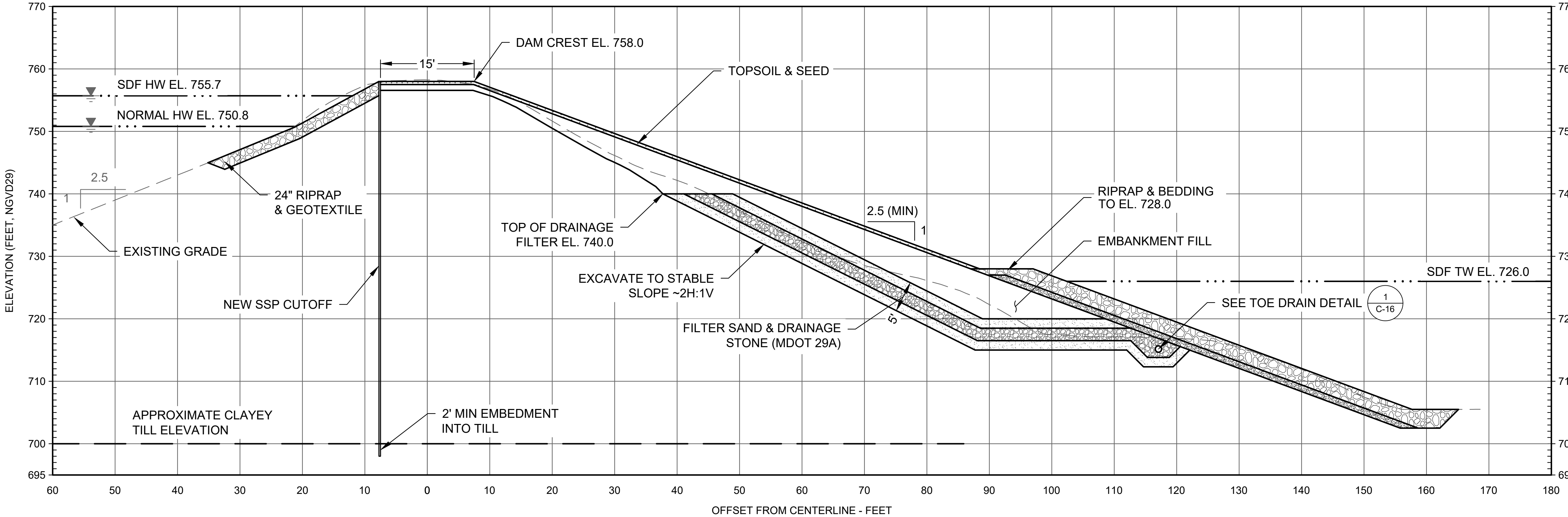
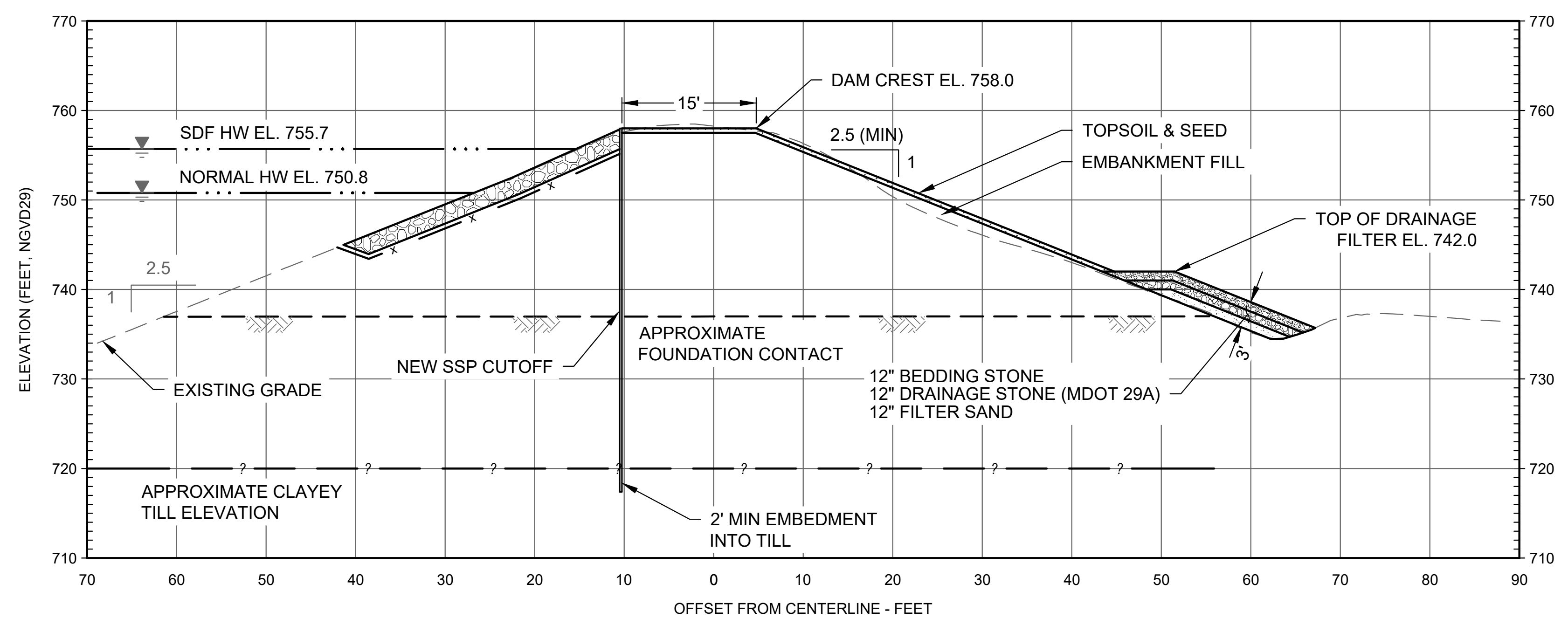


D
C-11
SECTION
RIGHT EMBANKMENT

HORIZONTAL SCALE, FEET
0 10 20
VERTICAL SCALE, FEET
NO VERTICAL EXAGGERATION



E
C-11
SECTION
RIGHT EMBANKMENT

HORIZONTAL SCALE, FEET
0 10 20
VERTICAL SCALE, FEET
NO VERTICAL EXAGGERATION

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

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Secord Dam Conceptual Design
Gladwin County, Michigan

RIGHT EMBANKMENT - MODIFIED SECTIONS

DWG. NO.
C-14
SHEET NO.
16

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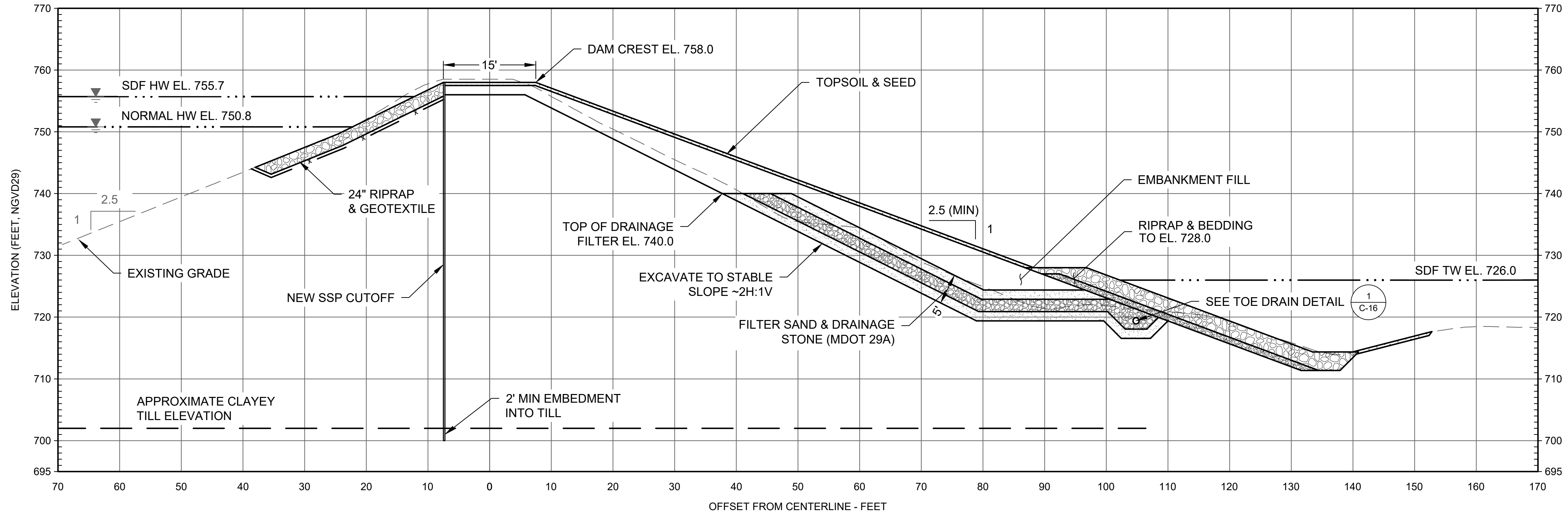
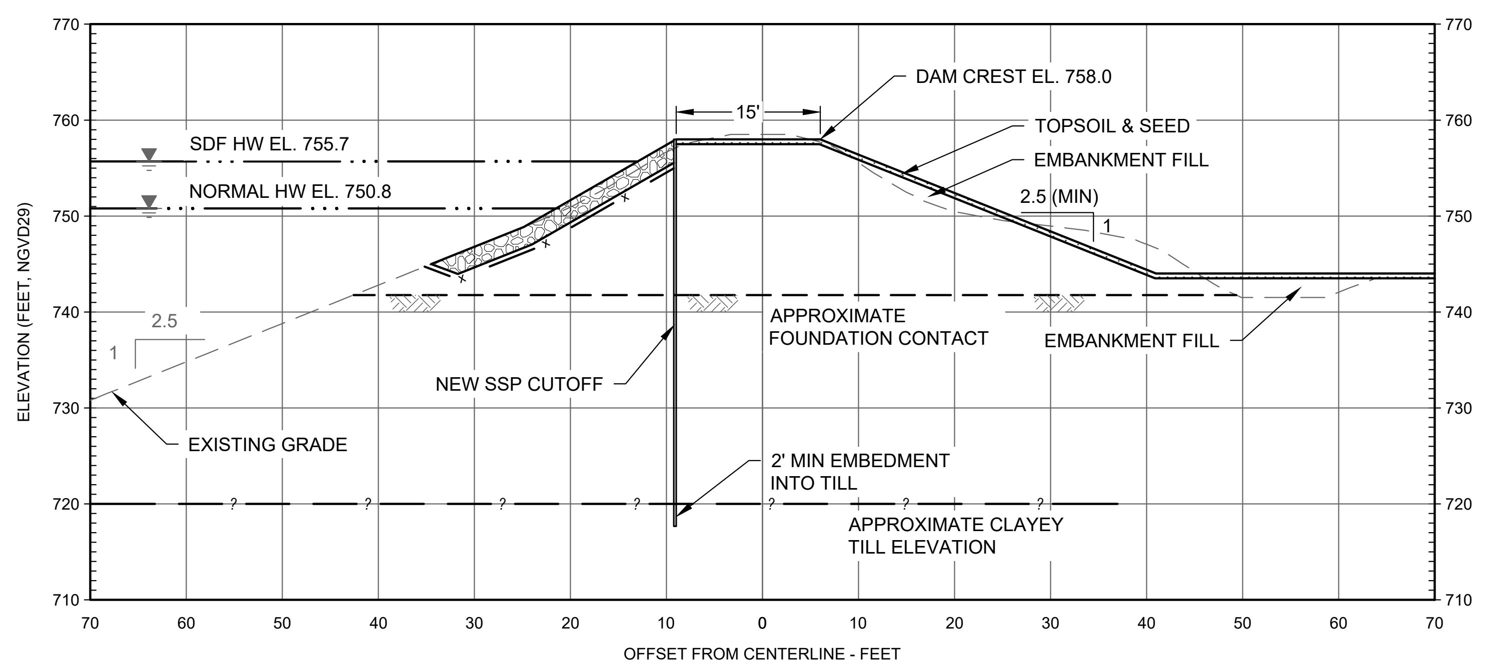


F
C-13
SECTION
LEFT EMBANKMENT

HORIZONTAL SCALE, FEET
0 10 20
VERTICAL SCALE, FEET
NO VERTICAL EXAGGERATION



G
C-13
SECTION
LEFT EMBANKMENT

HORIZONTAL SCALE, FEET
0 10 20
VERTICAL SCALE, FEET
NO VERTICAL EXAGGERATION

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

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0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Secord Dam Conceptual Design
Gladwin County, Michigan

LEFT EMBANKMENT - MODIFIED SECTIONS

DWG. NO. C-15
SHEET NO. 17

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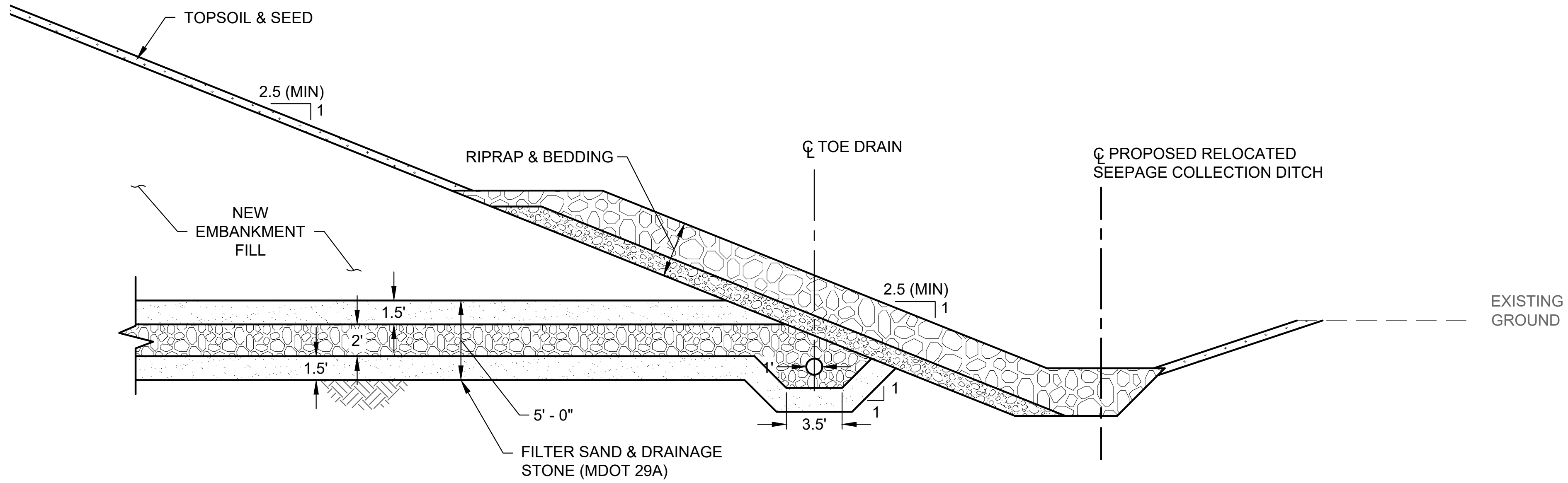

1 DETAIL
C-14
C-15
TOE DRAIN

0 5 10
SCALE, FEET

Attention:	NO.	DATE	ISSUE/REVISION	APP
0 1" If this scale bar does not measure 1" then drawing is not original scale.	0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Gladwin County, Michigan

RIGHT AND LEFT EMBANKMENTS - MODIFICATION DETAILS

DWG. NO. C-16
SHEET NO. 18

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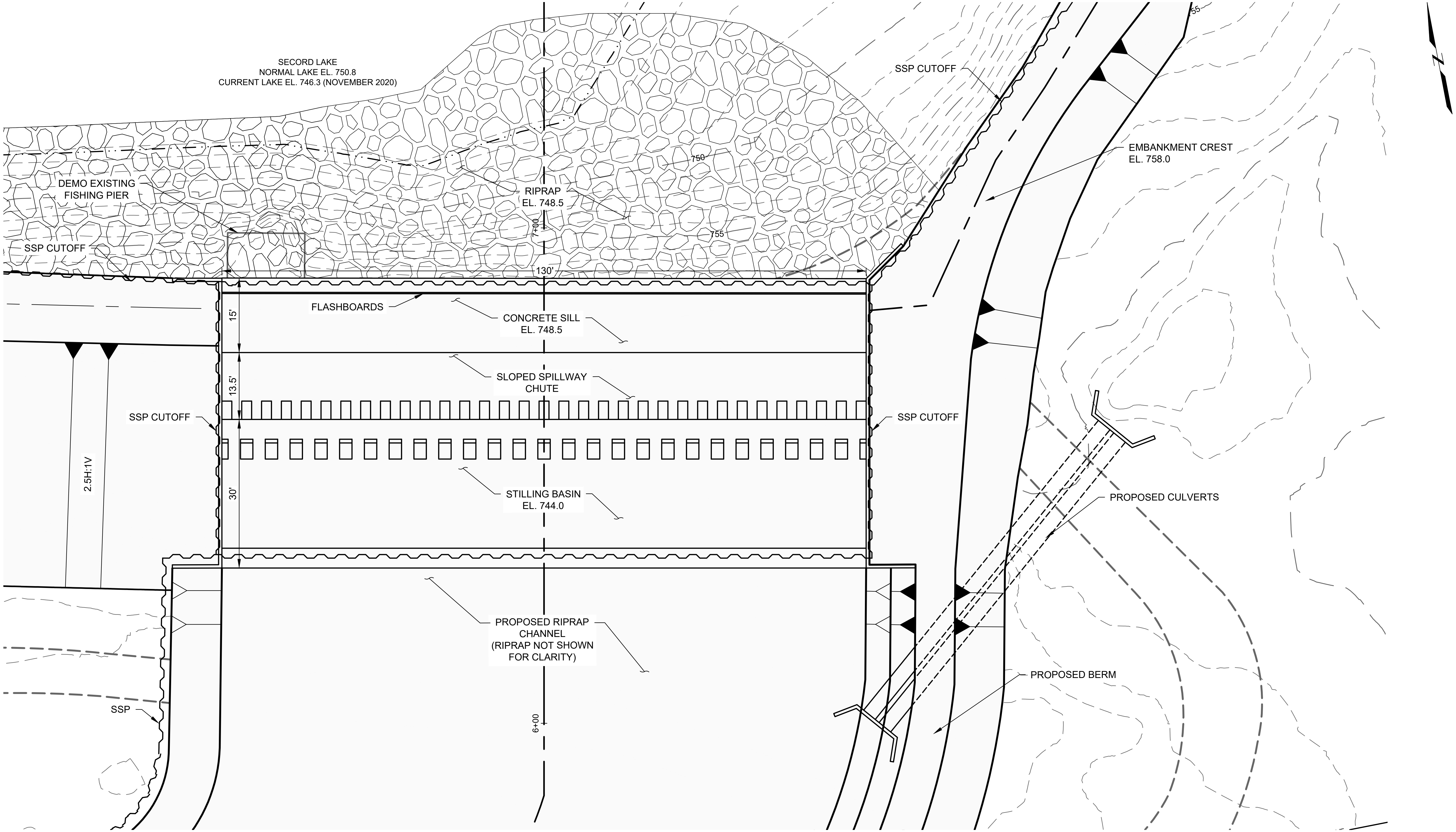

PLAN VIEW

PROPOSED AUXILIARY SPILLWAY

0 10 20
SCALE, FEET

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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Gladwin County, Michigan

AUXILIARY SPILLWAY - PROPOSED PLAN VIEW

DWG. NO. C-17

SHEET NO. 19

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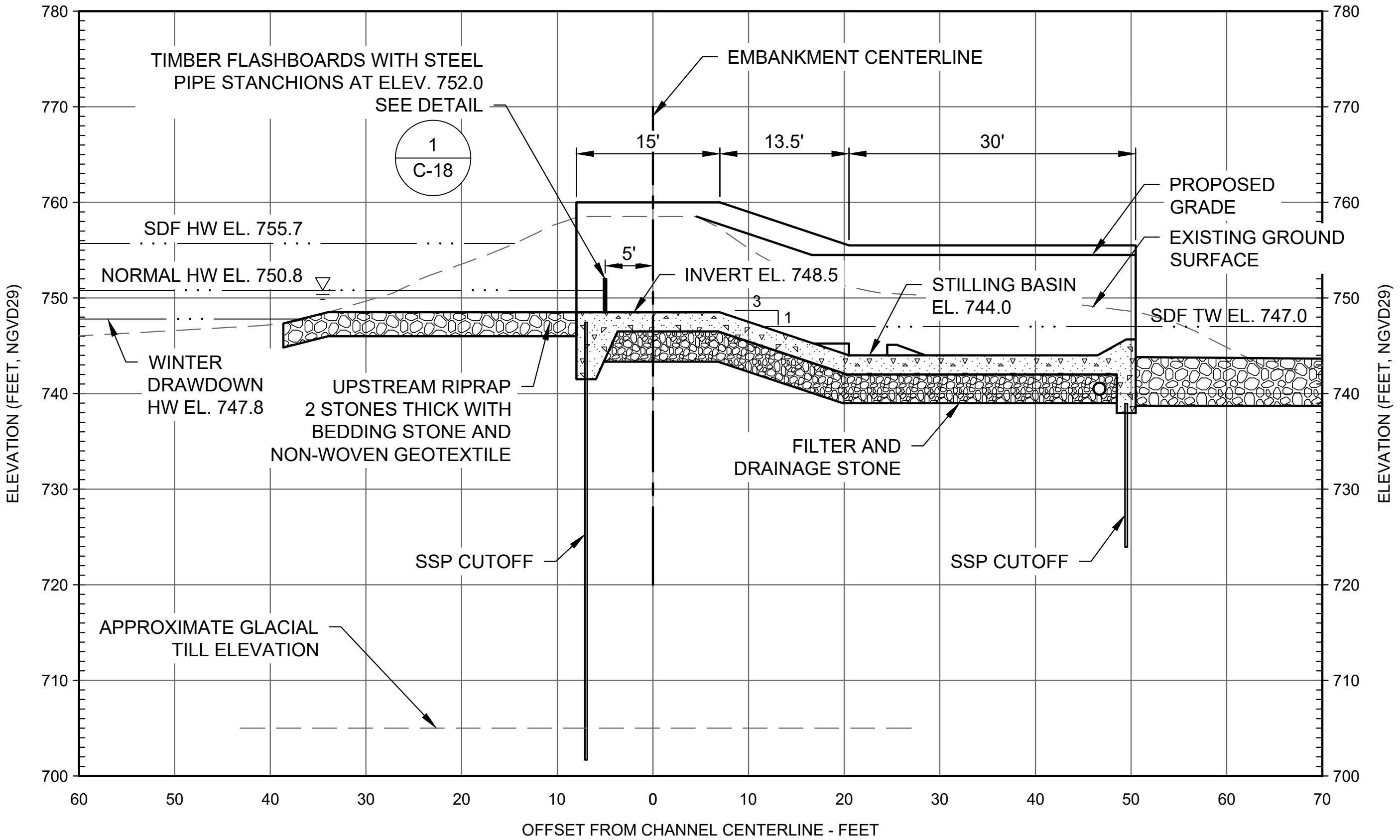
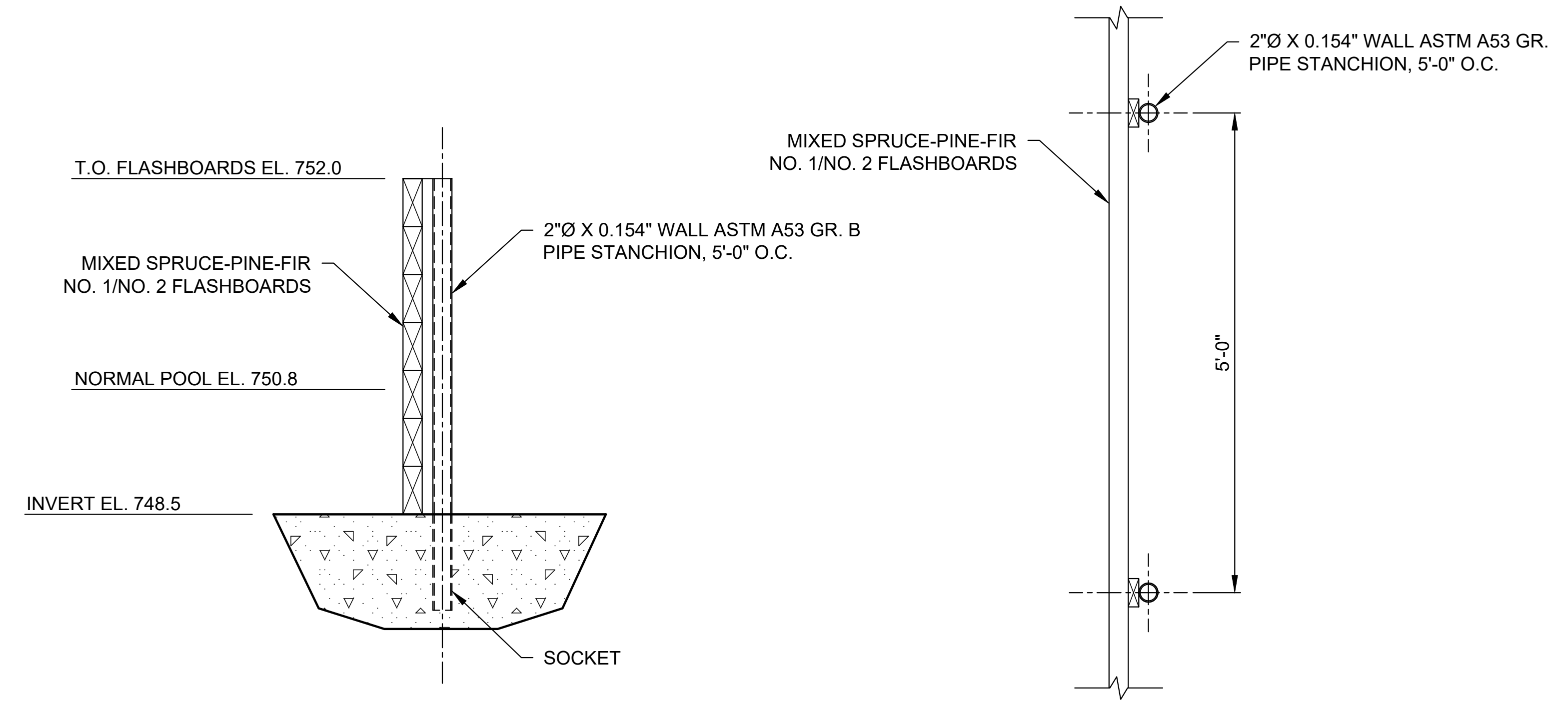


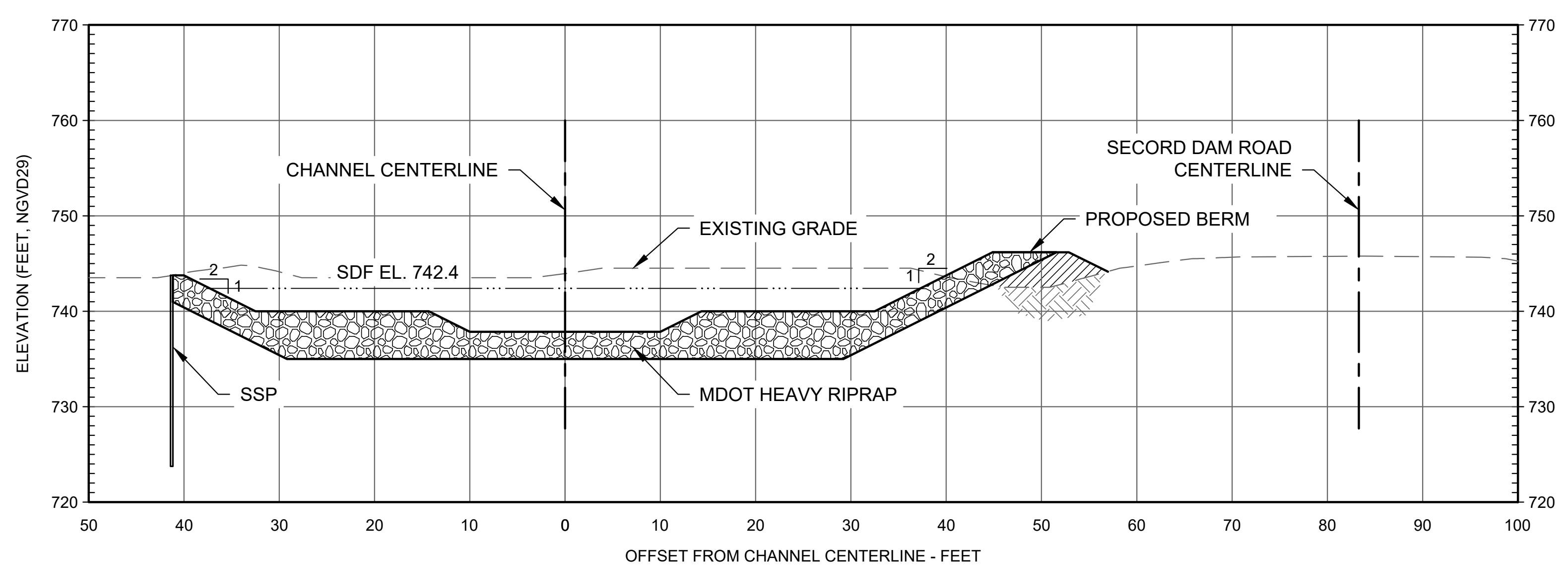
H
C-13
SECTION
PROPOSED SPILLWAY

HORIZONTAL SCALE, FEET
0 10 20
VERTICAL SCALE, FEET
NO VERTICAL EXAGGERATION



1
C-18
DETAIL
FLASHBOARD AND STANCHION

0 1 2
SCALE, FEET



J
C-13
SECTION
PROPOSED SPILLWAY CHANNEL

HORIZONTAL SCALE, FEET
0 10 20
VERTICAL SCALE, FEET
NO VERTICAL EXAGGERATION

Attention:
0 1"
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Approved By:	B. WALTON

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GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

AUXILIARY SPILLWAY - PROPOSED SPILLWAY CROSS SECTION

DWG. NO.
C-18

SHEET NO.
20

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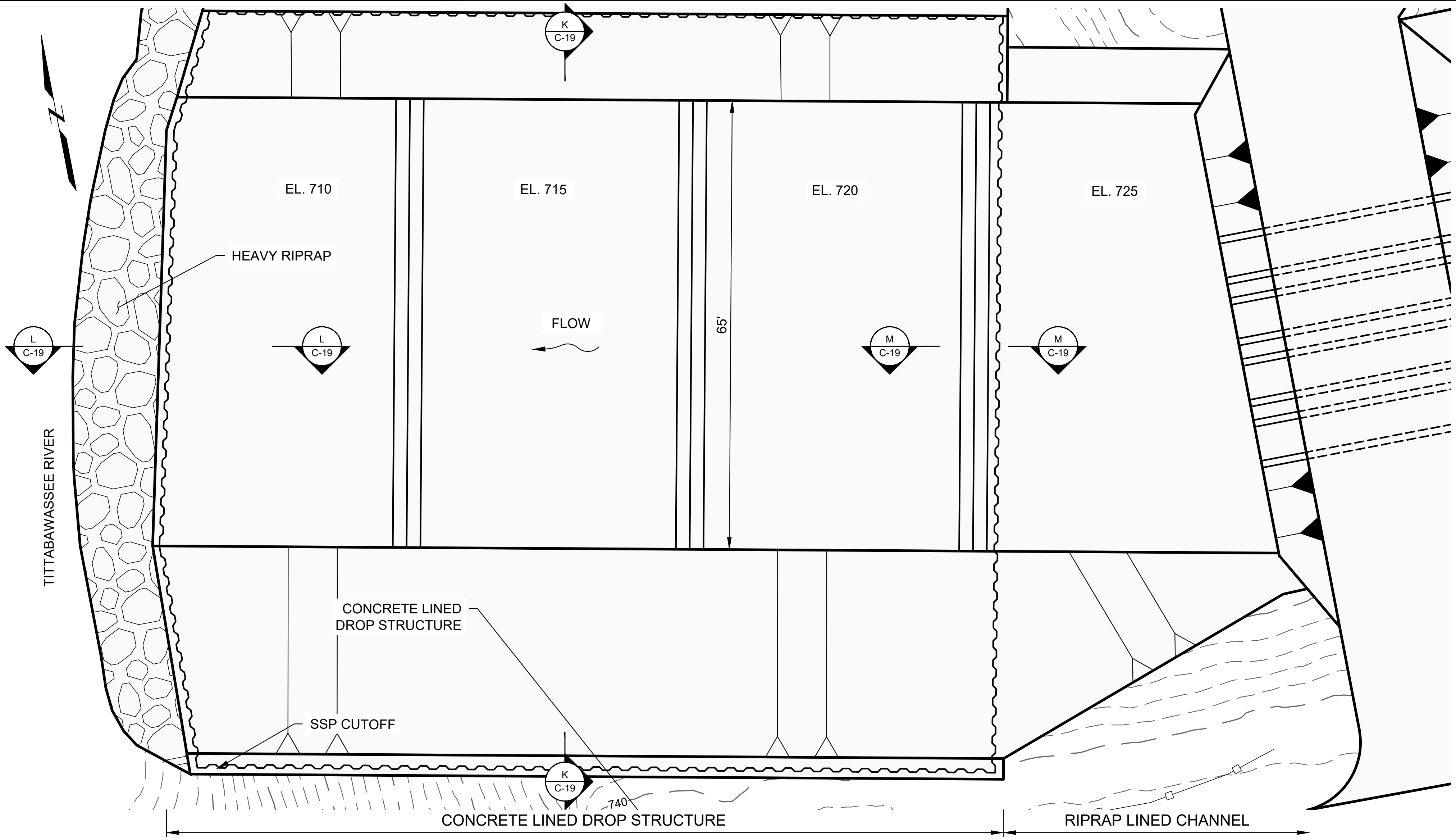
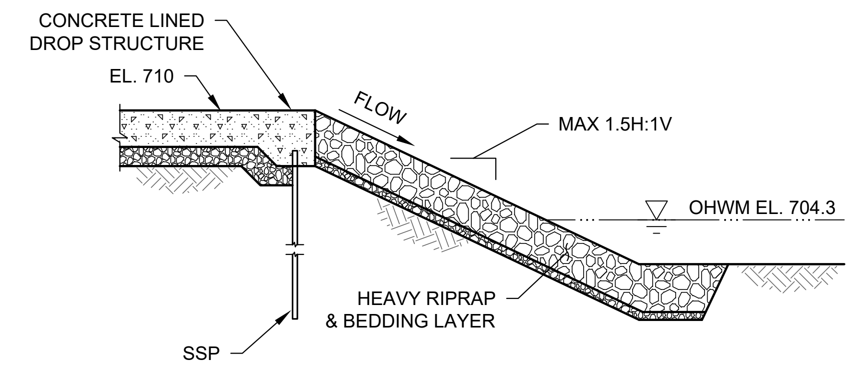


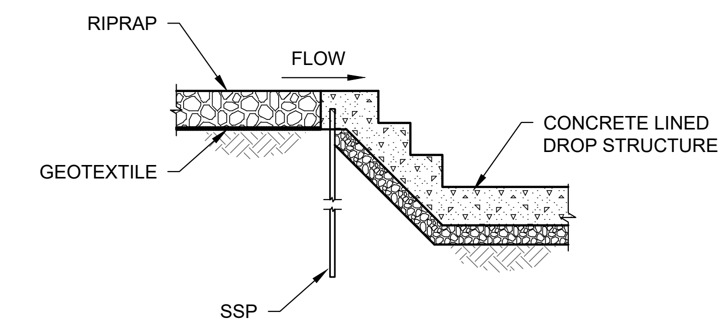
DROP STRUCTURE PLAN

0 10 20 SCALE, FEET



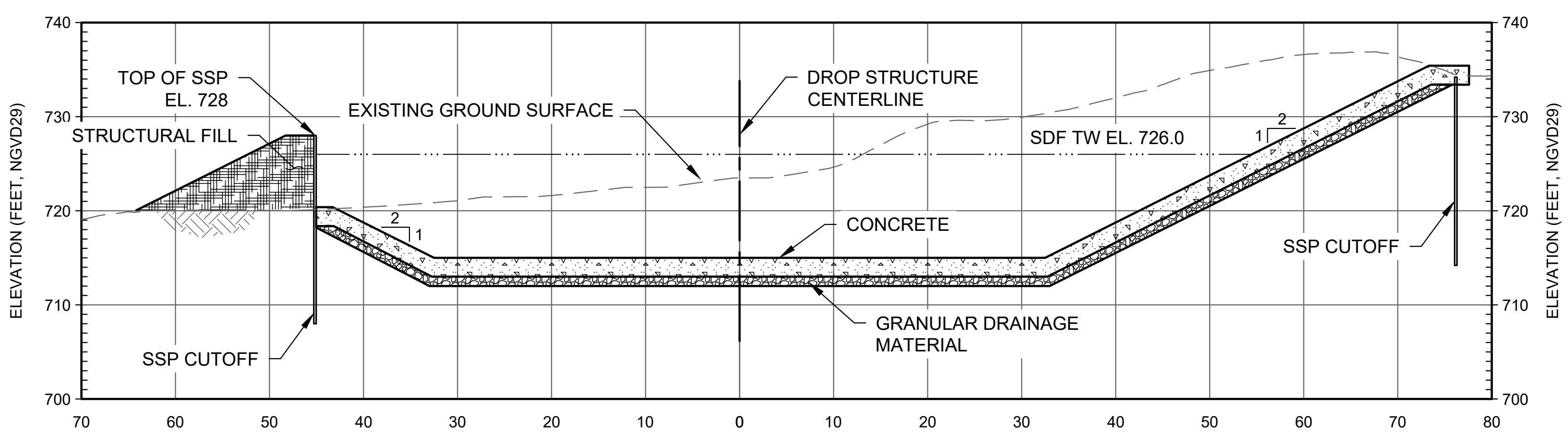
L C-19 SECTION
AUX. SPILLWAY OUTLET

0 5 10 SCALE, FEET



M C-19 SECTION
CHANNEL/DROP STRUCTURE CONNECTION

0 5 10 SCALE, FEET



HORIZONTAL SCALE, FEET 0 10 20

0 10 20 VERTICAL SCALE, FEET
NO VERTICAL EXAGGERATION

K C-19 SECTION
CONCRETE LINED DROP STRUCTURE

Attention: 0 1" If this scale bar does not measure 1" then drawing is not original scale.

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Drawn:	A. SAMPSON
Approved By:	B. WALTON

Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

AUXILIARY SPILLWAY TERMINAL STRUCTURE - PROPOSED PLAN AND SECTION

DWG. NO. C-19

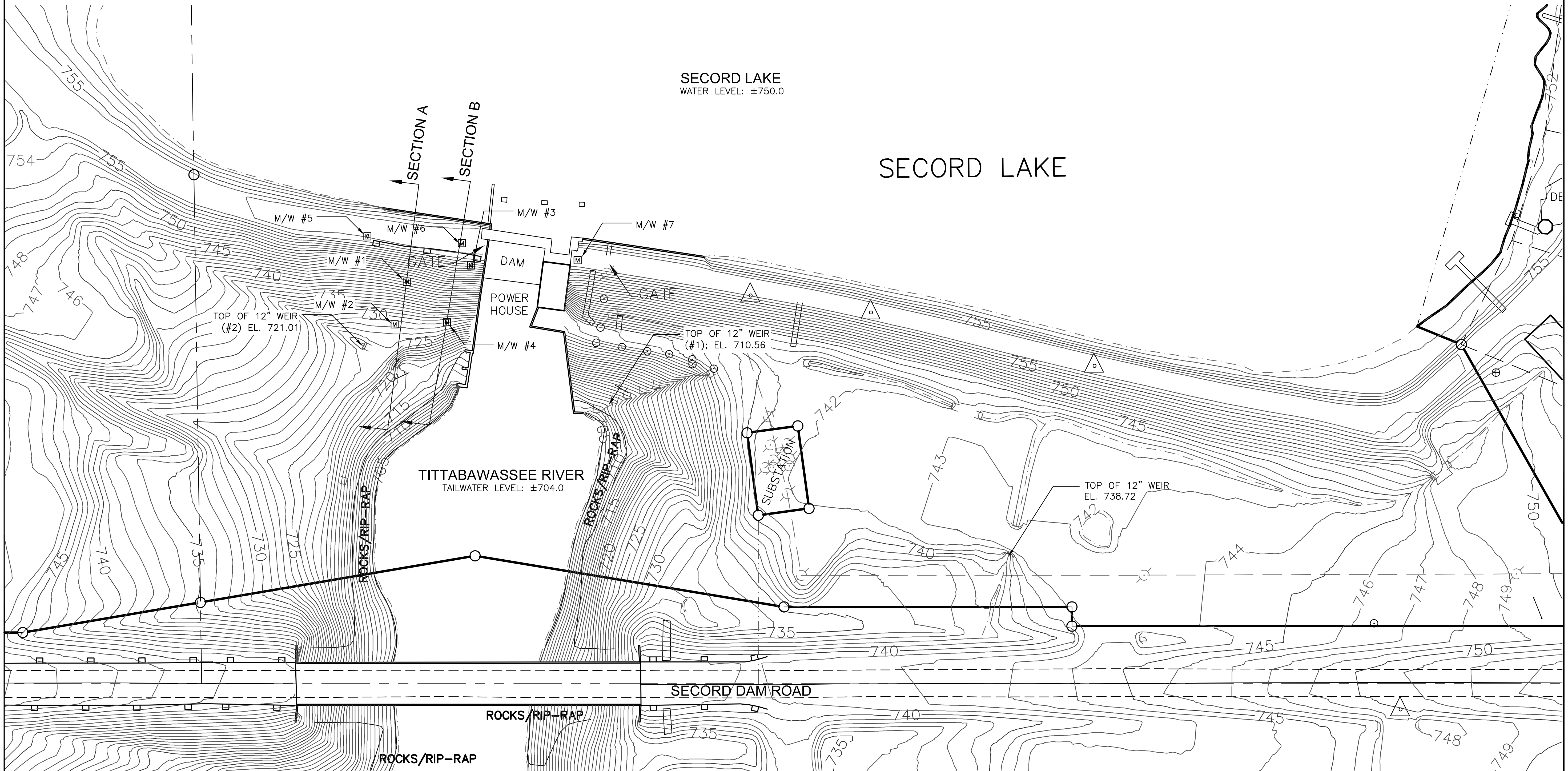
SHEET NO. 21

\\MSN1L-AMICH C:\Temp Local C\FLTF\Secord\CAD\Design\Task4.3_ConceptDesign\C-05_Proposed Auxiliary Spillway_Half PMF.dwg - 1/13/2021

Appendix D

Summary of Available Existing Subsurface Information

MONITOR WELL PLAN DRAWING



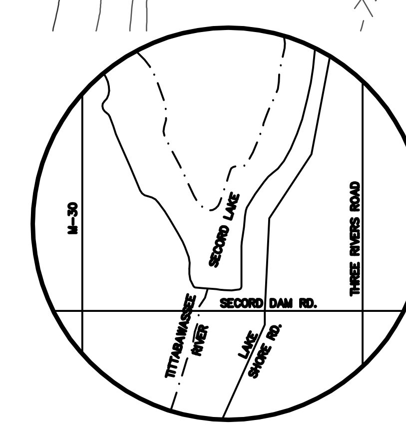
WELL	TOP OF PIPE	GROUND ELEV.
MW#1	744.78	742.95
MW#2	729.43	727.53
MW#3	758.33	757.43
MW#4	732.68	729.43
MW#5	758.79	757.98
MW#6	759.28	757.80
MW#7	760.43	758.04

LEGEND:

- OVERHEAD UTILITY LINE
- UTILITY POLE
- ANTENNA / TOWER
- BM#1 BENCHMARK LOCATION
- MONITOR WELL
- CATCH BASIN

THIS DRAWING IS SCALED TO PRINT ON 11X17 PAPER

0' 40' 80' 160'
SCALE: 1" = 80'



PART OF SECTION 15, T.19N.-R.1E., SECORD TOWNSHIP, GLADWIN COUNTY, MICHIGAN

LOCATION MAP
(NO SCALE)

NORTH

BOYCE HYDRO, LLC
Lee W. Mueller, Architect
Co-Member Manager
Frank O. Christie, P.E.
General Manager

PO BOX 15
6000 S-M30
EDENVILLE, MI 48620
(989) 689-3161

LICENSE STAMP

CONSULTANT

DRAWING ISSUED FOR
- CLIENT APPROVAL
- PLANNING APPROVAL
- PLAN CHECK #1
- PLAN CHECK #2
- BIDDING
- PERMIT
- CONSTRUCTION

REVISIONS

NO.	DATE	BY
DESCRIPTION		

PROJECT
BOYCE HYDRO POWER LLC
FERC PROJECT #10809
SECORD, MI

OWNER
BOYCE HYDRO POWER LLC
PO BOX 15
EDENVILLE, MI 48620
989-689-3161

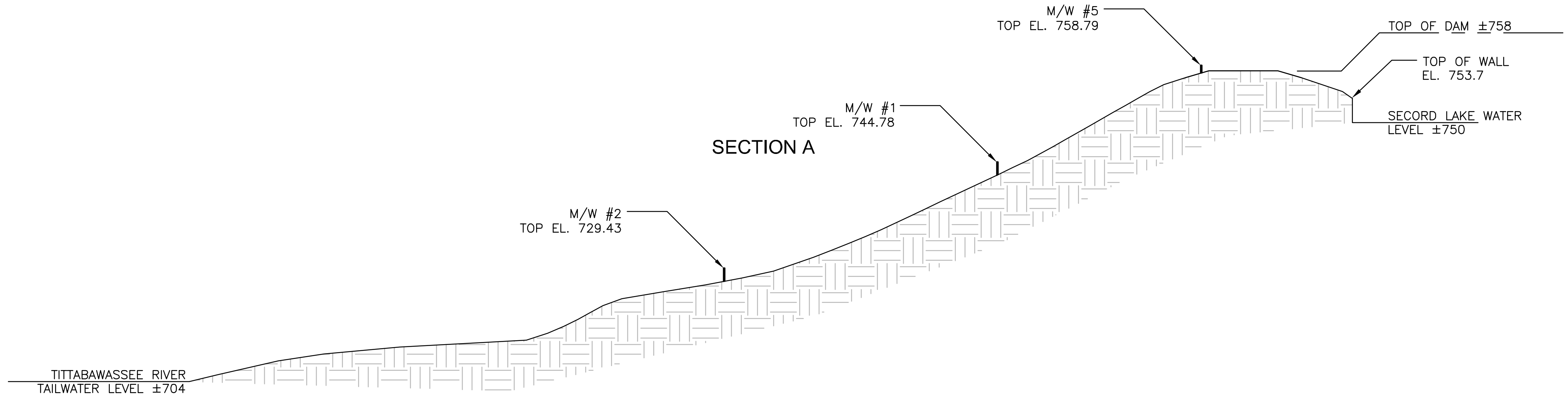
DRAWING TITLE
MONITORING WELL PLAN DRAWING SECORD

FILE	C070347C for SMP 2009
SCALE	AS NOTED
DRAWN	MGM
CHECKED	FOC
DATE	06/01/2009

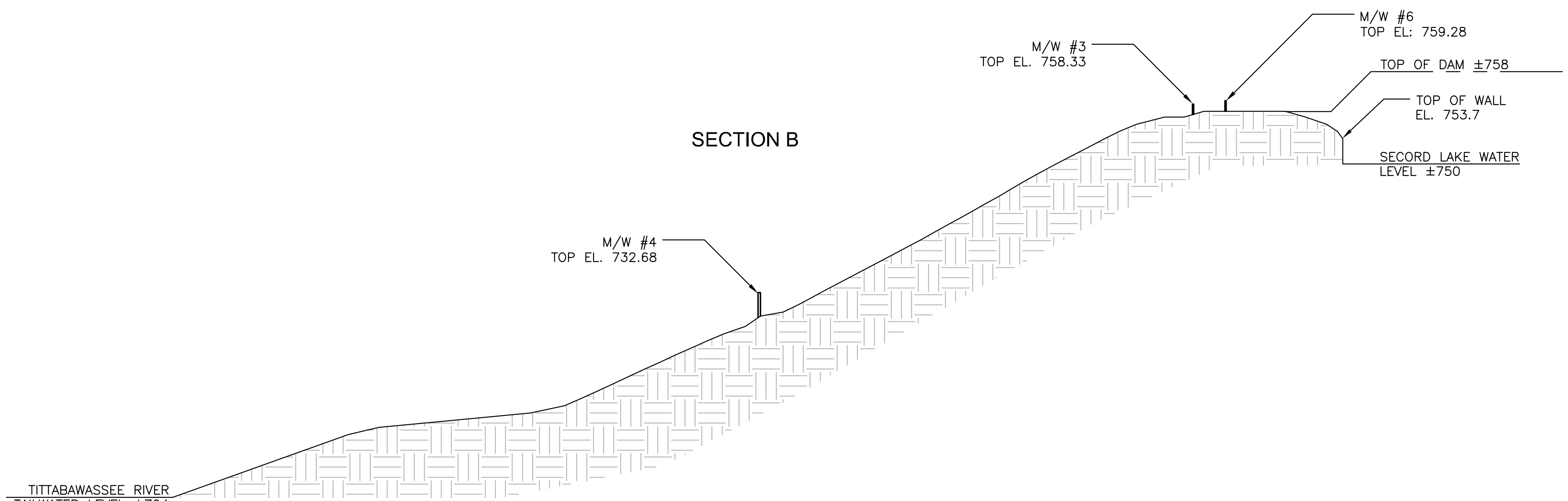
DRAWING NO.
.

MONITOR WELL SECTION DRAWINGS

SECTION A



SECTION B



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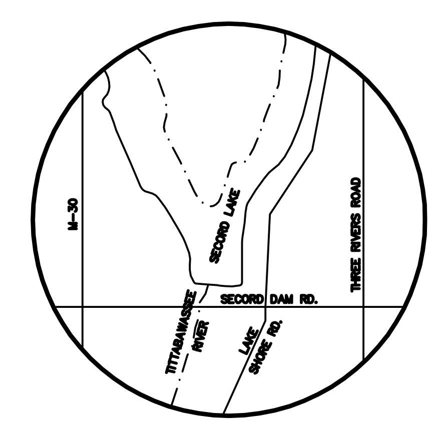
SCALE: 1" = 20'



PART OF SECTION 15, T.19N.-R.1E., SECORD TOWNSHIP, GLADWIN COUNTY, MICHIGAN

LOCATION MAP

(NO SCALE)

BOYCE HYDRO, LLC

Lee W. Mueller, Architect
Co-Member Manager
Frank O. Christie, P.E.
General Manager

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EDENVILLE, MI 48620
(989) 689-3161

LICENSE STAMP

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	PLAN CHECK #1
	PLAN CHECK #2
	BIDDING
	PERMIT
	CONSTRUCTION

REVISIONS

NO.	DATE	BY
DESCRIPTION		

PROJECT

BOYCE HYDRO POWER LLC
FERC PROJECT #10809
SECORD, MI

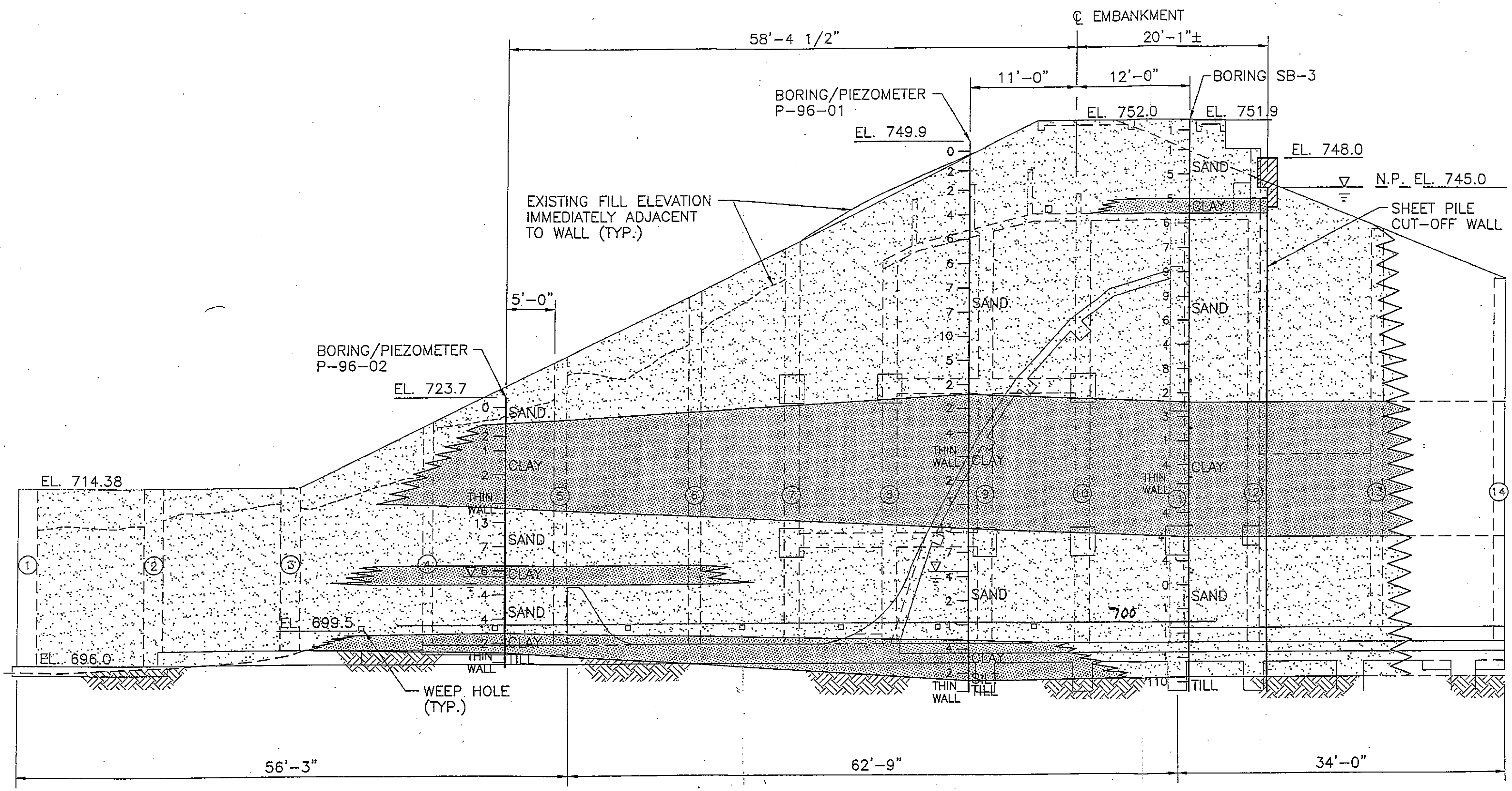
OWNER

BOYCE HYDRO POWER LLC
PO BOX 15
EDENVILLE, MI 48620
989-689-3161

DRAWING TITLE

MONITORING WELL SECTION DRAWING SECORD

FILE	C070347C for SMP 2009
SCALE	AS NOTED
DRAWN	MGM
CHECKED	FOC
DATE	06/01/2009
	DRAWING NO.
	.



LEGEND

▽ DENOTES PIEZOMETER WATER LEVEL READING ON JUNE, 1996.

NUMBERS ON BORING COLUMN DENOTE N-VALUES.

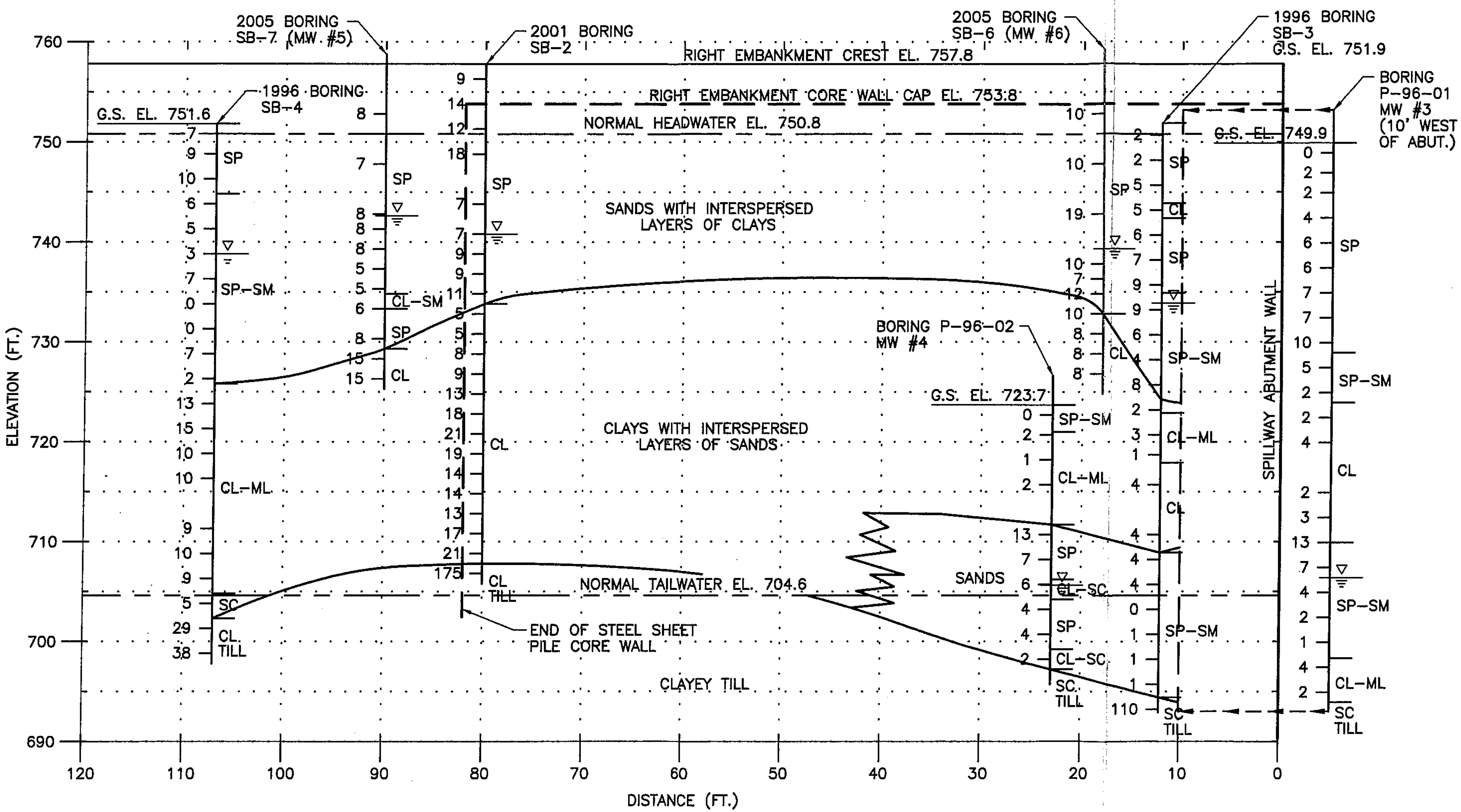
ALL ELEVATIONS ARE DAM DATUM
USGS = DAM DATUM + 5.6'

0 10 20
SCALE IN FEET

Figure D-1

GENERALIZED SOIL PROFILE
RIGHT RETAINING WALL – SECORD DAM
WOLVERINE POWER COMPANY

\22-56\009\SECORD\STABILITY\SOILFIG1.DWG -Plot-at 120 -10/09/2001 16:29:08

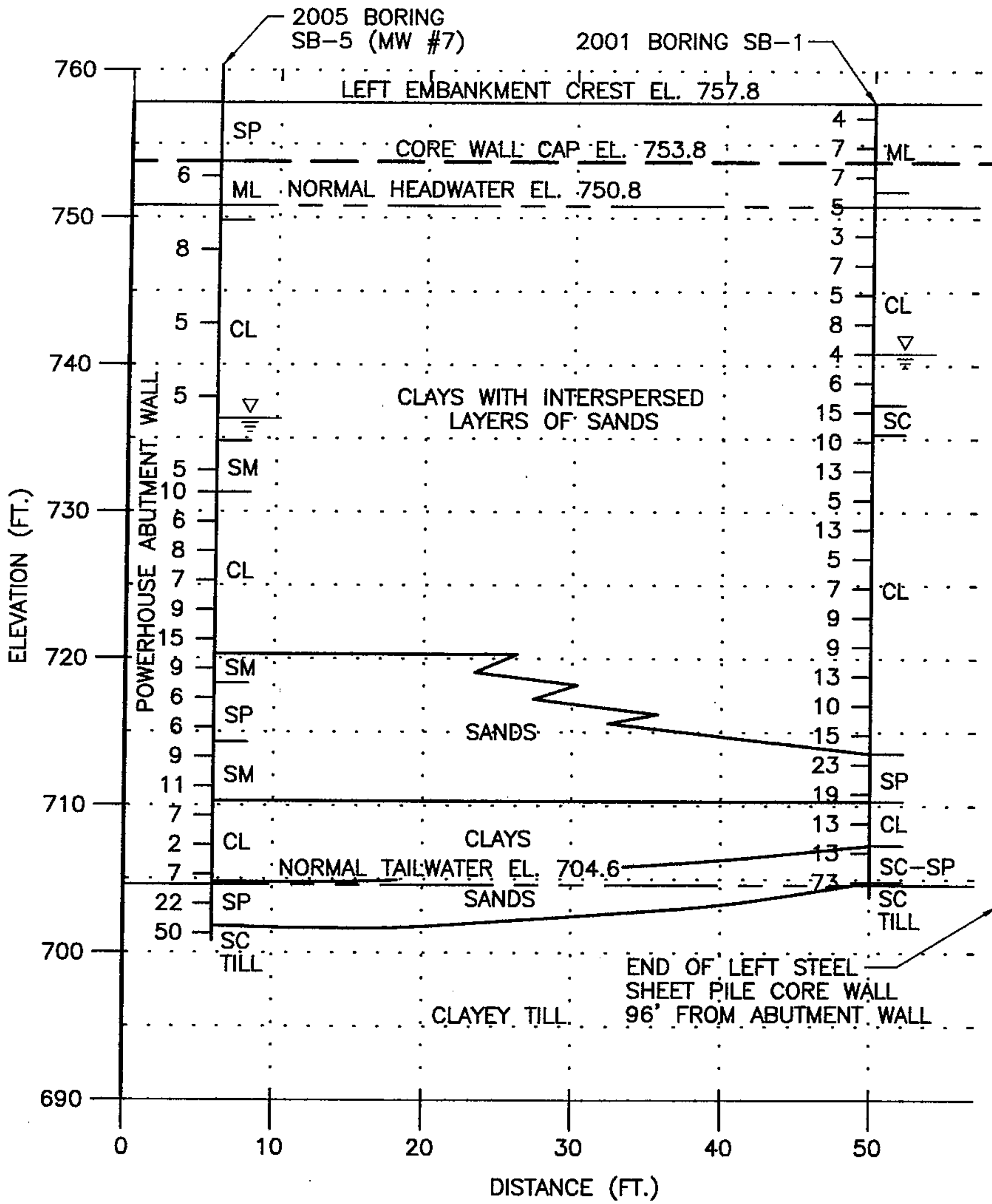


LEGEND

WATER LEVELS FROM BORING LOGS AND AVERAGE PIEZOMETER READINGS

NOTES ON BORING COLUMNS DENOTE N-VALUES AND SOIL TYPE.

FIGURE F-1
SECORD HYDROELECTRIC PROJECT
RIGHT EMBANKMENT SOIL PROFILE
A. Rieli & Associates, LLC



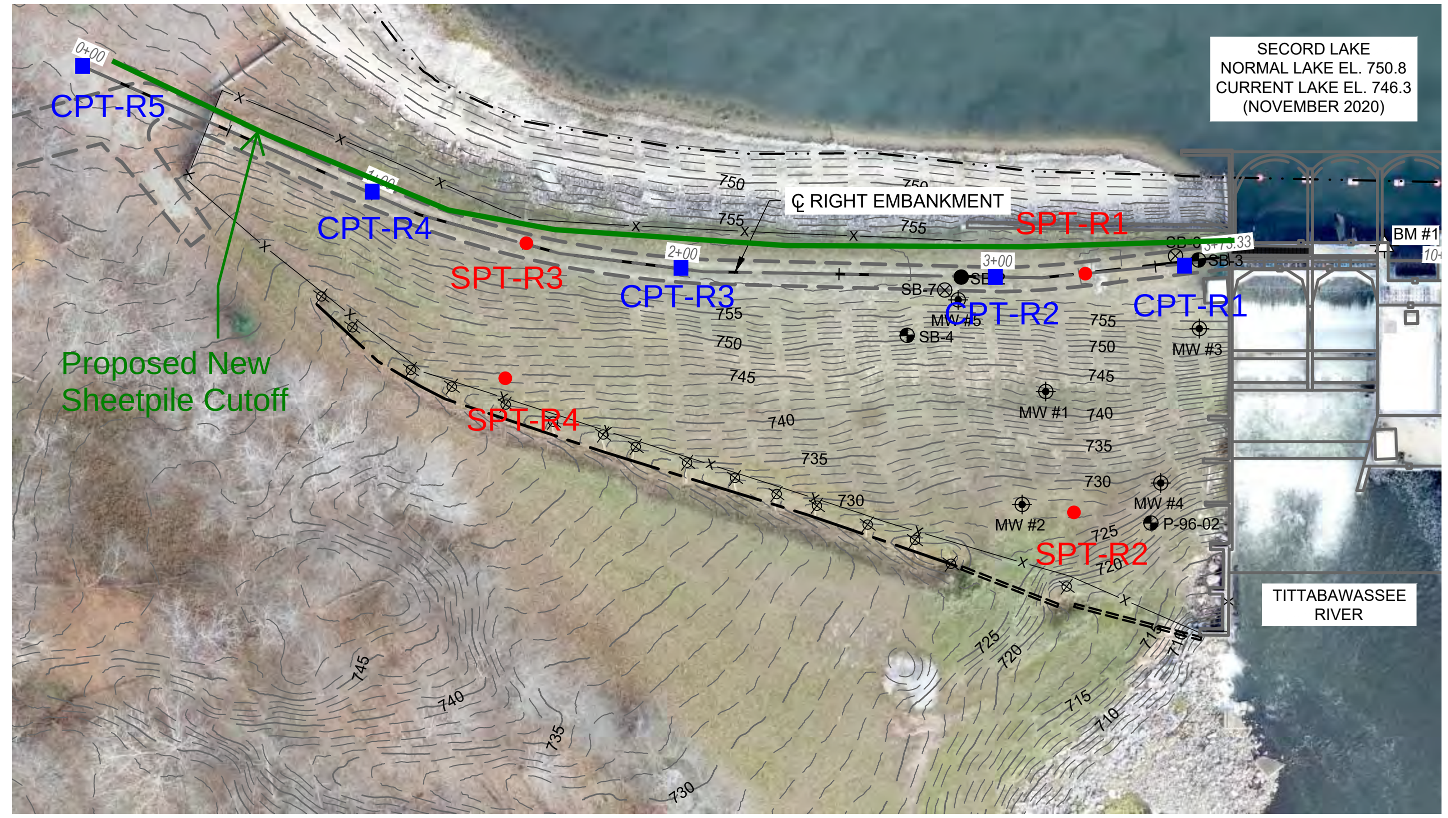
LEGEND

WATER LEVELS FROM BORING LOGS AND AVERAGE PIEZOMETER READINGS

NOTES ON BORING COLUMNS DENOTE N-VALUES AND SOIL TYPE.

FIGURE F-2

SECORD HYDROELECTRIC PROJECT
LEFT EMBANKMENT SOIL PROFILE
A. Rieli & Associates, LLC



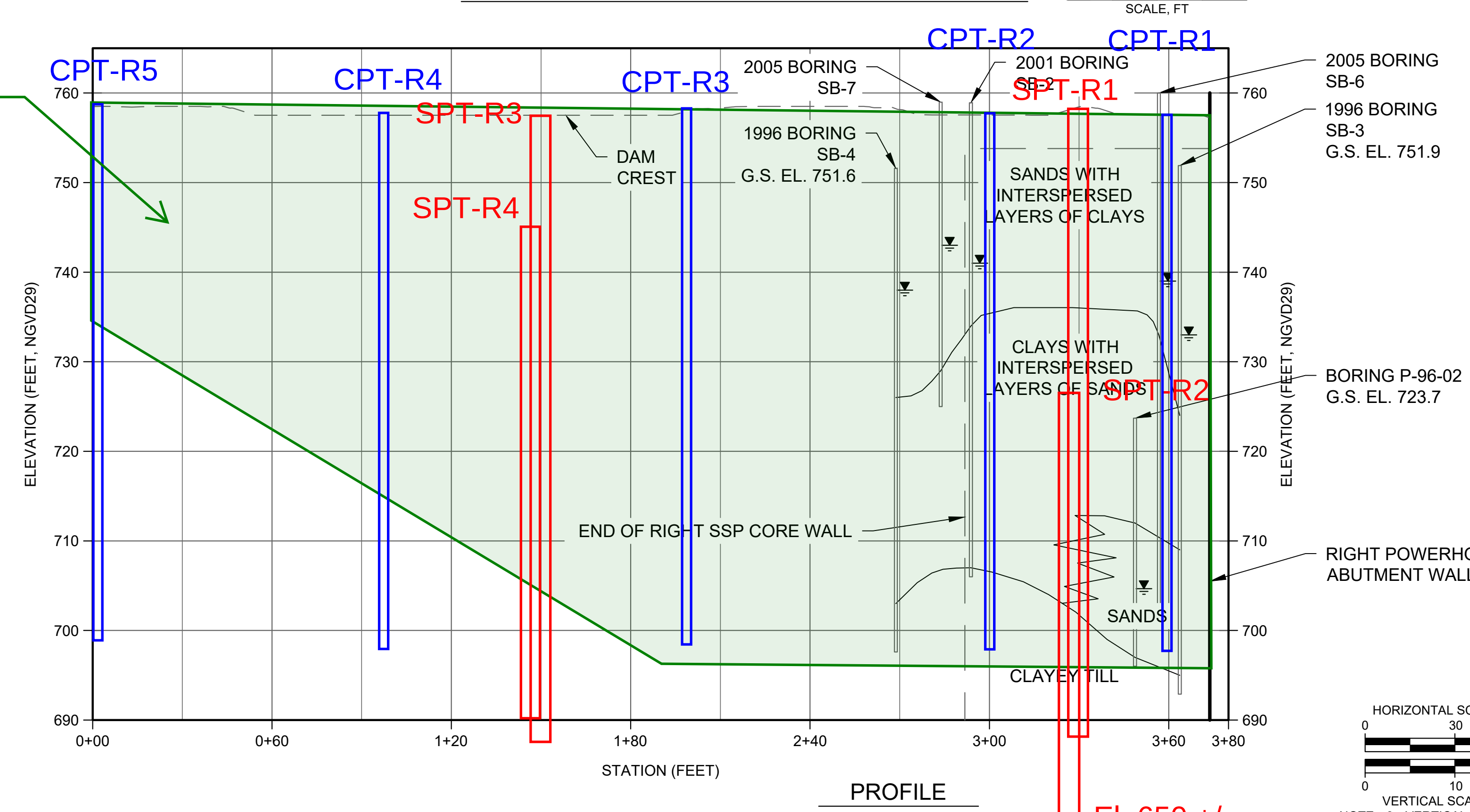
RIGHT EMBANKMENT EXISTING CONDITIONS PLAN

0 30' 60'
SCALE, FT

SPT-XX ● PROPOSED 2021 GEI BORING

CPT-XX ■ PROPOSED 2021 GEI CPT

Proposed New
Sheetpile Cutoff



PROFILE
RIGHT EMBANKMENT

HORIZONTAL SCALE, FEET
0 30 60
0 10 20
VERTICAL SCALE, FEET
NOTE: 3x VERTICAL EXAGGERATION

LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- FENCE LINE (STEEL)
- FENCE LINE (WOOD)
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- 750 EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS
- EXISTING SURFACE ELEVATION
- SSP CORE WALL EXTENTS

SYMBOLS LEGEND

- SB-3 SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
- SB-1 SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
- SB-5 SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
- DRAIN TILES
- MW #1 MONITORING WELL
- BM #1 SURVEY REFERENCE MONUMENT

NOTES:
1. RIGHT EMBANKMENT SOIL PROFILE DEVELOPED FROM SECORD SUPPORTING TECHNICAL INFORMATION DOCUMENT, FEBRUARY 2006.

Attention: If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

DRAFT

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(414)930-7540

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Drawn:	A. SAMPSON
Approved By:	B. WALTON

Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

RIGHT EMBANKMENT - EXISTING SITE PLAN AND ELEVATION PROFILE

DWG. NO. C-10

SHEET NO. 12

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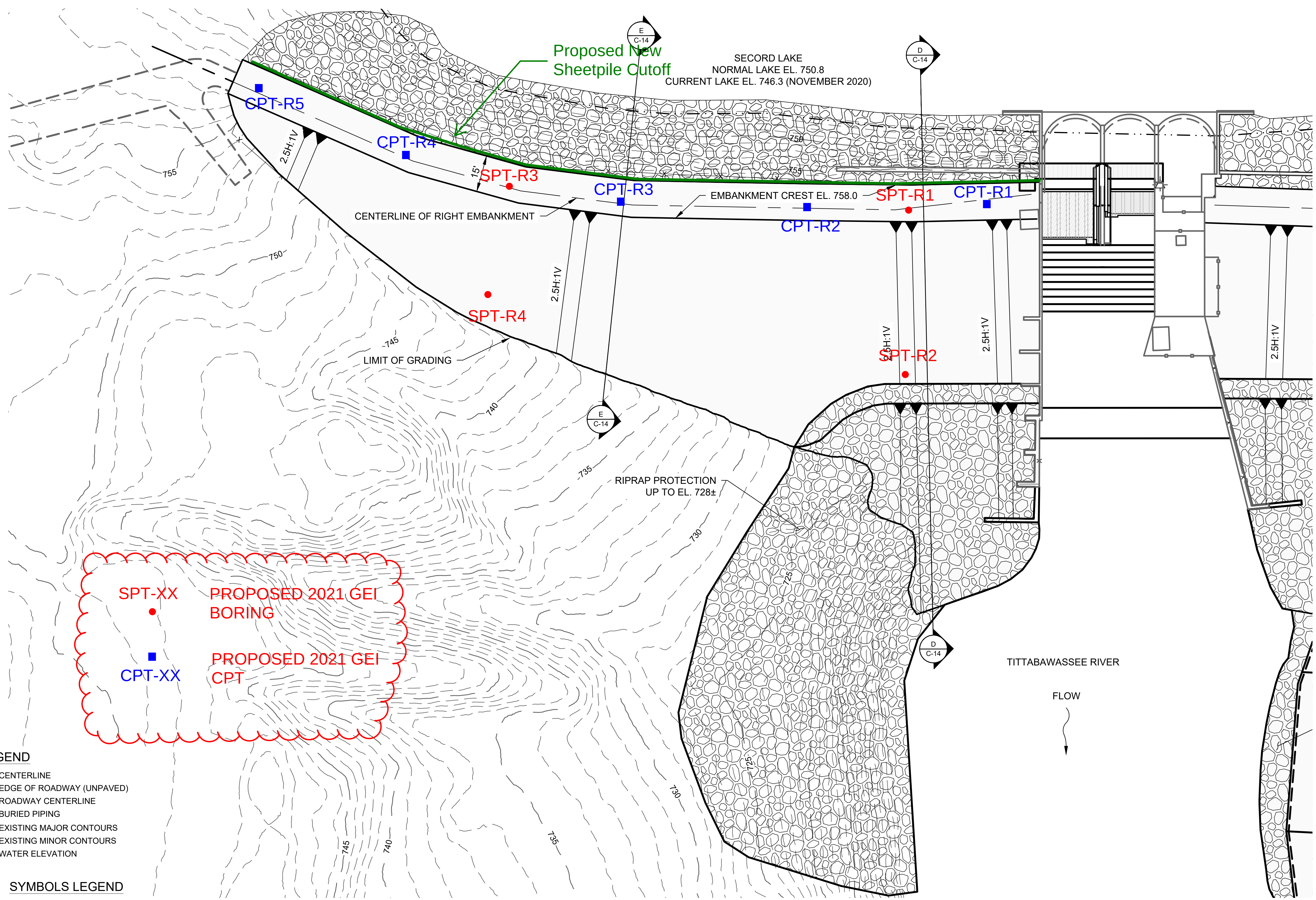

LINETYPE LEGEND

- CENTERLINE
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- 750 EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS
- WATER ELEVATION

HATCH LEGEND

- RIPRAP
- BERM FILL AREA

SYMBOLS LEGEND

- 1H:1V CUT SLOPE
- 1H:1V FILL SLOPE

RIGHT EMBANKMENT MODIFICATIONS PLAN

0 20 40
SCALE: 1" = 20'

Attention: 0 1"
If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

RIGHT EMBANKMENT - MODIFICATIONS PLAN

DWG. NO. C-11

SHEET NO. 13

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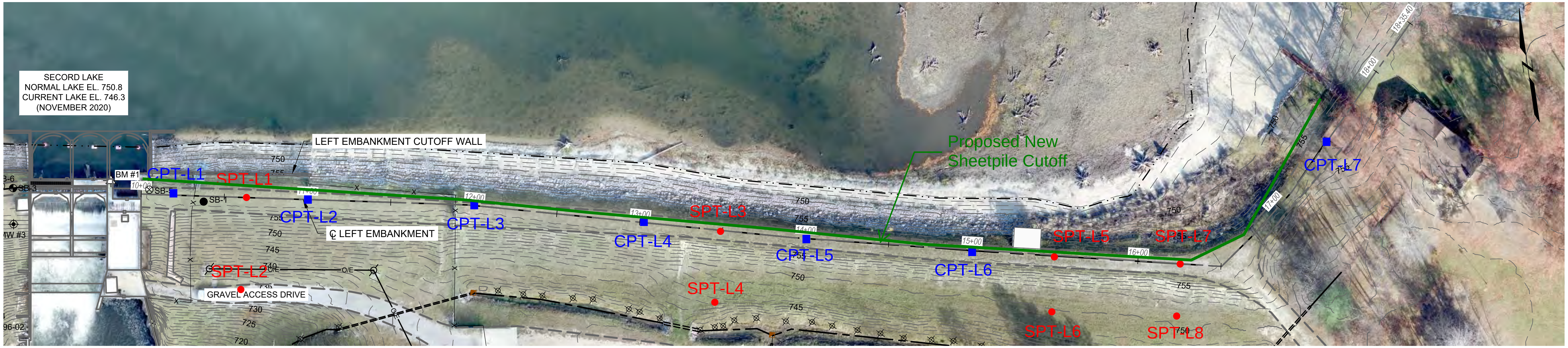
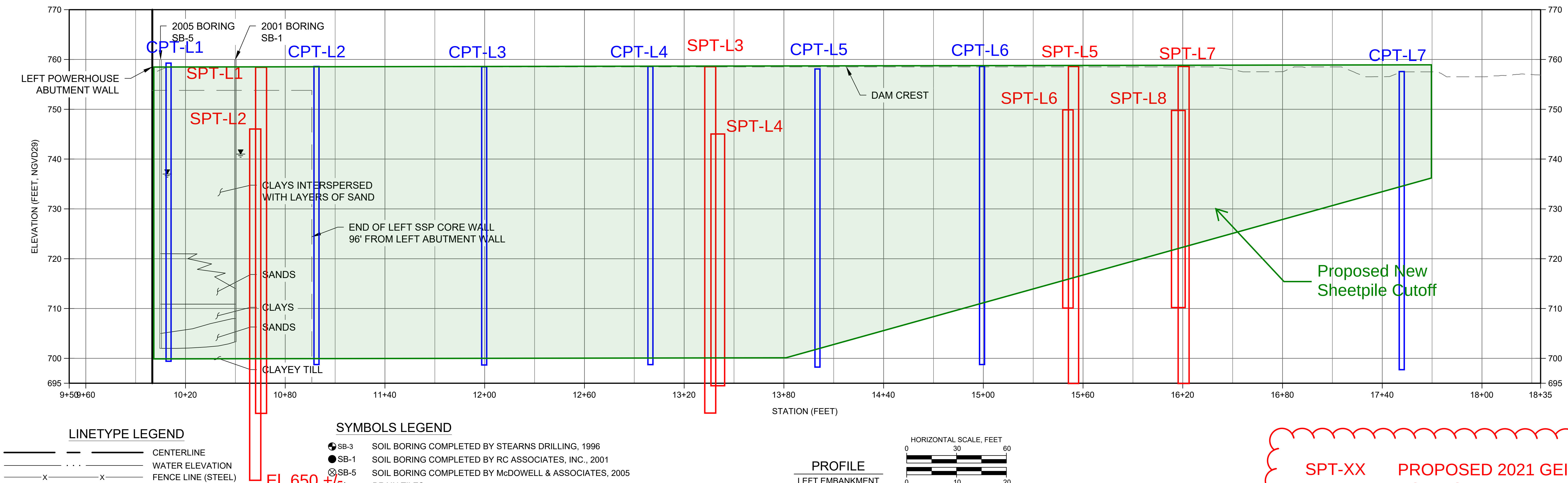


LEFT EMBANKMENT EXISTING CONDITIONS PLAN

SCALE, FT (0, 30', 60')



PROFILE

LEFT EMBANKMENT

HORIZONTAL SCALE, FEET (0, 30, 60)

VERTICAL SCALE, FEET (0, 10, 20)

NOTE: 3x VERTICAL EXAGGERATION

LINETYPE LEGEND

- CENTERLINE
- WATER ELEVATION
- FENCE LINE (STEEL)
- FENCE LINE (WOOD)
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- EXISTING MAJOR CONTOURS (750)
- EXISTING MINOR CONTOURS
- EXISTING SURFACE ELEVATION
- SSP CORE WALL EXTENTS

SYMBOLS LEGEND

- SB-3 — SOIL BORING COMPLETED BY STEARNS DRILLING, 1996
- SB-1 — SOIL BORING COMPLETED BY RC ASSOCIATES, INC., 2001
- SB-5 — SOIL BORING COMPLETED BY McDOWELL & ASSOCIATES, 2005
- DRAIN TILES
- MW #1 — MONITORING WELL
- BM #1 — SURVEY REFERENCE MONUMENT

SPT-XX — PROPOSED 2021 GEI BORING

CPT-XX — PROPOSED 2021 GEI CPT

NOTES:
1. LEFT EMBANKMENT SOIL PROFILE DEVELOPED FROM SECORD SUPPORTING TECHNICAL INFORMATION DOCUMENT, FEBRUARY 2006.

Attention:

If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

DRAFT

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GEI Consultants — GEI CONSULTANTS OF MICHIGAN, P.C., 10501 WEST RESEARCH DRIVE G100, MILWAUKEE, WI 53226, (414)930-7540

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Approved By:	B. WALTON

Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

LEFT EMBANKMENT - EXISTING SITE PLAN AND ELEVATION PROFILE

DWG. NO. C-12

SHEET NO. 14

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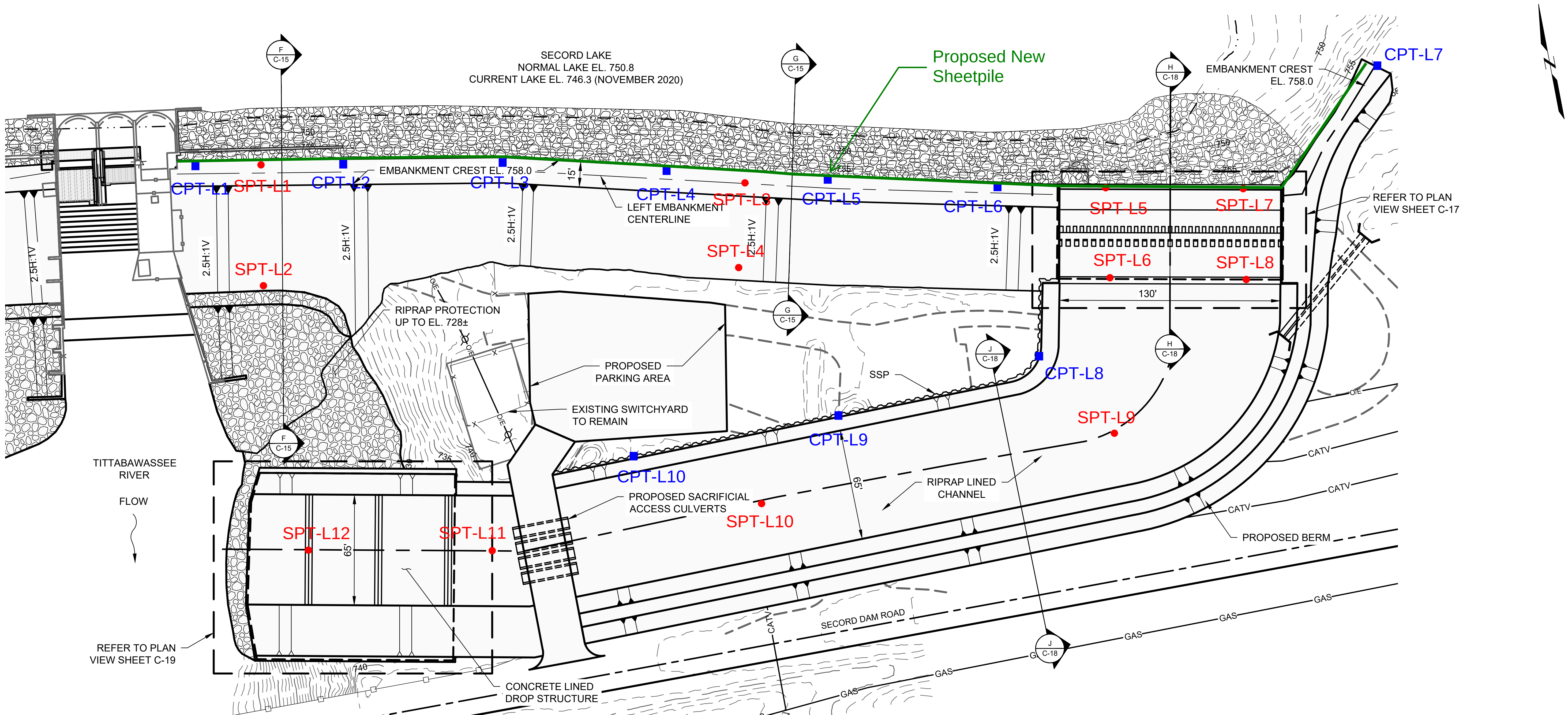

AUXILIARY SPILLWAY PLAN

0 30 60
SCALE, FEET

SPT-XX ● PROPOSED 2021 GEI BORING

■ CPT-XX PROPOSED 2021 GEI CPT

LINETYPE LEGEND

- CENTERLINE
- EDGE OF ROADWAY (UNPAVED)
- ROADWAY CENTERLINE
- BURIED PIPING
- 750 EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS
- WATER ELEVATION

HATCH LEGEND

RIPRAP

BERM FILL AREA

SYMBOLS LEGEND

1H:1V CUT SLOPE

1H:1V FILL SLOPE

Attention: If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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Approved By: B. WALTON

Four Lakes Task Force
FERC Project No. 10809

GEI Project 2002879

Secord Dam Conceptual Design
Gladwin County, Michigan

LEFT EMBANKMENT - MODIFICATIONS PLAN

DWG. NO. C-13

SHEET NO. 15

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Appendix E

Conceptual Cofferdam Designs

	Client	Four Lakes Task Force			Page	
GEI Consultants	Project	FLTF Post-May 2020 Flood Services			Pg. Rev.	
	By	M. Guay	Chk.	M. Flynn	App.	
	Date	2021-03-02	Date	2021-03-02	Date	
Project No.	2002879	Document No.				
Subject	Secord and Smallwood Dam – Cofferdam Conceptual Design					

Purpose

The purpose of this document is to present the conceptual design and rough order of magnitude costs for the cofferdam construction at Secord and Smallwood Dams.

Background

Secord Dam:

Secord Dam consists of a 650-foot-long left embankment; a 25-foot-wide powerhouse, a 43.5-foot-wide gated spillway, and an approximately 350-foot-long left embankment. The reinforced concrete spillway structure is a hollow reinforced concrete arch structure with two tainter gate bays. The left tainter gate is 20.5-feet-wide by 10-feet-high and the right tainter gate is 23.6-feet-wide by 10-feet-high. The spillway ogee crest is at elevation 742.8 feet.

Smallwood Dam:

Smallwood Dam consists of a 1,000-foot-long left embankment, a 52.2-foot-wide gated spillway, a 25-foot-wide powerhouse, and a 125-foot-wide right embankment. The reinforced concrete spillway is a hollow reinforced concrete arch structure with two tainter gate bays. The left and right tainter gate is 25.4-feet-wide by 10-feet-high. The spillway ogee crest is at elevation 694.8 feet.

Proposed Repairs at Spillway:

The proposed repairs at both dams includes partial demolition of the tainter gates to be replaced with hydraulic crest gates to increase spillway capacity. Additionally, the powerhouse will be decommissioned, and the draft tube bay converted to a low-level outlet and the remaining water passaged filled with lightweight grout or mass concrete.

Proposed Cofferdam Approach

Our conceptual design for the cofferdam consists of sheet pile cells constructed in three stages at the powerhouse and each bay. Stage 1 is constructed at the powerhouse to allow conversion to the low-level outlet while the spillway remains open to flow. Stage 1 requires an upstream cofferdam only. Stage 2 would occur at one of the bays to allow replacement of the gate and concrete repairs. The opposite bay and the outlet at the powerhouse would remain open to flow. Finally, Stage 3 would occur at the last bay and similar to Stage 2 the opposite bay and the outlet at the powerhouse would remain open to flow. Stages 2 and 3 requires upstream and downstream cofferdams.

The cofferdams will consist of steel sheet piles braced internally with three levels of wales and struts. All three levels of bracing will be required to be installed prior to dewatering, which will require some underwater installation. Sheet piles running upstream/downstream will be cut with the arch and require a closure connection between the sheet pile and concrete to create a watertight seal. The internal bracing will react against the end walls, the powerhouse structure, or the interior pier.

Our conceptual design is presented in Figures CD-01 to CD-05.

GEI Consultants	Client	Four Lakes Task Force			Page	
	Project	FLTF Post-May 2020 Flood Services			Pg. Rev.	
	By	M. Guay	Chk.	M. Flynn	App.	
	Date	2021-03-02	Date	2021-03-02	Date	
Project No.	2002879	Document No.				
Subject	Secord and Smallwood Dam – Cofferdam Conceptual Design					

Design Criteria:

Secord Dam

- 100-year HW = El. 751.5 ft
- 100-year TW = El. 710 ft
- U/S Top of Cofferdam = El. 752.5 ft (100-year + 1 ft freeboard)
- D/S Top of Cofferdam = El. 711 ft (100-year + 1 ft freeboard)
- U/S Interior Cofferdam Water = El. 720 (max dewatered)

Smallwood Dam

- 100-year HW = El. 711 ft
- 100-year TW = El. 693 ft
- U/S Top of Cofferdam = El. 712 ft (100-year + 1 ft freeboard)
- D/S Top of Cofferdam = E. 694 ft (100-year + 1 ft freeboard)
- U/S Interior Cofferdam Water = El. 680 (max dewatered)

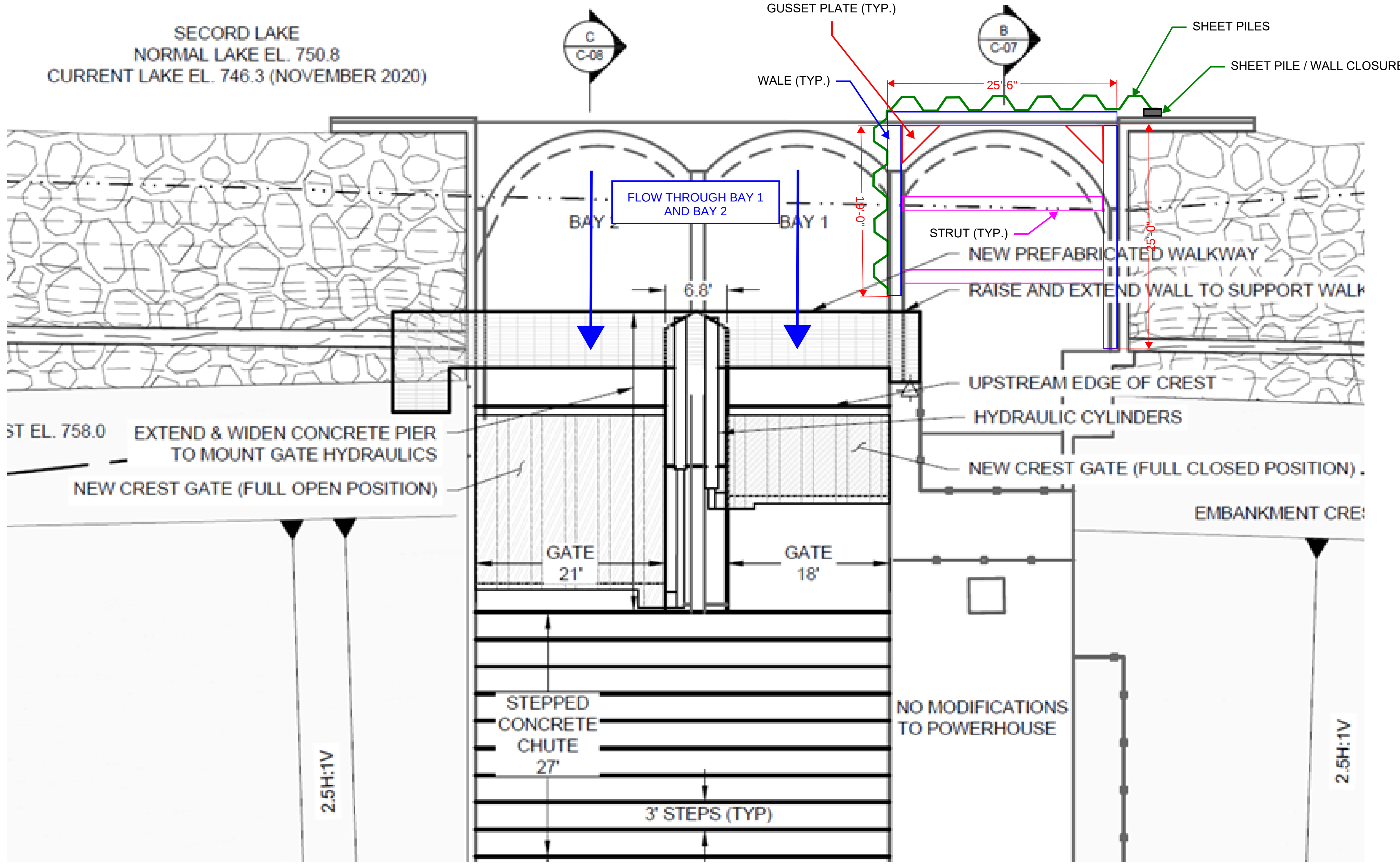
Conceptual Design:

We performed lateral analyses to estimate wall stresses and brace loading. We prepared a preliminary cofferdam layout and sized bracing and sheet piles based on our analyses. Based on our analyses, we estimate PZC-26 sheet piles or similar. There are three brace levels on the upstream cofferdam cells, the upper two levels are supported by W24 wales and struts. The lower level is supported by a double W24 wale. There are two levels of bracing on the downstream side supported by W24 wales. The downstream cofferdams for Secord Dam are about half the height of Smallwood due to the lower tailwater condition.

Based on our preliminary design, we estimate the following:

- PZC-26 Sheet Pile: 17,250 s.f. of wall, (275 tons)
- Bracing: 120 tons of steel

Based on the quantities, size and sequence indicated above, we estimate approximately $1.1 million and $1.3 million to furnish and install the cofferdams at Secord and Smallwood, respectively. Our opinion of cost is based costs from similar projects, engineering judgement, and published cost data and intended as a rough order of magnitude estimate.

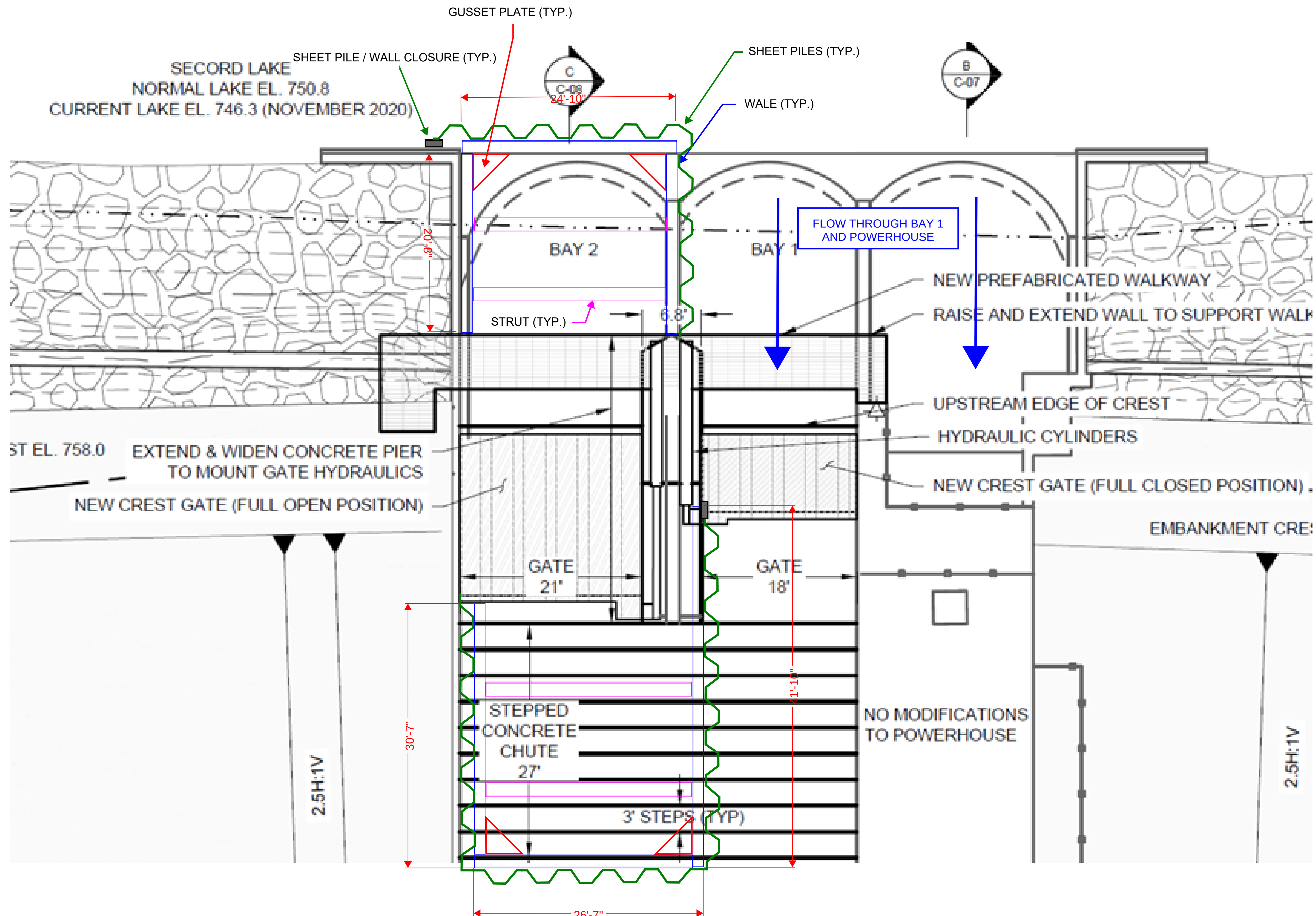


MATERIALS:

SHEET PILES: PZC-26, 50 ksi min.
WALES: W24x104 (Level 1 and 2), (2) W24x176 (Level 3), 50 ksi min.
STRUTS: W12x72 (Level 1 and 2), W24x176 (Level 3), 50 ksi min.
GUSSET PLATES: 24-Inch (Level 2 and 3), 50 ksi min.

CONCEPTUAL DESIGN ONLY

SECORD AND SMALLWOOD DAM	GEI Consultants	SECORD DAM COFFERDAM PHASE 1 PLAN: POWERHOUSE
FOUR LAKES TASK FORCE	Project 2002879	February 2020 Fig. CD-01



CONCEPTUAL DESIGN ONLY

MATERIALS:

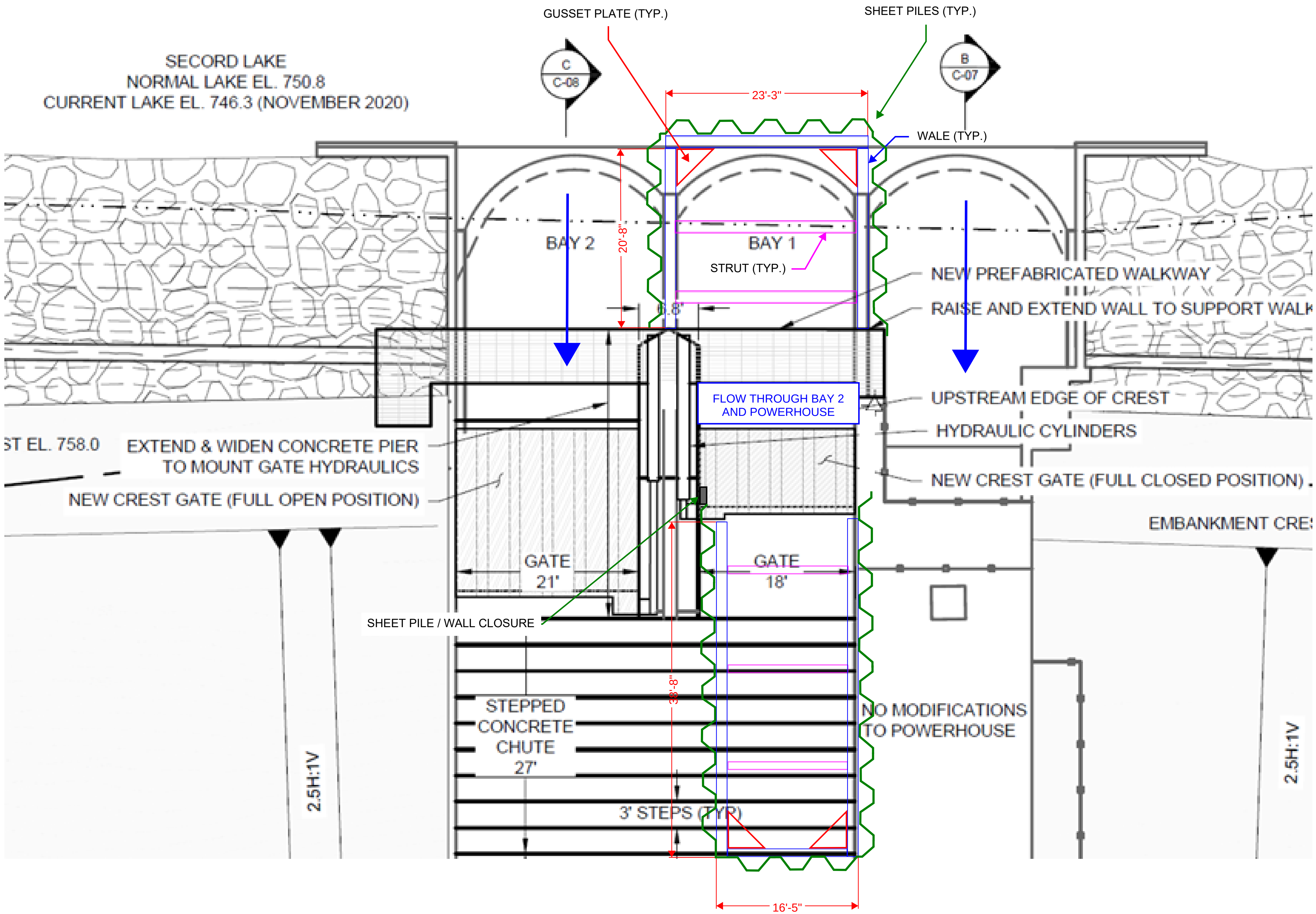
SHEET PILES: PZC-26, 50 ksi min.

WALES: Upstream: W24x104 (Level 1 and 2), (2) W24x176 (Level 3); Downstream: W24x104 (Level 1), (2) W24x176 (Level 2), 50 ksi min.

STRUTS: Upstream: W12x72 (Level 1 and 2), W24x176 (Level 3); Downstream: W12x72 (Level 1), W24x176 (Level 2) 50 ksi min.

GUSSET PLATES: Upstream: 24-Inch (Level 2 and 3); Downstream: 24-Inch (Level 2), 50 ksi min.

SECORD AND SMALLWOOD DAM	GEI Consultants	SECORD DAM COFFERDAM PHASE 2 PLAN: POWERHOUSE
FOUR LAKES TASK FORCE	Project 2002879	February 2020 Fig. CD-02



CONCEPTUAL DESIGN ONLY

MATERIALS:

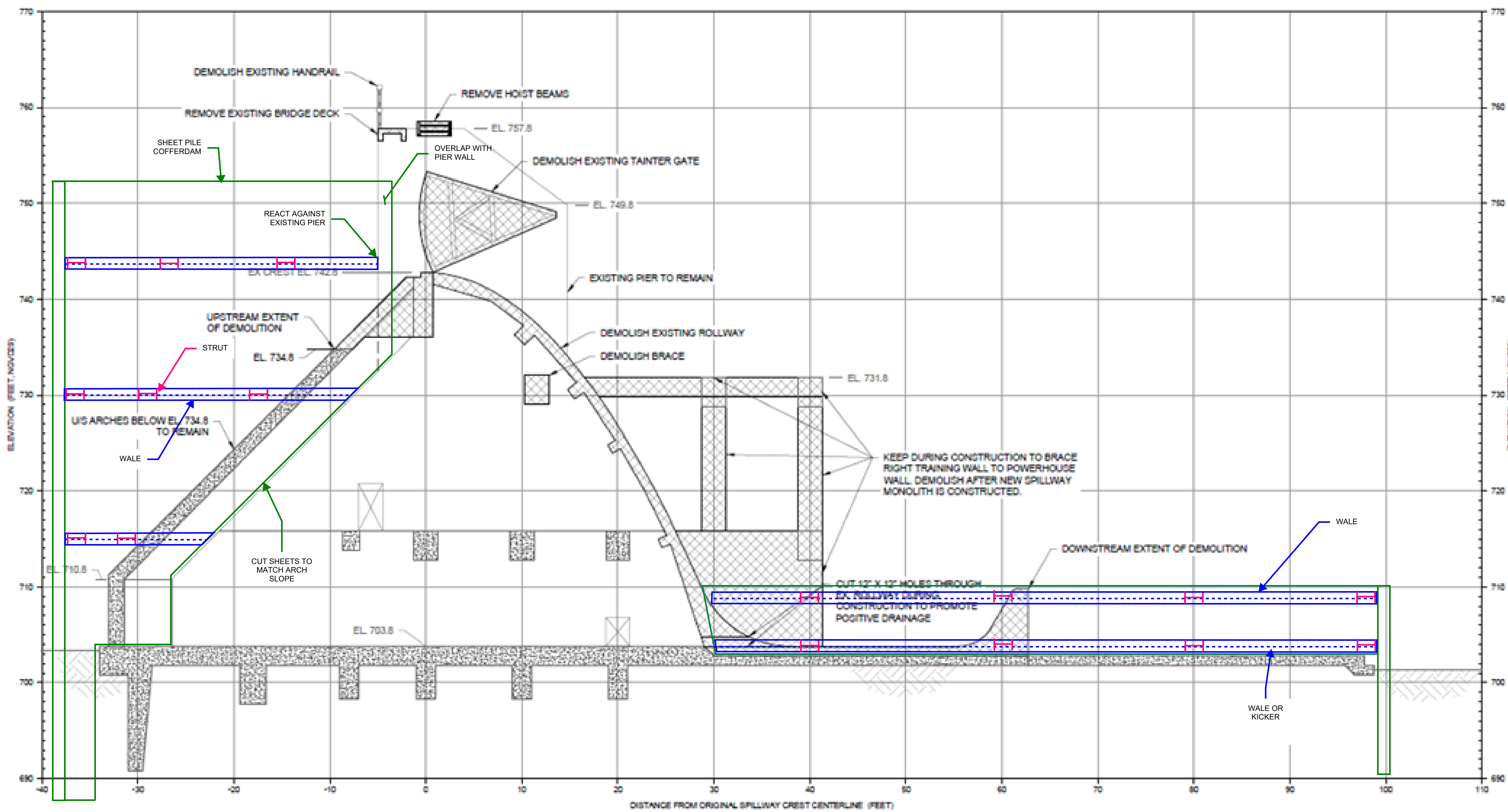
SHEET PILES: PZC-26, 50 ksi min.

WALES: Upstream: W24x104 (Level 1 and 2), (2) W24x176 (Level 3); Downstream: W24x104 (Level 1), (2) W24x207 (Level 2), 50 ksi min.

STRUTS: Upstream: W12x72 (Level 1 and 2), W24x176 (Level 3); Downstream: W12x72 (Level 1), W24x176 (Level 2) 50 ksi min.

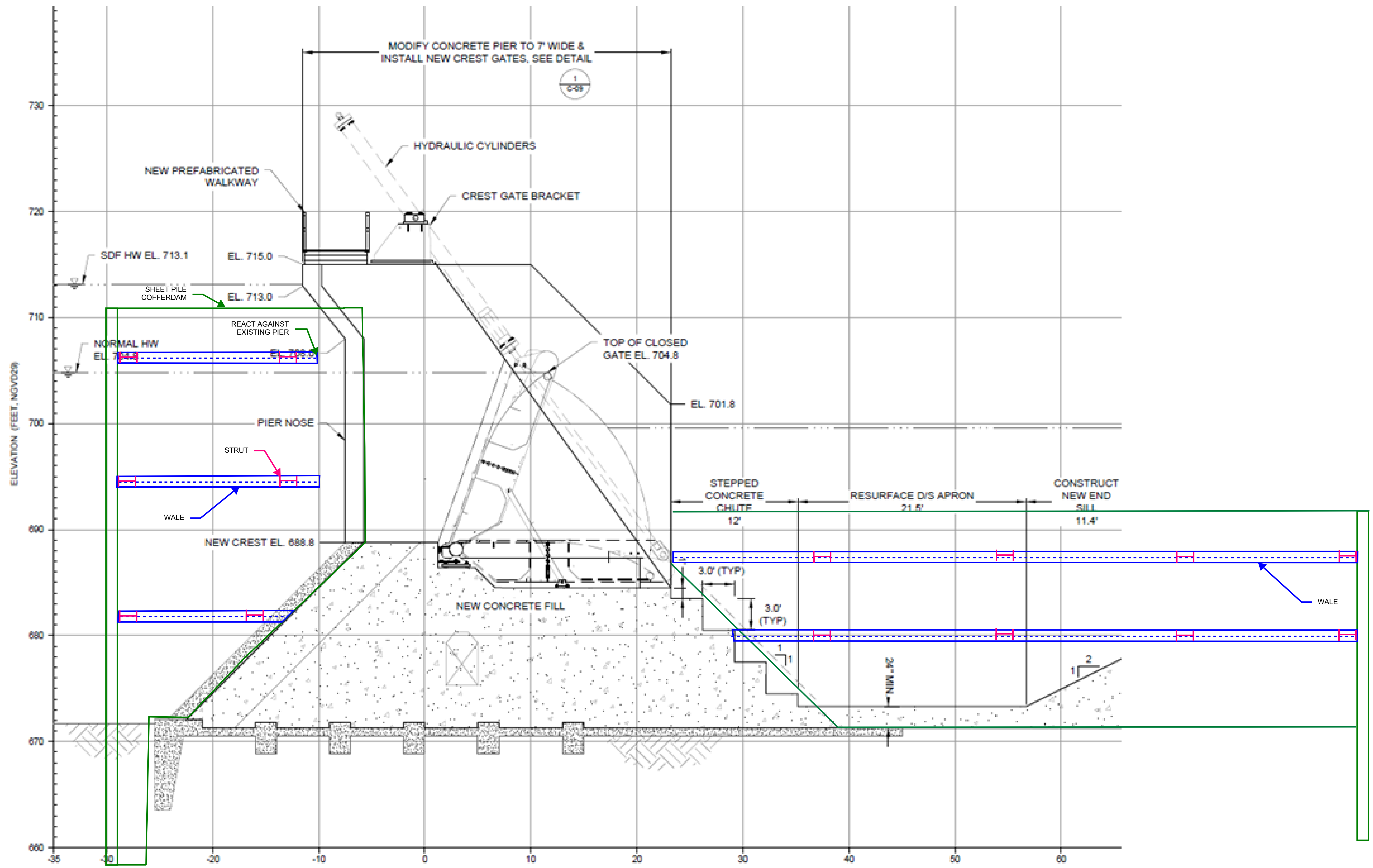
GUSSET PLATES: Upstream: 24-Inch (Level 2 and 3); Downstream: 24-Inch (Level 2), 50 ksi min.

SECORD AND SMALLWOOD DAM	GEI Consultants	SECORD DAM COFFERDAM PHASE 3: PLAN: POWERHOUSE
FOUR LAKES TASK FORCE	Project 2002879	February 2020 Fig. CD-03



CONCEPTUAL DESIGN ONLY

SECORD AND SMALLWOOD DAM	GEI Consultants	SECORD DAM COFFERDAM	
FOUR LAKES TASK FORCE	Project 2002879	February 2020	Fig. CD-04



CONCEPTUAL DESIGN ONLY

SECORD AND SMALLWOOD DAM	GEI Consultants	SMALLWOOD DAM COFFERDAM
FOUR LAKES TASK FORCE	Project 2002879	February 2020 Fig. CD-05

Appendix F

Opinions of Probable Construction Costs (OPCC) Worksheets

OPINION OF PROBABLE COST

Project: Secord Dam
Client: Four Lakes Task Force (FLTF)

Project No.: 2002879
Date: 2/8/2021
Estimated by: A. Michaud, P. Grodecki
Checked by: P. Drew, W. Walton, R. Anderson

Item	Description	Quantity	Units	Unit Price	Total Cost	Notes
0.00	**General Conditions**					
0.01	Contractor Mobilization / Demobilization	1	LS	$ 876,000	$ 876,000	5% of Other Costs
0.02	Bonds and Insurance	1	LS	$ 350,000	$ 350,000	2% of Other Costs
0.03	Construction Permits	1	LS	$ 10,000	$ 10,000	
				Subtotal	**$ 1,236,000**	
1.00	**Site Preparation**					
1.01	Erosion and Sediment Control	1	LS	$ 20,000	$ 20,000	
1.02	Temporary Access Roads, Facilities and Laydown Areas	1	LS	$ 200,000	$ 200,000	
1.03	Cofferdams	1	LS	$ 1,250,000	$ 1,250,000	
				Subtotal	**$ 1,470,000**	
2.00	**Site Demolition (Spillway & Powerhouse)**					
2.01	Powerhouse Concrete Demolition	53	CY	$ 100	$ 5,263	
2.02	Gated Spillway Demolition and Disposal	1	LS	$ 100,000	$ 100,000	
2.03	Gated Spillway Concrete Demolition	351	CY	$ 100	$ 35,077	
2.04	Mechanical and Electrical Equipment Demolition and Disposal	1	LS	$ 250,000	$ 250,000	
2.05	Mass Concrete Fill within Sluiceway	614	CY	$ 700	$ 429,612	
2.06	Reinforced Concrete Cap Above Cellular Grout Fill	8	CY	$ 700	$ 5,582	
				Subtotal	**$ 825,534**	
3.00	**Left Embankment Repair and Stabilization (L=622 FT)**					
3.01	Excavation	3,035	CY	$ 20	$ 60,698	
3.02	Sheet Pile Cutoffs	31,100	SF	$ 65	$ 2,021,500	Assumes SSP length of 50'
3.03	Embankment Fill	3,475	CY	$ 30	$ 104,264	
3.04	Filter Sand	782	CY	$ 40	$ 31,271	
3.05	Drainage Stone	590	CY	$ 40	$ 23,616	
3.06	Toe Drain	161	LF	$ 25	$ 4,025	
3.07	Upstream Riprap Protection	1,090	CY	$ 125	$ 136,264	
3.08	Geotextile	15,660	SF	$ 2	$ 31,320	
3.09	Downstream Riprap Protection	2,139	CY	$ 125	$ 267,320	
3.10	Bedding Stone	234	CY	$ 45	$ 10,534	
3.11	Crest Gravel	173	CY	$ 35	$ 6,047	
3.12	Topsoil, Seed and Temporary Erosion Protection	575	CY	$ 45	$ 25,855	
				Subtotal	**$ 2,722,715**	
4.00	**Right Embankment Repair and Stabilization (L=336 FT)**					
4.01	Excavation	133	CY	$ 20	$ 2,660	
4.02	Sheet Pile Cutoffs	16,800	SF	$ 65	$ 1,092,000	Assumes SSP length of 50'
4.03	Embankment Fill	1,770	CY	$ 30	$ 53,094	
4.04	Filter Sand	1,029	CY	$ 40	$ 41,174	
4.05	Drainage Stone	782	CY	$ 40	$ 31,267	
4.06	Toe Drain	100	LF	$ 25	$ 2,500	
4.07	Upstream Riprap Protection	578	CY	$ 125	$ 72,289	
4.08	Geotextile	11,136	SF	$ 2	$ 22,272	
4.09	Downstream Riprap Protection	2,331	CY	$ 125	$ 291,425	
4.10	Bedding Stone	410	CY	$ 45	$ 18,463	
4.11	Crest Gravel	93	CY	$ 35	$ 3,267	
4.12	Topsoil, Seed and Temporary Erosion Protection	391	CY	$ 45	$ 17,578	Assumed to be 6" thick
				Subtotal	**$ 1,647,989**	
5.00	**New Crest Gated Spillway and Outlet Works**					
5.01	Mass Concrete (includes Stepped Rollway)	2,689	CY	$ 700	$ 1,882,041	
5.02	Reinforced Concrete Downstream Apron	170	CY	$ 700	$ 118,844	
5.03	Reinforced Concrete End Sill	178	CY	$ 700	$ 124,606	
5.04	Reinforced Concrete Structure Piers	112	CY	$ 900	$ 100,809	Assumes existing piers remain.
5.05	Crest Gates - Installed with Hoists and Controls	2	EA	$ 750,000	$ 1,500,000	Pricing from Steel Fab
5.06	Steel Frame Operators Deck	1	LS	$ 750,000	$ 750,000	
5.07	Raised and Extended Left & Right Concrete Training Walls	73	CY	$ 900	$ 65,478	
				Subtotal	**$ 4,541,778**	
6.00	**Powerhouse Rehabilitation**					
6.01	Misc. surface concrete and masonry repairs	1	EA	$ 200,000	$ 200,000	
6.02	Convert water passages to low level outlet	1	EA	$ 500,000	$ 500,000	
6.03	Head Gate and Hoist	1	EA	$ 300,000	$ 300,000	Pricing from Steel Fab
				Subtotal	**$ 1,000,000**	
7.00	**New 130' Auxiliary Spillway**					
7.01	Excavation	6,287	CY	$ 20	$ 125,750	
7.02	Reinforced Concrete Sill Slabs	220	CY	$ 700	$ 153,925	
7.03	Reinforced Concrete Chute Slabs	134	CY	$ 700	$ 94,067	
7.04	Reinforced Concrete Stilling Basin Floor Slabs	290	CY	$ 700	$ 202,829	
7.05	Reinforced Concrete Energy Dissipators	9	CY	$ 700	$ 6,494	
7.06	Reinforced Concrete End Sill	20	CY	$ 700	$ 13,953	
7.07	Flashboards and Stanchions	1	LS	$ 50,000	$ 50,000	
7.08	Reinforced Concrete Spilllway and Stilling Basin Walls	45	CY	$ 700	$ 31,642	
7.09	Steel Sheet Pile Cutoffs (Add downstream to quantity and side walls, update dra	9,555	SF	$ 65	$ 621,075	
7.10	Upstream Riprap	486	CY	$ 125	$ 60,811	
7.11	Bedding	122	CY	$ 45	$ 5,473	
7.12	Geotextile	7,073	SF	$ 2	$ 14,146	
7.13	Filter Sand	385	CY	$ 40	$ 15,388	
7.14	Drainage Stone	398	CY	$ 40	$ 15,925	
7.15	Drain Pipe (Solid and Slotted)	150	LF	$ 25	$ 3,750	
				Subtotal	**$ 1,415,229**	
8.00	**New Discharge Channel and Drop Structure for Auxiliary Spillway**					
8.01	Excavation	25,738	CY	$ 20	$ 514,756	
8.02	Downstream Heavy Riprap (Riprap Lined Channel)	8,230	CY	$ 125	$ 1,028,773	
8.03	Geotextile	51,555	SF	$ 2	$ 103,110	
8.04	Right SSP wall for erosion protection	7,020	SF	$ 65	$ 456,300	
8.05	Left Ditch Culverts	160	LF	$ 100	$ 16,000	
8.06	Left Berm	447	CY	$ 40	$ 17,871	
8.07	Sacrificial Access Bridge - Crushed Stone	2,245	CY	$ 45	$ 101,008	
8.08	Sacrificial Access Bridge - Culverts	160	LF	$ 100	$ 16,000	
8.09	Drop Structure - Concrete Slabs	1,206	CY	$ 700	$ 844,109	
8.10	Drop Structure - Granular Drainage Stone	603	CY	$ 45	$ 27,135	
8.11	Drop Structure - SSP Cutoff	9,000	SF	$ 65	$ 585,000	
8.12	Drop Structure - Structural Fill	419	CY	$ 35	$ 14,673	
8.13	Drop Structure - Heavy Riprap	108	CY	$ 125	$ 13,489	
8.14	Drop Structure - Bedding Stone	22	CY	$ 45	$ 1,012	
				Subtotal	**$ 3,739,237**	
9.00	**Site Restoration**					
9.01	Place Overburden, Seed, Fertilize, and Mulch Slopes	1	LS	$ 100,000	$ 100,000	
9.02	Dam Safety Monitoring Instrumentation	1	LS	$ 50,000	$ 50,000	
				Subtotal	**$ 150,000**	
	Subtotal				$ 18,748,481	
	Contingency			25%	$ 4,687,000	
	Construction Subtotal				**$ 23,435,481**	
	Engineering, Site Investigations, Design (GEI) and Construction Engineering	-	-		**$ 1,700,000**	
	Total Estimated Cost				**$ 25,135,481**	
				say	**$ 25,136,000**	

Information presented on this sheet represents our opinion of probable costs in 2021 dollars. Unit and lump-sum prices are based on costs for similar projects, engineering judgment, and/or published cost data. Client administrative/engineering costs and regulatory fees not included. Actual bids and total project costs may vary based on contractor's perceived risk, site access, season, market conditions, etc. No warranties concerning the accuracy of costs presented herein are expressed or implied.