merjent

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August 6, 2021

To:

Brian Grennell, Cultural Resources Management Coordinator
State Historic Preservation Office
300 North Washington Square
Lansing, MI 48913

From:

Robb Roos, Project Manager and Senior Environmental Analyst
Mike Madson, Senior Cultural Resources Specialist
Angela Julin, Cultural Resources Specialist

Subject:
Four Lakes Task Force: Edenville Dam Rehabilitation
Edenville Dam, Gladwin and Midland Counties, Michigan

Dear Mr. Grennell:

With this letter Four Lakes Task Force (FLTF) provides your office information on the efforts to stabilize the Edenville Dam in Gladwin and Midland Counties, Michigan. The Edenville Dam is located on the Tittabawassee and Tobacco Rivers in the town of Edenville, Michigan, approximately 22 river miles upstream of the City of Midland, Michigan (see Figure 1 and Figure 2, attached). The facility is owned and operated by the FLTF. Construction of the dam was completed in 1925 to provide storage and headwater control for the purpose of hydroelectric power generation.

From left to right, the Tittabawassee River portion of the project consists of a 680-foot-long left embankment with a minimum crest at El. 682.1, a 68.6-foot-wide gated spillway with three Tainter gates, a 50.6-foot-wide powerhouse containing two turbine generating units with a combined rated capacity of 6 MW with an operating head of 45 feet, and a 2,800-foot-long right embankment that extends to the Michigan M-30 Highway embankment to the west.

From left to right and prior to the May 2020 breach, the Tobacco River portion of the project consisted of a 520-foot-long left embankment with a minimum dam crest at El 683.1, a 72.2-foot-wide gated spillway with three Tainter gates, and a 2,050-foot-long right embankment that extends to Hunter Road. The Edenville Dam structures impound Wixom Lake and the dam is classified as having a high hazard potential based on estimated downstream impacts in the event of a failure.

Merjent, Inc. is a subcontractor to FTLF's consultant Spicer Group. In April 2021 Merjent archaeologists initiated an archaeological survey of the Edenville Dam, and the results of that survey are pending. An architectural history review was not part of our scope, but it now appears that consideration of Edenville Dam's structural components is now of interest to parties consulting with the FLTF, most notably the Natural Resources Conservation Service (NRCS). Recently, NRCS advised FLTF to communicate with your office on the measures being taken to stabilize failed dams across the FLTF area of concern. This includes interim and long-term

proposed rehabilitation measures at the Edenville Dam. The proposed rehabilitation efforts for the Edenville Dam are depicted on the Edenville Dam Conceptual Design which is provided as **Appendix A**. These plans depict the proposed work that is discussed within the narrative sections of this report.

Tittabawassee Tainter Gate Spillway

The reinforced concrete spillway is a hollow reinforced concrete arch structure with three Tainter gate bays. The left gate (Bay 6) is 23.6-feet-wide by 9.5-feet-high and the center and right Tainter gates (Bay 5 and Bay 4) are 20.0-feet-wide by 9.5-feet-high (see Photo 1). The gates are operated by hydraulically operated chain and single cable hoist and reel system with the operators located directly adjacent to the hoist above each gate on an elevated platform. The gates are now fully open and dogged off and flows currently pass through the breach channel.

Photo 1. Tittabawassee Spillway upstream, on May 25, 2021 after completion of initial stabilization modifications.

Tittabawassee Powerhouse

The powerhouse is located immediately to the right of the Tittabawassee Tainter Gate Spillway. The powerhouse is approximately a 50.6-foot-wide powerhouse containing two generating units with a combined rated capacity of 6 MW (see photo 2). The normal headwater and tailwater pools at the Edenville Spillway are 675.8 and 630.8 feet, respectively.

Photo 2. Tittabawassee Spillway and Powerhouse downstream, October 2020.

Tittabawassee Embankments

The (former) left embankment was approximately 680-feet long, with maximum structural height of 46 feet near the spillway (see Photo 3). The embankment was reportedly constructed of native, poorly graded sand from onsite sources. The embankment slopes are 2.5H:1V on the upstream slope and 2H:1V on the downstream slope. Riprap protection was placed along the upstream slope of the embankment. A failed steel sheet pile cutoff wall once extended from the left upstream side of the Tainter gate spillway into the upstream slope of the left embankment for approximately 80 feet. The remaining right embankment is approximately 2,800-feet long, with a maximum structural height of 46 feet near the spillway. The embankment slopes are 2.5H:1V on the upstream slope and 2H:1V on the downstream slope. Riprap protection is placed along the upstream slope of the embankment. A steel sheet pile cutoff wall extends from the left upstream side of the spillway into the upstream slope of the left embankment for a distance of approximately 65 feet. A toe filter drain was constructed by the previous owner on the downstream slope of the right embankment in 2005 due to observed seepage. The original embankment plan overlain on a 2020 aerial is provided as Figure 3 (attached).

Photo 3. Left embankment along the Tittabawassee Reach of the Edenville Dam.

Tobacco Tainter Gate Spillway

The reinforced concrete spillway is a hollow reinforced concrete arch structure with three Taintergate bays. The left gate (Bay 3) and right gate (Bay 1) are 23.6-foot-wide by 9.5-feet-high and the center Tainter gate (Bay 2) is 20.0-feet-wide by 9.5-feet-high. The gates are operated by hydraulic hoist with the operators located directly adjacent to the hoist above each gate on an elevated platform. The normal headwater and tailwater pools at Tobacco Spillway are El. 675.8 and 630.8 feet, respectively. At the time of this report, the three Tainter gates have been removed and modifications completed to get the Tobacco River flowing, over a lower ungated concrete broad-crested weir, to its original channel (see Photo 4).

Photo 4. The Tobacco River reach of the Edenville Dam on March 30, 2021 after completion of initial stabilization modifications.

Tobacco Embankments

The left embankment is approximately 520-feet long, with maximum structural height of 37 feet near the spillway (see Photo 5). The embankment was reportedly constructed of native, poorly graded sand from onsite sources. The embankment slopes are 2.5H:1V on the upstream slope and 2H:1V on the downstream slope. A steel sheet pile cutoff wall extends from the left upstream side of the spillway into the upstream slope of the left embankment for a distance of approximately 77 feet. A toe filter drain was constructed by the previous owner on the downstream slope of the right embankment in 2005 due to observed seepage.

The right embankment is approximately 2,050-feet long, with a maximum height of 46 feet near the spillway (see Photo 6). The embankment was constructed of native, poorly graded sand from onsite sources. The embankment slopes are 2.5H:1V on the upstream slope and 2H:1V on the downstream slope. A steel sheet pile cutoff wall extends from the left upstream side of the spillway into the upstream slope of the left embankment for a distance of approximately 75 feet. In addition, there is a short steel sheet pile section in the upstream slope of the right embankment located approximately 900 feet to the right (west) of the Tobacco spillway. A toe filter drain was constructed by the previous owner on the downstream slope of the right embankment in 2005 due to observed seepage. The original embankment plan overlain on a 2020 aerial is provided as Figure 3 (attached).

Photo 6. Right embankment overview facing east, on the east side of the Tobacco reach of the Edenville Dam.

Edenville Dam Failure

Over a two-day period from May 16 to May 18, 2020, the Tittabawassee and Tobacco River watersheds incurred heavy rainfall totals, ranging from 6 to 8 inches concentrated in Gladwin and Midland Counties. Saturated ground conditions combined with additional rainfall starting in the evening of May 18th through the early afternoon of May 19th, 2020, resulted in the Tittabawassee and Tobacco Rivers surpassing flood stages in many areas. During the flood event, Boyce opened all six (6) Tainter Gates (Tobacco Bays No. 1 through No. 3, and Tittabawassee Bays No. 4 through No. 6) were opened (8 feet to 9 feet) to keep up with the flows of the Tittabawassee River. At approximately 5:30 p.m. Eastern Standard Time (EST), the Wixom Lake water surface elevation rose to El. 680.6 within 1.5 feet of the embankment crest (El. 682.1) and a portion of the left embankment failed due to saturation of the downstream shell and excessive seepage gradients that resulted in a downstream slope failure that breached the dam crest and caused an uncontrolled release of the reservoir. The internal erosion failure of the left embankment resulted in a breach channel that extended approximately 500 feet from the left abutment to immediately adjacent to the Tittabawassee Tainter gate spillway. The flood wave was conveyed south through approximately 1,300-feet long, 400-foot-wide and 40-feet-deep (from the former embankment crest) breach channel formed by the failure. The left embankment failure and breach channel are illustrated in Photo 7.

Photo 7. Edenville Dam Embankment Failure

During the failure, the Tittabawassee River side of the impoundment drained rapidly. Increased flow and velocities resulted in the scour and erosion of the embankments. The headwaters of the Tobacco River bypassed the limited capacity of the Tobacco Tainter gate spillway and head cut a breach channel that extended from the M-30 Bridge to the Tittabawassee River breach channel. The downstream embankment adjacent to the concrete training walls and toe of the embankment were severely damaged from high tailwater circulation, splash, and spray erosion above the downstream training walls. The splash and spray and high tailwater elevation resulted in significant erosion and loss of embankment material on the downstream embankment slope flanking the spillways with tailrace training wall lengths and heights.

Photo 8. Tittabawassee Reach overview post-flood, October 2020.

Reservoir Operations

Prior to the failure, the project was operated as a “run-of-river.” Per the former FERC license, the reservoir is to be operated at a summer and winter elevation with three feet of difference. The summer headwater level is maintained higher with the normal summer level at elevation 675.8 feet. The winter headwater level is maintained lower with the normal winter level at elevation 672.8 feet. Currently, the Tainter gates are in the fully open position and Tittabawassee River bypasses the Tainter gate spillway through the breach channel at approximate Wixom Lake. The Tobacco River is currently passing through the Tobacco spillway at approximate Wixom Lake.

Edenville Dam Stabilization

The ongoing Edenville Dam interim stabilization consists of two construction phases as part of the State of Michigan EGLE, Water Resources Division Conditional Permit (Emergency Permit). The permit was issued on November 19, 2020, and includes permit conditions for Wixom Lake (Edenville Dam impoundment), and the Tobacco and Tittabawassee Rivers. Phase I construction of the Edenville Dam stabilization is currently underway on the Tobacco spillway and includes lowering the existing Tainter gate spillway, reinforcing the training walls and restoring the natural flow path of the Tobacco River. The Phase I construction is expected to be completed in in Summer 2021 (see Photo 9).

Photo 9. Phase I Interim Stabilization at Tobacco Spillway

Phase II stabilization encompasses the Tittabawassee reach of the Edenville Dam. The primary goal of the Phase II stabilization task is to divert the Tittabawassee River flow from the current breach channel to the natural flow path through the existing spillway and river channel. Phase II is being designed under the FLTF in close coordination with EGLE. GEI is currently developing an alternatives analysis of four (4) potential stabilization approaches for the project. The four proposed stabilization alternatives are presented in Table 1. Alternative No. IV is the current preferred alternative that is being progressed toward final design and includes demolishing the Tainter gate spillway, stabilizing the powerhouse and training walls and constructing a rock-filled berm with steel sheet pile in the left embankment breach channel. The recommended Alternative No. IV is illustrated in Figure 4 below.

TABLE 1.

Proposed Alternatives for Edenville Dam Interim Stabilization

Alternative	Description
I	Demolish powerhouse, spillway bays, and counterfort training walls down to the concrete slab. Concrete slab and apron to remain. Spillway side slopes graded with riprap and bedding; rock-filled berm to El. 652.0.
II	Demolish left training wall and Tainter gate spillway down to the concrete slab. Concrete slab, apron, and powerhouse to remain. Left spillway side slope graded with riprap bedding; rock-filled berm to El. 652.0.
III	Demolish left half powerhouse and Tainter gate spillway down to the concrete slab. Left training wall, counterforts, concrete slab, apron, and left half of powerhouse to remain. Existing embankment excavated to El. 662.0; rock-filled berm at El. 652.0.
IV	Demolish Tainter gate spillway down to the concrete slab. Left training wall, counterforts, concrete slab apron, and powerhouse to remain. Existing embankment excavated to El. 662.0; rock-filled berm at El. 652.0.

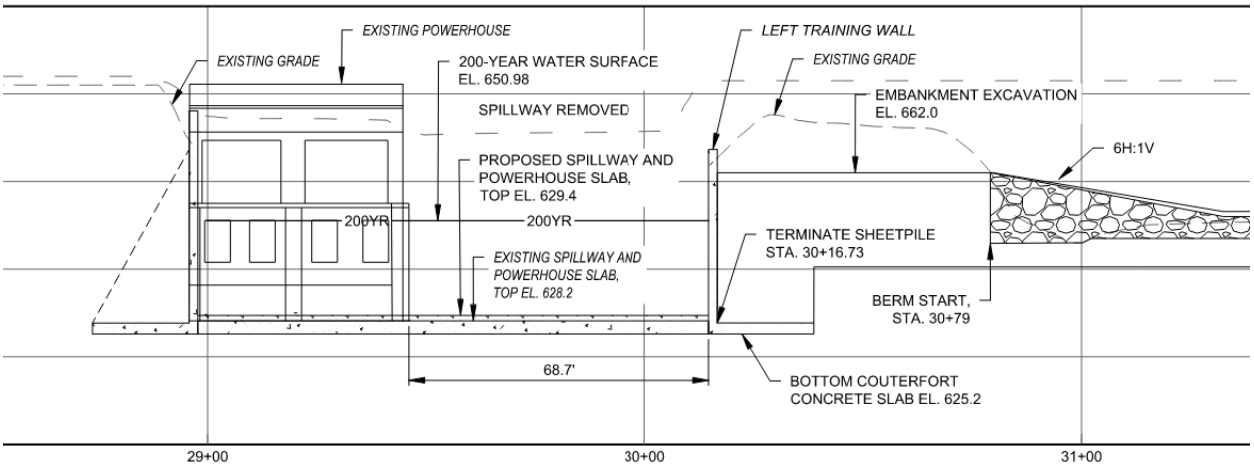


Figure 4. Phase I Interim Stabilization Alternative IV Elevation View

SUMMARY OF DAM REPAIRS AND FLOOD CAPACITY UPGRADES

Primary Spillway Modifications

The Edenville Tainter gate spillway and powerhouse will be demolished and the three (3) Tainter gate spillway bays will be replaced with hydraulically operated crest gates at sill El. 659.8 to increase the spillway capacity. Each gate will be 24-feet wide by 16-feet high. The hydraulic gate operators will be supported on new, reinforced concrete piers. The gates will discharge into a concrete rollway and new reinforced concrete stilling basin. The leftmost powerhouse bay will be converted into an additional crest gate bay and the rightmost draft tube bay converted to a low-level outlet. Remaining sections of hollow bays and water passages will be filled with mass concrete.

The Tobacco Dam Tainter gate spillway will be partially demolished and the three (3) Tainter gates will be replaced with automated hydraulically operated crest gates at El. 659.8 to increase spillway capacity. The left and right crest gates (Bay No. 3 and Bay No. 1) will be 18.3-feet wide by 16-feet high and the center crest gate (Bay No. 2) will be 15.5-feet wide by 16-feet high. A new low-level outlet structure will be constructed as a means to pass base river flow.

Auxiliary Spillway

A new reinforced concrete 250-foot-wide 12-cycle labyrinth auxiliary spillway will be constructed at El. 678.0 within the former left embankment of the Edenville Dam to provide additional spillway capacity during the ½ PMF + design storm. The proposed spillway structure will discharge through a 250-foot-wide concrete spillway chute. The new chute slope would be constructed at 2.5H:1V. To meet current freeboard requirements, the new chute walls will vary from approximately 30-feet high downstream of the labyrinth spillway to approximately 20-feet high in the steep portion of the chute. The new chute reinforced concrete slab would be a minimum of 2-feet thick and would have an upstream sheet pile cutoff extended into the glacial till foundation and would include an appropriate sand filter and gravel underdrainage system to reduce hydrostatic uplift. A concrete cutoff wall would also be constructed at the downstream end of the auxiliary spillway chute for scour protection. The overflow spillway will discharge into a 250-foot wide USBR Type III stilling basin to dissipate energy and to reduce scour and erosion in the discharge channel. Further

downstream of the stilling basin, the ½ PMF + design storm is routed approximately 1,200 feet downstream to the confluence with the Tittabawassee River through the Edenville Dam breach channel.

Powerhouse Modifications to Provide a Low-Level Outlet

As highlighted by the ongoing ice issues experienced at the upstream Secord Dam during the winter of 2020 / 2021, it is crucial to develop a reliable low-level outlet design to pass base flows in the winter at the Edenville Dam to minimize active daily ice management. For the long-term reconstruction, we are proposing to retrofit the existing powerhouse to pass base flows (200 to 300 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. The low-level outlet conceptual design was developed by GEI, Essex and SGI. The proposed low-level outlet design consists of the following:

- Demolish the leftmost turbine bay.
- Fill the abandoned sluice bay below the rightmost right powerhouse intake with either cellular grout or mass concrete.
- The total impoundment drawdown potential is from El. 675.8 to El. 647.2 ±.
- Construct new vertical slide gates with integrated bulkhead slots upstream of existing head gate.
- Remove the generator, turbine shaft, and wicket gates.
- Construct a new steel bulkhead over the runner pit in the powerhouse floor slab.
- Affix (weld) the runner in place to the new bulkhead.
- Re-establish the trash racks upstream of the vertical slide gates.
- The upstream slide gates will be used to throttle base flows to pass 200 to 300 cfs.
- The upstream bulkhead and head gate will allow for full de-watering for maintenance and inspections of the downstream water passages.

Tobacco Low-Level Outlet

The low-level outlet for the Tobacco River side could be a HDPR siphon over the crest of the dam designed to pass 200 to 300 cfs, or a low-level outlet could be installed in a mass pour under one of the crest gates.

EMBANKMENT MODIFICATIONS

The former left embankment will be re-constructed with a minimum 15-foot crest width at El. 685.5 and minimum 2.5H:1V upstream and downstream slopes to provide adequate stability in accordance with EGLE stability requirements under normal and flood pool loading criteria. A hot-rolled steel sheet pile cutoff with interlock sealants will be provided along the upstream edge of the crest and be founded in the clay glacial till to provide a continuous seepage cutoff. A vertical filter sand chimney immediately downstream of the sheet pile cutoff and a horizontal filter and blanket drain will be provided under the downstream embankment shell to provide additional

seepage conveyance and protection against seepage-induced internal erosion. Appropriately sized riprap and bedding layers to prevent internal erosion (e.g., nonwoven geotextile under bedding stone under the upstream slopes and reverse sand the gravel layer under the bedding stone on downstream slopes) will also be provided along the upstream and downstream slopes to protect against drawdown, wave-induced erosion and high tailwater, respectively. The former right embankment will be reconstructed with a new permanent steel sheet pile cutoff and extend into the clayey glacial till to provide a seepage cutoff.

Embankment Fill

New embankment fill will be used to reconstruct the downstream slope of the embankment sections. The embankment fill will consist of material either salvaged from on-site excavations or imported from an approved off-site source, as required. All cobbles greater than 2/3 the lift thickness (e.g., remove cobbles larger than 8 inches for 12-inch lifts) will be screened out. The embankment fill 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 term 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.

Reverse Filter and Toe Drain

A vertical chimney drain and horizontal blanket drain consisting of filter sand and drainage stone will be constructed downstream of the sheet pile cutoff and at the embankment – foundation contact, respectively, to mitigate against seepage and internal erosion of the embankment and foundation soils. The toe drain will generally consist of 18 inches of fine filter (MDOT 2NS natural sand) and 24 inches of coarse filter (MDOT 29A stone). The seepage will be collected in a minimum 8-inch diameter slotted 0.1 inch) flexible HDPE pipe 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 volume and potential fines movement can be collected and monitored.

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 apron 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 upstream riprap and bedding subgrades, the bedding material can be placed on non-woven geotextile.

EDENVILLE DAM ARCHITECTURAL HISTORY

Frank Wixom founded the Tittabawassee Power Company in 1906 with a vision to dam the Tittabawassee and Tobacco River to provide cheap electricity to farmers and the local community, and to create a recreational area for the greater region. Although the initial plans were not financially feasible at the time for Wixom’s power company, the Wolverine Power Company was formed in 1923, with Wixom as president. Sponsored by Wolverine Power Company, construction of the Edenville Dam, designed by consulting engineers Holland, Ackerman & Holland, was

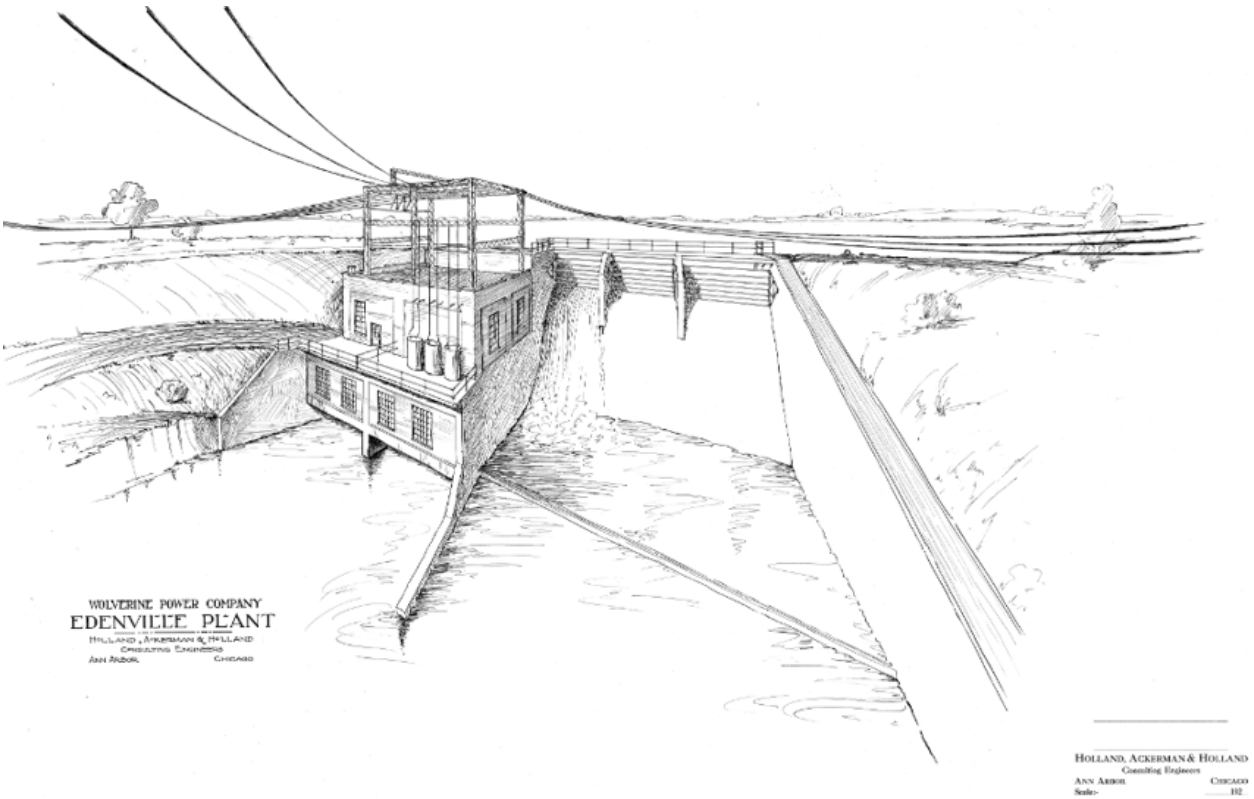
completed in 1925 to provide storage and headwater control for the purpose of hydroelectric power generation.

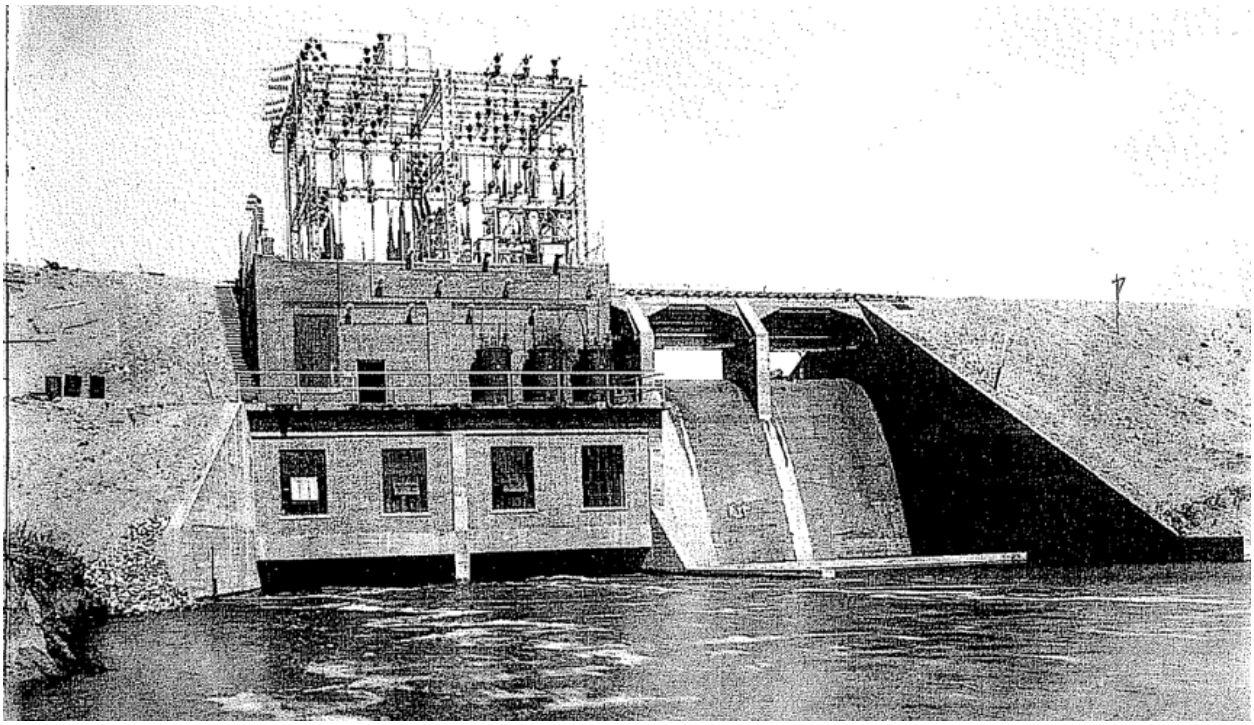
FLTF maintains a collection of historic Photos taken during the construction of the of the Edenville Dam, as well as sheets of construction plans and improvements (1920s), as-builts (1930s), and common lifecycle modifications (into the 2000s).

Edenville Dam as a Cultural Resource

To understand the eligibility of the Edenville Dam as a cultural resource, all built components of the dam were considered, including both spillways, the powerhouse, and the earthen embankments. None of these elements have previously been evaluated for inclusion on the National Register of Historic Places (NRHP). According to historic documentation on file with the FLTF, modifications to the original spillway structures began as early as 1929 and continued in to the 2000s. Interim stabilization efforts under the emergency provisions have altered both original and historically modified spillway components, including, but not limited to, the addition of multiple new paving slabs and the repair and replacement of paving slabs and training walls. Interim stabilization efforts under the emergency provisions have altered both original and historically modified spillway components. All pre-disaster modifications were performed by Wolverine Power Company, followed by Boyce Hydro. Modifications extended to the earthen embankments, which were heavily impacted by the flooding events, eroding and removing large portions of the embankments during the flooding. Visual inspection of the berms did not reveal any exposed structures or associated historic debris along the Edenville embankments. A file search did not return information on the application of federal funds, licenses, or other permits related to these modifications. The Michigan Department of Environment, Great Lakes, and Energy (EGLE), which since 2018 has regulated the Edenville Dam, assumed authority under the emergency provisions of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). EGLE has been working to address the stability of the Edenville Dam earthen embankments and the natural resources impacts associated with the diversion of the Tobacco and Tittabawassee Rivers through the breach in the dam.

The Edenville Dam appears to be a specification-design typically utilized by hydroelectric dam engineers, such as Holland, Ackerman & Holland, in the first half of the 20th century. Construction Photos and period construction plans and as-builts in the hands of FLTF show common design and construction methods, shown below in Figure 5 and Photo 10.


WOLVERINE POWER COMPANY
EDENVILLE PLANT
HOLLAND, ACKERMAN & HOLLAND
CONSULTING ENGINEERS
ANN ARBOR
CHICAGO
HOLLAND, ACKERMAN & HOLLAND
Consulting Engineers
ANN ARBOR
CHICAGO



There are more than 50 hydroelectric dams in Michigan, which provide approximately 1.5% of Michigan's energy. Four of these facilities are listed on the NRHP. The Cooke Dam, constructed on the Au Sable River in 1911, is listed due to presence of associated outbuildings, including a powerhouse, substation, storage shed, and Classic-Revival style Attendant's House. The Croton Dam on the Muskegon River is listed on the NRHP as it attracted international attention in 1907 due to the 110,000-volt transmission line, which was the highest in use at that time. The Five Channels Dam, constructed in 1912, is listed on the NRHP as a District, which was known for its associated 45-acre worker's camp, which is also listed on the NRHP as an archaeological site. The Hardy Dam was constructed in 1931 and at the time was one of the largest earthen dams in the United States. Two additional dams are listed as Michigan State Historic Sites, including the Rugg Pond Dam constructed in 1904 on the Rapid River which was constructed with materials delivered via wagon and lists Ernest Hemingway as a notable guest. The other, the Mio Dam on the Au Sable River, was constructed in 1916 and is unique for its conduit spillways underneath the powerhouse foundation which paved the way for design innovations in icy rivers.

Of the hydroelectric dams in Michigan, most were constructed in the second quarter of the 20th century. To determine the presence of distinguishing features that might inform the significance of the Tobacco Spillway, Merjent reviewed four other dams designed by Holland, Ackerman and Holland, all constructed between 1922 and 1927. These dams include the Chalk Hill Dam, the Victoria Dam, the Union City Dam, and the Quaker Mill Dam (see Table 2 below).

TABLE 2.

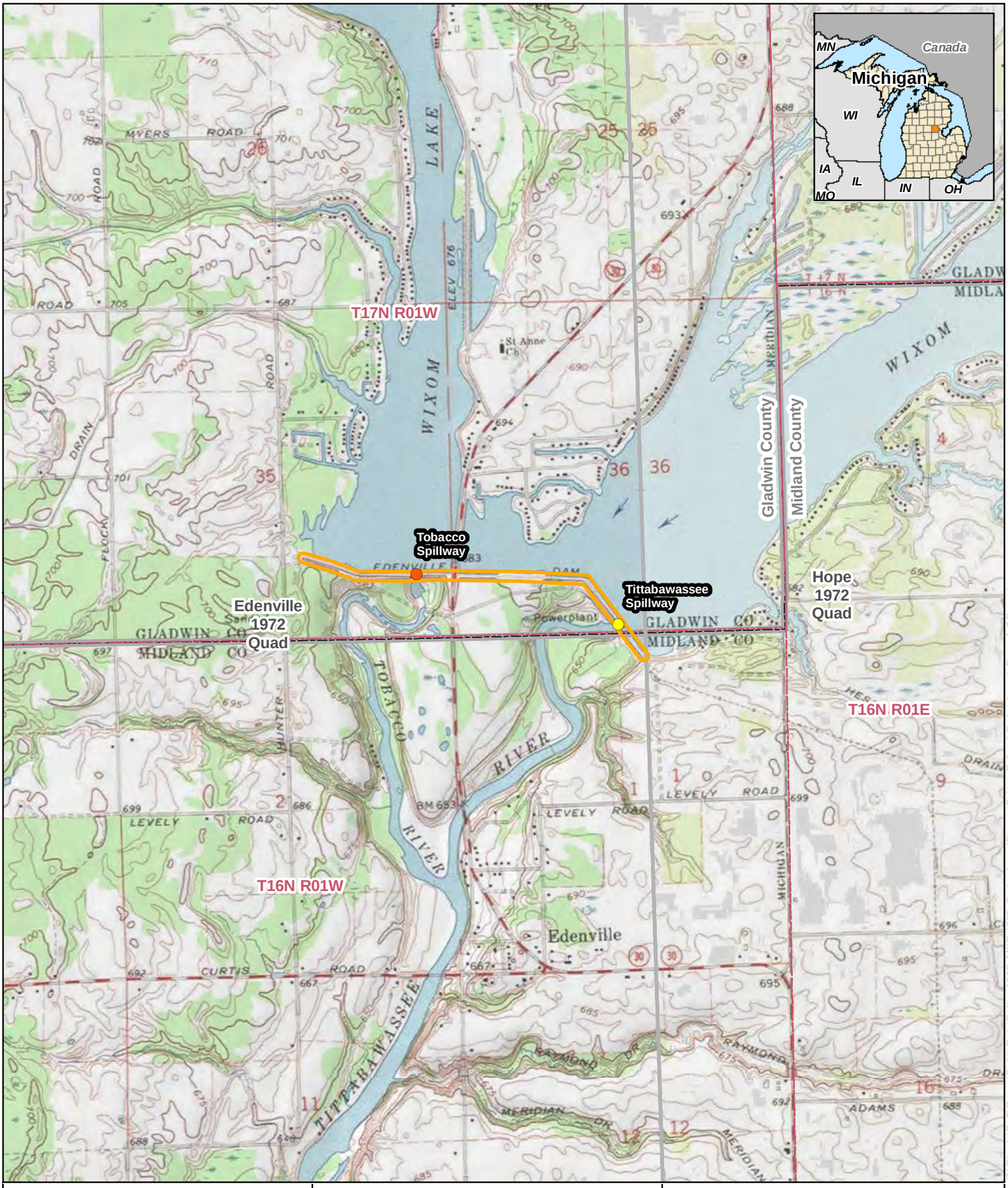
List of notable Holland, Ackerman and Holland Dams

Dam Nam	State	Contractor	Power Company	Features
Union City Dam	Michigan	Benjamin Douglas Company	"municipality owned"	Tainter Gates (5)
Quaker Mill Dam	Iowa	Unknown	Iowa Electric Company	One Tainter Gate
Edenville Dam	Michigan	Unknown	Wolverine Power Company	Tainter Gates (3)
Chalk Hill Dam	Wisconsin	Siems, Helmer, Shaffner, Inc.	Northern Electric Company	Tainter Gates (11)
Victoria Dam	Michigan	Price Brothers Company	Copper Range Company	No tainter gates

Other properties designed by Holland, Ackerman and Holland, exhibit unique architectural elements such as stained glass within the powerhouse (Chalk Hill Dam) or sweeping arches (Victoria Dam). The Quaker Mill Dam; demolished in 2017, was previously listed on the NRHP due to a few unique characteristics, namely a monumental concrete fishway and a single Tainter gate with a manually operated hoist. While both the Chalk Hill Dam and the Tobacco River Spillway are hollow, the hollow nature of the Chalk Hill Dam was utilized to access the powerhouse, which is not present at the Tobacco River. The Chalk Hill Dam was also distinctive due to a large concrete fishway, its size (early 300 feet wide), and the decorative elements within the powerhouse (see Photo 11). Other than some being hollow and/or having multiple Tainter gates, unique architectural features and associated structures set these facilities apart from the Edenville Dam.

Photo 11. Chalk Hill spillway (left) and powerhouse (right).

When considering the eligibility of the Edenville Dam, the National Register Criteria for Evaluation were considered (36 CFR 60.4). It is of our opinion that the Edenville Dam is not eligible for inclusion on the NRHP, either in and of itself or as a contributing property of a historic district. Lacking unique architectural elements present among other dam spillways, powerhouses, or embankments (particularly those listed on the NRHP with associated powerhouses or other notable engineering elements), it is our professional opinion that the Edenville Dam does not meet the criteria established by the Secretary of the Interior as detailed in 36 CFR 60.4.



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For Environmental Review Purposes Only

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Figure 1: 24k Topo
Edenville Dam
Gladwin County, Michigan

- Tobacco Spillway
- Tittabawassee Spillway
- Embankment
- Quad Map Boundary
- Township Boundary
- County Boundary

Source: Z:\Clients\Q_T\Spicer\Field_Data\Cultural\002_MXDs\005_Embankment\Figures\Spicer_Cultural_Embankment_Figure1_24k.mxd

Date: (6/4/2021)

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Figure 2: 2020 Aerial Map
Edenville Dam
Gladwin County, Michigan

- Tobacco Spillway
- Tittabawassee Spillway
- Embankment
- Section Boundary

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Date: (8/4/2021)

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Figure 3: Embankment Plan Over 2020 Aerial Map
Edenville Dam
Gladwin County, Michigan

- Tobacco Spillway
- Tittabawassee Spillway

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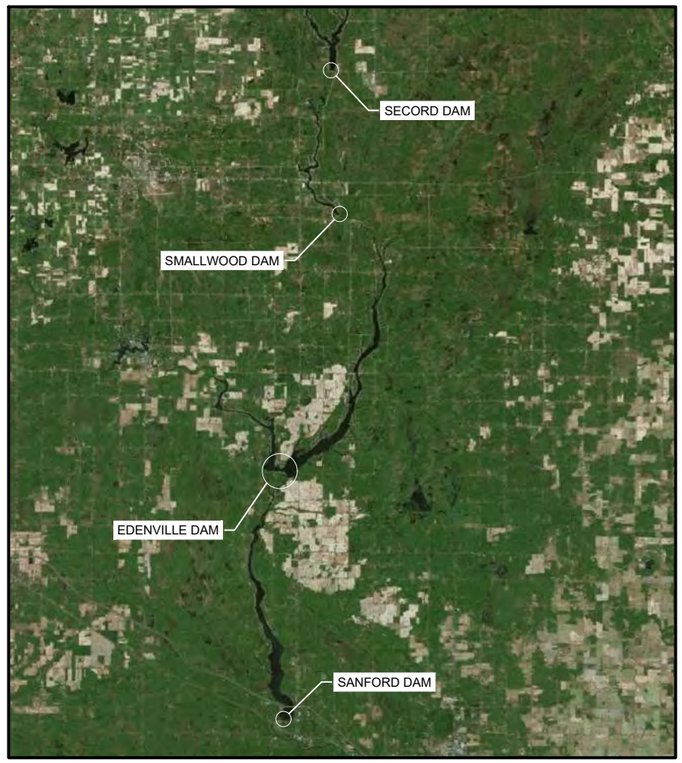
Date: (8/6/2021)

EDENVILLE DAM
CONCEPTUAL DESIGN

GLADWIN COUNTY, MICHIGAN
FOUR LAKES TASK FORCE

STATE MAP
(NOT TO SCALE)



SOURCE:
AERIAL IMAGE TAKEN FROM GOOGLE EARTH

SITE LOCATION
(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	TOBACCO SITE PLAN - EXISTING CONDITIONS "POST EDENVILLE DAM FAILURE"
4	C-02	EDENVILLE SITE PLAN - EXISTING CONDITIONS "POST EDENVILLE DAM FAILURE"
5	C-03	TOBACCO - EXISTING CONDITIONS PLAN "POST AECOM STABILIZATION"
6	C-04	TOBACCO OUTLET WORKS - DEMOLITION SECTION
7	C-05	TOBACCO OUTLET WORKS - MODIFICATIONS PLAN
8	C-06	TOBACCO PRIMARY SPILLWAY - MODIFICATIONS SECTION (SHEET 1 OF 2)
9	C-07	TOBACCO PRIMARY SPILLWAY - MODIFICATIONS SECTION (SHEET 2 OF 2)
10	C-08	TOBACCO PRIMARY SPILLWAY - CREST GATE DETAILS
11	C-09	EDENVILLE SITE PLAN - EXISTING CONDITIONS "POST GEI STABILIZATION"
12	C-10	EDENVILLE OUTLET WORKS - DEMOLITION PLAN
13	C-11	EDENVILLE OUTLET WORKS - MODIFICATIONS PLAN
14	C-12	EDENVILLE PRIMARY SPILLWAY - MODIFICATIONS SECTION
15	C-13	EDENVILLE POWERHOUSE - MODIFICATIONS SECTION
16	C-14	TOBACCO RIGHT EMBANKMENT - MODIFICATIONS
17	C-15	TOBACCO LEFT EMBANKMENT - MODIFICATIONS
18	C-16	EDENVILLE RIGHT EMBANKMENT - MODIFICATIONS SECTION
19	C-17	EDENVILLE EMBANKMENTS - MODIFICATIONS
20	C-18	EDENVILLE EMBANKMENTS - MODIFICATIONS SECTIONS & DETAILS
21	C-19	TITTABAWASSEE BREACH CHANNEL - PROPOSED LABYRINTH SPILLWAY PLAN
22	C-20	TITTABAWASSEE BREACH CHANNEL - PROPOSED LABYRINTH SPILLWAY SECTION & DETAILS

PREPARED FOR:

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

PREPARED BY:

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GEI PROJECT NO. 2002879

NO.	DATE	ISSUE/REVISION	APP
0	X/X/2021	CONCEPTUAL DESIGN SUBMITTAL	XXX

DRAFT

DWG. NO. G-01

SHEET NO. 1

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 670.0' AND AT NGVD29 DATUM IS 675.8').
- A CONVERSION OF -0.558' 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 675.8' (+0.3' / -0.4')
- WINTER RESERVOIR OPERATIONS: MINIMUM 672.8' (+0.7')

DESIGN REFERENCE STANDARDS

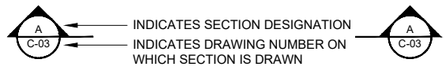
- (USBR, 1987) UNITED STATES DEPARTMENT OF THE INTERIORER, BUREAU OF RECLAMATION, "DESIGN OF SMALL DAMS", 1987.
- (USACE, 1995) UNITED STATES ARMY CORPS OF ENGINEERS, ENGINEERING AND DESIGN, "CONSTRUCTION CONTROL FOR EARTH AND ROCK-FILL DAMS", EM 1110-2-1911, 1995.
- (ACI, 2001) AMERICAN CONCRETE INSTITUTE, "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

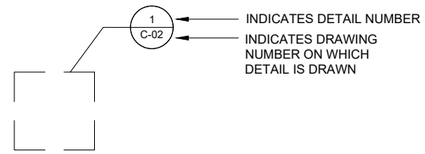
BO = BOTTOM OF
C = CENTER LINE
MM = MOVEMENT MONUMENT
CONC = CONCRETE
CONT = CONTINUOUS
CTRD = CENTERED
D/S = DOWNSTREAM
EO = EDGE OF
EX = EXISTING
EF = EACH FACE
EL = ELEVATION (FEET)
HW = HEADWATER
MAX = MAXIMUM
OC = ON CENTER
OCEW = ON CENTER EACH WAY
OHWM = ORDINARY HIGH WATER MARK
PL = PLATE
PMF = 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

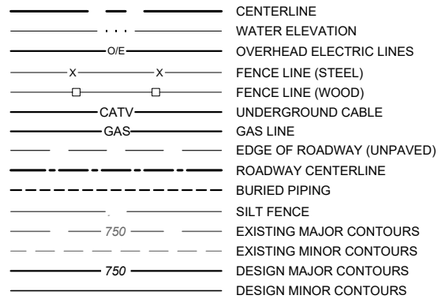
SECTION



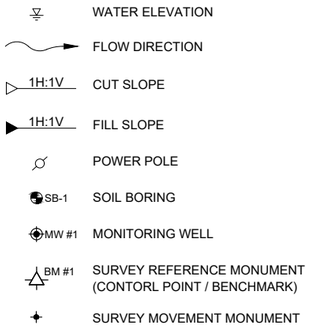
DETAIL



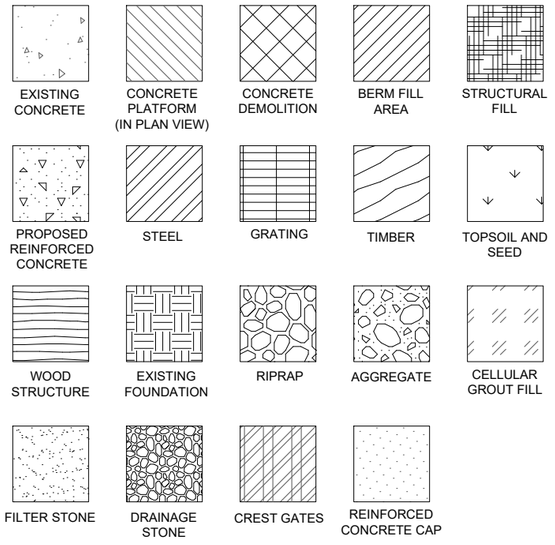
LINETYPE LEGEND



SYMBOLS LEGEND



HATCH LEGEND



Attention: 0 1" — If this scale bar does not measure 1" then drawing is not original scale.	NO.	DATE	ISSUE/REVISION	APP
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Drawn:	A. SAMPSON
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Edenville Dam
Conceptual Design
Gladwin County, Michigan

GENERAL NOTES AND LEGEND

DWG. NO. G-02

SHEET NO. 2

LINETYPE LEGEND

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

SYMBOLS LEGEND

- SB-3 — SOIL BORING
- FLOW DIRECTION
- BM #200 — SURVEY REFERENCE MONUMENT
- POWER POLE

TOBACCO SITE PLAN - EXISTING CONDITIONS
"POST EDENVILLE DAM FAILURE"

0 100 200
SCALE, FEET

NOTES:
1. VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29)
2. SPATIAL DATUM: NORTH AMERICAN DATUM OF 1983 (NAD83), MICHIGAN STATE PLANE, SOUTH ZONE

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TOBACCO SITE PLAN - EXISTING CONDITIONS "POST EDENVILLE DAM FAILURE"

DWG. NO. C-01

SHEET NO. 3

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LINETYPE LEGEND

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

SYMBOLS LEGEND

- SB-3 — SOIL BORING
- FLOW DIRECTION
- BM #200 — SURVEY REFERENCE MONUMENT
- POWER POLE

EDENVILLE SITE PLAN - EXISTING CONDITIONS "POST EDENVILLE DAM FAILURE"

0 100 200
SCALE, FEET

NOTES:

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2. SPATIAL DATUM: NORTH AMERICAN DATUM OF 1983 (NAD83), MICHIGAN STATE PLANE, SOUTH ZONE

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

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EDENVILLE SITE PLAN - EXISTING CONDITIONS "POST EDENVILLE DAM FAILURE"

DWG. NO. C-02

SHEET NO. 4

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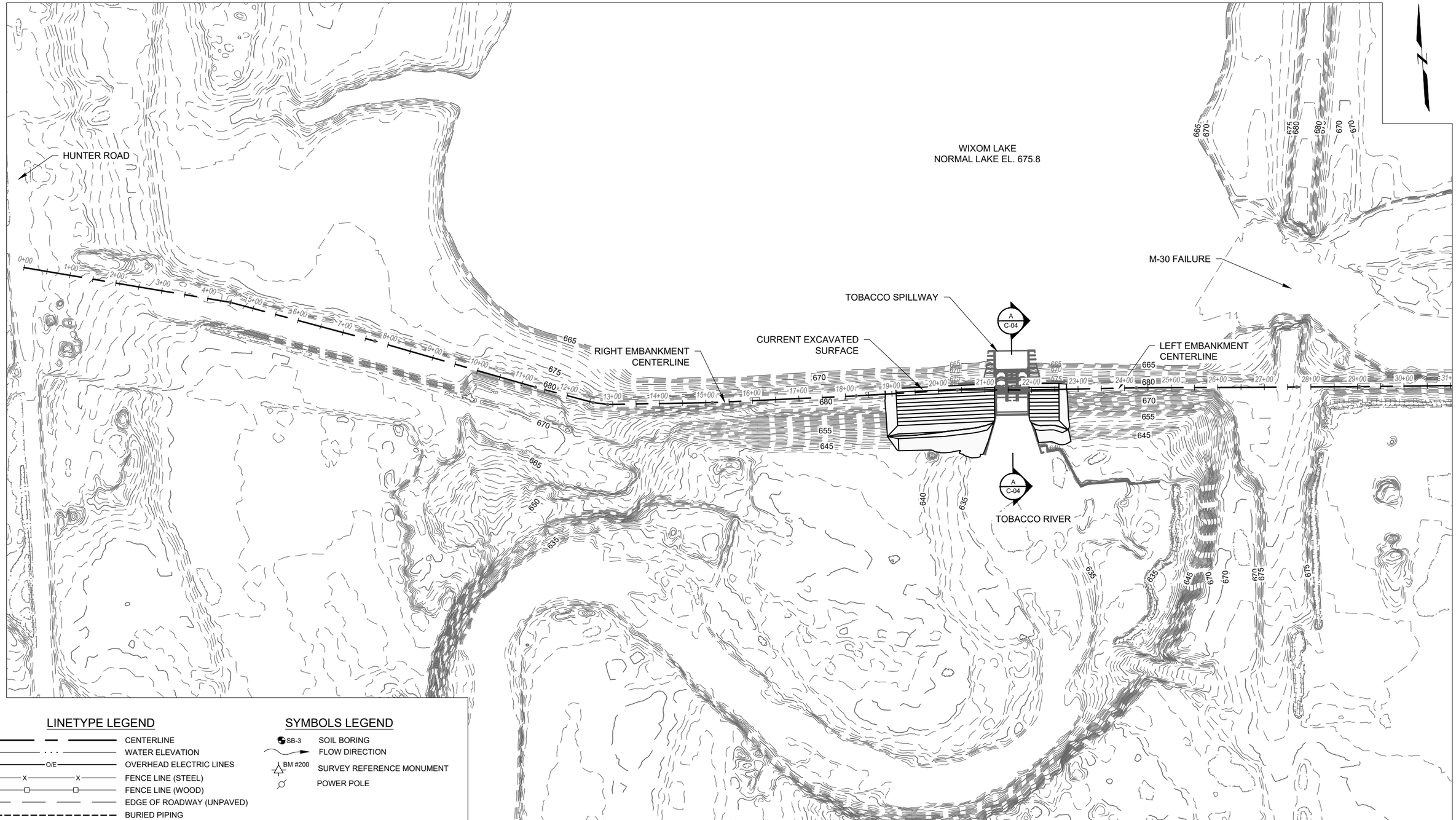

LINETYPE LEGEND

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

SYMBOLS LEGEND

- SB-3 — SOIL BORING
- FLOW DIRECTION
- BM #200 — SURVEY REFERENCE MONUMENT
- POWER POLE

TOBACCO - EXISTING CONDITIONS PLAN "POST AECOM STABILIZATION"

0 100 200
SCALE, FEET

NOTES:

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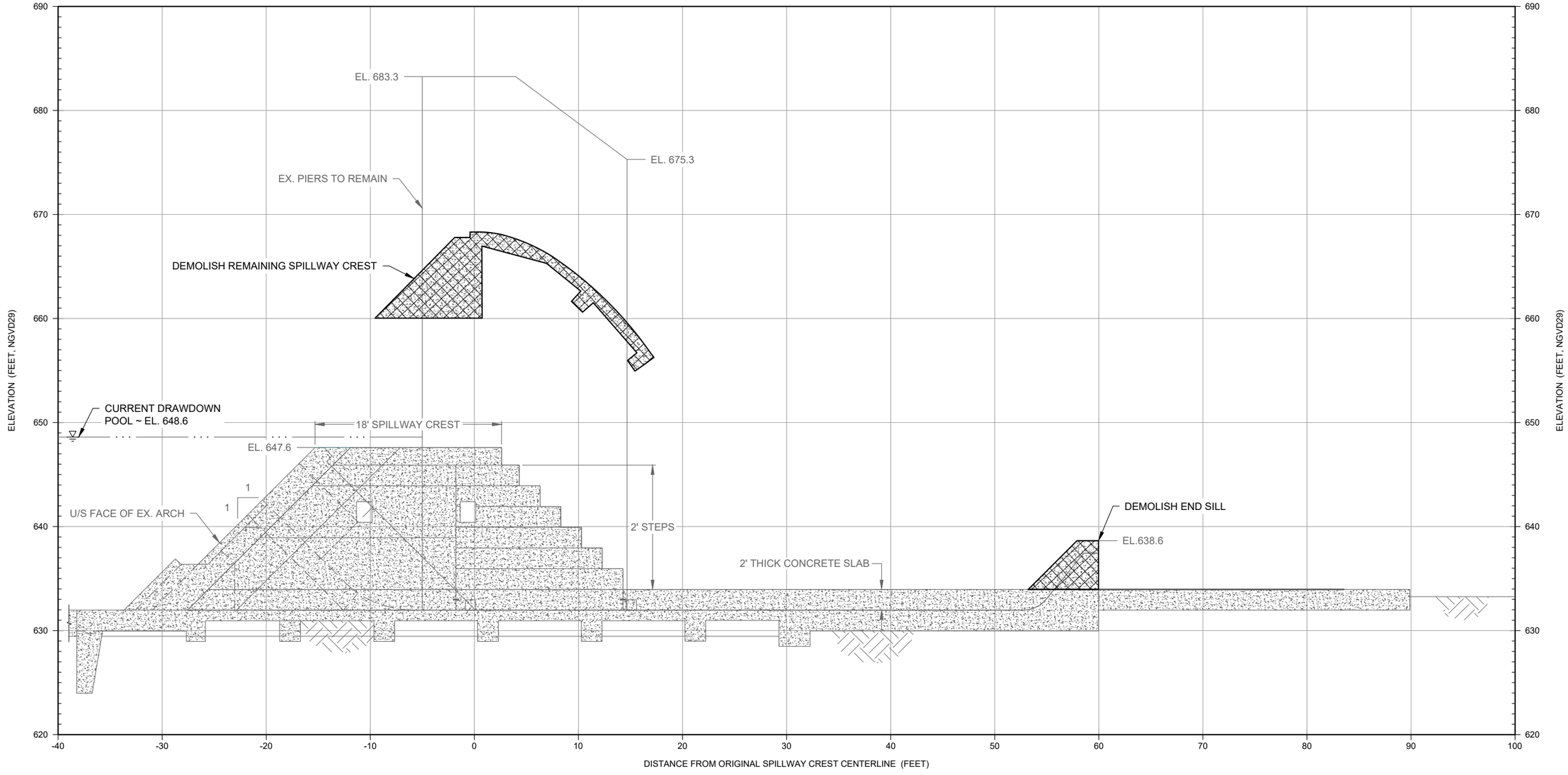
Gladwin County, Michigan

TOBACCO - EXISTING CONDITIONS PLAN "POST AECOM STABILIZATION"

DWG. NO. C-03

SHEET NO. 5



A / C-03 SECTION
SPILLWAY BAY 2

0 5 10
SCALE, FT

HATCH LEGEND

PROPOSED REINFORCED CONCRETE | EXISTING CONCRETE | EXISTING FOUNDATION | DEMOLITION

Attention:
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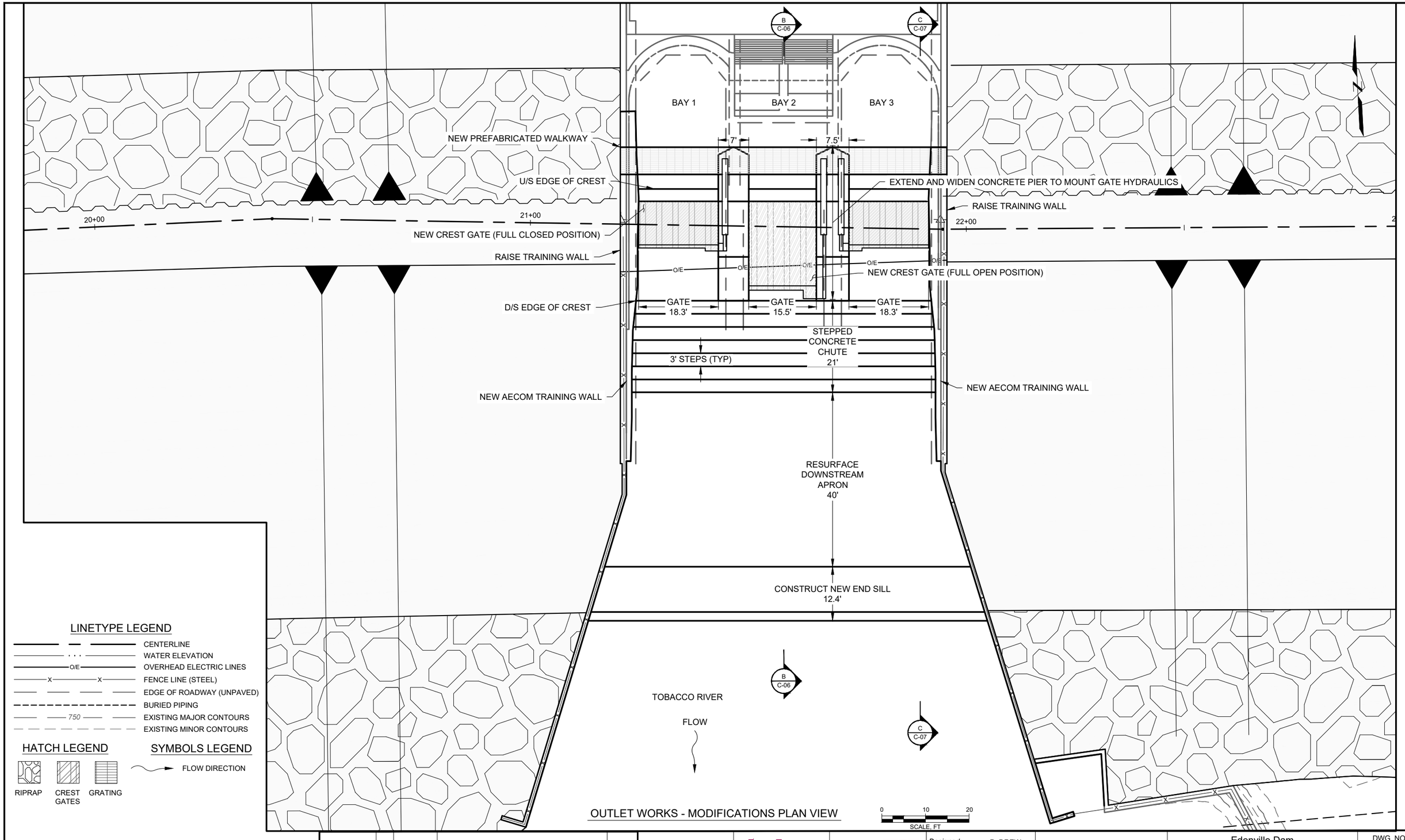
Conceptual Design
Gladwin County, Michigan

TOBACCO OUTLET WORKS - DEMOLITION SECTION

DWG. NO. C-04

SHEET NO. 6



LINETYPE LEGEND

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

HATCH LEGEND

RIPRAP, CREST GATES, GRATING

SYMBOLS LEGEND

FLOW DIRECTION

OUTLET WORKS - MODIFICATIONS PLAN VIEW

0 10 20
SCALE, FT

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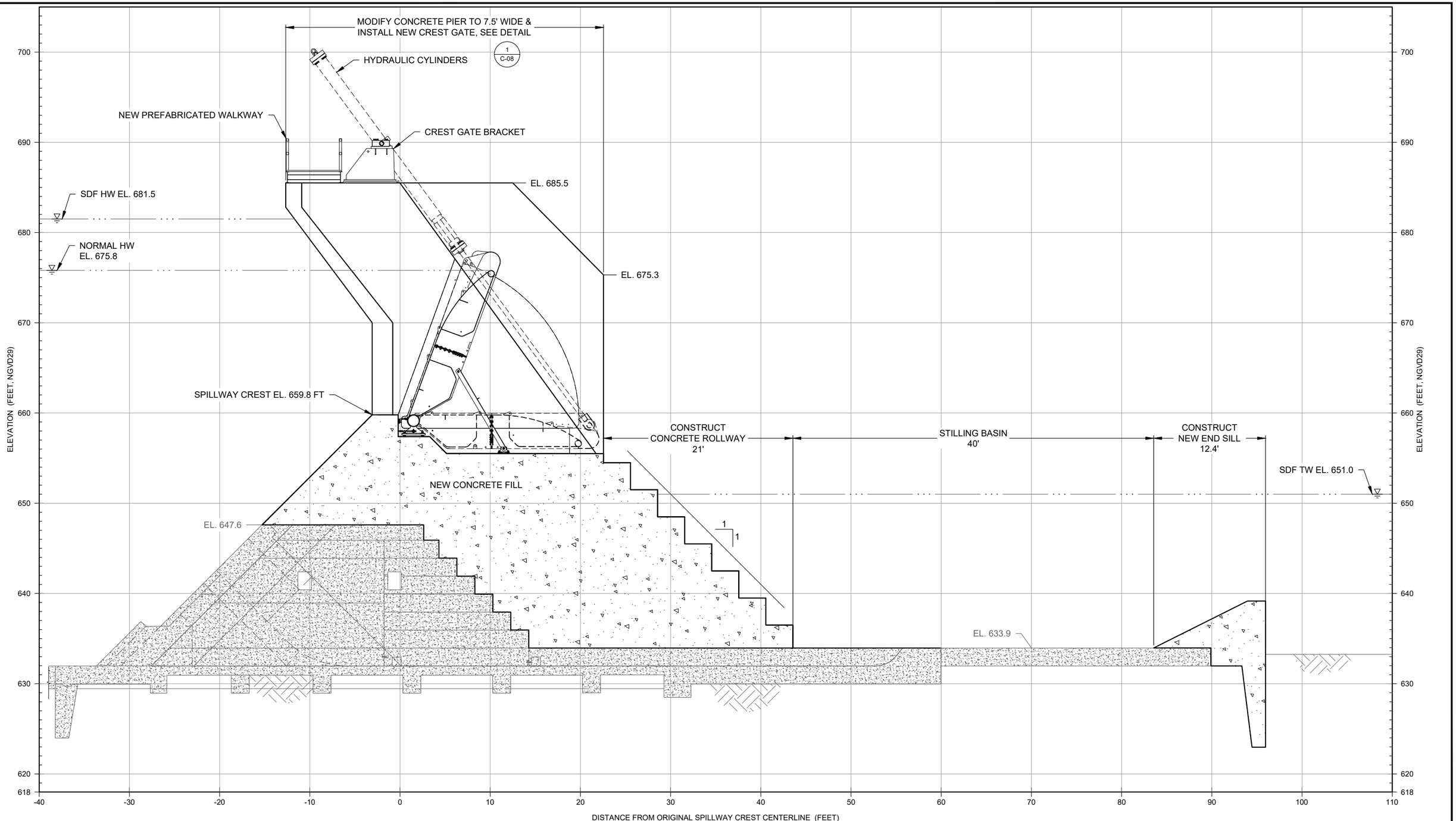
Conceptual Design
Gladwin County, Michigan

TOBACCO OUTLET WORKS - MODIFICATIONS PLAN

DWG. NO. C-05

SHEET NO. 7



B / C-05 SECTION
SPILLWAY BAY 2

0 5 10
SCALE, FT

HATCH LEGEND

PROPOSED REINFORCED CONCRETE

EXISTING CONCRETE

EXISTING FOUNDATION

NO.	DATE	ISSUE/REVISION	APP
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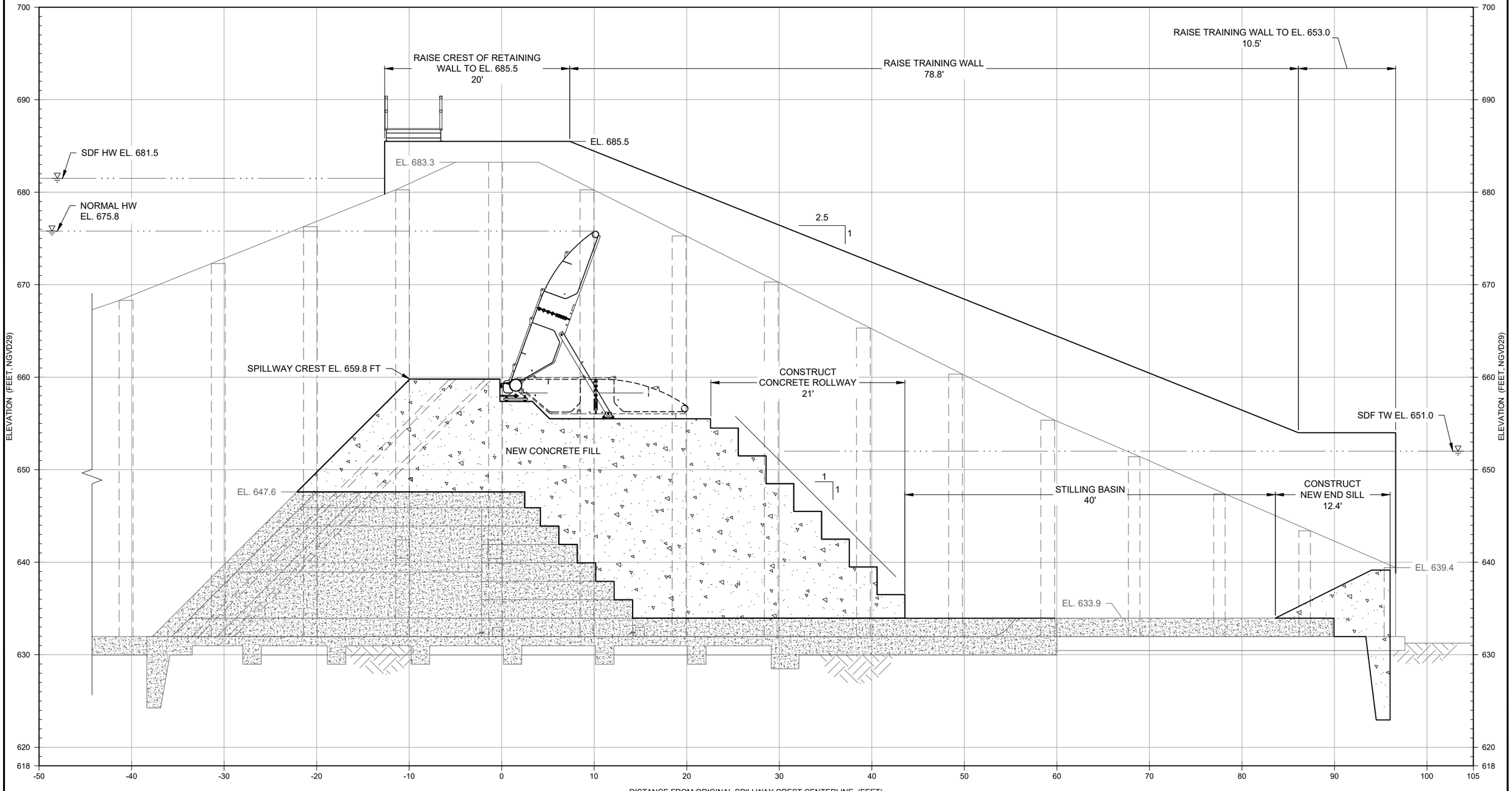
Conceptual Design
Gladwin County, Michigan

TOBACCO PRIMARY SPILLWAY - MODIFICATIONS SECTION (SHEET 1 OF 2)

DWG. NO. C-06

SHEET NO. 8



HATCH LEGEND

PROPOSED REINFORCED CONCRETE | EXISTING CONCRETE | EXISTING FOUNDATION

C / C-05 SECTION
SPILLWAY& LEFT TRAINING WALL

0 5 10
SCALE, FT

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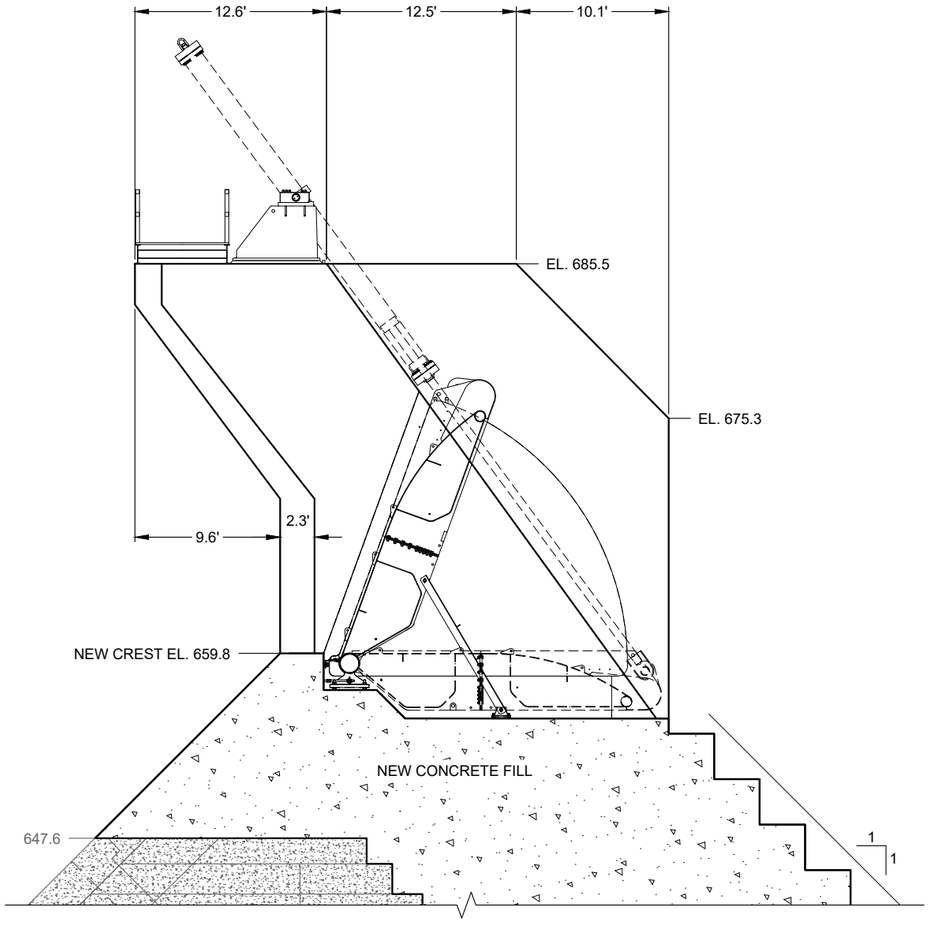
Conceptual Design
Gladwin County, Michigan

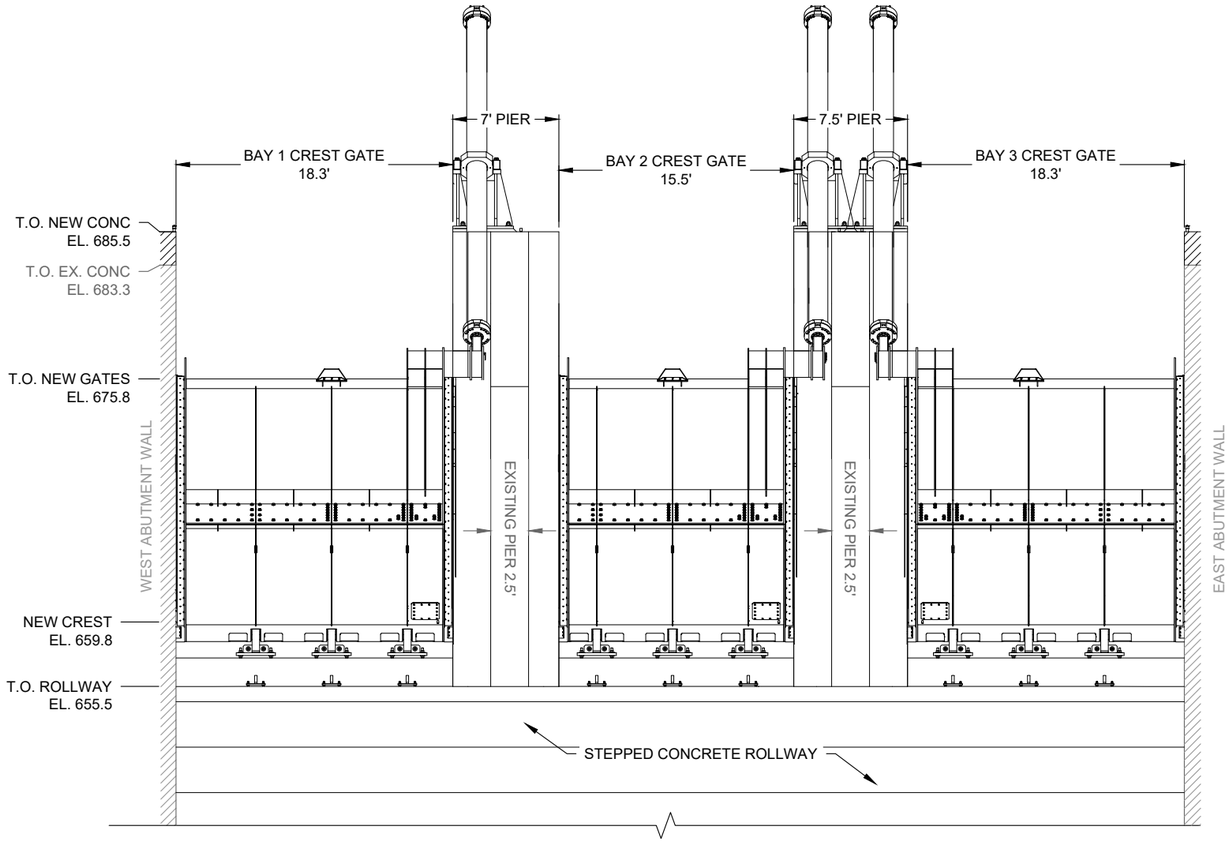
TOBACCO PRIMARY SPILLWAY
- MODIFICATIONS SECTION
(SHEET 2 OF 2)

DWG. NO. C-07

SHEET NO. 9



SECTION



DOWNSTREAM ELEVATION
(LOOKING UPSTREAM)

1 / C-06 DETAIL
PIER-MOUNTED CREST GATE

0 5 10
SCALE, FT

HATCH LEGEND

PROPOSED REINFORCED CONCRETE

EXISTING CONCRETE

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Edenville Dam
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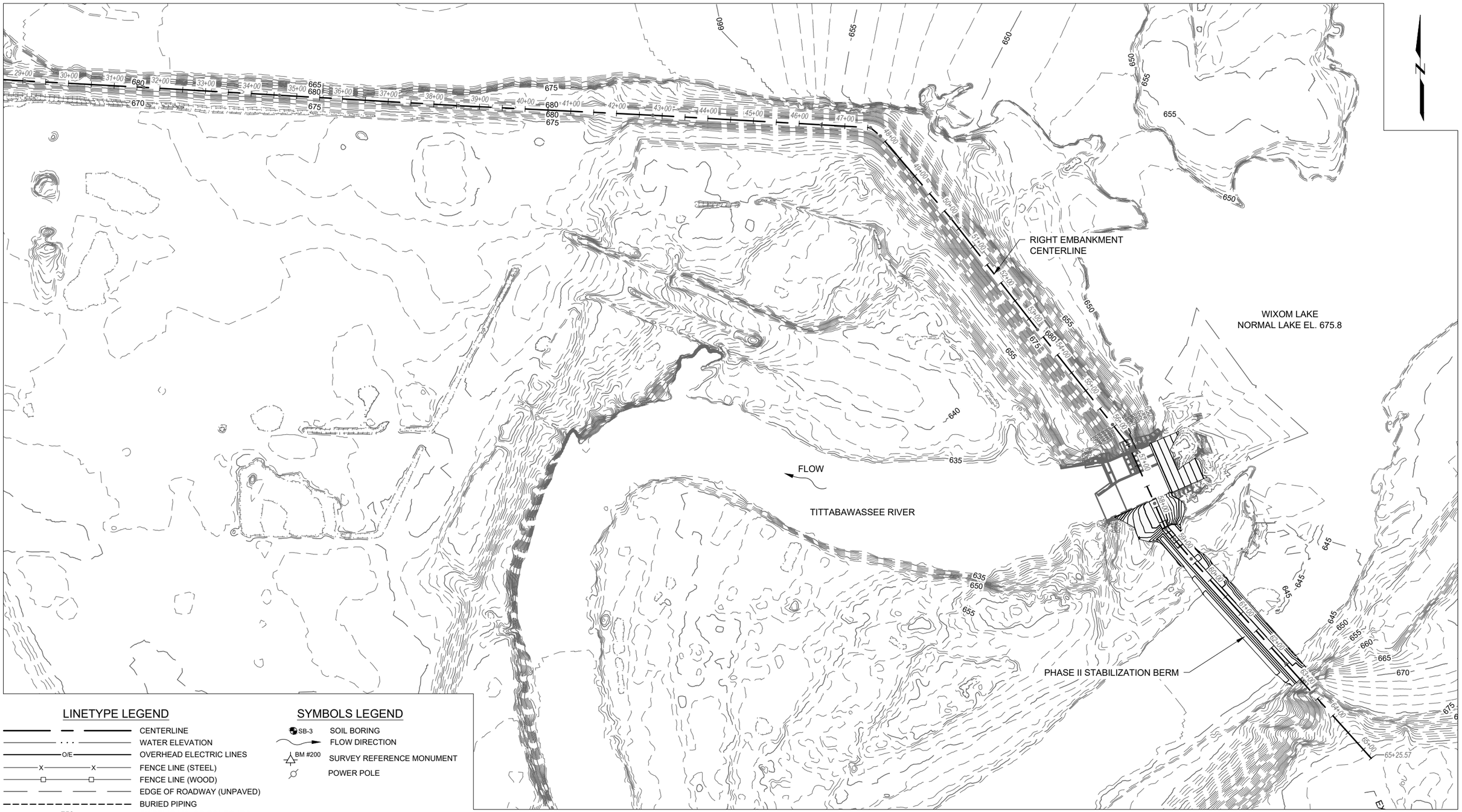
Gladwin County, Michigan

TOBACCO PRIMARY SPILLWAY - CREST GATE DETAILS

DWG. NO. C-08

SHEET NO. 10



LINETYPE LEGEND

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

SYMBOLS LEGEND

- SB-3 — SOIL BORING
- FLOW DIRECTION
- BM #200 — SURVEY REFERENCE MONUMENT
- POWER POLE

EDENVILLE SITE PLAN - EXISTING CONDITIONS
"POST GEI STABILIZATION"

0 100 200
SCALE, FEET

NOTES:

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EDENVILLE SITE PLAN - EXISTING CONDITIONS "POST GEI STABILIZATION"

DWG. NO. C-09

SHEET NO. 11

PHOTO 1

WIXOM LAKE
NORMAL LAKE EL. 675.8

SPILLWAY AREA DEMOLISHED TO BASE SLAB DURING PHASE II STABILIZATION

DEMOLISH POWERHOUSE SUPERSTRUCTURE & REMOVE GENERATOR & ALL ANCILLARY EQUIPMENT

DEMOLISH POWERHOUSE TO BASE SLAB

DEMOLISH APRON TO EL. 628.3
35.6'

DEMOLISH APRON
49'

DEMOLISH POWERHOUSE TRAINING WALL

57+00

58+00

655
660
665
670
675
680
650
645
640

PHOTO 1

LINETYPE LEGEND

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

HATCH LEGEND

DEMOLITION

SYMBOLS LEGEND

FLOW DIRECTION

OUTLET WORKS - DEMOLITION PLAN VIEW

0 10 20
SCALE, FT

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

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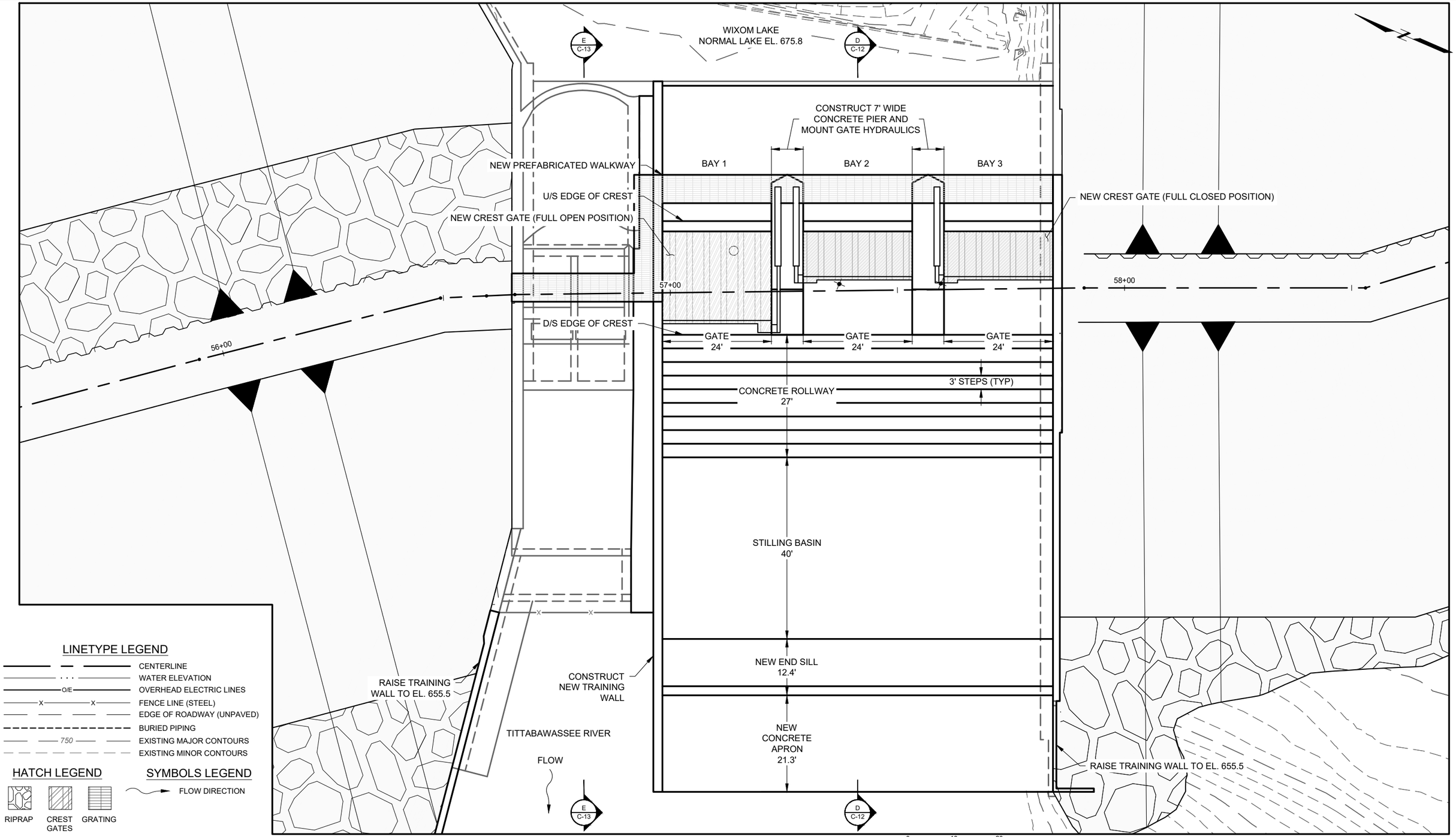
GEI Project 2002879

Edenville Dam
Conceptual Design
Gladwin County, Michigan

EDENVILLE OUTLET WORKS - DEMOLITION PLAN

DWG. NO. C-10

SHEET NO. 12



OUTLET WORKS - MODIFICATIONS PLAN VIEW

0 10 20
SCALE, FT

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

Attention:
0 1"
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EDENVILLE OUTLET WORKS - MODIFICATIONS PLAN

DWG. NO. C-11

SHEET NO. 13

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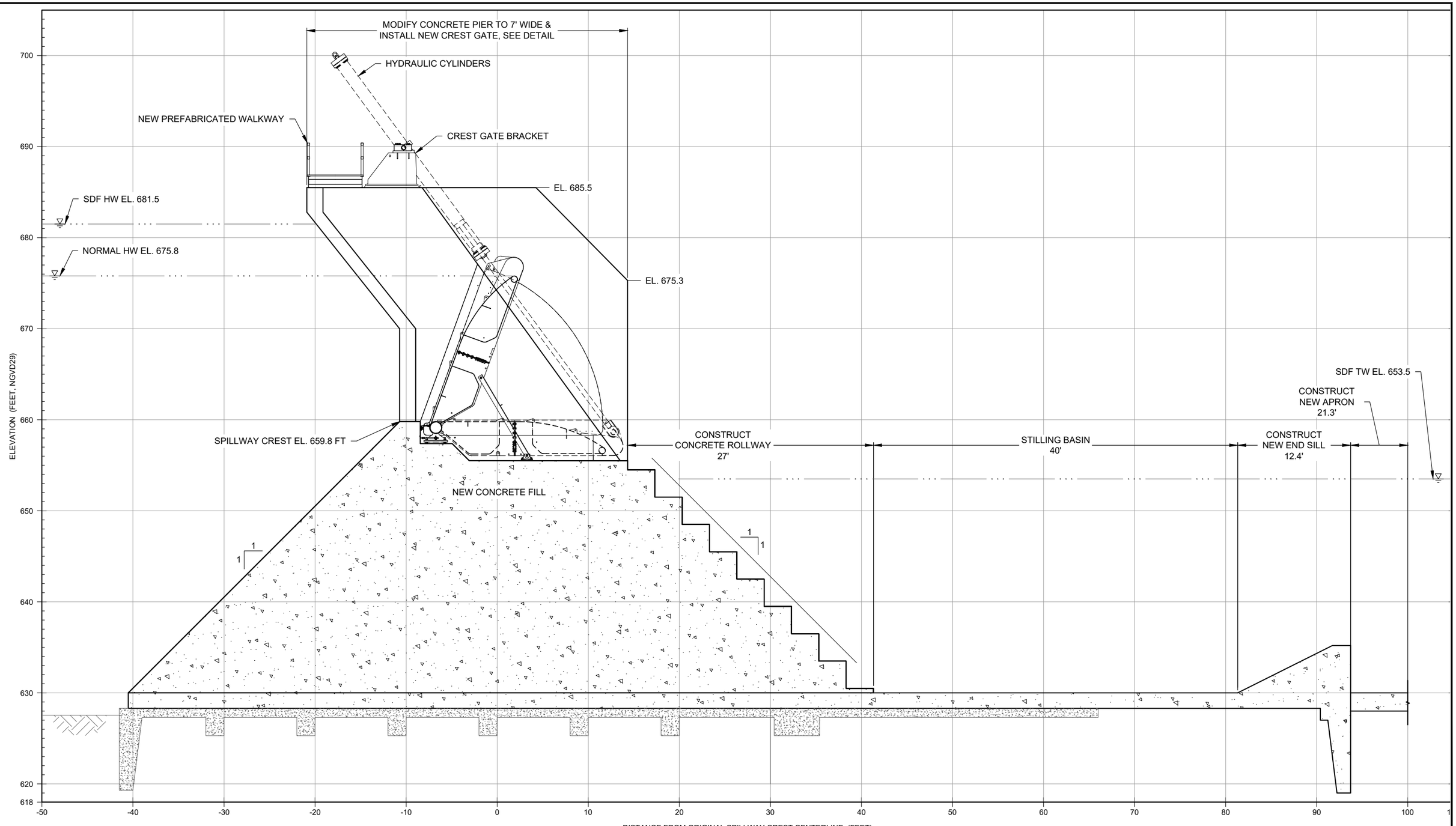

D / C-11 SECTION SPILLWAY

SCALE, FT 0 5 10

HATCH LEGEND

EXISTING CONCRETE | EXISTING FOUNDATION | PROPOSED REINFORCED CONCRETE

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

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

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EDENVILLE PRIMARY SPILLWAY - MODIFICATIONS SECTION

DWG. NO. C-12

SHEET NO. 14

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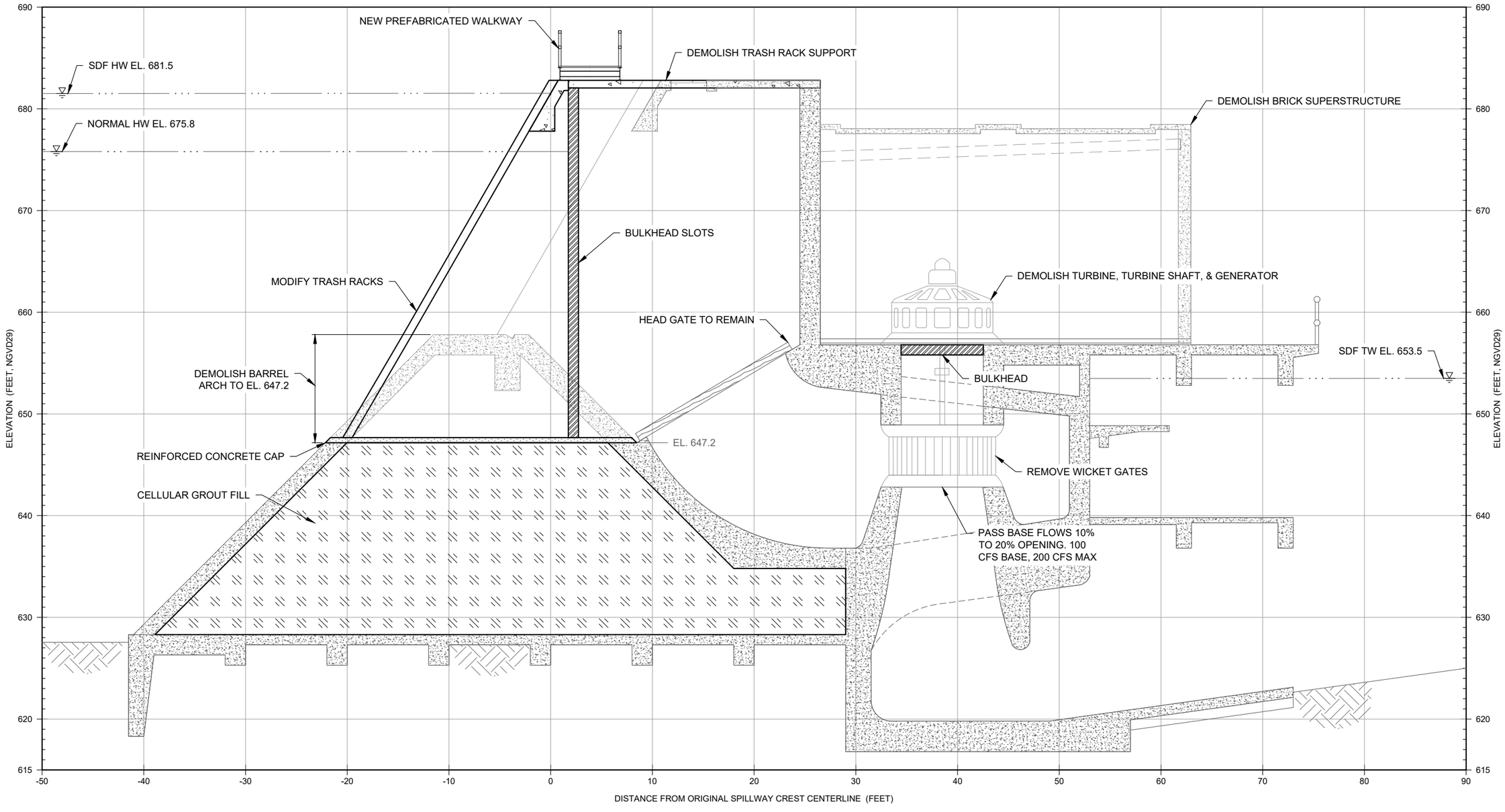

HATCH LEGEND

EXISTING CONCRETE TO BE DEMOLISHED
EXISTING CONCRETE
EXISTING FOUNDATION
STEEL
REINFORCED CONCRETE CAP
CELLULAR GROUT FILL
TIMBER

E / C-11 SECTION POWERHOUSE

0 5 10
SCALE, FT

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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EDENVILLE POWERHOUSE - MODIFICATIONS SECTION

DWG. NO. C-13

SHEET NO. 15

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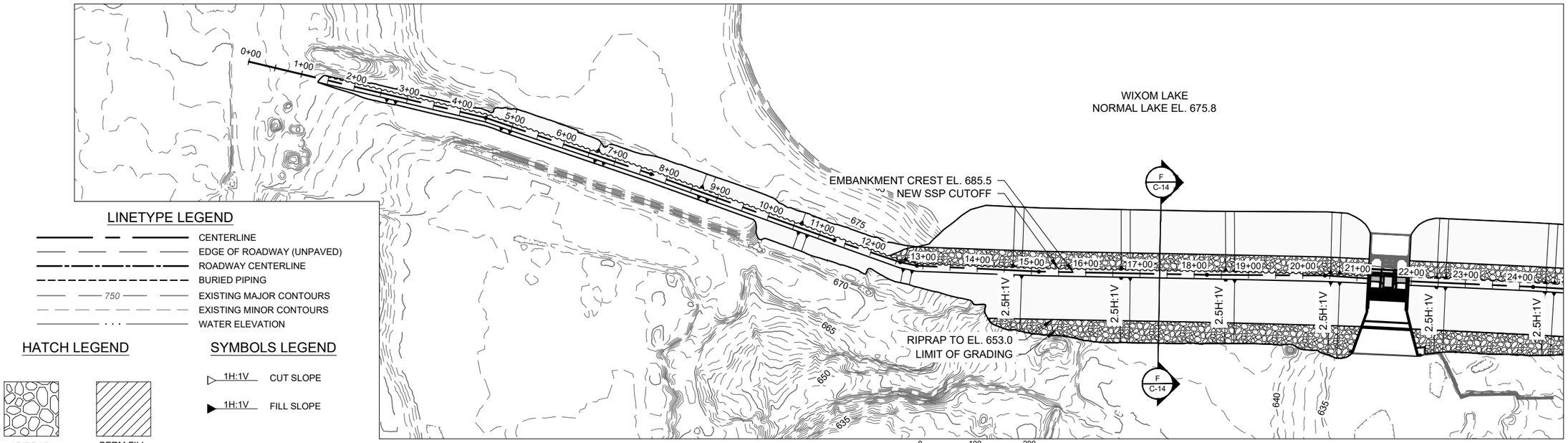
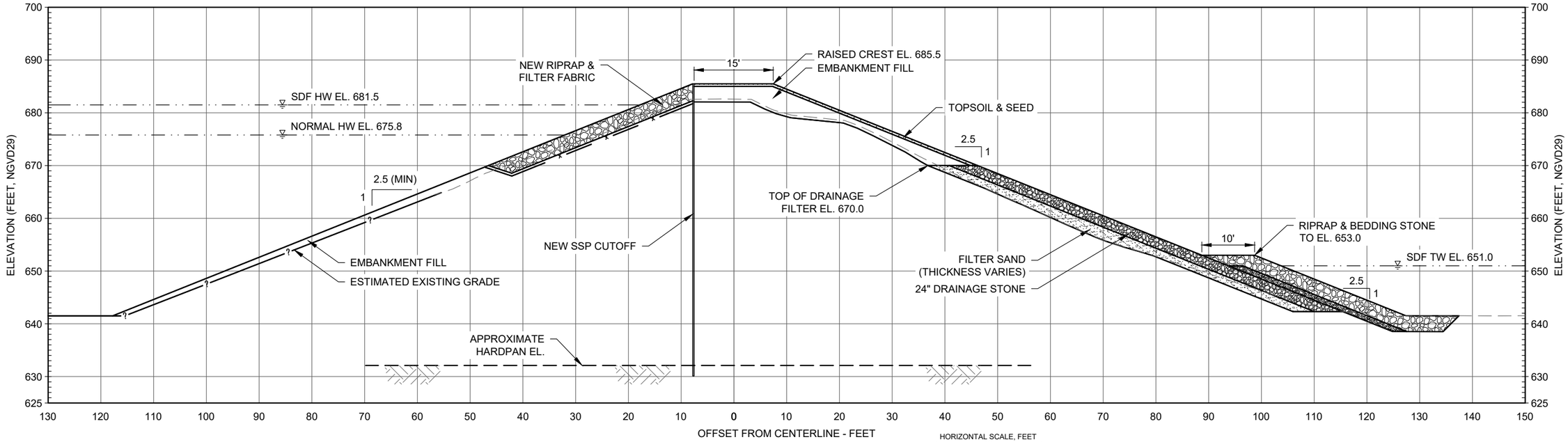


SITE PLAN - PROPOSED MODIFICATIONS

TOBACCO - RIGHT EMBANKMENT



F / C-14 SECTION

TOBACCO - RIGHT EMBANKMENT

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

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

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

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TOBACCO RIGHT EMBANKMENT - MODIFICATIONS

DWG. NO. C-14

SHEET NO. 16

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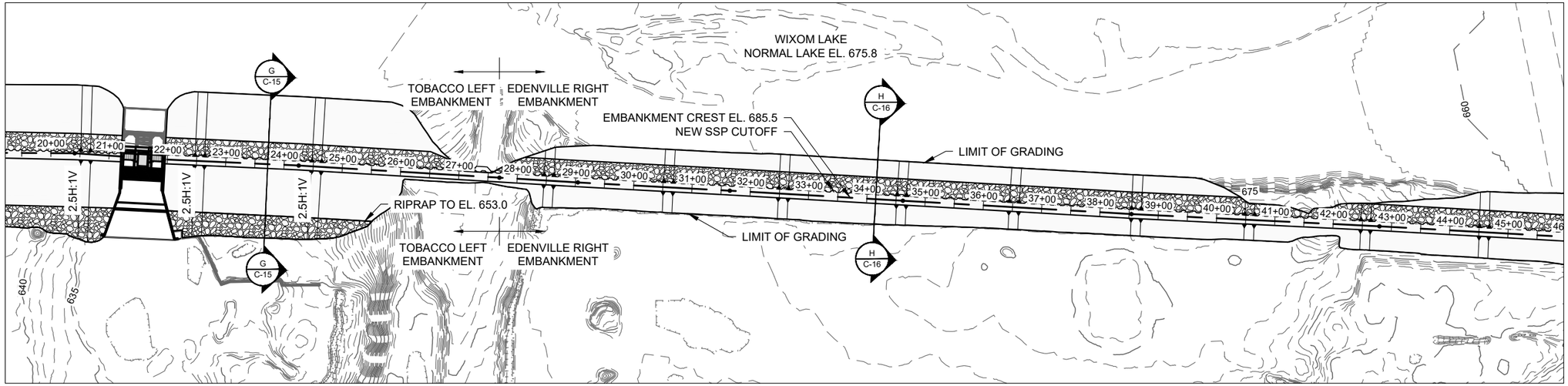
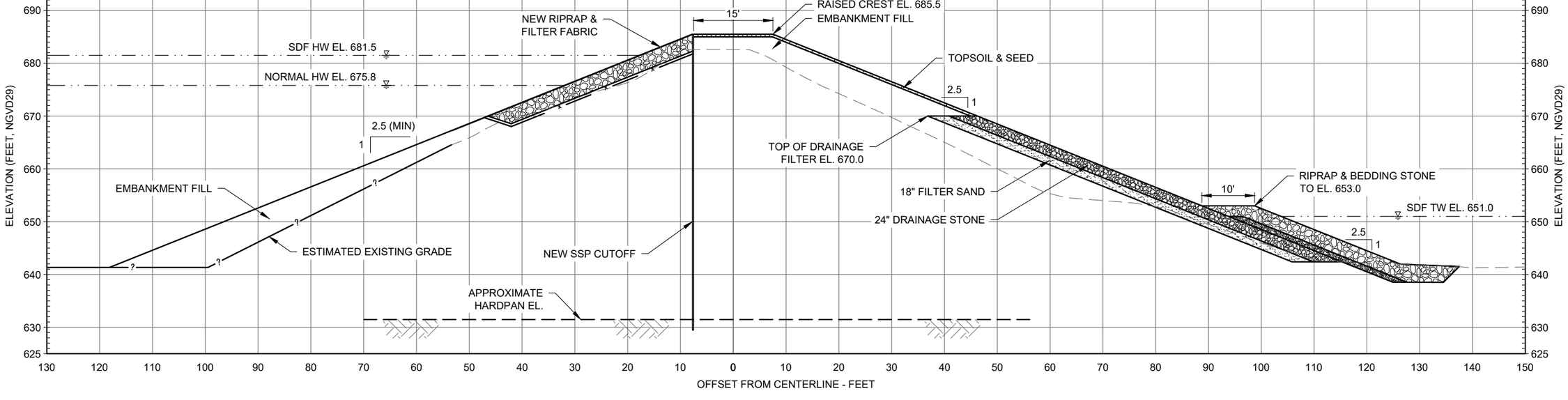


SITE PLAN - PROPOSED MODIFICATIONS

TOBACCO LEFT & TITTABAWASSEE RIGHT EMBANKMENTS

0 100 200
SCALE, FEET



G
C-15
SECTION
TOBACCO LEFT EMBANKMENT

HORIZONTAL SCALE, FEET
0 10 20
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.	NO.	DATE	ISSUE/REVISION	APP
	0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--

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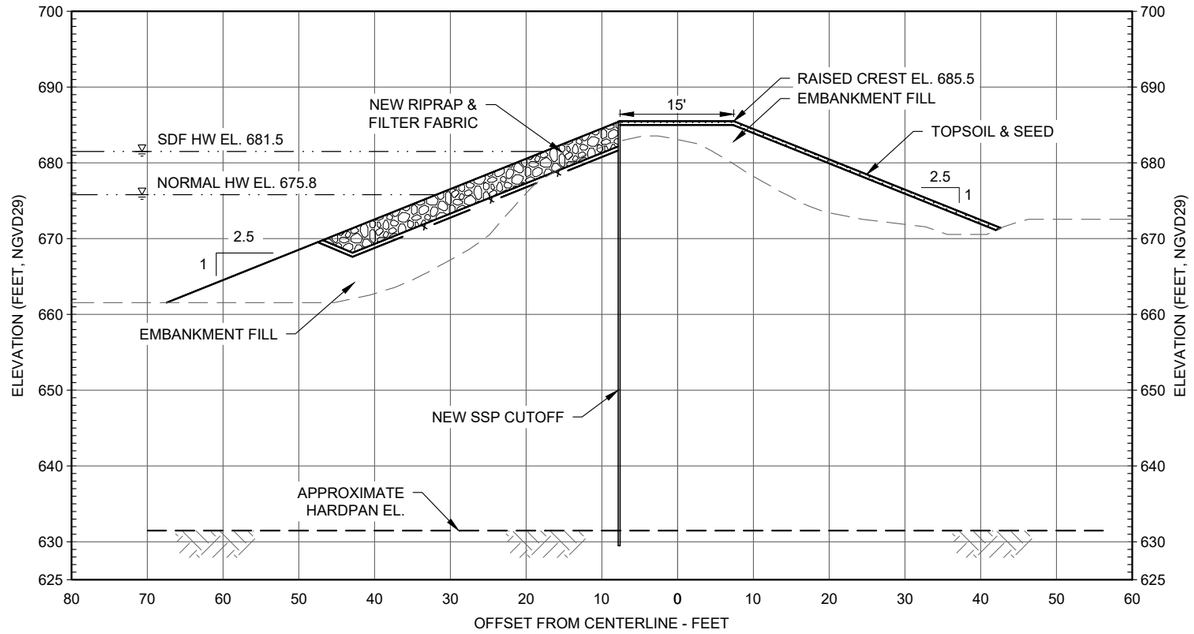
TOBACCO LEFT EMBANKMENT - MODIFICATIONS

DWG. NO. C-15

SHEET NO. 17



H C-15 SECTION
EDENVILLE RIGHT EMBANKMENT

HORIZONTAL SCALE, FEET
0 10 20
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.				
	0	xx/xx/xxxx	CONCEPTUAL DESIGN SUBMITTAL	--
	NO.	DATE	ISSUE/REVISION	APP

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EDENVILLE RIGHT EMBANKMENT - MODIFICATIONS SECTION

DWG. NO. C-16

SHEET NO. 18

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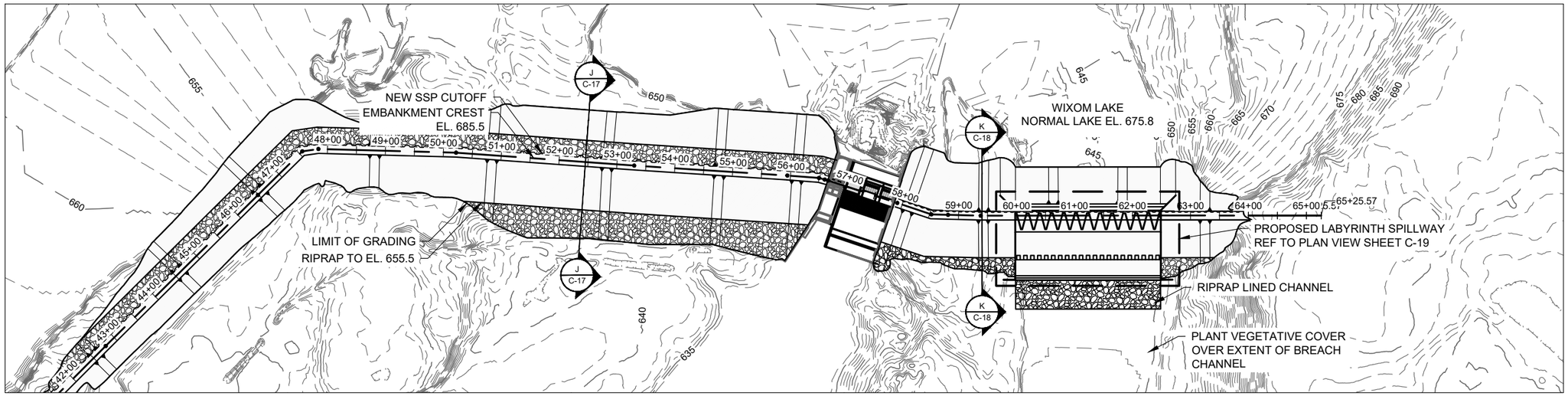
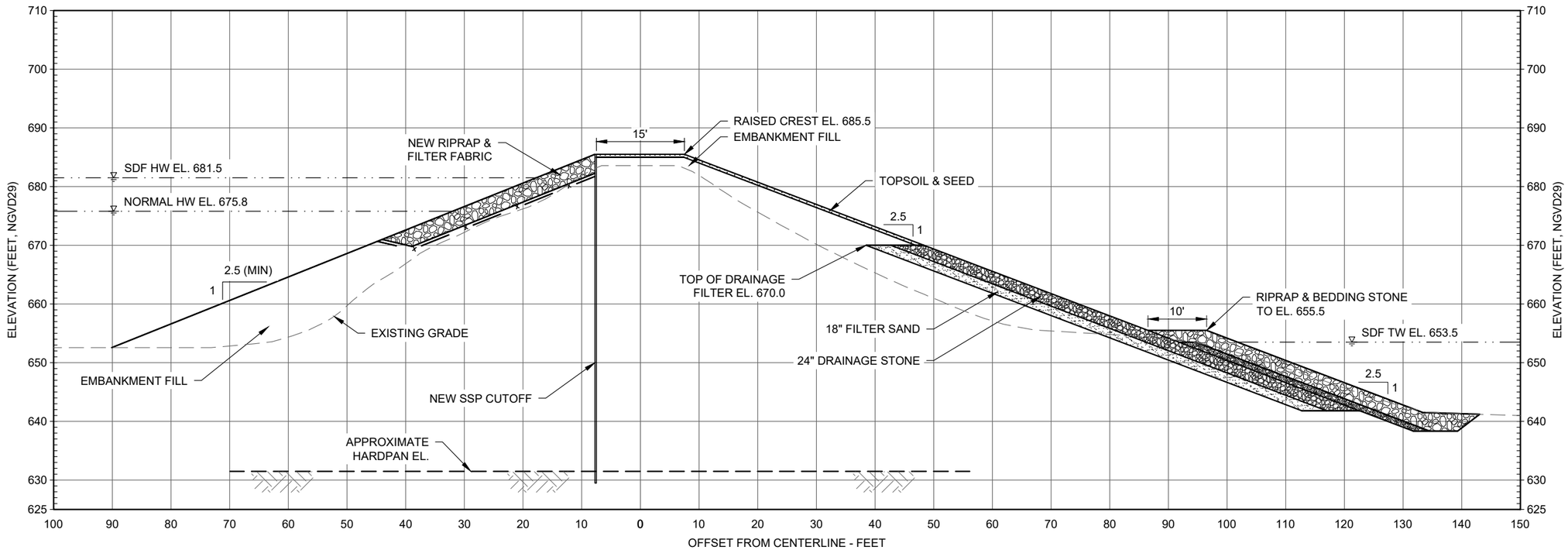


SITE PLAN - PROPOSED MODIFICATIONS

EDENVILLE RIGHT & LEFT EMBANKMENTS

0 100 200

SCALE, FEET



J
C-17

SECTION

EDENVILLE RIGHT EMBANKMENT

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

NO.	DATE	ISSUE/REVISION	APP
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EDENVILLE EMBANKMENTS - MODIFICATIONS

DWG. NO. C-17

SHEET NO. 19

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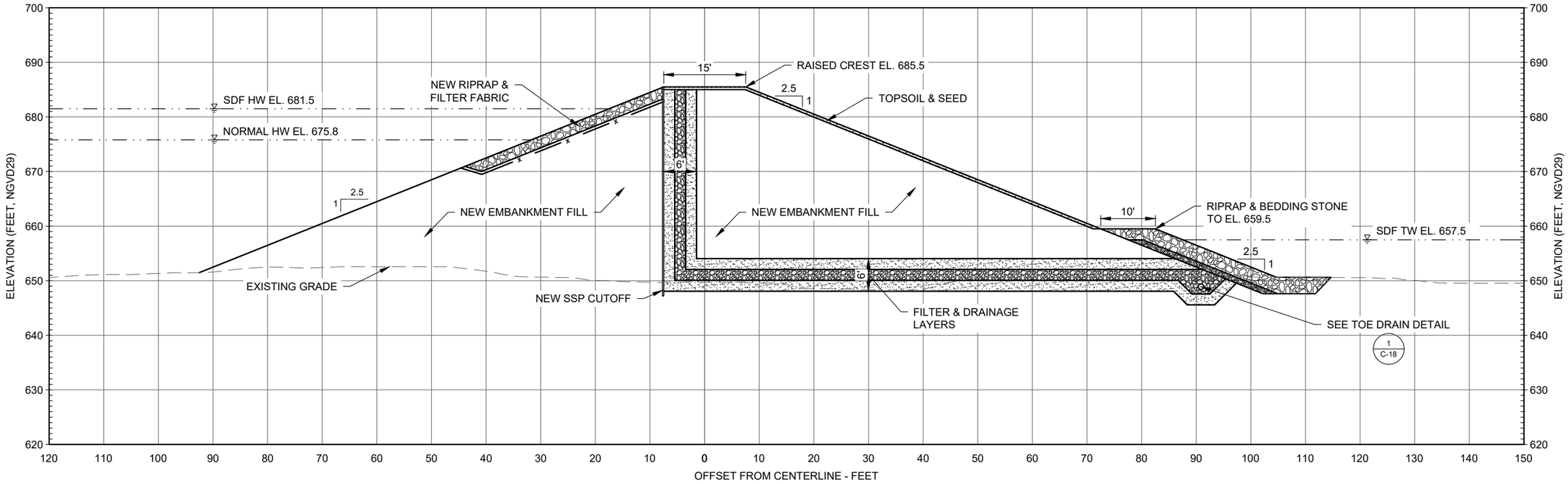
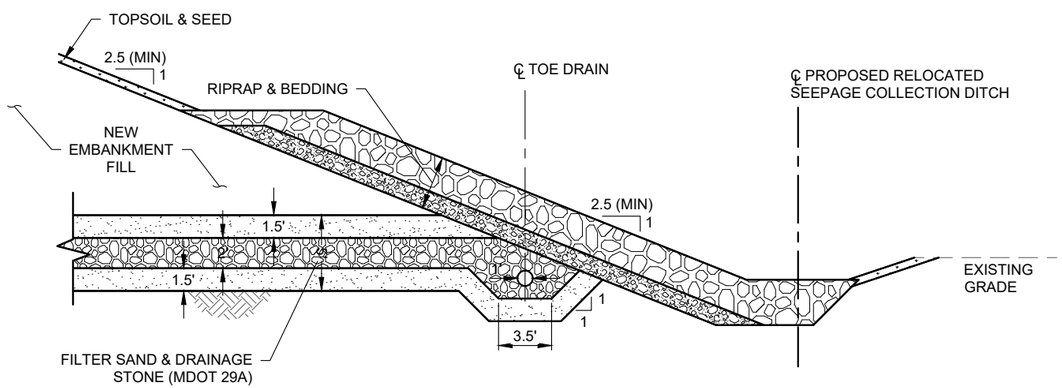


K / C-17 SECTION
EDENVILLE LEFT EMBANKMENT

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



1 / C-18 DETAIL
TOE DRAIN

0 5 10
SCALE, FEET

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

Attention:
0 1"
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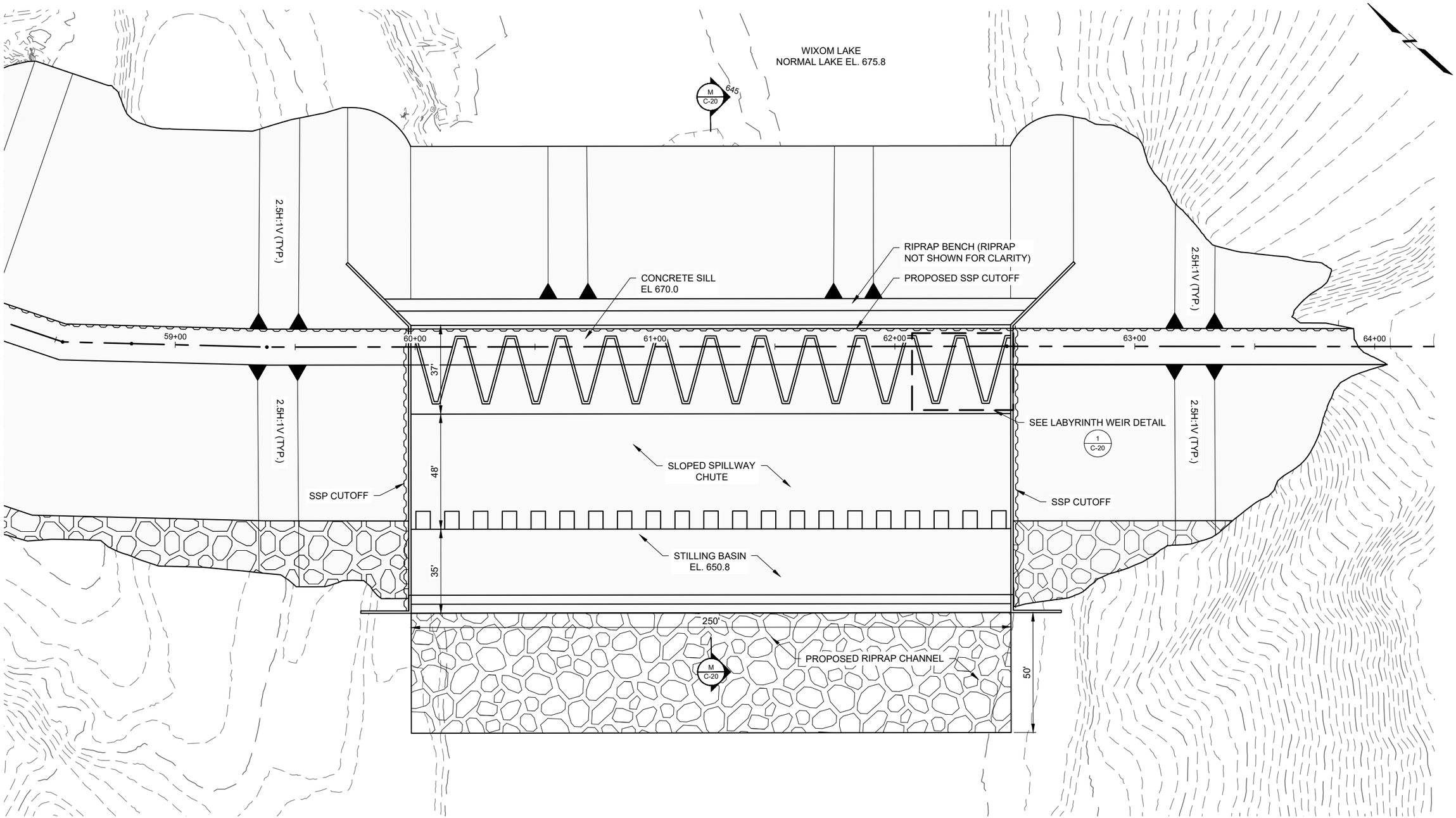
EDENVILLE EMBANKMENTS - MODIFICATIONS SECTIONS & DETAILS

DWG. NO. C-18
SHEET NO. 20



PLAN VIEW

PROPOSED LABYRINTH SPILLWAY

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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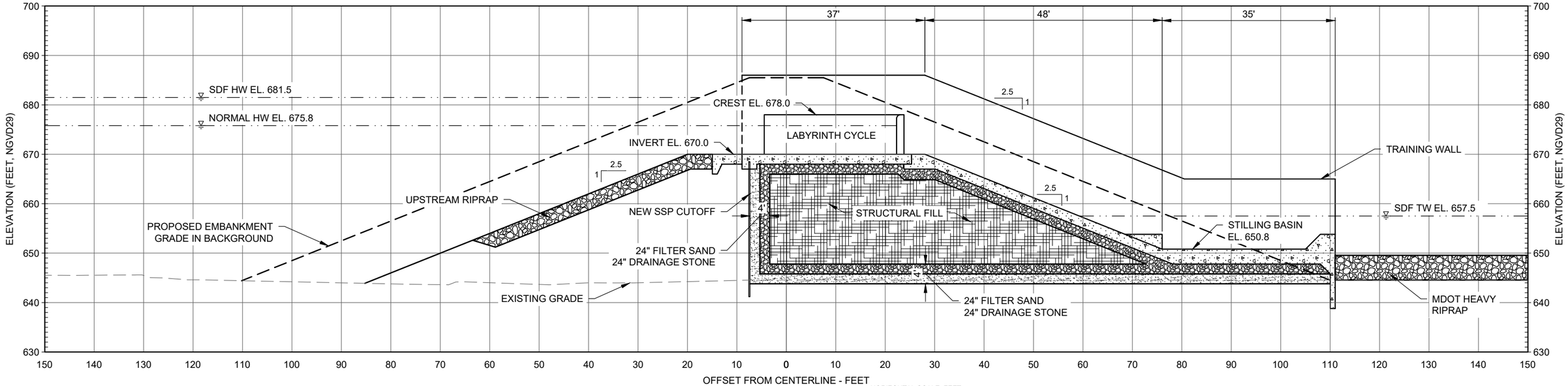
TITTABAWASSEE BREACH CHANNEL - PROPOSED LABYRINTH SPILLWAY PLAN

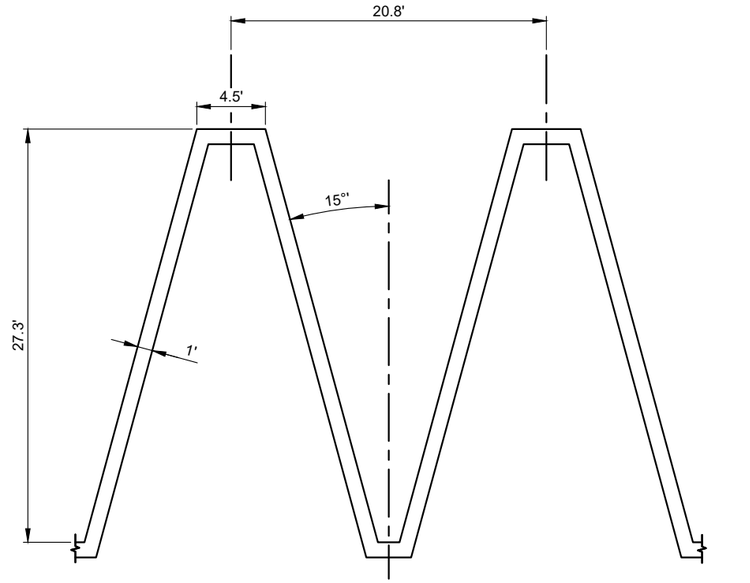
DWG. NO. C-19

SHEET NO. 21



M / C-19 SECTION
PROPOSED SPILLWAY

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



1 / C-19 DETAIL
LABYRINTH WEIR CYCLE

0 5 10
SCALE, FEET

NO.	DATE	ISSUE/REVISION	APP
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TITTABAWASSEE BREACH CHANNEL - PROPOSED LABYRINTH SPILLWAY SECTION & DETAILS

DWG. NO. C-20

SHEET NO. 22