US Army Corps
of Engineers
Great Lakes and Ohio River Division
LOUISVILLE DISTRICT / HUNTINGTON DISTRICT

Ohio River Mainstem Systems Study (ORMSS)

Interim Feasibility Report:

J.T. Myers and Greenup Locks Improvements

INDIANA, KENTUCKY and OHIO

Document ED-2:

Greenup L&D Engineering Site Appendix

April 2000

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
P.O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

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SECTION 1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this appendix is to present the feasibility level design of the principal features of the Greenup Lock extension. The appendix contains the engineering, design and cost data to support the plan/project recommended in the Main Report. Included are estimates of costs, descriptions of structures and improvements, schedules for design and construction, and operational requirements. Detail computations of individual features of the project will be covered in separate design memoranda to be submitted prior to the plans and specifications.

1.2 STUDY AUTHORITY

Authorization for the Ohio River Main Stem Systems Study was given in the resolution adopted by the Committee on Public Works of the U.S. Senate, dated 16 May 1955. Further authorization was given by a resolution adopted by the U.S. House of Representatives Committee on Public Works and Transportation on 11 March 1982. (See the Main Report for more detail.)

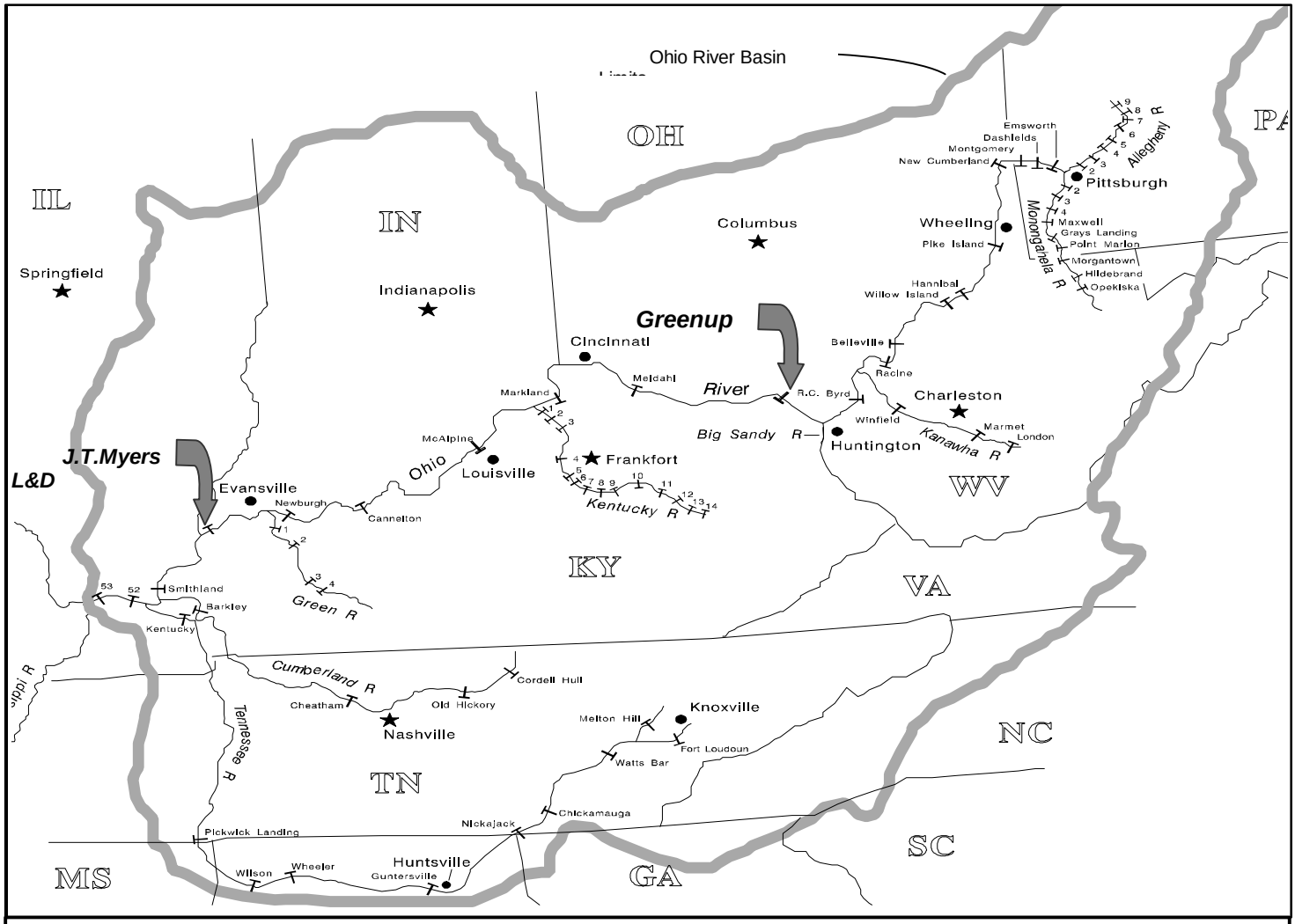
1.3 DESIGN APPROACH

The Design approach for this project has evolved from an overall study of the Ohio River Navigation System known as the Ohio River Main Stem Systems Study (ORMSS). This study has developed a number of possible alternatives, which could be applied to most, if not all, of the existing lock projects on the Ohio River. The emphasis is on the 1200/600-foot lock that represents the middle 14 locks. The design schemes which have been studied from the very beginning of the ORMSS are briefly described below.

An additional 1,200' lock could be constructed at Greenup landward of the existing chambers. The significant riverbank excavation (6 million c.y.), location of a pier for the highway bridge and utility line relocation make this alternative very costly ($350 million). Since most of the additional lock capacity is not needed (for benefits), this alternative is not economically feasible. (Refer to the main report)

Extending the existing auxiliary chamber is the most feasible way to address the lockage problems at Greenup. The chamber could be lengthened by retaining most of the existing lock structure and extending the landwall downstream, adding upper and lower guide and guard walls, and a new downstream miter gate. If the chamber is extended 600-feet, in effect creating another 1,200-foot lock, then all double lockage would be eliminated even if the main chamber is closed for maintenance of an emergency.

Figure 1. Ohio River Navigation System, highlighting location of Greenup and J.T. Myers Locks and Dam Projects



Through refinement of the lock extension alternatives, four plans have been developed to extend the auxiliary lock. These final 4 alternative plans are similar to those under consideration for the J.T. Myers site. (More details on plan formulation and screening are in the Main Report and Plan Formulation Appendix.) Detailed design and cost data in this document applies only to these four alternative plans, which are discussed in detail in SECTION 2.

1.3.1 Extended Lock Chamber Design Approach

For the purposes of this study, the design of the project is divided into five elements:

- the land wall
- the land wall gate monolith
- the middle wall gate monolith
- the miter gate and bulkhead sills
- the supplemental filling and emptying system.

Several different in-the-wet construction methods have been investigated for the lock wall elements: (1) lift-in, (2) float-in, and (3) floating, (4) caisson as well as conventional in-the-dry construction methods. The design of each of these construction alternatives is taken to the point to permit comparison with the other methods, and will be investigated further in the PED phase.

The construction method for each of the project elements has been considered on an element by element basis. This results in a number of project element/construction method combinations. For example, one combination considered is float-in middle wall gate and land wall gate monolith in conjunction with constructing the land wall in the dry. The different combinations have been evaluated based on cost and construction techniques.

A major consideration in all construction methods is the minimization of lock chamber closure times. Closure of both locks simultaneously is considered on an hourly increment. Closure of the auxiliary lock with the main lock open is considered on a daily basis. Closure of the main lock with the auxiliary lock open is considered on a contingency basis. Under normal conditions, it is expected that the auxiliary lock will be closed for the majority of the project. Nevertheless, construction methods were evaluated on the capability to permit the auxiliary chamber to be used if an emergency were to force the main chamber to be closed.

1.4 EXISTING CONDITIONS

Greenup Locks and Dam is located on the Ohio River at river mile 341 and was completed in 1962. The structure is two lock chambers, a riverward 110' x 1200' "Main" chamber and a landward 110' x 600' "Auxiliary" chamber, that are fed by a gravity flow filling and emptying system. Greenup has 30' lift and maintains a normal upstream pool elevation of 515 Feet. (FOR MORE DETAIL, See the General Engineering Site Appendix (GE).

SECTION 2 DESCRIPTION AND GENERAL LAYOUT

The efforts of this design study have been focused on two basic alternatives. Once the alternatives were looked at from a constructability and economic standpoint, it was determined that four different plans should be studied and a cost estimate generated for each. This section contains a description of each of the four selected plans to study.

2.1 PROJECT FEATURES COMMON TO ALL PLANS

Much of the site layout for the lock extension project remains consistent regardless of which plan is selected. The majority of differences involve the methods of constructing the extended auxiliary lock chamber. Below is a description of those features, which are common to all the plans. Those features, which differ or could be constructed in a different manner, will be discussed later.

2.1.1 Proposed Approach Walls

Currently, the existing upstream approach conditions are less than desirable. The crosscurrents encountered by barges approaching the lock forces them to use a flanking maneuver with the nose being pulled toward the river. (See Figure 2). In order to ensure a safe approach condition for the main and auxiliary chamber the approach walls will be lengthened and configured to allow a 1,200' landing zone for each chamber. During the DDR phase of this project, hydraulic modeling will be performed at WES to improve the approach conditions and shorten the walls (landing zones) as much as possible.

The pontoon wall is made up of a number of pontoon segments, each ranging between 380 feet and 440 feet in length. Pre-tensioned high strength bolts connect these sections. Each pontoon segment is designed as a watertight concrete box structure that is compartmentalized into chambers. The chambers are watertight and are composed of transverse bulkheads (typically at 20-foot spacing), the segment end walls, the deck and keel slabs, and the pontoon sidewalls. Because of its watertight construction, each segment can be individually launched, towed, maneuvered, and ballasted. However, the connection provided by the pre-tensioned bolts is considered permanent and is not intended to be undone during the service life of the structures.

The overall width of the pontoons has been based on the estimated weight of the pontoons and the required flotation characteristics such as freeboard and draft. The weight of the pontoons will depend on the required wall thickness, which was designed to resist barge impact forces. For detailed discussion of the barge collision load reference Section 10.7.1.5 and Engineering Appendix Calculations.

In order to facilitate the approach to Greenup Locks after the landward existing 600' lock chamber is extended; the following approach wall lengths are proposed:

- Extend the existing Upper River Wall (URW) and Upper Middle Wall (UMW) by approximately 1,345 feet.
- Extend the existing Lower Land Wall (LLW) by approximately 1,184 feet beyond the new Lower Landside Lock Monolith (thus, projecting 1,100 feet beyond the new lower middle Wall Monolith).

- Extend the existing Lower River Wall (LRW by approximately 295 feet.

The upper approach walls are proposed to be floating pontoons, which are restrained laterally by nose piers and pylons. The following two options are proposed for the lower walls:

1. A floating pontoon concept similar to those proposed for the upstream walls, or
2. A fixed wall comprised of precast panels supported by drilled shafts.

The overall width of the pontoons has been based on the estimated weight of the pontoons and the required flotation characteristics such as freeboard and draft. The weight of the pontoons will depend on the required wall thickness, which was designed to resist barge impact forces. For detailed discussion of the barge collision load reference Section 10.7.1.5 and Engineering Appendix Calculations.

The pontoons of the UMW, URW, LRW and LLW are anticipated to be of similar geometry and be comprised of similar structural elements. Each pontoon wall is made up of three pontoon segments. The Upper Middle Wall is 38 feet wide, matching the width of the existing middle wall. The Upper River Wall, Lower River Wall and Lower Land Wall (pontoon alternative) are 42 feet wide. They are aligned with the Lock Chamber Walls to provide a smooth approach. The segments are "integrated" or connected by pre-tensioned high strength bolts to form a structurally continuous pontoon.

The nose piers are located at the leading ends of the approach walls and are designed to serve a multitude of functions, including the following:

- Protect the approach wall pontoons against head-on barge impacts,
- Provide lateral and longitudinal support for the approach wall pontoons.

The nose pier superstructure is composed of a steel box shell filled with tremie concrete. Three drilled shafts support the superstructure. The drilled shafts are 10-foot diameter reinforced concrete shafts with steel casings.

The pontoon is connected to the lock wall and nose pier by guide keys that are matched to guide recesses cast into the lock wall monolith and nose pier. Debris inhibitors protect these guides from potential damage and congestion by debris. More detailed descriptions of the proposed pontoons, nose piers, and pylons are given in Section 10.4.1 and 10.4.2.

<u>NOTE:</u> During preparation of the Detailed Design Report (DDR), physical hydraulic modeling will be done to study the approach conditions and minimize the lengths of the approach walls, regardless of the plan selected. However, there is greater potential for reducing the length of the approach walls associated with the *Plan 1 – Auxiliary Extension* plan. The reason for this is Plan 1 does not have an option for an additional filling inlet. Consequently, the 1,200' approach wall landing zone could be in parallel, utilizing the existing URW as is, and adding an extension to the Upper Land Wall of approximately 1,000'. All of the other plans include an upstream inlet system or provisions for the inlet system. This necessitates the need for the riverward 1,200' approach wall landing zones that are in series. Under these plans, both the URW and the UMW are being extended 1,345' each.

Figure 2. **Existing Upstream Approach Conditions**

2.1.1.1 Gate Bay

An additional downstream gate bay will be constructed in conjunction with the extension of the lock walls. It will consist of precast concrete structures, which will be lifted in place.

The pintle for the downstream miter gate will be located at station 12+20B.

The additional gate bay will be capable of accommodating new miter gates and the existing operating equipment.

The size and geometry of the miter gate and machinery recesses will be the same as the existing recesses and will be capable of accommodating a control structure similar to the existing control structure.

The additional gate bay will incorporate lock maintenance bulkhead recesses on both the upstream and downstream side of the miter gates and will be capable of accepting 42 feet of bulkheads to provide flooding protection to elevation 512 with the top of the bulkhead sill at elevation 470.

The top of the miter gate sill will be at elevation 470 between the upstream lock bulkhead recess and the miter location (similar to the existing sill).

The sill will incorporate a dry utility crossover.

2.1.2 Lift-in Demonstration Project - Mooring Cells

Mooring facilities are needed at the downstream approach to reduce environmental damage caused by towboat grounding on the bank during maintenance closures and/or times of heavy traffic. In addition to the environmental benefits, the towing industry has also requested that the Greenup extension plans include fixed mooring cell on the downstream end. The location of these proposed facilities is shown in Document PE– Plan Formulation and General Engineering Reference Data.

The ability to use lift-in construction methods is critical to the success of the proposed project. Similar items have been successfully constructed. However, theseitems were only used as massive objects, not pieces of complex structures. Therefore, the lack of structural integrity did not impair the functionality of these items. The construction of lock chamber walls is quite different. They must be watertight, so the construction of lock walls requires tighter tolerances beginning with the design phase and continuing through the construction process.

The initial phase is to mathematically design the structure using the computer program "Nonlinear, Incremental Structural Analysis (NISA)." During this phase, special attention will be given to minimizing thermal expansion and the resultant cracking common to large monolithic concrete placement. Cracking is one of the key components that has a major impact on the uncertainty of the designs and associated costs. The designers will also be working very closely with Waterways Experiment Station (WES) to develop an instrumentation plan to gather and monitor all critical inputs into the NISA analysis including; thermal expansion, generated forces, stresses, strains, temperatures, etc. The information gathered from this demonstration will be used for five useful purposes:

1. Further refine the Greenup lock wall NISA analysis. We expect the final lock wall designs to more efficient than the initial designs, neither wasteful on materials, nor will the inherent flaws interfere with the operational effectiveness of the lock walls.
2. Validate (or dispute) the NISA analysis of large monolithic pours.
3. Reduce the cost of the project by providing information to produce more precise Plans and Specifications.
4. Reduce the amount of the contractors' bid estimates. In building a single, full size monolith, we will demonstrate the construction techniques. This will reduce the contractor's fear of uncertainty, which in recent bid openings involving innovative construction techniques has significantly increased the project costs. This demonstration project should help to eliminate contractor's fears and consequently reduce their bid estimates.
5. Disseminate the information learned from this demonstration project both from the constructional techniques and NISA analysis to the rest of the CoE. We expect to have WES publish the results and distribute it as a REMR report.

This demonstration project consist of two different styles of fixed mooring cells. The first is based on the lift-in design used to construct the chamber wall. This plan uses the same central tower design with four hanging wall panel (one on each side) to form the sides of the mooring cell. The second mooring cell will be used to simulate the construction of a prototype bullnose. This cell design is based on Mississippi River Lock and Dam No. 24 Downstream Protection Cell. The basic design is to place a cylindrical steel can into the water and fill it with tremie concrete. In the Downstream Protection Cell, the internal cracking caused by thermal expansion was not an issue. However, it does become an issue in the design of our bullnoses. These cells

will have to support the forces generated from the proposed floating approach wall, some of which are almost 1400-ft long.

2.1.3 Wall Demolition

The upstream and downstream ends of the existing landwall will be removed:

1. Landwall from station 5+04A to station 8+23.3A on the upstream end (monoliths L-29 through L-37) will be removed for plans 1, 3 and the 2nd phase of plan 4. If plan 2 were constructed these monoliths would not be removed due to the chance that the intake structure needed to make the auxiliary chamber fully functional could be needed due to traffic concerns. Currently these monoliths will be used in conjunction with a cofferdam to dewater the area where the intake would be constructed. Therefore, these monoliths will remain for plan 2.
2.
   A. Landwall from station 6+00B to station 8+03.3B on the downstream end (monoliths L-1 through L-5) will be removed only for plans 2,3 and 4 because they either utilize or make previsions for a future F/E system.
   B. Only monolith L-1 would be removed for the simple ***Plan 1 - AUXILIARY LOCK EXTENSION***.

2.1.4 Stone Slope Protection

Currently all the plans require that SSP will be needed for the proposed harbor area as shown in plates 1-4 through 1-8. In addition, SSP will be required on the riverbank near the Existing Landwall monoliths L-1 through L-5. This SSP will be required because the bank in that area will be degraded during the construction of the landwall extension. The extent of SSP placement in this reach will depend upon which plan is chosen. (See Plates 1-4 through 1-8 for detail.)

2.1.5 Operations Harbor

The operations harbor will be located on the upstream side of the auxiliary lock chamber. The harbor will be approximately 200-feet long and will have a width of approximately 120-feet. The harbor will be dredged to an elevation of 503 and the bank surrounding the harbor will be protected with stone slope protection to the top of bank. The slopes will be 3 horizontal to 1 vertical.

Note: The harbor will be constructed in Plans 1 and 3. The harbor will not be constructed for Plan 2 because of the possibility that the intake structure and wrap-around culvert would be needed later to make the auxiliary lock fully functional. Also, for plan 4 the harbor would not be constructed until the second phase for the same reason as stated earlier for plan 2. See plates 1-4, 1-7 and 1-8 for plan location.

2.1.6 Miter Gate Quick Changeout System (MGQCS)

This system consists of:

Gate lifter, the Assembly Pier, adjustable wall quoins and spare miter gate.

2.1.7 The R.C. Byrd Dry Dock

Future lock construction will increasingly use methods, which expedite the construction process, reduce the impacts to navigation and/or reduce construction costs. One area that shows growing promise is off-site construction. Two off-site construction methods currently being investigated under Ohio River Main Stem Systems Study are float-in and floating technologies. The float-in method consists of manufacturing large gravity monolith shells off-site. This reduces the on-site construction time and impact to navigation. The shells are then floated to the job site, positioned, and submerged. Concrete, such as tremie and traditional cast-in-place, are then used to complete the monolith. The cost savings are generated from the elimination of the traditional sheet pile cofferdams and reduction of impact to the navigation industry. The floating method consists of the offsite manufacturing of hollow wall structures. This greatly reduces the amount of material used; thus, floating walls have greater savings than the float-in method. These floating walls are ideal for approach walls where large pool fluctuations are present. Current projects considering either the float-in or floating technologies include the new dam on the Lower Monongahela River at Lock and Dam # 2, Olmsted, J.T. Myers, and Greenup L&D just to name a few.

Both float-in and floating concrete structures are built in the dry. The structures can be built on or in: (1) a submersible barges, (2) a river bank launch ramp, (3) a commercial dry dock, (4) or a lock chamber converted into a dry dock.

With the completion of the new R.C. Byrd Lock, the old Gallipolis lock chambers have been decommissioned. These old Gallipolis lock chambers could easily be converted to a dry dock with minimal modifications. The chambers are already sealed on three of their four sides. The downstream end is permanently sealed off with a concrete filled sheet pile cofferdam. This dam provides excellent heavy truck access to the middle river walls. The wall culverts are also sealed with concrete.

The upper end of the chamber remains open. We propose to seal the main lock chamber (land chamber) end by upgrading the existing poiree dam to a conventional 110' wide bulkhead system. The bulkheads will extend the full height of the lock wall (36 feet) for maximum protection against flooding. Stability analyses indicate the current lock walls and poiree sill will not meet current stability regulations. The lock walls can be stabilized by placing 19 feet of sand in the bottom of the chamber or stabilized with additional rock anchors. The poiree dam sill can be stabilized with 12 rock anchors. We are also proposing to place a one-foot thick reinforced concrete slab on top of the sand fill as a working surface. Dewatering equipment will also be provided. When completed, the dry dock would provide a clear working space of 550 by 110 feet. *(See Plates 51 through 54 in Section 26.4.5 for detail.)*

Figure 3. **Sheet Pile Cofferdam on the downstream end of the old Gallipolis Main Lock**

Figure 4. **Open Upstream end of the Old Gallipolis Main Lock Chamber**

2.1.7.1 R.C. Byrd Dry Dock Construction Sequence for Old Gallipolis main lock chamber

- Remove silt and sediment from old main lock chamber floor.

- Inspect and set poiree dam on the existing poiree sill.
- Anchor existing poiree sill.
- Dewater lock chamber.
- Construct seepage collection system and fill chamber with 19' of sand.
- Extend the downstream face of the existing poiree sill by 11'.
  - Drill and set steel dowels.
  - Cast-in-place the concrete addition.
- Place 1' concrete cap on sand fill.
- Cut bulkhead slots and install embedded metals in lock walls for bulkhead shoes.
- Cast-in-place a bulkhead sill across the poiree sill.
- Install 110' bulkheads.
- Re-water between the poiree dam and the bulkheads.
- Remove poiree dam.

2.2 PLAN 1 – AUXILIARY LOCK EXTENSION

Besides the features listed in Section 2.1 this basic plan requires that the existing 600' auxiliary lock chamber be extended 650' on the downstream end. *(See plate 1-4 for layout)*

Upstream construction requires that landwall monoliths L-29 through L-37 be demolished to provide 1,200' clear access to the floating approach wall (Upstream Guide Wall). *(See plate 1-1 for existing lock layout)*

A 1,346' floating upstream middle wall will be attached to the existing middle wall monolith M-34. The wall will consist of a pre-cast concrete pontoon structure, and will be floated to the site and anchored using 10' diameter drilled caisson shafts. The upstream end of the wall will measure 1,640' from the upstream auxiliary chamber miter gates providing 1,640' of approach/landing wall surface for locking.

There will also be a 1,346' floating upstream guard wall to be attached to river wall monolith R-86. This wall will measure 1,200' from the upstream end of the floating upstream middle wall.

Downstream construction requires that landwall monolith L-1 be demolished to construct the landwall extension. The extended landwall will be constructed using lift-in construction techniques. Existing landwall monoliths L-2 to L-5 will need to be anchored so that they will be able to handle the differential head placed upon them once they become part of the extended portion of the auxiliary chamber. A lift-in style monolith will be used to place monolith NL-1 along with monolith NM-1 and NM-2.

A Lower Landwall wall will tie to the new land wall downstream miter gate monolith (NL-1) and extend downstream for 1,184'. (This wall could not be extended enough to create the desired 1,200' landing zone without requiring the relocation of twin 26" high-pressure gas lines.) The existing downstream river wall will be extended from monolith R1 for a distance of 295' to provide 1,100' clear access to the downstream middle wall.

The existing fill/empty system for the 600' auxiliary lock will be used for this plan. This non-supplemented fill/empty system will, however, be unbalanced. This imbalance will manifest as a hydraulic gradient between the upper and lower ends of the chamber. This gradient will exasperate the Hawser forces, causing the fill/empty to be slowed down to keep the hydraulic

gradiating and resultant Hawser forces within acceptable levels. The fill/empty cycle will also be slowed because the chamber volume is doubled while filling/emptying capacity is not supplemented. The existing lower miter gate machinery & latches will be relocated downstream in the new miter gate monoliths.

2.2.1 Landwall Extension

Existing landwall monoliths L-2 through L-5 will be anchored and used as part of the extended chamber. The remainder of the downstream landwall extension will be constructed using lift-in construction techniques. Construction will take place in the wet.

2.3 PLAN 2 – AUXILIARY EXTENSION WITH MODIFICATIONS

This plan is the same as ***Plan 1 – AUXILIARY LOCK EXTENSION,*** as described in section 2.2 with the exception of the land wall construction. This new configuration will incorporate a culvert within the landwall.

This plan would function as a 1,200-foot lock with a slow unbalanced filling system and a normal balanced empty system. It will have a cycle time between what the ***Plan 1 – AUXILIARY LOCK EXTENSION*** would provide and what the ***Plan 3 – AUXILIARY EXTENSION WITH CULVERT*** would provide. In the event that future traffic exceeds current projections then the additional filling system could be constructed landward of the auxiliary lock to upgrade the filling cycle to standard lock design criteria. Since the laterals, empty culvert and outlet structure would already be in place in this plan; the auxiliary chamber would not be shut down by future construction necessary to complete the additional filling system. Thus, impacts to river traffic due to future construction needs would be minimal. Those components necessary for the construction of this plan are:

2.3.1 Landwall Extension

The landwall extension will be constructed using lift-in construction methods, similar to ***Plan 1 -AUXILIARY LOCK EXTENSION***, however, the wall will be founded at a lower elevation.

The extended portion of the landwall will be designed to accommodate a culvert for all the plans utilizing an additional filling and emptying system.

- Demolish existing downstream landwall monoliths L-1 to L-5.
- Lift-In landwall extension between existing landwall monolith L-6 and new landwall monolith NL-2. (This Lift-In section will be founded at elevation 458 because the culvert is at elevation 463. Monoliths NL-1 and NL-2 will be founded at El. 444 due to the invert of the culvert, which is at El. 449).

2.3.2 Additional Filling/Emptying System

Those additional F/E system components included in this plan but not included in the ***Plan 1 – AUXILIARY EXTENSION*** are:

- **Culvert in the New Landwall Monoliths**
- **Concrete Laterals in the Lock Chamber**

- **Emptying Culvert Valve in the New Landwall Structure**
  Construct empty valve structure with valve and empty system-operating machinery.
- **Emptying Culvert**
  The culvert will cross the auxiliary chamber at an angle of approximately 60 degrees and miss new monolith NM-1. It will then cross the main chamber and exit through the existing river wall.
- **Concrete Outlet Located Riverward of the Existing River Wall.**

2.4 PLAN 3 – AUXILIARY EXTENSION WITH CULVERT

This plan has a similar layout for the upstream and downstream approach wall configurations as ***Plan 2 - AUXILIARY EXTENSION WITH MODIFICATIONS***. This plan, however, incorporates a fully functional fill/empty system in the extended section of the chamber walls. Thus, the filling and emptying characteristics of this chamber will be equivalent to the main chamber (A standard speed, fully balanced, filling and emptying system). (See plate 17 for layout)

The filling and emptying system will be supplemented by constructing an intake structure just behind existing monoliths L-30 through L-37 of the upstream landwall. A wrap-around-culvert will be constructed between bridge piers of Kentucky State Route 10/Ohio State Route 253 on the Kentucky side of the Ohio River. The culvert will then transition back towards the auxiliary lock chamber and will be incorporated into the extended land wall, transition through monoliths NL-1/NL-2 and cross the auxiliary and main lock chambers at approximately a 60 degree angle. The culvert would then pass through the river wall. The miter gate machinery & latches from the existing downstream auxiliary lock miter gate will be moved downstream to the new miter gate sill.

Those components not common to ***Plan 2 – AUXILIARY EXTENSION WITH MODIFICATIONS*** but are necessary to construct this plan are discussed below:

2.4.1 Additional Filling/Emptying System

The additional filling and emptying system will consist of:

- **Concrete Intake**
- **Wingwalls**

2.4.1.1 Reinforced Concrete Culvert (Wrap-Around Culvert)

Due to the site restrictions at Greenup, it will be necessary to construct the culvert such that it passes between two bridge piers of the KY State Route 10 Highway Bridge. This bridge carries traffic across the Ohio River. *(See Figure 5)*

Figure 5. **Ky State Route 10 Bridge Piers**

2.4.1.2 Filling Valve Structure Located in the Esplanade

2.4.1.3 Filling Culvert Valve

The filling valve will be a vertically framed reverse tainter style. The hoist machinery will be the wire rope style with turning sheave and horizontally mounted hydraulic actuator. The valve will have both mechanical & remote electrical position indication. Valve control will include an automatic operating sequence to limit lock overfill. Valve operation will be interlocked to insure 'miter at the downstream miter gates before filling begins.

2.4.2 Temporary Upstream Cofferdam

In order to construct the intake structure and the upstream portion of the filling/emptying culvert, a temporary cofferdam will tie into the existing upstream land wall and connect to the riverbank. Once the cofferdam is constructed this area can be dewatered and the intake structure and the culvert can be constructed in the dry. When the intake structure has been constructed, the cofferdam will be removed and the upstream portion of the landwall would be demolished as described in Section 2.1.3. *(See Plate 17.)*

2.5 PLAN 4 – AUXILIARY EXTENSION - PHASED CONSTRUCTION

This plan is similar to ***Plan 3 -AUXILIARY EXTENSION WITH CULVERT*** as described in section 2.4, except it will be built in two phases. This plan has two economically timed construction phases. The first phase is ***Plan 2 – AUXILIARY EXTENSION WITH MODIFICATIONS*** as described in section 2.3. With the completion of the second phase the auxiliary lock extension would have a dual filling/emptying 1,200' lock as described under ***Plan 3 – AUXILIARY EXTENSION WITH CULVERT*** in section 2.4. This alternative provides for

the supplemental fill system to be constructed during a later phase when it could be more economically justified. *(See plate 18 for layout)*

2.5.1 Phase I Construction activities:

- Demolish existing downstream landwall monoliths L-1 to L-5.
- Lift-in extended landwall.
- Construct the filling/emptying laterals.
- Construct emptying valve structure in extended landwall and place valve in structure.
- Construct the emptying culvert and outlet
- Construct approach walls.

2.5.2 Phase II Construction activities:

Later the following steps would be taken to upgrade the system to the AUXILIARY EXTENSION WITH CULVERT configuration:

- Construct wrap-around-culvert.
- Construct intake structure.
- Install filling valve structure in the esplanade and place the valve operating machinery in the structure.

Table 1 Summary of Proposed Plan Alternatives

PLAN ALTERNATIVE	BRIEF DESCRIPTION	ADVANTAGES	DISADVANTAGES	CONSTRUCTED IN 1ST PHASE	CONSTRUCTED IN 2ND PHASE	1ST COST **	2ND COST (To Add F/E Sys.) **
Plan 1 – AUXILIARY LOCK EXTENSION	Auxiliary Lock Chamber is lengthened to a 1200' lock. Upstream & Downstream approach walls are added to improve navigation through the locks.	• Least Expensive Project	• If the aux. F/E system is required at a later date major modifications will be required	All constructed in 1st Phase	No future Phase	**$141,883,000**	**N/A**
Plan 2 – AUXILIARY EXTENSION WITH MODIFICATIONS	Auxiliary Lock Chamber is extended to a 1200' lock. Upstream & Downstream approach walls are added to improve navigation through the locks. Incorporates a culvert in the extended land wall, laterals in the chamber as well as the emptying culvert, outlet structure and emptying valve. This plan would thus have dual emptying systems and the additional Filling system could be added later.	• If it were deemed necessary to build the Aux. Filling system then the Aux. Lock Closure time would be minimized at that time.	• More costly than Plan 1. Would interfere with the Main Chamber more than Plan 1 during construction	All constructed in 1st Phase	No future Phase	**$149,441,000**	**N/A**
Plan 3 – AUXILIARY EXTENSION WITH CULVERT	Auxiliary Lock Chamber is extended to a 1200' lock. Upstream & Downstream approach walls are added to improve navigation through the locks. An Auxiliary F/E System is constructed with this plan including a new filling culvert	• Fastest Fill/Empty times because of new filling culvert. Project would be a fully functional twin 1200.	• Most expensive 1st phase project.	All constructed in 1st Phase	No future Phase	**$175,590,000**	**N/A**
Plan 4 – AUXILIARY EXTENSION - PHASED CONSTRUCTION	This alternative is to construct the Plan 3 in two phases. Basically building Plan 2 with the auxiliary emptying system and then building the auxiliary filling system around the year 2030 to take advantage of spending the money in the future when the extra capacity provided would be more of a benefit.	• Differs cost of additional filling system until traffic warrants additional capacity.	• Most expensive project (All phases)	Plan 2 as described above is constructed in the 1st phase.	In the second phase the bypass-culvert (additional filling culvert) and the Intake structure is constructed.	**$173,515,000**	**$25,901,000**

** - Cost includes design and construction of extension only. Rehab costs not included.

SECTION 3 LOCK AND DAM REHABILITATION

3.1 YEAR 2008 REHABILITATION WORK

Due to the age and use of Greenup Lock and Dam, there are a number of items that require major rehabilitation in order to remain in service throughout the estimated structural life of the project (approximately 100 years). Periodic Inspection Reports, maintenance records, availability and cost of spare parts, and extensive interviews with those involved with O&M of the project were all taken into account when deciding on the items requiring rehabilitation work.

The idea is that the rehabilitation work will be performed concurrently with the lock extension work when possible, such as cleaning & painting of the auxiliary chamber emergency gates during extension work. However, the bulk of the rehabilitation work must be performed after the auxiliary lock extension is complete to enable normal traffic flow through the newly extended auxiliary chamber during long main chamber closures for rehabilitation work. This plan should produce the most economical contracting scenario since contractor mobilization and demobilization would be reduced and more work can be accomplished during the same construction seasons.

3.1.1 Assembly Pier

Although the miter gate assembly pier is scheduled to be constructed during the lock extension work, it could easily be done as part of the rehabilitation work also. Either method must ensure that construction of the assembly pier is an early work item in order to ensure that gates can be assembled and ready for installation when required. Assembly of a miter gate is a high precision and time-consuming operation. Even though much of the work is performed in a fabrication shop, considerable effort is required at the project site. A gate leaf typically arrives at the job site in three or four segments because of size constraints during shipment. At the present time, it is assumed that a gate cannot be fully assembled by a manufacturer. Therefore, there would be no reason for the Division Gatelifter Crane to transport gates to the project. Once the gate sections are on site, they would be field welded to form a single leaf while on the assembly pier. After assembly and weld testing, the diagonal bracing, miter blocks, and quoin blocks would be installed and adjusted as best possible such that in-the-chamber work would be minimized. However, final tensioning and adjustment of the diagonals, quoin blocks, and miter blocks must be made with the gates in position in a dewatered area.

If all this work were to be done in-situ, in a dewatered lock chamber, it will greatly increase the closure duration. The assembly pier allows this work to be done outside the chamber and independent of the rest of the project. The gate lifter crane could then install the gate in a matter of a few days. Thus, reducing the construction and lock closure duration.

The current plan is to found the reinforced concrete assembly/storage pier on a landwall monolith between the bridge and downstream miter gates. In general, the pier measures 18' wide by 32' long by 66' tall and is positioned in proximity to the lock chamber so that the miter gates can be reached with the gate lifter crane. In addition, the pier is equipped with a jib crane,

electrical service and lighting. During construction, the contractor is allocated a staging area that utilizes part of the existing land wall esplanade. The contractor will be required to provide improved access, additional parking, alternate road layouts, and a temporary fence around the construction and staging areas during construction. Although this is the current plan, many other suggestions have been made to accommodate the assembly and storage of gates. The Huntington District will reevaluate this position after the success of the Louisville District's assembly pier at McAlpine Lock and Dam is analyzed.

3.1.2 Replace Main Chamber Miter Gates and Appurtenances

Reliability work conducted as part of the Ohio River Mainstem Study concluded that Greenup's main chamber miter gates were justified for replacement in 2004. The design of the gates, along with the rate of corrosion and number of loading cycles warrants this early replacement date. Lock extension work will not be complete until 2008. Therefore, main chamber gates will be replaced during rehabilitation soon after the auxiliary lock is open for 1200' tow traffic.

The miter gates will be partially fabricated and delivered to the job site. Two sets of gates are required for the main chamber (one set of gates will have already been installed at the downstream end of the extended auxiliary lock as part of the 600' lock extension project). The gates are steel, horizontally framed, and measure 62'-0" wide by 59'-0" tall. Due to their size and weight, the gates will be delivered in sections. Assembly of the gates involves welding the sections together, adding the walkway, gate quoin and miter blocks, bottom seals, fenders, and the diagonals. Installation of the diagonals and gate quoin and miter block will be performed to minimize in-the-chamber construction, but final adjustments must be made once the gates are installed in the chamber. Miter gate monolith components such as the pintle assembly, embedded wall quoins and embedded anchorages will be shipped separately and stored until the gate is installed in the chamber. After the gates are assembled, they will be stored on the assembly pier until they are to be installed. The assembly pier can support only one set of gates and requires that the first set of gates be installed in the chamber before delivery of the second set of gates.

The replacement of miter gates requires dewatering of the lock chamber. The existing gates will be removed and scrapped. Due to their age and condition, their rehabilitation and reuse is not planned.

Installation of new wall quoins will be another item of work done during the rehabilitation. A possible alternative to our current design is adjustable wall quoin design developed by Louisville District. The use of this design may make the quoins easily adjustable to ensure a better seal and full bearing of the gate against the lock wall. It is anticipated that the normal quoin adjustment work can be done in approximately a couple days instead of the extended closure time currently required. However, the new design is unproven and is definitely very difficult to install. The current maintenance performed for wall quoins includes applying epoxies to the wall quoins, applying a release agent to the gate quoins and closing the gates to allow the gate quoins to match the wall quoins in order for the epoxy to fill the gaps.

3.1.3 Miter Gate Operating Machinery

As part of the replacement of the miter gates, the operating machinery will also be replaced. Although normal maintenance has kept the items in working order, they are old and worn considerably. By the 2008 rehabilitation date, the machinery will be in need of major work. Replacement items may include: strut, sector arm, sector gear, sector base, rack, guides, and anchorage. It is logical to perform this work while the gates are being replaced.

3.1.4 Removal of Silt, Drift and Debris

3.1.4.1 Lock Drift and Debris

Hydraulic performance of the Greenup Locks has been monitored by the Periodic Inspection (P.I.) Program for many years. A slight change increase in fill and empty times has been identified and the cause isbelieved to be related to the amount of foreign matter in the fill and empty system and lock floor. Rehabilitation work will include the complete removal of all drift and debris from both locks when dewatered. Drift and debris is a significant problem at Greenup (see Figure 1.) and rehabilitation closures are the ideal opportunity to accomplish this work.

Figure 6. Accumulation of Drift & Debris in Auxiliary Lock

3.1.4.2 Cleaning Sediment out of the lateral fields

The culvert laterals provide efficient and balanced distribution of water for the filling and emptying cycles of the lock chambers. However, this efficiency has been reduced in recent years

due to clogging of the filling and emptying system caused by drift and debris settling into the culverts, laterals and laterals fields. This is getting to be a significant problem at Greenup. In recent years, the fleet has started to include the removal of the drift and debris as part of their normal maintenance cycle. However, due to the short closure times and limited resources, they have only concentrated their effort on only the most severe blockages. In addition, some of the culverts are filling up as some of the screen bars are missing. This will only exasperated the problem in the future. The extended lock closures for rehabilitation work provides the perfect opportunity to repair/replace screens and remove all of the drift and debris from all of the culverts, laterals and laterals fields.

The main chamber will be more difficult to clean out than the auxiliary chamber. The main chamber does not have any land access. Therefore, all work must be from a floating plant including double handling all material. What we have done in the past is to put men and construction equipment into the main chamber. The men with chainsaws will saw up the debris and remove it from the laterals. Construction type equipment like front end loaders and/or backhoes will then shove the waste material towards the river wall. Some type of crane, whether it be a land crane mounted on the river wall, or a floating crane that can reach over the river wall, will then hoist the material from the chamber and load it into a barge located on outside the river wall. The final step is to offload the material from the barge and placed it into dump trucks. The dump trucks then transport the material to the final land based disposal site.

The work on the auxiliary chamber will be easier since the access is land based. What we have done in the past is to set a crane on the land wall. The crane has the capacity to reach across the chamber and pick up any thing that needs to be removed. The crane will then swing around and load the dump trucks without any special efforts. All waste material will then be transported directly to the disposal site. In addition, the auxiliary chamber is only half the size of the main chamber. Therefore, the time needed to accomplish the work is also about half of what is needed for the main chamber.

3.1.5 Painting and Rehabilitation of Emergency Gates

Both main and auxiliary chamber emergency gates are in need of a major rehabilitation. Long chamber closures are not justified for these items. Thus, these gates have not had any major maintenance or repairs since they were put in service in the early 1960's. This is an item for the auxiliary chamber that should be performed concurrently with lock extension work to save another dewatering closure.

One major item of work associated with the emergency gates deals with the screens on the downstream side of the gates. The screens were in place to prevent large debris from entering the gates. However, in recent years, zebra mussels have essentially covered the screens – preventing silt form exiting the gates. This problem is a major concern since the hoist machinery could be overloaded due to the extra silt weight within the gate. For this reason, the screens have been removed from the gates. This condition allows larger debris to become lodged in the gate – causing other problems. If a system can be developed to keep the zebra mussels off the screens, they will be reinstalled, but they may not be reinstalled if no solution is in place to keep the mussels from returning.

In addition to work on the gates themselves, items such as the cable recess trash screens, gate guides, rollers, sheaves and pins, and operating machinery need rehabilitation work. For example, the trash screens for the gate recesses are heavily corroded and need to be cleaned, sandblasted, and painted or possibly replaced entirely. The electrical equipment for the

emergency gates of both locks will be replaced. This equipment consists all electrical equipment related to operation of the emergency gates including the controllers, pushbutton control stations, power distribution equipment in the pier houses, limit switches, lighting, hoists used for trash screen handling, replacement of the hoist machinery brakes. In addition, work would include rehabilitation of the gate hoist motors and replacement of the interconnecting power and control cables. Other items may require rehabilitation or total replacement.

3.1.6 Convert Poiree Dam Closures to Standard Bulkhead Closures

Typical repair fleets during the late 1950's (when Greenup Locks were designed and constructed) used only small dewatering pumps. This necessitated the ability to isolate the miter gates with pairs of closely placed closures units to reduce pumping time. Greenup uses two styles of maintenance closure for each of the four sets of miter gates. A poiree dam closure is located on the upstream side while a standard bulkhead closure is located downstream of each miter gate. In addition to these closure systems, the upstream miter gate system has an emergency gate located between the miter gate and the upstream poiree dam closure. Today, with advent of larger dewatering pumps, it is now easier to dewater the entire chamber than install the poiree dam. Therefore, the typical closure now consists of raising the emergency gate on the upstream side and setting the downstream bulkheads (below the downstream miter gates). Once the closures are in place, the chamber is dewatered. However, in November 1999, the main chamber emergency gate failed to operate and the poiree dam had to be installed. The poiree dam consists of vertical, steel A-frames that are anchored to a concrete sill by divers, horizontal beams which span between the A-frames, and a series of timbers placed vertically as the water barrier. This system is cumbersome and installation is time consuming. The November 1999 installation took 3½ days to complete and it typically takes another 10-hour shift to remove the system.

As a poiree dam reaches the end of its design life, rehabilitation or replacement alternatives must be considered. Rehabilitation or replacement considerations are necessary because the upstream, embedded anchorages for the A-frames corrode and lose their structural capabilities over time. The strength of the anchorages gradually becomes questionable. Other Districts have experienced failures of these components during service which, fortunately, did not result in loss of life or property. As part of a Corps wide safety program and prior to the installation of any poiree dam, all 21 upstream embedded steel anchorage castings must be tensile tested. The test consists of applying a test load of 45-kips to each upstream anchorage casting. Once each casting has been tested, the assembly of the poiree dam may begin. However, if any of the anchorage castings fail the test, it must be replaced with divers. In addition to installation concerns, maintenance to the system is also frequently necessary. Wooden members deteriorate quickly. Therefore, new wood timbers are frequently required to be fabricated.

A major advantage of the standard bulkhead system is its simplicity. It is composed of slots cut vertically into the chamber walls, a sill, and 4 to 5 universal bulkheads that are kept and used by the repair fleet. A typical installation takes just 4 hours; removal takes another 4 hours. Since this lock extension is primarily justified by the need for extensive maintenance closures, savings of 3½ days for any lock maintenance work is significant. Finally, the bulkhead system's

simplicity and ease of installation makes them extremely reliable and maintenance requirements are minimal.

As part of the rehabilitation work, only the upstream poiree dam closures will be converted to standard bulkhead closures. The conversion from a poiree dam system to a bulkhead system consists of the following:

1. Convert the existing poiree dam sill to be used as the maintenance bulkhead sill by filling the 21 anchorage point recesses.
2. Constructing the necessary seal and seating points for the bulkheads.
3. Cut vertical bulkhead slots in the face of the lock walls
4. Install embedded metal guides in lock walls
5. Grout embedded items

Figure 7. Main Chamber Poiree Dam, showing "A" frames and anchorage points

3.1.7 Culvert Valves and Operating Machinery

Although reliability data does not show replacement of valves until the 2030 rehabilitation, the operating machinery needs work in order for uninterrupted, continued use. Structurally, the valves are in good condition. However, the skin plates are significantly pitted, connections to the trunnion beam are worn, and the trunnion beam itself needs rehabilitation. The operating machinery will also require extensive work by the 2008 time frame. Cylinders, cross head, cross head guide, bell crank and strut will all be investigated for replacement. The equipment used to sense the position of the culvert valves will be changed from the current

selsyn type position indicators to either discrete limit switches or electronic sensors that convert angular rotation to valve percent open.

3.1.8 Hydraulic System

Both the main and auxiliary lock hydraulic system culvert valve and miter gate control valves were replaced in 1997 with manifold type components. It will be necessary to replace the hydraulic oil reservoir and main hydraulic pumps, holding pump, pump control components and pump motors during the 2008 rehabilitation.

3.1.9 Electrical Rehabilitation

In view of the age of the electrical power distribution, lighting and control systems at the time of the 2008 rehabilitation (48 years) and the 2030 rehabilitation (70 years), those systems should be rehabilitated in 2008 as described herein.

3.1.9.1 Motor Control Center (MCC)

The motor control centers will be replaced. There are currently two that serve the project. One is for the lock and dam. The other is for a gate closure system for the bridge that crosses the dam. It is anticipated that these two MCC's can be combined into one unit to simplify the electrical system and to free up space in the MCC room to facilitate maintenance and provide room for future equipment, if needed.

3.1.9.2 Lock Control System

The existing lock control relays have been in use since the initial construction of the project. These control components will be replaced using PLC type control system. The PLC processor will be housed in the MCC and will provide control logic forboth the auxiliary and main locks. A PLC will be used because it will minimize component space in the MCC and will facilitate a transition from on the wall lock control to a centralized control station should the decision be made to provide centralized control.

3.1.9.3 Cable Tray System

The existing cable tray system will be replaced. The existing cable tray was constructed of asbestos and should be replaced. The addition of electrical cables to these trays over the years has resulted in cable trays that are overloaded. This complicates the maintenance of the cable system and results in an arrangement where cables could become overheated. Since the electrical cables are theoretically nearing the end of their useful life (and certainly will be by 2030), the cables and tray should be replaced. Scheduling cable tray replacement concurrent with wire and cable replacement is ideal.

3.1.9.4 Wire and Cable

As mentioned above, the wire and cable are nearing the end of their useful life and should be replaced. This includes most of the wire and cable on the dam as well. It is recommended that changeout of the wire and cable not be put off until the next planned rehabilitation of 2030.

Also, replacement of the wire and cable becomes more appropriate if the existing discrete control relays are to replaced with a PLC control system as discussed above.

3.1.9.5 Dam Gate Equipment

This rehabilitation should also include replacement of the dam gate electrical controls, power distribution equipment, replacement of the gate hoist machinery brake and rehabilitation of the gate hoist motors. This equipment will be 48 years old by the scheduled 2008 rehabilitation and therefore should be replaced and rehabilitated as indicated.

3.1.9.6 Lock and Dam lighting

The general lock lighting was replaced in the late 90's with high mast lighting and will not be rehabilitated. However, specific lighting such as floating mooring bitt, miter gate recess, and pier lighting will be replaced during the rehabilitation.

3.1.9.7 Central Control System

One possible rehabilitation item will have to be evaluated as the actual rehabilitation work time frame draws closer. Centralized control of the entire project from one control room is a possible item of work during the rehabilitation contract. The most recent locks designed and constructed by the District (Winfield & Marmet) include a system to operate each new lock and dam from an indoor control room. The long-term advantages and disadvantages of such a system must be evaluated and compared to the initial cost.

The control system for the extended auxiliary lock could be included in the lock extension work. Rehabilitation work would include updating the existing main chamber and dam for centralized control. To accommodate the control system, an addition atop the existing lock operations building would be necessary to house the computer and surveillance equipment and to provide the operator with a view of the entire project for safety.

3.1.10 General Lock Appurtenances

In addition to the large rehabilitation items, there are many small areas that require attention during work at the project.

3.1.10.1 Floating Mooring Bitts

Many floating mooring bitts are need of repair or replacement. Normal wear and corrosion is the partially the cause. However, much of the damage comes from tows "checking" (stopping) their momentum by using the bitts. Many of the guides which allow the bitts to roll are badly damaged and need total replacement.

3.1.10.2 Middle Wall Fill Settlement

The middle wall soil fill (pansy beds) has been a continual maintenance problem since soon after the project went into operation. The center of the middle wall was filled with soil instead of solid concrete during construction. Constant soil settlement and saturation caused wall cracking and separation. The wall was pinned together several years ago with solid bar anchors to prevent further movement and the entire surface was covered with a concrete slab to minimize

water infiltration. Slab settlement continues to be a maintenance problem and major work will be performed during rehabilitationwork to permanently correct the situation.

3.1.10.3 General Concrete Work

Due to the age of the project, normal concrete maintenance is becoming a large effort for project employees. The rehabilitation work will include patching and sealing of any large concrete problem areas to ensure proper performance for several years.

3.1.10.4 Lock Wall Embedded Metal

Many areas of wall armor and corner protection are excessively worn and corroded such that replacement may be warranted. A thorough inspection and delineation will be performed prior to rehabilitation work in order to determine the exact areas requiring attention. It is estimated that approximately 10,000 lineal feet may need replaced.

3.1.10.5 Miscellaneous

The raw water pump, HVAC systems for the operations building and the maintenance building, sewage lift station and controller and sewage treatment plant and controls, potable water piping and building plumbing fixtures should be replaced during the 2008 rehabilitation work.

3.1.10.6 Dam

The hoist motor for the bulkhead crane should be rebuilt and the hoist controls, hoist brake and travel drive system for the crane should be replaced during the 2008 rehabilitation work. The piggy back crane is scheduled for replacement in 2002.

3.2 YEAR 2030 REHABILITATION WORK

3.2.1 Replace Auxiliary Chamber Miter gates

The time frame for the rehabilitation of the auxiliary chamber is around 2030. A major rehabilitation report will be completed at that time.

3.2.2 Miscellaneous Lock Items

- Refurbish miter gate operating machinery
- Refurbish culvert valve operating machinery
- Refurbish emergency gate operating machinery
- Hydraulic power system – replace control valves, refurbish pumps, tank, and piping
- Replace emergency generator and fuel reservoir
- Replace air compressors, control valves, and refurbish air piping
- Refurbish pump and raw water piping
- Operations Building – refurbish HVAC, potable water piping, plumbing fixtures, sewer piping, and lift stations

- Maintenance Building- refurbish HVAC, potable water piping, plumbing fixtures, sewer piping, and treatment plant

3.2.3 Dam

Replace bulkhead hoist machinery, drive machinery, and refurbish piggy back crane.

3.3 YEAR 2045 REHABILITATION

3.3.1 Rehabilitation of Dam

The time frame for the rehabilitation of the dam is around 2045. A major rehabilitation report will be completed for this work as well.

3.3.2 Miscellaneous Lock Items

- Refurbish or replace miter gate operating machinery
- Refurbish or replace culvert valve operating machinery
- Refurbish emergency gate operating machinery
- Hydraulic power system – replace control valves, refurbish pumps, tank, and piping
- Replace emergency generator and fuel reservoir
- Replace air compressors, control valves, and refurbish air piping
- Refurbish pump and raw water piping
- Operations Building – refurbish HVAC, potable water piping, plumbing fixtures, sewer piping, and lift stations
- Maintenance Building- refurbish HVAC, potable water piping, plumbing fixtures, sewer piping, and treatment plant

3.3.3 Dam

- Refurbish tainter gate hoist machinery
- Refurbish bulkhead hoist machinery, drive machinery, and piggy back crane

SECTION 4 HYDROLOGY

4.1 CLIMATOLOGY AND METEOROLGY

The Ohio River Basin is marked by moderately extreme variations of temperature and precipitation. The climate in the area of the Greenup Pool is classified as humid continental with rainfall being fairly evenly distributed throughout the year. The average annual precipitation for the Ohio River Basin is approximately 43 inches. Varying from 52 inches in the southwest to 56 inches in the southeast, and 36 inches along the northern divide. Snowfall averages 28 inches annually and constitutes only a minor portion of the total precipitation. The average annual temperature in the project area is approximately 54 degrees Fahrenheit (ºF), with temperatures varying with location and elevation. Summer months are moderately warm and humid with annual average temperatures ranging between 70 and 80ºF. Winters are reasonably cold with annual average temperatures ranging between 20 and 40ºF. Meteorological data for stations within the primary study area are provided in Table 2. Although the area exhibits a degree of homogeneity in climate, very hot and sub-zero temperatures often occur in the same year. Similarly, drought and flood events have been recorded in the same 12-month period. There have also been local droughts in various parts of the Ohio River Basin but in different years. Flood occurrences vary, seldom covering the entire Ohio River Basin during the same climatic period.

Because of varied topography and associated differences in local climates, generalized statements for humidity conditions cannot be made, with the exception that it is usually more intense in the early morning hours and tapers off shortly after noon. Heavy fog occurs most frequently during spring, summer and fall, with some averaging at least 50 days of heavy fog each year. These areas, particularly in the more industrial reaches of the Greenup Pool, are especially susceptible to atmospheric stagnation.

Prevailing winds are from westerly directions, averaging 5 to 7 MPH during the summer and winter months, respectively. Damaging winds occur most often during spring and summer months and are associated with major thunderstorms. There are several types of storm activity that can be expected to occur in the Ohio River Basin. The most frequent is a result of the passage of warm, moist air from the south or southwest coming into contact with the cooler, often drier, air from the north or northwest.

Flood producing storms, generally occurring in late winter through early spring months, are of two types. The first of these is characterized by long duration with relatively low intensity and of a wide extent. The opposing action of two large stationary anticyclones, or “highs”, one located off the Atlantic Coast and the other entrenched over the upper portions of the Mississippi and Missouri Basins, creates this type of storm. A stationary front lying northeast to southwest across the Ohio River Basin is produced. Along this front, a succession of “moist waves” may move northeastward, resulting in bursts of copious warm rains for prolonged periods. The condition continues to exist until there is a displacement of one or both of anticyclones. A tremendous amount of water falls during this type of storm.

Another type of storm causes moderate to fairly heavy and sometimes intense precipitation for a short duration and over broad but smaller area. One or more closely related cyclones, or "lows", are responsible. The impact of this type of storm on the area is compounded by the fact that it most frequently occurs between December and April, when soils are generally saturated. The storms occasionally occur during the summer months, which permit the soil to absorb a larger quantity of rainfall, therefore, resulting in lower runoff.

A study of past flood producing storms indicates that the general northeast-southwest alignment would continue. However, the storm center with heaviest rains could be transposed to almost any point in the Ohio River Basin, still distribution of rainfall would be affected by topographic features. Moderate rainfalls can occur on the perimeter of each storm. Storms covering the Greenup Pool area of 62,000 square miles may result in up to 15 inches of rainfall during a two- to five-day storm period. Areas as large as 20,000 square miles may experience 24-hour rainfalls in excess of six inches. The Ohio River Basin may experience several of these two- to five-day storms in succession, separated by only three or four days of clear weather. Thunderstorms often yield intense local rainfall that may cause flash flooding on small streams. The Ohio River Basin averages 30 to 50 days of thunderstorms each year, only a few severe.

Table 2 Meteorological Data for Various Stations Within the Primary Project Area

Station Location	Elevation (ft-NGVD)	Period of Record	Temperature (ºF)			Precipitation (inches)			Snowfall (inches)
			Average	Maximum	Minimum	Average	Maximum	Minimum	
Steubenville, OH	992	1941-present	52.1	102	-22	40.43	59.93	29.12	42.00
Parkersburg, WV	620	1926-present	54.4	105	-16	38.49	55.56	19.70	22.05
Gallipolis, OH	569	1936-present	55.3	109	-21	40.58	52.57	27.28	18.09
Huntington, WV	520	1967-present	57.1	102	-13	40.51	51.46	34.55	13.01
Ashland, KY	560	1932-present	54.9	105	-18	40.78	61.41	28.26	11.17
Greenup, KY	537	1961-present	----	----	----	39.35	48.91	30.29	11.22
Portsmouth, OH	540	1936-present	55.4	105	-20	41.12	55.88	29.91	14.68
Mayseville, KY	515	1948-present	53.6	105	-19	44.30	57.31	30.80	10.46

Note: Tabulated period of record extends to water year through 1993.

4.2 STREAM CHARACTERISTICS

The main stem of the Ohio River is formed by the junction of the Allegheny and Monongahela Rivers at Pittsburgh and then flows in a general southwesterly direction, falling 429 feet in its 981-mile course to Cairo. Considering the size of the overall drainage area, the valley is rather narrow which reflects the glacial changes. It ranges in average width from less than a half mile in the Pittsburgh to Wheeling reach to more than a mile between Cincinnati and Louisville. At Louisville, the Ohio River widens to approximately four miles and then contracts to a mile below the Salt River. Near the mouth, the Ohio River again widen to about six to eight miles. Elevations vary from 100 to 600 feet below the plateaus surrounding the valley. The only falls are at Louisville, where a 26-feet difference in water surface between the upper and lower pools existed prior to canalization. The total contributing drainage area of the Ohio River Basin is approximately 203,940 square miles, with 62,000 square miles being contributed at the Greenup Locks and Dam project.

Tributaries in the Ohio River Basin vary from very steep mountain streams with cascades and rapids to sluggish, meandering, marsh-like areas. Slopes of major tributaries vary from more than 100 feet per mile in the headwaters to less than two-tenths of a foot per mile in the flat areas near the main stem. In general, the streams are considerably steeper in the headwaters, becoming relatively level near the mouth. Post-glacial changes in stream patterns, local layers of hard rock and distribution of tributaries may cause local modifications in profiles.

In 1835, Lieutenant George Dutton first expressed his view that the construction of locks and dams was necessary to provide adequate navigation conditions for year round use of the Ohio River. Over the course of time, navigation structures have been constructed, altered and modernized to reflect the transforming needs of the navigation system. Some basic components of the Ohio River Navigation System have remained unchanged since canalization was completed in 1929. It consists of 981 river miles, with a navigable depth of nine feet and locks 110-feet wide. The significant modifications that have been made to the system fall into two categories: (1) replacement of low lift navigable lock and dam structures with a smaller number of high lift non-navigable structures and, (2) construction of 1200-feet lock chambers to accommodate longer tows. At the present time, there are twenty active locks and dams on the Ohio River. A plan profile of the Ohio River system is provided in Figure 8.

Figure 8. **Ohio River Mainstem Navigation System**

4.3 STREAMFLOW DATA

The collection of systematic hydrologic records on the Ohio River dates back to the flood heights recorded at Pittsburgh in 1806. At first, only significant hydrologic events were recorded. These events usually consisted of floods of unusual magnitude, extent or duration. Continuous record collection on the Ohio River began at Pittsburgh in 1847, Cincinnati in 1858, and Louisville in1866. Today the 981 navigable miles of the Ohio River is divided among three Districts within the Lakes and River Division of the U.S. Army Corps of Engineers. The Pittsburgh District (River Mile 0-127.2), Huntington District (River Mile 127.2-438), and Louisville District (River Mile 498-981) maintain a database of hydrologic information for their respected reach. Continuous hydrologic records are kept at locks and dams on the Ohio River. In addition, many communities and flood control projects havegages that provide a continuous record. Records of stage are most readily available with stream flow records being less common. Stage-discharge relationships have been developed at the gage locations. The locations of various stream flow gages together with other pertinent data are contained in Table 3.

Table 3 Ohio River Stream Flow Gaging Stations

Station Locations	River Mile	Drainage Area (square miles)	Period of Record	Maximum Stage (ft)	Gage Datum (ft)
Saint Marys, WV	155.0	26,850	1913-1972	54.20	577.30 1
Marietta, OH	174.3	35,600	1968-Present	38.52	567.12 1
Pomeroy, OH	251.3	40,520	1913-1968	55.00	514.10 1
Point Pleasant, WV	265.2	52,760	1940-Present	55.00	514.00 1
Huntington, WV	308.3	55,900	1935-Present	61.60	490.26 1
Ashland, KY	322.5	60,750	1884-Present	73.60	483.10 1
Greenup L&D	341.0	62,000	1968-Present	50.96	472.97 2
Maysville, KY	408.6	70,130	1937-Present	75.30	451.50 1

1. Denotes Sandy Hook Datum.

2. Denotes 1929 Datum.

The frequency of flooding relationships for the Ohio River Basin were produced by the U.S. Army Corps of Engineers for the Ohio River Basin Comprehensive Survey, dated August 1966. For the natural flood frequency computations, observed peak annual flows for all years since initiation of data storage were adjusted to natural conditions by evaluating actual reservoir effects existing at that particular time. The computed natural statistics (mean, standard deviation and coefficient of skew) for the entire period of record were adjusted by reconciling adjacent points and comparing drainage area proportions to produce consistent statistics throughout the length of the Ohio River. Stage-frequency curves were developed by converting flows to stage using crest stage-maximum discharge relationships plotted from historical data and extended rating curves prepared in connection with an Ohio River Standard Project Flood (SPF) study. To determine modified flood peaks for the Ohio River, twelve historical floods plus three hypothetical floods of greater magnitude were utilized in the analyses of flow modifications. The flows for those fifteen flood events, which are considered representative of the Ohio River Basin, were modified by the operation of U.S. Army Corps of Engineers reservoirs. The amount of reduction in peak discharge versus the natural discharge for the forgoing inundations were used to develop a series of curves, which indicate average reservoir system capability to reduce peak flows for various recurrence intervals. Table 4 through Table 9 provides the stage frequency relationships of various recurrence intervals for several gaging stations within the Ohio River Basin. Plate No. 6-1, shows historical high water surface profiles for the main stem of the Ohio River in the immediate project area.

Table 4 Ohio River Gaging Station - Saint Marys, WV

	Natural Condition			Modified Condition		
		Stage (ft)	Elevation (ft) 1929 Datum	Flow (cfs)	Elevation	
					1929 Datum	Sandy Hook
0.1	690,000	62.7	640.0	550,000	632.7	633.1
0.2	650,000	60.8	638.1	515,000	630.9	631.3
0.5	594,000	58.0	635.3	467,000	627.9	628.3
1	550,000	55.7	633.0	432,000	625.6	626.0
2	504,000	53.2	630.5	395,000	623.2	623.6
4	460,000	50.5	626.5	360,000	620.7	621.1
5	444,000	49.5	625.5	347,000	619.9	620.3
10	396,000	46.3	623.6	312,000	616.9	617.3
20	347,000	43.0	620.3	276,000	613.9	614.3
50	277,000	37.1	614.4	228,000	608.9	609.3
99.99	120,000	31.3	608.6	187,000	604.7	605.1

1929 Datum Gage Zero = 576.9, Sandy Hook Datum = 577.3

Table 5 Ohio River Gaging Station – Point Pleasant, WV

	Natural Condition			Modified Condition		
		Stage (ft)	Elevation (ft) 1929 Datum	Flow (cfs)	Elevation	
					1929 Datum	Sandy Hook
0.1	887,000	74.0	587.7	698,000	579.2	579.4
0.2	835,000	72.0	585.7	642,000	576.6	576.8
0.5	763,000	68.7	582.4	578,000	572.9	573.1
1	709,000	66.1	579.8	532,000	570.0	570.2
2	654,000	63.3	577.0	486,000	567.0	567.2
4	597,000	60.2	573.9	442,000	563.9	564.1
5	578,000	59.1	572.8	428,000	563.1	563.3
10	520,000	55.5	569.2	388,000	560.1	560.3
20	456,000	51.2	564.9	347,000	557.0	557.2
50	363,000	44.5	558.2	292,000	552.0	552.2
99.99	280,000	37.7	551.4	242,000	546.9	547.1

1929 Datum Gage Zero = 513.7, Sandy Hook Datum = 514.1

Table 6 Ohio River Gaging Station – Huntington, WV

	Natural Condition			Modified Condition		
		Stage (ft)	Elevation (ft) 1929 Datum	Flow (cfs)	Elevation	
					1929 Datum	Sandy Hook
0.1	902,000	77.8	567.6	732,000	560.8	561.8
0.2	853,000	76.0	565.8	672,000	557.9	558.8
0.5	784,000	73.2	563.0	604,000	554.6	555.6
1	728,000	70.7	560.5	560,000	552.1	553.1
2	683,000	68.2	558.0	517,000	549.8	550.8
4	615,000	65.3	555.1	477,000	547.3	548.5
5	595,000	64.4	554.2	464,000	546.4	547.7
10	533,000	61.0	550.8	426,000	543.7	545.2
20	470,000	56.9	546.7	385,000	540.4	542.1
50	374,000	49.7	539.5	327,000	535.5	537.5
99.99	287,000	42.2	532.0	277,000	530.1	533.0

1929 Datum Gage Zero = 498.8, Sandy Hook Datum = 490.3

Table 7 Ohio River Gaging Station – Ashland, KY

	Natural Condition			Modified Condition		
		Stage (ft)	Elevation (ft) 1929 Datum	Flow (cfs)	Elevation	
					1929 Datum	Sandy Hook
0.1	950,000	81.8	563.3	760,000	555.2	555.7
0.2	893,000	79.6	561.1	697,000	552.5	553.0
0.5	817,000	76.8	558.3	632,000	549.2	549.7
1	760,000	74.4	555.9	587,000	546.8	547.3
2	702,000	71.8	553.3	545,000	544.6	545.1
4	642,000	68.9	550.4	505,000	542.3	542.8
5	622,000	67.8	549.2	492,000	541.4	541.9
10	557,000	64.3	545.8	451,000	538.8	539.3
20	492,000	60.3	541.8	410,000	535.8	536.3
50	392,000	53.3	534.8	351,000	531.2	531.7
99.99	350,000	45.3	526.8	305,000	526.7	527.2

1929 Datum Gage Zero = 481.03, Sandy Hook Datum = 481.5

Table 8 Ohio River Gaging Station – Greenup L&D

	Natural Condition			Modified Condition		
		Stage (ft)	Elevation (ft) 1929 Datum	Flow (cfs)	Elevation	
					1929 Datum	Sandy Hook
0.1	1,005,000	81.2	551.4	818,940	549.3	549.9
0.2	948,000	79.0	549.2	756,400	546.9	547.5
0.5	868,000	75.7	545.9	683,940	543.5	544.1
1	807,000	73.2	543.4	633,300	540.8	541.4
2	744,000	70.5	540.7	585,660	538.4	539.0
4	680,000	67.8	538.0	538,000	536.0	536.6
5	660,000	66.7	536.9	523,130	535.0	535.6
10	593,000	63.1	533.3	477,470	532.0	532.6
20	522,000	58.8	529.0	427,830	529.0	529.6
50	416,000	51.7	521.9	359,340	524.0	524.6
99.99	300,000	43.0	513.2	297,800	519.2	519.8

1929 Datum Gage Zero = 472.43, Sandy Hook Datum = 472.97

Table 9 Ohio River Gaging Station – Maysville, KY

	Natural Condition			Modified Condition		
		Stage (ft)	Elevation (ft) 1929 Datum	Flow (cfs)	Elevation	
					1929 Datum	Sandy Hook
0.1	----	----	----	831,000	524.7	525.3
0.2	948,000	79.0	530.5	775,000	522.3	522.9
0.5	874,000	75.8	527.3	705,000	518.8	519.4
1	815,000	73.2	524.7	654,000	516.0	516.6
2	754,000	70.4	521.9	604,000	513.2	513.8
4	692,000	67.3	518.2	558,000	510.4	511.0
5	672,000	66.1	517.6	541,000	509.2	509.8
10	604,000	62.3	513.8	494,000	506.0	506.6
20	532,000	57.7	509.2	447,000	502.2	502.8
50	421,000	49.4	500.9	373,000	496.2	496.8
99.99	343,000	41.1	492.6	312,000	490.1	490.7

1929 Datum Gage Zero = 450.9, Sandy Hook Datum = 451.5

Likewise, general methods used in low-flow frequency analyses are the same as those used in analyses of flood frequency analyses, except the parameter of interest is minimum rather than maximum flow. Low flows are important parameters for navigation and hydroelectric power development. Hydrologic stream flow data pertinent to navigation interests can be summarized graphically in the form of flow duration and stage-duration curves. The curves show the relationship between percent time exceedence and either stage or flow. In a statistical sense, the stage-duration curve is a cumulative frequency curve of a continuous time series, displaying the relative duration of various magnitudes. The stage-duration curves were developed through

compiling historical stage information at various gage locations. Based upon mean daily stage values, this historical information was analyzed to determine statistical average monthly and average annual, percent stage exceedence. The annual stage-duration curves for the Greenup Locks and Dam upper and lower gages are provided in Figure 9 and Figure 10, respectively. In addition, monthly stage-duration curves are available, however, annual stage duration curves for the R.C. Byrd L&D, Huntington, and Ashland Gages are provided as Plates No. 6-3 through 6-6.

Figure 9. R.C. Byrd L&D Upper Gage Annual Stage-Duration Curve

R.C. BYRD UPPER GAGE
1963-1998

DURATION	STAGE
0.01	49.83
0.05	46.29
0.10	43.21
0.20	39.27
0.50	32.94
1.00	27.57
2.00	22.05
5.00	15.60
10.00	13.02
15.00	12.81
20.00	12.71
30.00	12.48
40.00	12.36
50.00	12.28
60.00	12.23
70.00	12.18
80.00	12.11
85.00	12.07
90.00	12.03
95.00	11.95
98.00	11.85
99.00	11.77
99.50	11.70
99.80	11.61
99.90	11.55
99.95	11.49
99.99	11.35

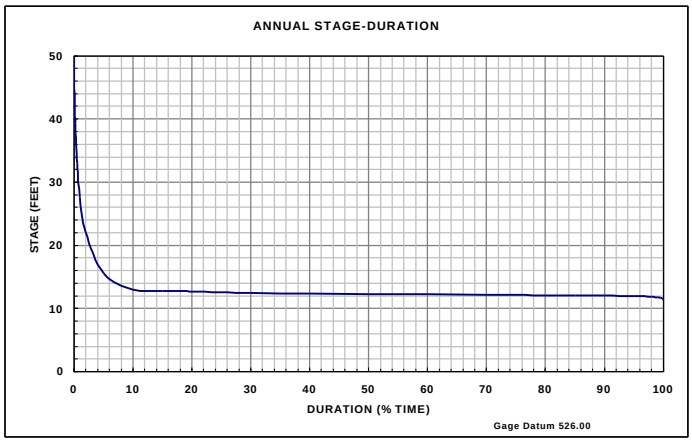
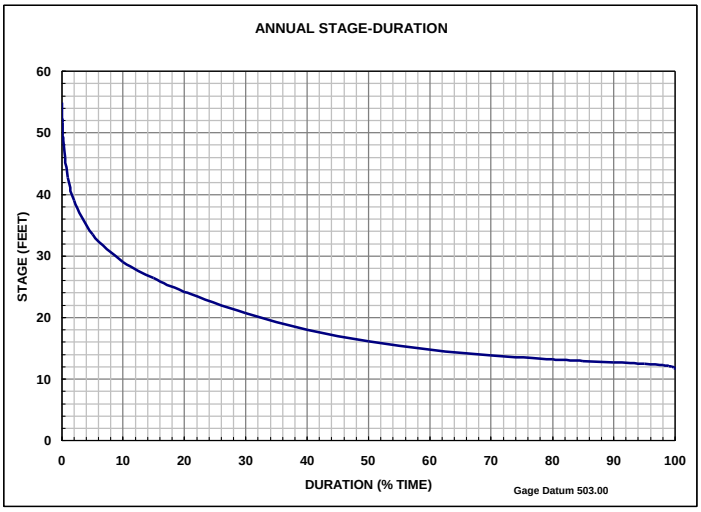


Figure 10. R.C. Byrd L&D Lower Gage Annual Stage-Duration Curve

R.C. BYRD LOWER GAGE
1963-1998

DURATION	STAGE
0.01	54.97
0.05	53.22
0.10	51.65
0.20	49.56
0.50	46.01
1.00	42.75
2.00	39.01
5.00	33.48
10.00	29.10
15.00	26.39
20.00	24.20
30.00	20.70
40.00	18.01
50.00	16.16
60.00	14.74
70.00	13.85
80.00	13.24
85.00	12.96
90.00	12.71
95.00	12.49
98.00	12.26
99.00	12.13
99.50	12.01
99.80	11.88
99.90	11.79
99.95	11.71
99.99	11.55



SECTION 5 SURVEYING & MAPPING REQUIREMENTS

5.1 FEASIBILITY STUDY MAPPING

Previous Survey and Mapping activities have included acquisition of aerial photography at the Greenup Lock and Dam site. The photography was taken in March, 1998 at photo scales of 1”=100’. Mapping was then generated using the Ohio Coordinate system South Zone. The horizontal control is based on 1927 North American Datum. Vertical Control is based on North American Vertical Datum (NAVD) 1929. Hydrographic data from later surveys (March 1999) conducted for navigation and dredging were added to the digital maps to form a more complete picture of site conditions. This mapping was then translated using CORPSCON to the Ohio River Vertical Datum of 1909. This was performed to match the elevations of the original plans and specifications used to construct the existing lock project.

5.2 MAPPING REQUIRED FOR FURTHER DESIGN

Future Survey and Mapping requirements include a determination of whether or not all areas affected by excavation, construction, borrow, and spoil deposition are covered by mapping with sufficient detail. New aerial photography (if required) should be acquired with leaf-off conditions for all areas described above. That photography should be compared with the March, 1998 photography to see if any changes are present. New mapping should be created for any areas that have changed or that have not been mapped previously. In addition, hydrographic surveys should be conducted of all the river areas adjacent to the lock structures and their approaches and merged with the topographic surveys. Control points that are suitable as primary control during construction should be established or recovered at each site. Geographic Information System (GIS) tools should be utilized where advantageous in displaying design features or in recording that information. Field surveys should also define the locations of boreholes, existing utilities and any environmental concerns within construction areas. In addition, existing points used to monitor the existing structures should be evaluated to see if they are sufficient to provide monitoring of the structures during construction. If additional points are required, then they should be established and read before any construction in order to define baseline conditions.

SECTION 6 GEOTECHNICAL

6.1 REGIONAL GEOLOGY

6.1.1 Topography and Physiography

The Greenup Locks and Dam Project is located in the Cumberland Plateau Section of the Appalachian Plateau Physiographic Province. This section is characterized by a maturely dissected, unglaciated plateau with steep-sided valley walls and narrow, winding ridges. This present landscape developed as a plateau of very little relief, which was uplifted and subsequently eroded by the downcutting of streams rejuvenated by the uplift. The region has a dendritic drainage pattern with the primary river being the Ohio.

At the project site, the Ohio River flows in a northerly direction, through a moderately wide valley (9,000 feet wide) with a relatively flat floodplain (Elevations 530' to 545'). The valley walls rise steeply from the floodplain to the ridge crest at approximate elevation 900', providing a 355-foot relief.

6.1.2 Stratigraphy

The regional rock types (within 50 miles) are sedimentary strata of the Paleozoic Era. Sedimentation took place on a hinge between the subsiding Appalachian Basin to the east and the uplifting Cincinnati Arch to the west. A contrast of deposition prevailed between these two environments.

In the western part of the region, the older Pre-Mississippian-aged carbonates and shales were formed in a marine environment on an epicontinental shelf. The uplifting of the Cincinnati/Waverly Arch complex influenced this environment. The arch prevented deposition of clastic materials from the east and would periodically expose the marine sediments resulting in many disconformities.

In the eastern part of the region, the younger Mississippian-aged and Pennsylvanian-aged shales, siltstones, sandstones and coal were formed from deposits of clastic materials from sources farther east. Depositional environments that formed the Mississippian-aged rocks ranged from deep marine basins through shallow-tidal to deltaic environments. The Pennsylvanian-aged rock was primarily formed by westwardly prograding deltas. These deltaic environments contain alluvial meandering streams, shallow fresh water, swampy environments and few marine transgressions. These sediments accumulated in the Appalachian Basin, which continued to subside, forming a wedge of clastic material that thickened toward the southeast.

6.1.3 Structure

Structurally, the region is situated on the western flank of the Appalachian Basin. However, the regional bedrock structure is also influenced by its proximity to the Cincinnati/Waverly Arch complex, which is located to the west. The axis of both of these features has a northeast to

southwest orientation. At the close of the Paleozoic Era, horizontal pressures originating from the Appalachian Mountain Orogeny were exerted on the thick sediments of the Appalachian Basin causing gentle deformations resulting in local anticline-syncline structures within the Appalachian Plateau. Throughout the mid to late Paleozoic Era the broad uplift of the Cincinnati/Waverly Arch created low angle dips away from the arch axis.

As a result of these structural features, the regional bedrock dips primarily to the east and southeast at a gradual rate. This produces a regional outcrop pattern that contains a series of northeast to southwest trending bands of bedrock formations ranging from Ordovician Age in the west to Pennsylvanian Age in the east. Locally, the bedrock is reported to dip to the southeast at a rate of 20 to 80 feet per mile. However, borings at the site could not reveal dips at this low magnitude and variations in the bedrock were attributed primarily to depositional influences.

Another major structural feature in the region is the Kentucky River Fault System, which is located approximately 30 miles south of the project. This feature is primarily a series of east-west oriented high-angled normal faults with the down-dropped block to the south. This fault system extends from central Kentucky to northeast Kentucky. These faults do not appear to influence the bedrock structure at the site.

6.1.4 Seismicity

Ground motion values were determined from available site data and published seismic zone maps as suggested in ER 1110-2-1806 titled "Earthquake Design and Evaluation for Civil Works Projects." The project lies in a relatively inactive seismic area, designated as seismic zone 1. Review of existing literature indicates that there are no local faults or structural features capable of being a seismic source which would alter selected ground motion values derived from published seismic zone maps. The nearest structural features to the project are the Waverly Arch, located approximately 20 miles west, and the Kentucky River Fault System, located approximately 30 miles south. Both features have been essentially dormant since the late Paleozoic Era and are not considered capable of generating seismic activity.

The Greenup project does not have critical hazard potential since failure is unlikely to cause a significant danger to life. Therefore, the project will not be designed to withstand the Maximum Credible Earthquake, and a smaller Maximum Design Earthquake can be used.

The progressive seismic analysis requirements in ER 1110-2-1806 indicate that a seismic coefficient method of analysis is suitable for a feasibility level study for projects located in seismic zone 1. A seismic coefficient value of 0.05 is attributed to the site for evaluating non-critical concrete dams as presented in Miscellaneous Paper S-73-1 "State-of-the-Art for Assessing Earthquake Hazards in the United States." This value is considered appropriate for analysis by the seismic coefficient method.

Additional ground motion data was obtained from spectral acceleration maps prepared by U. S. Geological Survey for the National Earthquake Hazard Reduction Program and included in ER 1110-2-1806. By extrapolating and converting data from these maps, estimated ground motions were obtained for an event having a 50 percent probability of exceedence during the 100-year service life of the project, which corresponds to a return period of 144 years. For this event, the maximum 0.3 second spectral response acceleration $S_{A(0.3)}$ is 0.10g, which corresponds to an effective peak acceleration Aa of 0.04g. The maximum 1.0 second spectral response acceleration $S_{A(1.0)}$ is 0.04g.

6.2 SITE GEOLOGY

Overburden within the floodplain, in the vicinity of the Greenup project site, ranges in thickness from approximately 65 to 75 feet. Typically, the top of ground is at approximate Elevation 539 and the top of rock is at approximate Elevation 470. The overburden can be generally characterized as a 40-foot thick clayey layer (clay, sandy clay and intermittent layers of clayey and silty sands) overlying a lower 30-foot thick layer of sands and gravels.

The top of rock surface is relatively flat with variations of only one foot or less from the stated elevation of 470. The bedrock underlying the project is sedimentary rock of the Lower Mississippian-aged Borden formation (equivalent to the Logan formation in Ohio). This formation at the site consists of a siltstone member overlying a sandstone member.

The upper siltstone member is approximately 17 feet thick from the top of rock surface to an average lower contact elevation of 452.6. This member is a sandy siltstone described as being: gray to light gray, moderately hard, sandy, with fine grained sandstone stringers and seams scattered throughout with a gradational lower contact. Thin clay seams (less than 0.1' thick) and clay coated bedding planes are also scattered throughout the siltstone.

One notable feature within this siltstone member was marked during drilling by the conspicuous loss of drill water when encountered. This feature has been labeled a "disconformity" in the original lock design memorandum and in construction documents. This disconformity is described as an open, broken zone with clay seams and clay coated surfaces, and can contain a clayey shale layer. The disconformity is thin (less that 1 foot thick) and nearly horizontal, located at approximate elevation 461. Most of the existing lock chamber monoliths are founded below this plane of weakness.

The top of the underlying sandstone member is at approximate Elevation 452.6, but ranges in elevation from 453.6 to 451.5. This sandstone member is at least in excess of 25 feet thick and is described as being light gray, moderately hard, fine grained and silty.

Structurally, the site's lithology is generally flat-lying and does not appear to be significantly influenced by local bedrock structure. However, the lithologic boundaries do vary slightly as a result of the initial sediment deposition. The bedrock is slightly fractured with occasional high-angled (65°-90°) joints. A weathered zone within two feet of the top of rock surface is typically moderately to severely broken. Below this weathered zone, the bedrock exhibits a high rock quality designation ranging between 73 to 100.

6.3 SUBSURFACE SAMPLING AND TESTING

6.3.1 General

Eleven sample borings were completed in July 1998 through September 1998 to provide geotechnical information for this report. Six (6) onshore borings and five (5) offshore borings were drilled and sampled by Huntington District drilling contractors. The locations of the borings, shown in Plate 7-2, were distributed throughout the project area along the proposed wrap-around culvert, selected guardwall and guidewall alternatives, and the downstream middle wall extension. Flush mount piezometers were installed in all onshore borings to monitor groundwater levels in the overburden. Continuous disturbed sampling with two-inch splitspoon samplers was accomplished at all six (6) onshore boring locations. Nine (9) five-inch diameter undisturbed (UD) samples were taken at five onshore boring locations. Upon examination of the

jar samples and borings logs, UD samples were selected in cohesive zones that would best characterize the site.

Bedrock core was obtained from eight boring locations. Three of these borings are onshore and five borings are located offshore. Rock core drilling was accomplished with hydraulically fed, rotary drill rigs using diamond-set bits with double-tube core barrels having a split inner barrel. Offshore drilling was accomplished by utilizing a barge as a drilling platform for a conventional truck-mounted drill rig. NQ-size or four-inch diameter core samples were obtained. Recovered bedrock was measured in the field to determine the amount of lost core and calculate the rock quality designation. An engineering geologist logged the core in detail. Samples for rock mechanics testing were then selected from the bedrock core.

Six borings were tested utilizing an NX-borehole jack, otherwise known as a Goodman jack. This jack induces a uni-directional load on the borehole wall with two curved steel platens. The hydraulic pressure is measured with a gauge at the surface and displacement of the platens is measured with two linear variable differential transformers. This data was then used to calculate the lateral Modulus of Deformation and is instrumental in establishing P-Y curves.

Two additional borings were hydraulically pressure tested to determine the water-tightness of the foundation and the condition of discontinuities. Pressure testing was accomplished by conducting pump-in tests in which the hole is divided into 5-foot increments using expanding packers. Water is then pumped, under pressure, into tested zone and the rate of flow is recorded.

Survey data for all borings is presented in Plate 7-4. Complete soil and rock subsurface information is presented on final graphic logs shown in Plates 7-5 to 7-8. The graphic logs combine field information with laboratory testing data and display the changes in material type with depth. A geology and soils legend for the borings and graphic logs is shown in Plate 7-1.

6.3.2 Overburden Laboratory Testing

Continuous sampling was performed at all disturbed boring locations as recommended in EM 1110-2-1804. Standard Penetration Testing (SPT) procedures as described in ASTM D1586 and EM 1110-2-1907 were used to recover the samples. All laboratory testing was performed by Bowser Morner, a Huntington District testing contractor that is certified in accordance with requirements in ER 1110-1-261 dated 31 March 1998. Visual descriptions, in accordance to the Unified Soils Classification System, were performed on all jar samples. Gradation tests were performed on approximately twenty-five (25) percent of the granular samples. Atterberg Limits testing was performed on approximately fifteen (15) percent of the cohesive samples. Test results are shown on the graphic logs on Plates 7-5 to 7-8.

Undisturbed overburden samples were recovered using procedures described in EM 1110-2-1907 with a Shelby tube. Unconsolidated-undrained triaxial tests (Q tests) were performed on eight (8) undisturbed samples and consolidated-undrained triaxial tests with pore pressure measurements (R-bar tests) were conducted on all nine (9) undisturbed samples. Resulting failure envelopes are presented in Plates 7-13 to 7-15.

6.3.3 Bedrock Laboratory Testing

Representative rock samples were tested to define the strengths and physical properties of the foundation bedrock. Bedrock sampled at the project site has revealed two lithologic members, which indude a siltstone member and the underlying sandstone member. Within the siltstone member a thin, open, broken, clayey horizontal feature or “disconformity” was also

revealed, which would have a comparatively reduced sliding resistance than the surrounding siltstone. NQ-size and 4-inch diameter samples were selected from the siltstone and sandstone members. However, sufficient material of suitable quality for testing was not obtained during drilling to adequately characterize the disconformity. All selected samples of the sandstone and siltstone were packaged and sent for testing to either Advanced Terra Testing, Inc. (ATT) located in Lakewood, Colorado, or to the Materials Testing Center located at the US Army Engineer Waterways Experiment Station (WES) in Vicksburg, Mississippi. All samples were prepared and tested in accordance with the applicable standards of the U.S. Army Corps of Engineers Rock Testing Handbook and American Society for Testing Materials. Types of rock mechanics testing included:

*Unconfined Compressive Strength w/ Elastic Modulus & Poisson's Ratio
*Rock Anchor Bond "Pull-out" Strength
*Moisture Content
*Unit Weight
*Shear Strength Testing:
Direct Shear of intact rock with sliding friction
Sliding Friction of natural rock surface

6.4 SUBSURFACE PROPERTIES

6.4.1 Overburden Properties

The focus of overburden construction is in the areas of the proposed filling and emptying system (wrap-around culvert and intake structure) and the downstream wall extensions. Onshore subsurface sampling indicates that overburden thickness remains fairly constant throughout the site, varying only between sixty-five to seventy feet thick. Top of ground is at approximately Elevation 539 and top of rock is at approximately Elevation 470. Two main layers of materials exist. The upper layer, approximately 40 feet deep (to Elevation 500), consists of medium stiff to stiff clay and sandy clay with intermittent layers of clayey and silty sands. The lower layer, approximately 30 feet thick (from Elevation 500 to top of rock), consists of medium dense to dense sands and gravels. Cross-sections showing the different stratigraphies are shown in Plates 7-9 and 7-10.

The 1998 subsurface exploration program conducted for this report has been the only drilling and testing performed at the project since the completion of Greenup Locks in 1959. Original boring information from the lock and bridge construction was reviewed for areas where in situ materials still exist. These field logs show an upper layer of clays to approximately Elevation 500 and a lower layer of sands and gravels to top of rock (Elevation 470), which agrees with the testing program completed for this report. Contract plans for lock construction show that insitu materials adjacent to the landwall were replaced with pervious fill at a 1.5 horizontal to 1 vertical slope from the wall. To verify this, boring G-98-3 was drilled adjacent to the landwall within the pervious fill zone. The field results show that the material near the landwall does consist of pervious materials.

6.4.2 Overburden Preliminary Design Parameters

For the upper clay layer, failure surfaces from unconsolidated-undrained (Q) tests and consolidated-undrained (R-bar) tests for undisturbed samples were combined to determine preliminary design envelopes (Plates 7-13 to 7-15). Testing for UD-98-3 was not considered when selecting strengths, because samples were taken from a deep thin clayey band and not from the upper clay layer. Consolidated-drained (S) strengths were calculated using pore pressure measurements from the R-bar test results. Strengths for sands and gravels were chosen based on common conservative values. Saturated and moist unit weights were determined from moisture contents measured in the laboratory. Table 10 presents preliminary overburden strength parameters for the project site. These values were used for stability analysis of excavation limits. Soil parameters used for areas around the wall extension elements are presented in corresponding paragraphs.

Table 10 Overburden Preliminary Design Strengths

	S Strengths		Q Strengths		R Strengths		Unit Weights	
	c' (psf)	N' (deg.)	c (psf)	N (deg.)	c (psf)	N (deg.)	Moist (pcf)	Saturated (pcf)
Clay	0	32	1800	0	700	15	126	130
Sands and Gravels (including pervious fill)								

6.4.3 Groundwater

In order to characterize groundwater conditions within the construction work limits, six (6) open tube piezometers were installed in all onshore borings. As expected, due to upper pool elevations, groundwater levels decrease from the upstream to the downstream end of the project. Readings taken between November 1998 and March 1999 show that the water level varies slightly with change in pool levels and is influenced by high water events. Readings varied between El. 492 and El. 516, with the average reading at El. 506 (33 feet below top of ground). In the vicinity of the wraparound culvert (D-98-1, D-98-2, and D-98-3), water levels varied 27 feet to 36 feet below top of ground.

6.4.4 Bedrock Properties

6.4.4.1 Foundation Conditions of Existing Lock

The foundations for most monoliths of the existing lock walls were excavated in the siltstone member just below the weak, horizontal "disconformity" to approximate Elevation 460. A few monolith foundations in each wall were excavated deeper into the sandstone member to accommodate the culvert design. Rock excavation was accomplished by drilling and blasting with the perimeters formed by line drilling. Typical foundation preparation included cleaning and removal of all loose and drummy rock.

The disconformity created an avenue for high velocity of groundwater flow into the open monolith foundations. Controlling this ground water became a problem in most monoliths during construction. Typical solutions consisted of packing the seam with oakum, installing

horizontal grout pipes, and injecting a cement/water grout into the seam to seal it. Temporary drains and sump pumps were also used to control groundwater. In addition to this disconformity, a lower erosional contact surface at approximate Elevation 452 also produced groundwater in deeper foundations. To control this groundwater, the feature was treated in a similar manner as the upper disconformity.

Some additional problems were encountered during the preparation of the foundations for monoliths NL-1, NL-2 and NL-3. A very poor grade of siltstone was encountered in the center of NL-1 and NL-2 and along the joint of NL-2 and NL-3. This area produced water continuously during construction. A trough was excavated and filled with graded aggregate from the mixing plant and pumped free of water during the placement of concrete. After two lifts of concrete were placed, grout was pumped into the aggregate filled trough. No other monoliths had this weak siltstone in their foundations.

The Upper Guide Wall, and Upper and Lower Guard Walls are founded on siltstone. The Upper Guide Wall (L-27 through L-37) is built on steel bearing piles with a sheet pile cut-off wall on the riverside. The Lower and Upper Guard Wall monoliths (R-1 through R-26 and R-67 through R-86, respectively) are built on concrete-filled sheet pile cells. All bearing and steel sheet piles cells are driven to the top of rock surface.

6.4.4.2 Foundation Conditions for New Lock Extension

All gravity structures for alternative designs of the proposed lock chamber extension will be founded on the siltstone member. This siltstone member should provide a suitable foundation for bearing and resistance to sliding if it is intact and confined. However, three areas of concerns exist for the structures that are founded on this siltstone member. These concerns include the weathered rock near the top of rock surface, foundation treatment for in-the-wet construction, and horizontal planes of weakness including the disconformity within the siltstone.

A weathered zone is located within approximately 2 feet of the top of rock surface. This weathered zone is typically iron-stained and moderately to severely broken having occasional clay-coated planes. This zone represents a depth of reduced bearing capacity and resistance to sliding. This weathered rock should be removed or bedrock parameters should be reduced accordingly.

Performing proper foundation treatment while utilizing in-the-wet construction techniques will be difficult. Removal of loose and drummy rock will be difficult if not impossible. In addition, foundation cleaning to assure complete rock/concrete contact is not achievable under water. Reduction of bedrock parameters may be required to compensate for these conditions. This reduction is justified since bedrock parameters are established from rock mechanics testing of intact samples or of natural bedding planes with full contact, which would represent sound and clean foundations.

Horizontal planes of weakness within the siltstone member present design concerns, especially the identified disconformity, which is continuous throughout the project at approximate Elevation 461. This disconformity is a horizontal plane of weakness that creates a potential deep-seated sliding hazard. This feature should be suitably confined such that resistance to sliding can be enhanced by incorporating a passive wedge that utilizes the higher cross-bed shear strength of the siltstone. "Daylighting" this feature beneath a foundation into an adjacent lower excavation would produce an unconfined condition and a deep-seated sliding hazard. This condition should be avoided unless suitable precautions are implemented.

Features having a drilled caisson design will be socketed either solely in the siltstone member or through the siltstone and into the sandstone member. With sufficient depth, these members should provide adequate lateral, axial compression, and uplift load resistance. The relatively high Rock Quality Designation (RQD) and unconfined compressive strength may represent material that will pose challenges to caisson drilling production, as well as rock excavation.

6.4.5 Bedrock Preliminary Design Parameters

6.4.5.1 General

The rock test results were analyzed to develop bedrock strength parameters in accordance with EM 1110-1-2908 titled "Rock Foundations." Typically, tested rock samples do not represent the weakest rock types or features of the rock mass. The weakest materials are often lost during the drilling process, broken during shipment, or are of lengths unsuitable for testing. Therefore, bedrock design parameters were chosen based on combined consideration of rock test results; rock mass characteristics, and data obtained from the exploration program. Table 11 summarizes the bedrock strength parameters selected for design.

Table 11 Bedrock Design Parameters

	Sliding Friction		Cross Bed Shear		Allowable Bearing Capacity	Working Bond Strength	Modulus of Deformation
					psi	psi	psi x 10^6
Siltstone Member	27	3*	50	115	190	103	0.59
Disconformity	16	0*	N/A	N/A	N/A	N/A	N/A
Sandstone Member	32	4*	55	125	138	138	1.74

* Reduce sliding friction cohesion value by 50% for in-the-wet construction.

6.4.5.2 Sliding Friction

Sliding friction, for purposes of this report, is defined as the ability of the bedrock mass to resist sliding along near horizontal discontinuities. This value is obtained from the sliding shear strength testing of natural discontinuities taken from core samples. The design sliding friction phi angle is established from the lower bound of the test data. The design value of apparent cohesion is added to this lower bound. The cohesion value is established from engineering judgment after consideration of the physical characteristics of the potential failure planes and the peak strength values from testing of these planes. The design values for the disconformity within the siltstone member was selected from the lowest phi angle that would encompass all test data points. This conservative method is justified since insufficient number of samples suitable for testing was obtained from this disconformity. A cohesion value of 0 psi was assigned to the disconformity due to the open nature of this feature.

The sliding friction cohesion value will be reduced by 50 percent for foundations of structures that are constructed with in-the-wet techniques. In-the-wet construction inhibits the removal of loose and drummy bedrock, silt, and clay, which deposits on the foundation surface. The existence of loose and drummy rock indicates the possibility of open bedding planes, which

reduces the area of rock-to-rock contact. This condition reduces the area in which the apparent sliding friction cohesion can be applied. In addition, small areas of silt will remain in low-lying pockets of the foundation after the initial concrete placement. These areas of silt will prevent a rock-to-concrete contact, therefore also reducing the area in which the apparent sliding friction can be applied. Vertical loads will be transferred to areas of proper concrete to rock contact and will bridge these pockets of silt. Therefore, a reduction in phi angle will not be required. It is expected that 50 percent of the foundation surface will have either loose and drummy rock or pockets of silt. An alternative to reducing the sliding friction cohesion would be to simply reduce the foundation surface area by 50 percent for sliding stability computations.

6.4.5.3 Cross-Bed Shear

The cross-bed shear strength is representative of the ability of the bedrock mass to resist sliding at angles greater than the nearly horizontal bedding. These values are to be used in analyses that utilize the passive wedge for structural sliding or failure planes and cones through rock associated with the design of single rock anchors or a single row of anchors. The cross-bed shear values were established from peak values of direct shear testing of intact pieces of rock core. The design phi angle and cohesion intercept for cross-bed shear is based on the lower bound of this plotted data. The plotted cohesion intercept is reduced by half to obtain the design cohesion value, as suggested in EM 1110-1-2908. This reduction in cohesion is necessary to account for scale effects of the small tested samples when compared to the intact, in-situ rock mass.

6.4.5.4 Allowable Bearing Capacity

The allowable bearing capacity of the rock mass is developed by applying a factor of safety of 3 to the ultimate bearing capacity. The ultimate bearing capacity is established utilizing calculations from EM 1110-1-2908 [Eq. 6-5], and is based on the assumed foundation condition of open joints with a joint spacing less than the foundation width. The phi angle values used in the bearing equation are developed from the lower bound of peak direct shear tests from intact core. The appropriate cohesion values, representing a confined rock mass resisting bearing forces, are established from an equation supplied in EM 1110-1-2908 [Eq. 6-7]. Additional input parameters for this equation included the mean unconfined compressive strength and the Rock Mass Rating.

6.4.5.5 Working Bond Strength

The working bond strength for rock anchors is established by applying a factor of safety of 2 to the ultimate bond strength as indicated in EM 1110-1-2908 [Eq. 9-6b]. The ultimate bond strength is established at one standard deviation below the mean of anchor bond "pull-out" test data.

6.4.5.6 Modulus of Deformation

The horizontal modulus of deformation is developed from equations based on empirical relationships for the insitu rock mass using values of Rock Quality Designation (RQD) and laboratory elastic modulus [EM 1110-1-2908, Eq. 4-5]. The mean values for RQD were obtained from core log information. The elastic modulus was obtained from the mean of the Young's Modulus values developed from laboratory testing.

6.4.5.7 Laterally Loaded Drilled Shaft Parameters

Methods of obtaining the geotechnical parameters that are required for analysis of laterally loaded drilled shafts are not well established for bedrock. These parameters include: undrained shear strength (s_u), modulus of subgrade reaction (k_s), lateral modulus of deformation, and maximum allowable deformation in rock. P-Y curves are developed from these parameters to predict the response of the rock to lateral loading. These curves were then used as geotechnical input parameters for analyzing the proposed shafts using the computer software LPILE Plus by Ensoft, Inc. This software, in part, models the response of the rock and the proposed shaft design to the varying lateral loads. See Section 26.4.7 for P-Y curves, test data and computations to establish geotechnical parameters.

Three separate zones or foundation conditions were identified at the site for lateral loading. These conditions include: weathered rock near the top of rock surface, bedrock which is subjected to cross bed shearing, and confined bedrock. Bedrock within 2 feet of the top of rock surface is weathered and slightly to severely broken with open bedding planes. This weathered rock zone cannot provide significant lateral resistance and will be disregarded in design computations.

Below the weathered zone is sound, unweathered siltstone and sandstone which is subjected to cross bed shearing as a result of lateral loading due to its proximity to the top of rock surface. This zone is located between 2 feet below the top of rock surface and 4- to 6-feet below the top of rock surface. Lateral resistance within this interval of the drilled shaft will be provided by a passive wedge, which utilizes the cross bed shear strength of the bedrock. The general wedge equation [EM 1110-1-2908, Eq. 7-3] was used to establish the depth of this interval and the required geotechnical parameters.

The third foundation condition is bedrock that has a confined condition such that the subjected lateral loads are insufficient to create a shear plane to the top of rock surface. This confined zone or condition exists from 6- to 8-feet below the top of rock surface. The lateral resistance for this condition is dependent upon the deformation properties of the confined rock mass. To establish these lateral deformation properties, diametrically loaded 76mm borehole jack (otherwise known as a Goodman jack) testing was performed in subsurface exploratory holes. The siltstone and sandstone members have similar deformation characteristics as a result of lateral loading in this confined zone. Therefore, these members were assigned the same values and were not differentiated. The disconformity within the siltstone member was ignored for purposes of analysis of the drilled shafts, due to the thin nature of this feature.

6.5 FOUNDATION AND SLOPE ANALYSIS

6.5.1 Slope Analysis for Typical Sections

A preliminary slope analysis was performed on two typical sections for the temporary excavation cut limits involving construction of the wraparound culvert for the new filling and emptying system. The height of overburden excavation varies between sixty (60) and seventy (70) feet. The slopes analyzed were seventy (70) feet deep set at 2 horizontal to 1 vertical (2:1). The first cross-section, shown in Plate 7-16, is taken from excavation limits between the bridge piers. Due to the depth of excavation and the limited spacing, an anchored wall system will be needed to construct the culvert. The second cross-section shown on Plate 7-

16 represents excavation limits beyond the bridge piers.

During construction of the wraparound culvert, groundwater levels will not exist or vary on the cutslopes; therefore, sudden drawdown case was not applicable. Construction of the culvert can be accomplished using a staged dewatering system operating over an extended period of time. Therefore, both sections were analyzed for steady seepage in accordance with EM 1110-2-1902. Analysis was performed using Spencer's procedure on the UTEXAS3 Slope Stability Program, written by Stephen G. Wright at the University of Texas. Soil strengths were selected based on limited subsurface exploration performed for this report. Phreatic levels used in the analysis represent the current best estimate based on active operation of the dewatering system. As displayed on Plate 7-16, critical failure circles for both sections were selected based on influence to the first bench, which is the location forthe initial dewatering stage. Factors of safety for both cases were approximately 1.38, which is slightly below the recommended factor of safety of 1.5 set in EM 1110-2-1902. EM 1110-2-1902 is generally regarded as the Corps of Engineers standard manual for performing slope stability analyses. However, because this manual was developed specifically for analyzing embankment dams, failure of which presents a significant hazard to life and property, the methodologies presented can be overly conservative when applied to less critical features, such as disposal embankments and cutslopes. For this reason, EM 1110-2-1902 was used as guidance in analyzing the stability of cutslopes associated with this project. Realizing the failure of the excavation cut limits for this project would mainly only affect the proper functioning of the dewatering system and applying engineering judgement to the situation, it was concluded that the factors of safety calculated for the two sections are reasonable. During the design phase, additional stability analysis, including hand checks to verify computer program results, will be performed to determine whether further slope stabilization is necessary during construction.

6.5.2 Disposal Area

Based on expected low quantities of disposal materials, there does not appear to be a concern with slope stability of potential disposal areas. Locations of possible disposal sites are discussed in Section 8.3. During the Preconstruction, Engineering, and Design (PED) phase, all disposal sites will be reevaluated to ensure that a stability analysis is not necessary.

6.5.3 Liquefaction

Invert elevations vary throughout the length of the proposed wrap-around culvert. The highest invert elevation is 483.0 over a length of approximately 388 feet. With top of rock at El. 470.0 and assuming the culvert wall is three (3) feet thick, the bottom of this segment will be ten (10) feet above top of rock. The invert then gradually slopes down to below top of rock. Details of how portions of the culvert above top of rock will be founded have not been designed at this phase. Because differential settlement as a result of liquefaction could cause cracking in the culvert, a brief liquefaction screening was conducted for segments of culvert above top of rock. Review of the graphic logs (Plate 7-5) show that there are some areas where the uncorrected blow counts are less than twenty-five (25). Areas of pervious material with such blow counts may be susceptible to liquefaction during seismic events. The concern of liquefaction can be eliminated during construction with removal and replacement of low blow count materials. During closely monitored replacement, materials can be compacted to the proper density to

safeguard against liquefaction. Further investigation of differential settlement and liquefaction will be conducted, if necessary, during the design phase of the wrap-around culvert.

6.6 CONSTRUCTION CONSTRAINTS

6.6.1 Dewatering

A sophisticated dewatering system will be requiredfor the construction of the new filling/emptying system and intake structure. A cofferdam will be installed at the tip of existing upstream landwall. It is assumed that an existing sheet pile wall located at Station 3+00 (based on original lock stationing) will not serve as an appropriate cutoff barrier and will be removed during construction. Removing the wall may impact the existing lock wall. Effects of removing the wall will be fully evaluated during the design of the project. For construction ofthe wraparound culvert, the use of a multistage system was selected over methods such as sump pumping, tunneling, and bentonite slurry walls based on several reasons. Construction will take place below the water table and the water level will have to be lowered more than thirty feet, therefore, sump pumping is not a reasonable option. There is a large degree of risk involved with tunneling, in addition to, not being economically feasible. Based on the complex geometry of the proposed culvert, use of a bentonite slurry wall is not feasible. A deep slurry wall would have to be constructed on each side of the culvert to be effective.

Plates 4-3 and 4-4 show typical sections for the possible dewatering system. Excavation approximately one hundred feet either way of the centerline between the bridge piers will have a two-stage well system. This boundary was established in order to protect the H-piling for the bridge piers. Because the construction trench for the culvert will be as deep as 28 feet within this boundary, anchored walls will be needed to brace the excavated area. Box trenching is not a viable alternative of bracing, because of the large size of trench that will be required for construction of the culvert. A potential problem of the anchored wall is that it may not be feasible to remove the walls after the culvert is complete. One possible solution is to incorporate the anchored walls as a permanent part of the culvert. The walls may be used as forms for cast-in-place type construction. Another option is to use a reinforced slurry wall embedded in rock on each side of the culvert trench. The slurry walls will become part of the culvert walls and serve as a cutoff for groundwater flow during construction. After the slurry walls are in place, cast-in-place techniques can be used to form the inside of the culvert to the exact size and elevations. The remaining areas of excavation beyond the bridge piers may be accomplished using cutslopes with slopes of 2 horizontal and 1 vertical (2:1) and a three stage well system. Minor seepage can be stopped with sandbags and sumping.

For the downstream portion of the filling/emptying system, a temporary sheet pile cut-off wall will be needed to serve as a downstream cutoff during the attachment of the culvert to the landwall.

6.6.2 Borrow Material

The requirement of a borrow site is not anticipated for any phase of this project. Material removed for the wraparound culvert will be stockpiled temporarily and placed back over the culvert. Except for possible suitable disposal material, additional backfill will not be placed behind the downstream landwall extension.

6.7 ADDITIONAL INVESTIGATIONS

Additional borings will be required during future investigations to establish foundation conditions for the final selected design, which may have been optimized or altered since the original exploration program was initiated. For alternatives that require dewatering, additional overburden borings will be necessary to further supplement investigations to date. The rate at which the water can be pumped from the excavation area is directly proportional to the permeability; therefore, it will be necessary to accurately determine the permeability of the soil formation. This will be accomplished with visual classifications, empirical relationships, field pumping tests, and field tests of piezometers. Continued monitoring of groundwater at the site will extend throughout the PED phase to establish patterns of normal fluctuations. Additional instrumentation will be installed. Water quality tests will be necessary to determine if the groundwater is corrosive or incrusting, which can cause clogging and reduce efficiency of the dewatering system. For design alternatives that do not require dewatering, minimal additional overburden investigations will be necessary.

Further bedrock investigations will be required to better characterize foundation parameters for drilled shaft design. This investigation may include load testing of large scale drilled shafts.

SECTION 7 DESIGN CRITERIA

7.1 DESIGN GUIDANCE

Both INCA and Black and Veatch need to add a write-up for this section. It should describe which Corps regulations were used for design of which particular features and which private sector regulations were used because no applicable Corps regulations were available.

7.2 BASIC DESIGN OBJECTIVES

7.2.1 Lock Chamber Extension

The following objectives guide the design of the lock chamber extension.

- The design will provide for a 600 ft. extension to the existing auxiliary lock chamber.
- All feasible construction methods are to be considered including float-in, construction in-the-dry, lift-in and the use of drilled caissons.
- Closure times of the operating lock chambers are to be minimized with preference to keeping the main chamber open.
- The new gate monoliths will provide for using the existing gate operating mechanisms.
- The design will accommodate including or omitting a supplemental filling and emptying system.
- The outlet for the provisional filling/emptying system will be on the channel side of the river wall.
- All monoliths will be stable according to USACE criteria.
- Overall project cost will be minimized.
- The existing RC Byrd decommissioned lock chamber will be used as a dry dock where feasible.
- The existing state highway bridge piers shall not be disturbed.
- A new dry crossover tunnel shall be incorporated in the bulkhead or gate sill.

7.2.2 Approach Walls

The following objectives will guide the development of the floating approach wall design through the development of plans and specifications:

- Nominal design life of 50 years.
- Minimizing misalignments and limiting global displacements and deflections to a tolerable range for navigational purposes.
- Minimizing interference with the lock's intake structures and manifolds.

- Providing for ease of construction, functional monitoring, and inspections.
- Durability of materials and performance of the structure while accounting for marine growth.
- Providing high-cycle and low-cycle fatigue resilience.
- Providing for an appropriate level of ultimate structural strength exceedingthe factored capacity demand.
- Ability of the pontoon to sustain flotation after accidental, partial flooding.
- Ability to dewater and repair the pontoon in situ after partial flooding to facilitate the return of the pontoon to operational status.
- Ability to survive extreme events such as MDE or head on impact by an uncontrolled downstream drifting barge tow.
- Ability to remove and relocate the floating pontoons.

It is understood that the structures will be monitored, inspected and maintained to assure undiminished performance during the service life.

7.3 COMPONENTS OF A COMPLETE APPROACH WALL DESIGN

There are numerous components that make up a navigation lock approach wall system. Each of these components must be designed in an interrelated fashion in order forthe approach wall system to meet the basic design objectives. The following list represents the major components that must ultimately be analyzed and designed, although not necessarily at this feasibility stage of design.

- Floating Wall
    - Pontoons
    - Parapets
    - Guide Keys
    - Pontoon Ballasting
    - Hatches and Access Ports
    - Wall Armor
    - Ladders, Stairs, and Access Platforms
    - Line Hooks and Check Posts
    - Debris Inhibitors
    - Impact Shields
    - Utilities / Interface

- Nose piers
    - Drilled Shafts
    - Wall Armor
    - Debris Shields
    - Personnel Access
    - Guide Recesses
    - Utility Interface

- Lock Structure
  - Guide Recess
  - Personnel and Equipment Access
  - Utility Interface

- Electrical Features
  - Power
  - Lighting
  - Water Quality and Water Level Sensors
  - Grounding
  - Lightning Protection
  - Control System
  - Closed Circuit TV

- Appurtenant Features
  - Safety Yawl and Jib Crane
  - Signage
  - Fire Protection
  - Safety Equipment

- Construction and Operational Considerations
  - Dry Dock/Graving Dock
  - Construction Sequence and Limitations
  - Dredging/Scour Protection
  - Debris
  - Corrosion Protection
  - O&M Manual

7.4 GEOTECHNICAL PARAMETERS

7.4.1 Geotechnical Design Parameters

For Rock Design Parameters see Table 11 located in Section 6.4.5.

The Huntington District COE provided specific P-Y curves for the LPILE Plus analysis of the drilled caisson. The curves provided by Mike Nield, COE, are summarized in Table 12 to Table 14 and presented in the calculations. Two different rock strength layers were identified. The following parameters are applicable design criteria whether the excavation is at elevation 468 or elevation 455:

- <u>Zone Subject to Cross Bed Shearing:</u>
  - * 2 to 5 feet below top of rock.
  - * Modulus of Subgrade Reaction, Ks = 9,750 pci
  - * Maximum Deformation, y = 0.04 in
  - * Ultimate Capacity, Su = 390 psi
- <u>Confined Siltstone and Sandstone</u>
  - * Deeper than 5 feet below top of rock.

    * Ks = 75,000 pci
    * Varying y (see Table 14).
- Varying Su (see Table 12)

Table 12 Caisson Strength & Deformation

Caisson Diameter, ft	Maximum Deformation, y, in	Ultimate Capacity, Su, psi
8	0.0384	3,058
10	0.0400	3,823
12	0.0400	4,500

The P-Y curves for each zone are shown below:

Table 13 P-Y Curve Data Cross Bed Shearing Zone

Caisson Diameter, ft	Point 1 P1, y1	Point 2 P2, y2
8	0 lb/in 0 in	37,440 lb/in 0.04 in
10	0 lb/in 0 in	46,800 lb/in 0.04 in
12	0 lb/in 0 in	56.160 lb/in 0.04 in

Table 14 P-Y Curve Data Confined Siltstone/Sandstone Layer

Caisson Diameter, ft	Point 1 P1, y1	Point 2 P2, y2	Point 3 P3, y3
8	0 lb/in 0 in	234,824 lb/in 0.0384 in	293,568 lb/in 0.2305 in
10	0 lb/in 0 in	305,800 lb/in 0.0400 in	458,800 lb/in 0.4400 in
12	0 lb/in 0 in	360,000 lb/in 0.0400 in	648,000 lb/in 0.6800 in

Based on a review of the boring logs provided and the summary of soil parameters provided with the existing drawings for the Greenup Locks and Dam Lock Extension Plan, the following values were used for the sand and gravels in the overburden soils on the landside of the wall elements:

Table 15 Soil Properties

Overburden Soils	K_a = .307	K_p = 3.25	Wt_{sat} = 126 pcf	Wt_{eff} = 63.6 pcf

7.4.2 Rock and Tieback Anchors

Bar anchors will be used to brace the excavation for the culvert in the vicinity of the state highway bridge piers. The anchors for that section are soil anchors designed with the following criteria:

Soil Properties
- Description: medium to dense SAND w/gravel
- Dry unit weight = 110 pcf
- Moist unit weight = 125 pcf
- Phi angle = 30°

Water Table
- Drawn down to elevation 470 in the zone of wall loading by dewatering

Factors of Safety
- 2.0 applied to the passive pressure and crossbed shear of the rock
  - Calculated anchor load = .60 Ultimate anchor strength
  - Calculated moment in the sheet pile = 0.65 Ultimate sheet strength

Strength Parameters
- Soil-Anchor Bond = 30 psi allowable (pressure grouted and regrouted)
- Anchors = ??? diameter Grade 150 ksi

Anchor Ultimate Strength = ??? kips
Sheet Pile Ultimate Strength = 38 ksi (A328)

Muti-strand anchors will be used to stabilize the existing land wall monoliths L-2 to L-5 in order to meet current stability criteria. The anchors have been designed with the following criteria:

Rock Properties

Description: Sandstone
Unit Weight = 151 pcf
Working Anchor Bond Strength = 100 psi
Cross-bed shear: phi = 45 deg. and c = 45 psi

Factors of Safety

Calculated anchor load = 0.60 Ultimate anchor strength
Anchor load used for depth of anchorage = 0.80 Ultimate anchor strength

Anchor Parameters

Anchors: 12 – 0.6" diameter strands, uncoated, Grade 270 ksi
Anchor Ultimate Strength = 703.2 kips

7.5 NAVIGATION CONDITIONS

Where the float-in method was evaluated as a viable alternative, moving the floating elements from the R.C. Byrd L&D to Greenup, an 11-foot draft in the channel is needed. Although the COE maintains a minimum channel draft of 9 feet, it is assumed the contractor by timing the movement of the float-in shells can get 11 feet with minimal impact on the schedule.

The construction of the lock chamber extension is mostly on the downstream side of the dam, where the normal tailwater elevation is 485 feet. The bottom of the channel is siltstone/sandstone at approximately elevation 470 feet. Thus, the normal draft in the construction area is 15 feet, with some periods of higher water available. Extensive rock excavation would be required to provide a draft greater than 15 feet.

7.6 MATERIAL PROPERTIES

The following material properties are assumed for this project:

7.6.1 Concrete

f_c' = 3000 psi for tremie concrete
f_c' = 4000 psi for cast in place
f_c' = 5000 psi for concrete in prestressed elements
E_c is calculated by ACI 318-95, Section 8.5 - Modulus of Elasticity

7.6.2 Reinforcing Steel

f_y = 60 ksi for deformed bars
f_y = 50 ksi where steel shapes are used
$E_s = 29 \times 10^6$ psi

7.6.3 Structural Steel

f_y = 36 ksi
$E_s = 29 \times 10^6$ psi

7.7 LOADS AND LOAD COMBINATIONS

The following loads and load combinations are used in the design for this study.

Load Factors:

Water	1.4
Dead Weight	1.4
Soil	1.7
Seismic	1.7
Wind	1.7

Factors of Safety:

Sliding Stability	2.0
LPILE	1.5

Overturning of Gravity Structures

Usual Loading	100% compression
Unusual Loading	> 75% compression
Extreme Loading	> 0% compression

Monolith Loading

The load cases considered for stability of the monoliths are illustrated in Section 26.2.

7.7.1 Design Loads Analyzed for Extended Lock Wall

Barge Impact (COE)

100 kip applied to the full length of an equivalent monolith length - 50-ft.
137.5 kip applied normal to each miter gate

Miter Gate Weight (COE)

270T per leaf + 35T debris per leaf

Bulkhead Weight (COE)

3 panels 4 foot high @ 23T +
5 panels 6 foot high @ 27T = 204T total weight

Wind

Design Speed: 90 mph
Max Velocity during float-in operations: 35 mph

Seismic

Pseudo static factor: 0.024 x Mass
(The stability was checked using a very conservative 0.15x mass and it was determined seismic does not control)

Water, Uplift

A unit weight of 0.0625 kcf was used for water. Uplift is assumed to vary linearly from 100% of headwater to 100% of tailwater on the compression area and 100% of headwater is applied to the non-compression area.

Overburden Soil on the Landside of the Land Wall:

The esplanade is not to be extended.
Siltation and waste disposal will not exceed 20 foot above the rock

7.7.1.1 Load Factors (used for caisson strength only - not used for monolith stability):

Water	1.4
Dead Weight	1.4
Soil	1.7
Seismic	1.7
Wind	1.7

7.7.2 Design Loads Analyzed for Approach Walls

The following loads and loading conditions must be accounted for in the final design of the approach walls.

Dead Load

Dead loads include self-weight of the structure and all embedded and permanently attached installations and fixtures. Dead load calculations are also critical to determining the required ballast.

River Current and Flow

Model testing is often required to provide predictions of current flow velocities to be used to generate current forces, as they would apply to the pontoons and as they influence barge collisions and barge operations.

Wave Loads

Waves generated by wind have a period and height that translates into a wave load. This wave load causes a varying lateral load along the face of the pontoon and variations in the hydrostatic loading on the sidewalls and keel slab. The waves also cause the pontoon to flex vertically and bend the pontoon up and down at varying points along its length. This is called hogging and sagging and will be accounted for in design.

Wind Loads

Both wind speed and direction are important in determining wind loads acting on the approach walls. The effect of these wind loads on vessels moored to the wall also translates into a load on the wall itself.

Snow and Ice Accumulation

These will be accounted for in accordance with local design standard practices and building codes.

Ice Floe Load

Pressure by ice floes is caused by wind and current. Ice sheets will be accounted for in accordance with local design standard practices.

Seismic

The magnitude and peak horizontal acceleration for seismic events can be used to develop acceleration time histories, which can then be used for approach wall design. Once the appropriate seismic event has been selected for the design, acceleration, velocity and displacement values can be developed. The design process stipulated in ER 1110-2-1806, July 1995 Edition, Earthquake Design and Analysis for Corps of Engineers Projects will be followed for this study. For this study a pseudo-static analysis will be performed

Partial Flooding

Flooding of one and two adjacent chambers is a design analysis that will be made. Critical flooding locations that result in the maximum stress in the various components of the pontoon must be determined and designed to be within elastic limits.

Grounding

If the river level drops, grounding may occur at low water levels in the lower pool, causing the pontoon to be unevenly supported. Induced moments in the pontoon caused by this condition must be accounted for. Although grounding is not considered a likely problem for the middle and river approach walls at Greenup, it is a concern for the Lower Land Wall and will be evaluated as part of the design.

Post-tensioning

Post-tensioning of the pontoon segments must be considered, accounting for both local stress concentrations and differential shrinkage. Longitudinal post-tensioning will be used for crack control and to increase moment capacity of the pontoon.

Truck and Uniform Live Load

Operation of a maintenance vehicle on the deck slab of the pontoon will be incorporated into the design loads to facilitate maintenance of the approach wall.

Construction Loads

The pontoons will be equipped with towing eyes and cleats. Other construction loads include initial floatation, ballasting, and assembly stresses.

Barge Impact Loads

The design for impact follows provisions stipulated in the ETL 1110-2-338, Barge Impact Analysis. The procedure for the determination of impact loads acting on floating approach walls is still in development. As the use of floating approach walls has become more common, the research conducted by Waterways Experiment Station and other private and public organizations continues to refine and improve the understanding of varying large collision mechanics.

At this stage in the design, the extreme barge impact loads developed by the Louisville District for design of the Olmsted Approach walls will be used as the governing load case for the design of the nose piers and the pylons.

<u>Extreme Barge Impact Design Loads for the Nose Piers</u>

4,000 kips nose impact load, direction parallel to the approach wall, at El. 538. 1,000 kips impact load, direction perpendicular to the approach wall, at El. 538. (El. 538 is 4 feet above the normal maximum pool, El. 534.)

2,500 kips nose impact load during flood stage parallel to the approach wall at El. 552.8, which is 4 feet above the maximum flood of record (El. 548.8).

<u>Impact Design Loads for the Upper River Wall Pylon</u>

The following barge impact loads will be applied at El. 538, which is 4 feet above the operating high pool water elevation.

Usual barge impact load = 500 kips

Unusual barge impact load = 700 kips

Extreme barge impact load = 800 kips

It is assumed that the load conditions during the flood stage will not govern the pylon design.

Pontoon Delivery

Since pontoon delivery will produce unique hydrostatic loads, these will be accounted for in the design. These include stresses due to bow waves, grounding, towing, and maneuvering loads.

Temperature

Significant stress may be produced in the deck and keel slabs due to winter and summer temperature differentials induced by changes in both air and water.

Propeller Thrust

"Prop wash" may exert significant forces on the skirts. The effect of this force on the skirts (and its connection to the pontoon) should be examined during future design phases.

7.7.3 Loading Conditions

The load cases considered for stability of the monoliths are illustrated in Section 26.2. The following load cases were analyzed for the land wall extension. The existing esplanade will not be extended; therefore, a soil load was not applied to the landside of the land monoliths.

Case 1: Tailwater elevation 512 feet (top of the bulkhead)
Inside the chamber dewatered to elevation 460 feet

Case 2: Tailwater elevation 485 feet
Inside the chamber water at elevation 517 feet

The following load cases were analyzed for the new miter gate monoliths.

Miter Gate Weight (COE):
270T per leaf + 35T debris per leaf

Bulkhead Weight
3 panels 4 foot high @ 23T +
5 panels 6 foot high @ 27T = 204T total weight

Barge Impact (COE):
100 kip applied to the full length of an equivalent monolith length - 50 ft.
137.5 kip applied normal to each miter gate

Stability of the Gate Monolith
A 3D analysis of the loading including the following cases:
Gates closed chamber full
Gates closed chamber empty
Barge impact on closed gates
Gates open
Maintenance with one bulkhead in place and the chamber dewatered
Maintenance with two bulkheads in place and the space between dewatered

The load cases analyzed for the approach walls, including the nose piers and pontoons, are shown in Table 16 – Pontoon Load Combinations for Allowable Stress Design, Table 17 - Pontoon Load Combinations for Strength Design, and Table 18 - Nose Pier Load Combinations Table for Strength Design.

7.7.4 Stability and Sliding Criteria

7.7.5 Load Combinations

7.7.5.1 Structural Performance

The structural performance is based on a comparison of the strength of the structure with the demands of different loads upon the structure. To obtain the structural capacity demand, different loads are individually factored (as discussed below) and combined by superposition Proof of the structural adequacy is provided using the allowable stress method and/or the ultimate strength method and/or Load Resistance Factor Design (LRFD) as provided for in the appropriate code(s). When using the ultimate strength method in the design of conventional reinforced concrete structures, a hydraulic load factor (H_f) is utilized in accordance with Corps design practices. This factor results in reinforcing steel requirements that are similar to those that would be obtained using the allowable stress method of design. The H_f factor for each load case is shown on the ultimate strength load combination table.

The following list compiles applicable loads with respect to each structural performance category:

Construction Load:

- Dead load
- Post-tensioning
- Buoyancy, hydrostatic pressure
- Currents, sagging & hogging, waves, and wind
- Launching, towing, and installation
- Temporary anchorage forces
- Temperature

Usual Load:

- Dead load of structure and fixtures
- Buoyancy, hydrostatic pressure
- Currents, sagging & hogging, waves, ice floe pressure, snow, and wind
- Operation of the crane-truck on the deck slab
- Zebra-mussel growth
- Usual barge impact
- Temperature
- Mooring point load (Line hook and Timberhead, 160K)

Unusual Load:

- Dead load, controlled ballast, and fixtures
- Buoyancy, hydrostatic pressure
- Currents, sagging & hogging, waves, ice floe pressure, snow, and wind
- Operation of the crane-truck on the deck slab
- Zebra-mussels growth
- Unusual barge impact

- Mooring point load
- One chamber pontoon flooding
- Operating Basis Earthquake (OBE)
- Temperature

Extreme Load:

- Dead load, controlled ballast, and fixtures
- Buoyancy, hydrostatic pressure
- Currents, sagging & hogging, waves, ice floe pressure, snow, and wind
- Zebra-mussel growth
- Extreme barge impact
- Maximum Design Earthquake (MDE)
- Two chamber pontoon flooding
- Temperature
- Grounding

7.7.5.2 Load Combination Tables

Adopting provisions of the ACI 318 Building Code *Requirements for Reinforced Concrete*, EM 1110-2-2104, June 1992 Edition, *Strength Design for Reinforced Concrete Hydraulic Structures*, and AASHTO Manual, Section 3.22, *Combination of Loads*, the ultimate factors were carefully studied for establishing the attached load combination tables.

Load combination coefficients are applied in accordance with building code provisions that specify an increase of allowable stresses (for example, AISC Manual of steel Construction (Ninth Edition), Section A5 [2]), or allow a reduction of the respective load (for example ACI-318 Building Code Requirements for Reinforced Concrete, Appendix A, Section A.2.2), when wind and/or earthquake forces are included in the load combination. In this application, load combination coefficients shall be multiplied by the magnitude of the individual design loads prior to their superposition.

The following three tables were developed for the Olmsted Locks Floating Approach Walls and are applicable directly to this project:

Table 16, Pontoon Load Combinations Table for Allowable Stress Design
Table 17, Pontoon Load Combinations Table of Strength Design
Table 18, Nose and Pylon Load Combinations Table for Strength Design

Table 16 Pontoon Load Combinations Table for Allowable Stress Design

Load Type			Construct'n Condition [7]					Usual Condition							Unusual Condition						Extreme Condition			
Load Symbol	**Load Description**		CDW	PtDH	PTtDH	PDH	PGGDH	PDHB	PDVH	PDVHS	PDHT	PDHW	PDHW	PDBHW	PDHMW	PDHW	PDHIW	PDBHTW	PDHFW	PDHEW	PDBHW	PDHF	PDHE	PDHG
			Durability Factor																					
			1.0	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
			Demand Reduction Factor																					
			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
			Load Combination Numbers																					
		Notes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	23
Constr. & Transp.			Load Combination Coefficients																					
C	Construction Phase	6	1.00																					
P	Posttensioning			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
T	Deformation Loads (Dif'ntl. Temper., Shrinkage, & Friction)				1.00																			
t	Towing			1.00	1.00																			
G	Partial Grounding	1					1.00																	
Dead Loads																								
D	Dead Load (solids)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D	Water Accumulation Allowance							1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D	Zebra-Mussels Growth Allowance							1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vehicle																								
V	Wheel Load (static load + 15% dynamic allowance)	2							1.00	1.00														
Mooring & Collision																								
B	Mooring Force	8						1.00																
B	Usual Barge Collision with Pontoon (Initial barge damage limit)													1.00										
B	Unusual Barge Collision with Pontoon (100 year event)																	1.00						
B	Extreme Barge Collision with Pontoon (1000 year event)																				1.00			
Hydraulic Forces																								
H	Hydrostatic Pressure			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
H	Water Current										1.00	0.50	1.00	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
H	Waves (horizontal forces)										1.00		1.00			1.00					1.00			
H	Waves (sag & hog)								1.00	1.00	1.00		1.00			1.00					1.00			1.00
H	Check Post Mooring Loads										1.00													
I	Ice Floes pressure																1.00							
M	Work Barge Mooring Forces	4													1.00									
Ambient Forces																								
S	Snow and Ice Accumulation	2								1.00														
T	Deformation Loads (Differential Temperature & Shrinkage)										1.00			1.00				1.00						
W	Wind Pressure		0.50									1.00	0.50	0.75	0.75	1.00	0.75	0.75	0.50	0.50	1.00			
G	Partial Grounding	1																						1.00
F	Flooding of one pontoon chamber	3																	1.00					
E	Operating Basis Earthquake (OBE)																			1.00				
E	Maximum Design Earthquake (MDE)																						1.00	
F	Flooding of two pontoon chambers	3																				1.00		

Notes:
1: Design accounts for partial grounding of the pontoon during launching and tow as well as during the design life. Critical low water levels with respect to the limiting design criteria shall be stated in the pertinent drawings.
2: Truck mounted crane for maintenance work. Lifting allowance to be applied only for the design of the top slab (local effect) and not simultaneously applied with snow and ice accumulation.
3: Different crack control limits apply to flooding of one compartment as opposed to flooding of two compartments.
4: Applied to Upper River Approach Walls only.
5: Prestressing level determined by allowable stress design.
6: This construction phase load yields the maximum tolerable vertical load (e.g., weight of the fresh concrete of the top slab and its forms) imposed on the cantilevering side walls and bulkheads during the construction of the top slab.
7: Analysis of these combinations are Contractor's responsibility and are to be submitted to the Contracting Officer for approval.
8: Mooring force of 160kips is an unfactored force applied at a single mooring point and varied for worst direction.

Table 17 Pontoon Load Combinations Table for Strength Design

Load Symbol	Load Description	Notes	Basic Ultimate Factor *	Construct'n Condition [7]					Usual Condition							Unusual Condition						Extreme Condition			
				CDW	PtDH	PTtDH	PDH	PGGDH	PDHB	PDVH	PDVHS	PDHT	PDHW	PDHW	PDBHW	PDHMW	PDHW	PDHIW	PDBHTW	PDHFW	PDHEW	PDBHW	PDHF	PDHE	PDHG
				Hydraulic Factor, Hf																					
				1.0	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.0	1.0	1.0	1.0
				Demand Reduction Factor																					
				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00
				Load Combination Numbers																					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	23
Constr. & Transp.				Load Combination Coefficients																					
C	Construction Phase	6	1.40	1.00																					
P	Post-tensioning		1.05		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
T	Deformation Loads (Dif'ntl. Temper., Shrinkage, & Friction)		1.70			1.00																			
t	Towing		1.70		1.00	1.00																			
G	Partial Grounding	1	1.00					1.00																	
Dead Loads																									
D	Dead Load (solids)		1.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D	Water Accumulation Allowance		1.40						1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
D	Zebra-Mussels Growth Allowance		1.40						1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vehicle																									
V	Wheel Load (static load + 15% dynamic allowance)	2	1.70							1.00	1.00														
Mooring & Collision																									
B	Mooring Force	9	1.70						1.00						1.00										
B	Usual Barge Collision with Pontoon (Initial barge damage limit)		1.70																						
B	Unusual Barge Collision with Pontoon (100 year event)		1.70																1.00						
B	Extreme Barge Collision with Pontoon (1000 year event)		1.00																			1.00			
Hydraulic Forces																									
H	Hydrostatic Pressure		1.40		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
H	Water Current		1.70									1.00	0.50	1.00	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
H	Waves (horizontal forces)		1.70									1.00		1.00			1.00					1.00			
H	Waves (sag & hog)		1.70							1.00	1.00	1.00		1.00			1.00					1.00			1.00
I	Ice Floe pressure		1.70															1.00							
M	Work Barge Mooring Forces	4	1.70													1.00									
Ambient Forces																									
S	Snow and Ice Accumulation	2	1.70								1.00														
T	Deformation Loads (Differential Temperature & Shrinkage)		1.70									1.00			1.00				1.00						
W	Wind Pressure		1.70	0.50									1.00	0.50	0.75	0.75	1.00	0.75	0.75	0.50	0.50	1.00			
G	Partial Grounding	1,8	1.00																						1.00
F	Flooding of one pontoon chamber	3	1.40																	1.00					
E	Operating Basis Earthquake (OBE)		1.00																		1.00				
E	Maximum Design Earthquake (MDE)	8	1.00																					1.00	
F	Flooding of two pontoon chambers	3,8	1.00																				1.00		

Notes:
1: Design accounts for partial grounding of the pontoon during launching and tow as well as during the design life. Critical low water levels with respect to the limiting design criteria shall be stated in the pertinent drawings.
2: Truck mounted crane for maintenance work. Lifting allowance to be applied only for the design of the top slab (local effect) and not simultaneously applied with snow and ice accumulation.
3: Different crack control limits apply to flooding of one compartment as opposed to flooding of two compartments.
4: Applied to Upper River Approach Walls only.
5: Prestressing level determined by allowable stress design.
6: This construction phase load yields the maximum tolerable vertical load (e.g., weight of the fresh concrete of the top slab and its forms) imposed on the cantilevering side walls and bulkheads during the construction of the top slab.
7: Analysis of these combinations are Contractor's responsibility and are to be submitted to the Contracting Officer for approval.
8: Basic ultimate factors of unity applies to MDE, compartment(s) flooding, and part. grounding loads (perf. categ. 'extreme'), i.e., Uh = 1.0 D + 1.0 L + 1.0 (E or F or G).
of their nominal weight.
9: Mooring force of 160 kips is an unfactored force applied at a single mooring point and varied for worst direction
*: Basic ultimate factor of 0.90 applies when pertinent loads (either dead or live) have a relieving effect on the factored load. For example, bottom slab and water content in the flooded compartment will counteract hydrostatic pressure only at 90%.

Table 18 Nose Pier Load Combinations Table for Strength Design

Load Type				Load Combination Coefficients																
				Constr'n		Usual						Unusual						Extreme		
Load Symbol	Load Description			DPH	DPHT	DPH	DPHS	DPHT	DPHW	DPHW	DPHWB	DPHWM	DPHW	DPHWI	DPHWR	DPHWB	DPHWE	DPHWB	DPH	DPHE
				Hydraulic Factor, H_f																
				1.00	1.00	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.00	1.00	1.00
				Demand Reduction Factor																
				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	1.00	1.00	1.00
			Basic	Load Combination Numbers																
		Notes	Ultimate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Dead Loads			Factor	Load Combination Coefficients																
D	Dead Load (solids)		1.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Collision																				
B	Usual Barge Collision with Pontoon (Initial barge damage limit)		1.70								1.00									
B	Unusual Barge Collision with Pontoon (100 year event)		1.70													1.00				
B	Extreme Barge Collision with Pontoon (1000 year event)		1.00															1.00		
B	Head on Impact		1.00															1.00		
Hydraulic Forces																				
H	Hydrostatic Pressure		1.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
H	Water Current		1.70					1.00	0.75		0.75	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	0.50
H	Waves (horizontal forces)		1.70		1.00			1.00	0.75											
I	Ice Floe pressure		1.70											1.00						
M	Mooring		1.70									1.00								
Ambient Forces																				
W	Wind Pressure		1.70						1.00	0.50	0.75	0.75	1.00	0.75	0.50	0.75	0.50	1.00		
E	Operating Basis Earthquake (OBE)		1.00														0.50			
E	Maximum Design Earthquake (MDE)		1.00																	1.00

7.7.6 References

For the design of structural components where hydraulic forces are significant, the design predominantly follows the provisions of the EM 1110-2-2104, June 1992 Edition: Strength Design for Reinforced-Concrete Hydraulic Structures.

A list of technical references relevant to this project follows:

7.7.6.1 General Industry and Corps of Engineers References and Codes

ACI 318 Building Code Requirements for Reinforced Concrete.
ACI 350R-89 Environmental Engineering Concrete Structures.
ACI 357.2R-88 state-of-the-art Report on Barge-Like Concrete Structures.
ACI 357R-84 Guide for the Design and Construction of Fixed Offshore Concrete Structures.
AISC-Steel Construction Manual.
UBC 1991.

- AASHTO Manuals were referenced with respect to the provisions governing the durability of structures exposed to the elements.
- Design Guidance on the Determination of Barge Impact Loads on Rigid Structures, Prepared by The Glosten Associates, Inc. for the Civil Engineering Research Foundation, Washington, D.C.
- U. S. Army Corps of Engineers REMR Technical Note D2, "Optimal NDE Selection for Sheet Piling at Ohio River Lock and Dam 53" (1986) was referenced for corrosion rate information on the Ohio River.

7.7.6.2 Engineering Manuals (EMs)

• EM 385-1-1	Edition: September 1996	Safety and Health Requirements Manual
• EM 1110-2-1604	Edition: June 1995	Hydraulic Design of Navigation Locks
• EM 1110-2-2000	1 February 1994	Standard Practice for Concrete For Civil Works Structures
• EM 1110-1-2101	Edition: November 1963	Working Stresses for Structural Design
• EM 1110-2-2104	Edition: June 1992	Strength Design for Reinforced Concrete Hydraulic Structures
• EM 1110-2-2105	Edition: May 1994	Design of Hydraulic Steel Structures Change 1
• EM 1110-2-2602	Edition: September 1995	Planning and Design of Navigation Lock
• EM 1110-2-2906	Edition: January 1991	Design of Pile Foundations
• EM 1110-2-xxxx	Edition: Draft	Seismic Design and Evaluation of Free Standing Intake Towers
• EM 1110-1-1807	30 July 1990	Standards Manual for USACOE CADD Systems
• EM 1110-2-2503	29 Sept 1989	Design of Sheet Pile Cellular Structures
• EM 1110-2-1804	29 February 1984	Geotechnical Investigations
• EM 1110-2-1902	1 April 1970	Stability of Earth and Rockfill Dams
• EM 1110-2-1906	31 March 1972	Laboratory Soils Testing
• EM 1110-2-1907	31 March 1972	Soil Sampling
• EM-1110-1-2908	30 November 1994	Rock Foundations

7.7.6.3 Engineering Technical Letters (ETLs)

• ETL 1110-2-220	Edition: June 1976	Layout of Navigation Locks and Dams
• ETL 1110-2-247	Edition: December 1979	Lock Wall Accessories
• ETL 1110-2-256	Edition: June 1981	Sliding Stability for Concrete Structures

- ETL 1110-2-301 Edition: August 1983 Interim Procedure for Specifying Earthquake Motions
- ETL 1110-2-303 Edition: August 1985 Earthquake Analysis and Design of Concrete Gravity Dams
- ETL 1110-2-338 Edition: April 1996 Barge Impact Analysis

7.7.6.4 Engineering Regulations (ERs)

- ER 1110-2-1150 Edition: March 1994 Engineering and Design for Civil Works Projects
- ER 1110-2-1806 31 July 1995 Earthquake Design and Evaluation of Civil Works Projects
- ER 1110-1-261 31 March 1998 Quality Assurance of Laboratory Testing Procedures

7.7.6.5 Technical Manuals (TMs)

- TM 5-818-5 November 1983 Dewatering and Groundwater Control

7.7.6.6 Technical Publications

- EC 1110-2-291 31 Oct 1997 Stability Analysis of Concrete Structures

7.7.6.7 American Society for Testing and Materials (ASTM)

- ASTM D1586 [1995] Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils
- ASTM C150 [1985a] Portland Cement
- ASTM D4992 [1994] Practice Evaluation of Rock to be Used for Erosion Control

7.7.6.8 Miscellaneous

1. CRD-C133 [1984]. "Standard Specifications for Concrete Aggregates"
2. Miscellaneous Paper S-73-1, "State-of-the-Art for Assessing Earthquake Hazards in the United States"
3. Department of the Army - UTEXAS3, Version 3, with User's Guide, Volume 4 dated November 1992. "UTEXAS3 Slope Stability Package"
4. US Army Corps of Engineers, "Rock Testing Handbook"
5. Dodson-Stilson, Inc. (September 1998). "Marmet Replacement Lock Dewatering Study"
6. CEORH (December 1993). "Marmet Lock Replacement Interim Feasibility Report"

7. Das, Braja M. Principles of Geotechnical Engineering, 3rd Edition. Boston: PWS, 1994.
8. Driscoll, Fletcher G. Groundwater and Wells. St. Paul: Johnson Filtration Systems, Inc., 1986.
9. Leonards, G.A. Foundation Engineering. McGraw-Hill, 1962.

SECTION 8 CIVIL ENGINEERING DESIGN REQUIREMENTS

8.1 EARTHWORK AND BACKFILL

Earthwork for the project addressed by this study may be placed in three categories:

1. Common Excavation
2. Dredging for the fit-out area
3. Rock excavation for the lock extension.

8.1.1 Common Excavation

The supplemental filling and emptying system is composed of five separate elements for the purposes of excavation. The elements are the intake structure, bypass culvert, the laterals, the outlet culvert, and the outlet structure. Drawings of the supplemental fill/empty system are in Section 26.4.4, Plates 4-1 through 4-7.

The intake structure will be excavated in the dry after a cutoff wall is constructed from the existing land wall to the existing riverbank. Excavation will use conventional excavators and will stop at approximate elevation 480 where the structure will be founded on soil.

Excavation for the bypass culvert will proceed from the intake toward the chamber extension. The majority of the excavation will be cut and cover with excavation sides sloped at 2H:1V. The culvert will be cast in place in the bottom of the excavation. At its deepest point, the excavation will be approximately 70 feet deep and will be over 55 feet deep over most of its length. The completed culvert will be covered with the excavated material. A total of 351,000 CY of earth will be excavated for construction of the bypass culvert.

The existing state highway bridge piers presents a problem to the excavation for the bypass culvert since the cut slope would undermine the piers. Therefore, an anchored sheet pile wall will support the bottom 28 feet of the excavation. The wall will be founded at elevation 466 and will have a top at elevation 497. The rock at elevation 470 will have to be predrilled to achieve the required penetration into sound rock. One row of anchors will be required at elevation 488. The wall will act as a cantilevered wall for excavation to elevation 485. The anchors will be 60-ton (design load) soil anchors at 6-foot spacing along the wall. Approximately 70 anchors will be required. For additional details, refer to Plate 4-4.

The excavation for the laterals will be entirely in rock. The bottom of the excavation will be at elevation 460 feet requiring the removal of approximately 13,000 CY of rock. For alternatives in which the laterals are built as part of the lock extension contract, such as Plans 2, 3, and 4, the excavation will be done in the wet concurrent with excavation for the chamber extension. This will lengthen overall construction time as compared to plan 1 and will add several auxiliary chamber closure days to the excavation total. However, it will reduce auxiliary lock closure time with the bulkhead in place, which are inflexible full day closures.

Likewise, the excavation for the outlet culvert will be entirely in rock. A trench 25 feet deep by 22 feet wide will be required for the outlet culvert. A total of 6,000 CY of rock will be

removed in two phases. The first phase will be the half of the trench that crosses the auxiliary chamber. The first phase will be excavated concurrently with excavation for the extension. The second phase will be the main chamber crossing and will extend halfway under the existing guardwall. This phase will be delayed until the auxiliary chamber extension is fully operational and passing traffic. Then the main chamber can be closed and the outletextended across that chamber.

Excavation for the outlet structure will be entirely in rock. The excavation will be approximately 60 feet x 60 feet with an average depth of 13 feet resulting in approximately 2,000 CY of rock removal. This excavation willinclude the tie-in under the remaining half of the guard wall. A braced cofferdam will be constructed around the outlet structure and the excavation will be in the dry. This excavation will not require closure of either of the lock chambers.

8.1.2 Dredging for Fit-Out Area

Overburden soils are dredged to clear the top of the rock for the fit out area. The limits of the fit-out area and the associated dredging are shown on Plate 2-1 for Plan 1 and Plate 2-11 for Plans 2 through 4.

The dredge limits shown assume the navigation channel is dredged to the top of rock at elevation 470 feet. Therefore, dredging the channel will not be required for this project. The purpose of the dredging shown on the drawings is to remove the overburden soils to the top of rock back to the toe of the existing fill area slope. The slope is not to be disturbed. This dredged area will be available to the contractor for the transfer of blocks and wall panels from the shore to barges. It can also be used for mooring construction barges.

The estimated quantity of dredging is 15,000 CY of soil. This is based on an average thickness of 3 feet of soil removal over the entire dredged area.

8.1.3 Rock Excavation for the Lock Extension

There are two plans for rock excavation. The first excavation plan, Plate 2-1, shows rock to be removed for Auxiliary Extension, Plan 1. The second excavation plan, Plate 2-11, shows excavations for the remaining alternatives, Plans 2 through 4. Excavations that may be deferred are shaded and labeled for the appropriate alternative in which they are to be deferred. Various section views of the different wall types show the rock excavation at the base of each wall type. These are also included in Section 26.4.2.

8.1.3.1 Plan 1 - Auxiliary Lock Extension

The foundation of the gravity monoliths for the lift-in land wall extension and lift-in miter gate monoliths are at elevation 461 feet. Thus, 9 feet of rock will have to be removed under all of the new wall sections. In addition, rock excavation is required for placement of the miter gate sill, the bulkhead sill, and the crossover tunnel. In general, these features require excavation to elevation 450 feet or 20 feet of rock. A total of 20,000 CY of rock will be excavated for this alternative. All of the excavation will be in the wet except the miter gate sill. The miter gate sill represents 7,000 CY and will be done in the dry. It is assumed the rock will be fractured by controlled blasting and removed by clamshell excavators.

8.1.3.2 Plan 2 - Auxiliary Extension with Modifications

This alternative consists of extending the auxiliary chamber with provision for addition of a supplemental fill and empty system at an undefined future date. This alternative consists of constructing the land wall with a culvert incorporated, construction of the laterals, outlet culvert and outlet structure. This eliminates the need for all major construction related closures of the auxiliary chamber in the future. Since the emptying valve is incorporated in the extension, the empty time of the auxiliary chamber can be reduced compared to Plan 1. Rock excavation for this alternative is approximately 52,000 CY.

8.1.3.3 Plan 3 - Auxiliary Extension with Culvert

This alternative represents construction of the extension complete with a supplemental fill and empty system. It is the same as the previous alternative but also includes the intake structure and bypass culvert. Since no part of the system is deferred, a total of 52,000 CY of rock must be removed.

8.1.3.4 Plan 4 - Auxiliary Extension - Phased Construction

This alternative represents construction of the Auxiliary Extension Modified alternative, Plan 2, and the construction of the bypass culvert and intake approximately 20 years in the future. A total of 52,000 CY of rock must be removed for this alternative at the time of original construction.

8.1.4 Earthwork for the Lower Land Wall (LLW)

Excavation of topsoil and rock (sandstone) material is required for both fixed and floating alternatives for the full length of the approach wall. The required depth and widthof the excavation, however, differs for the alternatives. The excavation of the rock material for the fixed wall would be about 20 feet wide and 4 to 5 feet deep (measured from the design El. 469.0), whereas the excavation for the floating alternative would be about 46 feet wide and 4 to 5 feet deep centered under the pontoon footprint.

It is anticipated that upon completion of the construction, the riverbed elevation in proximity to the LLW would be filled to grade (with the natural silt and sand found in the riverbed material in proximity to the construction site) to El. 469.0 which is the design depth of the navigation channel. The grading is required to prevent entrapment of bulky debris such as down drifting logs and root balls in the otherwise depressed area.

The dredging of the alluvial deposits of the riverbed and of the riverbank would require conventional equipment such as self-loading scraper pans, backhoes, trucks, and dozers. Draglines or other suitable equipment may be required for saturated riverbed material with very soft consistency. Most dredging can be carried out independently of other operations, in which case the rate of production will be relatively high.

Whether or not the borrow material would balance or exceed the amount of the alluvial deposits required for grading of the riverbed under the LLW pontoon will be deferred to future design stages. If excess material should be encountered, the material may be stockpiled temporarily near the excavation site or directly loaded onto a barge. No land surface transport would be required for the disposal traffic.

The removal of the sandstone rock is anticipated to require blasting. An underwater hydraulic breaker ram or chisel, however may accomplish the removal of about 2 feet of top

layer of weathered sandstone (if sufficiently fractured). At this stage, it has not been determined whether the contractor will adopt blasting alone or a combination of varying techniques. Because of the required integration of sequential activities (such as removing the rock material in 'bites' of the bucket, with teeth), the blasting is expected to slow down the removal work appreciably. Depending on the size of the material excavated, the material may be used near the site for shoreline and scour protection or hauled off site by barges.

For blasting the rock, the sandstone will be drilled and shot underwater by a drill barge using the OD method of casing. Holes will be loaded (for detonation) immediately upon completion of drilling of the individual hole, which will be placed about 7-foot on center each way. Typically, one or two lines will be shot at a time to keep an open face. The drill barge will drill and shoot 14 – 16 holes/shift. Then the clamshell crane barge, with a heavy-duty bucket and teeth, will excavate the sandstone.

8.1.5 Rock Excavation Beneath Lower Land and River Walls

Alluvial deposits will be dredged to elevation 570 beneath the Lower River Walls. The possibility exists that after a flood event trees or other hard debris could be lodged beneath the floating walls and could potentially cause the floating walls to break if these objects were trapped between the rock and the wall to come down onto the lodged object after the high water event. As a precaution against possible pontoon damage rock will be excavated 3' outside of the perimeter of the footprint to elevation 460. If any hard object, such as a tree root ball, were trapped beneath the wall it would be crushed when the river elevation went back down to normal elevations.

8.1.6 Rock Excavation for Deep Foundations

Rock excavation of sandstone and siltstone material incidental with the construction of the drilled shafts (serving as deep foundations for the nose piers and pylons) and for the fixed LLW alternative will be accomplished by specialty contractors. A probable construction scenario using a permanent steel casing and a temporary steel casing is depicted on Plate No. 3-12 entitled: Nose Pier Construction Sequence.

8.2 FOUNDATION PREPARATION

Some additional work is required to prepare the excavations for the new monoliths. This effort will include survey, leveling, evaluation, and cleaning. When these operations are complete, the monoliths may be set in the excavations.

For stability purposes, it will be essential to remove all fractured rock on the edges and bottom of the excavation. Stability against sliding requires the strength of intact rock for the monoliths to satisfy the required factors of safety. Therefore, tremie concrete in the bottom of the excavation must contact sound rock in the excavation.

8.2.1 Survey

A bathymetric survey is required on completion of the excavation. This survey will identify uneven areas on the bottom of the excavation. Some unevenness can be accommodated by the

leveling systems incorporated in monolith blocks. Current survey techniques can easily produce a contour plan of the excavation to the desired accuracy, +/- 0.25-foot.

The bottom is evaluated with respect to the type of element being installed. Large mounds or deep cavities must be evaluated for their impact on the overall levelness of the monoliths and for their potential interference with the installation process.

The lift-in blocks for Plan 1 are small with plan dimensions of 19 feet x 21 feet. The individual blocks must be level, but they do not all need to be at the same exact elevation. There is also flexibility in the location of the blocks. They only need to be positioned within +/-1 foot of the planned location. In contrast, the blocks that incorporate culvert sections will have much lower tolerances for their placement. Thus, the evaluation of the bottom of the excavation for lift-in without culverts will be much less stringent than for elements, which must be precisely located.

8.2.2 Leveling

After evaluation of the bottom survey of the excavation, some work will be required to remove or modify rock discontinuities. It is likely that, because of the low volume of this work, the spot excavation will be completed by mechanical methods. Unsatisfactory humps will be removed and unsatisfactory depressions will be filled with tremie concrete. Additional blasting is to be avoided to prevent excessive fracturing of the foundation rock.

8.2.3 Inspection

The bottoms of the excavations must be inspected to assure the quality of the exposed rock is at least as good as expected from the subsurface investigation. Inspection will be difficult because of the turbidity of the river. Turbidity curtains or other measures may be employed around the excavation to improve visibility. The inspection will confirm the excavation has been cleaned to sound rock and that excess debris or spoil has been removed. Any excess rock identified by the inspection will be removed.

8.2.4 Cleaning

It is likely that some time will pass between the excavation of the rock and the placement of the first structural elements. In this period, siltation and sedimentation of debris will have occurred within the excavation areas even with the use of the turbidity curtains. It is necessary for a high percentage of the structural tremie concrete to bond directly to the exposed rock at the bottom and sides of the excavations.

Cleaning can take place after the installation of the blocks and wall panels. This is possible because open cells of the blocks do not have bottoms and the rock is exposed. Immediately prior to placement of all concrete base lifts, sea vacuums will be used to clean the rock to the extent possible.

8.3 DISPOSAL

Expansion of the 600’ lock will require removal of approximately 250,000 cubic yards of common excavation and dredging for all the described plans and 50,000 cubic yards of rock

excavation and concrete demolition for plan 1. Plans 2, 3 and 4 will create approximately 100,000 cubic yards of rock excavation and concrete demolition.

Excavated rock and concrete rubble from the site will be used will be used to construct dikes and T-dikes for aquatic habitat. Specific locations for the dikes and the number of T-Dikes will be determined once one of the four proposed plans is chosen and the quantity of rock available from excavation is known within a smaller range.

All excavated material, except suitable backfill, course materials suitable for creation of environment design features and demolition debris, will be spoiled in the disposal areas 1 through 3 as shown on plates 1-4 through 1-8.

8.3.1 Spoil Site #1

This site is located on the most southwestern portion of the government's property. It is currently seeded with grass and is a large depression along the permanent access road. This site should be the first area utilized for spoil and contoured to a final grade as shown on plates 1-4 through 1-8. It will hold approximately 44,000 CY of spoil.

8.3.2 Spoil Site #2

This site is located across the main access road and to the east of the spoil site #1. This area is currently covered with grassy type vegetation. This spoil site will be the 2nd area utilized for spoil. This spoil site should be contoured as shown on plates 1-4 though 1-8. The fill provided by the spoil at this site would increase the size of usable recreational area near thepicnic shelters. This site will hold approximately 105,000 CY of spoil.

8.3.3 Spoil Site #3

This area is located on the most northern portion of the project's property. It is currently covered by trees and will require clearing and grubbing over the entire area prior to using as a spoil site. It will be filled to an elevation as needed. It can hold up to approximately 150,000 CY of spoil (if needed).

8.3.4 Dredge Material Disposal.

Material from dredging operations will be spoiled in spoil Site #3. Approximately 60,000 cubic yards of wet material must be excavated from the channel as part of required construction activities. This excavation will be accomplished primarily by dredging. Preliminary calculations have been completed to determine the required dimensions of a disposal area for this material. Unfortunately, settling tests have not been performed on samples of anticipated dredge material, so calculations were performed using selected soil parameters based on normal values found in design literature.

Preliminary design was completed in accordance with guidance from EM 1110-2-5027, Confined Disposal of Dredged Material. Dredged soils were estimated to have 80% fines and only 20% sand and gravel. Furthermore, these soils were assumed to exhibit flocculent settling instead of zone settling. It was assumed that dredging will be accomplished using an 18” dredge. Calculations using conservative assumptions concerning the design criteria show that the disposal area must be 22 acres in area and have an embankmentheight of 7.5 feet. The overflow

weir must be at least 60 feet in length to discharge the expected flow from the dredge. Embankments will have 1V:2.5H slopes and a crest width of 10 feet.

Sampling and testing of soils in areas to be dredged will be completed during the design phase of this project. Once this information is collected, the final dimensions and configuration of the disposal area will be determined.

8.4 BUILDINGS AND GROUNDS

8.4.1 Project Operations Facilities

Existing project operations facilities at the site include an operations building located on the middle wall, a maintenance building located on the service mound, and a garage/storage building located on the service mound. The facilities are located inside a security fence and accessed by a paved access road. The facilities will remain accessible and operational during expansion of the lock. The existing paved roadway will access the maintenance building and garage/storage building. A temporary gravel access roadway to the land wall will be maintained at all times. Access to the middle wall and operations building will be maintained at all times. The temporary gravel access roadway will need to be shifted from time to time as work on the wrap around culvert progresses in the event that Plan 3 or Plan 4 is constructed.

Parking along the esplanade will be temporarily eliminated during construction of the wrap around culvert. There is ample parking available in the existing public parking lot and service mound to accommodate employee and service vehicle parking during construction. Also, see the Visitors Facilities 8.4.2 below.

8.4.2 Visitor's Facilities

Existing visitors facilities consist of a parking lot adjacent to the service mound, connected to the esplanade by a 6-foot wide concrete fenced walkway. From the esplanade, a painted crosswalk directs the visitor to fenced viewing areas on the existing land wall and middle wall. Access from the land wall to the middle wall is provided over the existing downstream miter gates. No public restrooms are provided on the lock wall monoliths. Public restrooms are provided in the adjacent public use area located just upstream of the locks.

Construction of the wrap around culvert will temporarily prohibit access to the visitors' facilities making it necessary to close the facilities during construction. An added benefit of temporarily closing the visitors' facilities is that the existing visitor parking lot is then fully available for employee parking and construction activities.

8.4.3 Esplanade

Currently there are no plans to extend the esplanade but to only repair any portion of it that would be damaged during the construction of the project.

8.4.4 Public Use

An existing public use area is located just upstream of the locks. This area consists of picnic shelters and limited recreation area. The area is accessed from the main access roadway.

Construction of the fill/empty intake structure and relocation of the mooring facility may encroach upon the public use area. During this construction, all or portions of the public use area will be temporarily closed to allow for construction activities. In case of partial closure, temporary fencing will be installed to protect the public from construction activities.

8.5 RESIDENT ENGINEERING OFFICES

A project resident office will be constructed for this project similar to the one being prepared for the Marmet Extension Project. The design and location of this office will be prepared during the Detailed Design Report (DDR) for this project.

8.6 UTILITY RELOCATIONS

No off-site or public utilities are impacted by the proposed lock construction.
The utilities will need to be supported and maintained over the excavation of the wrap around culvert. Note the raw water system provides fire protection and must remain operational at all times.

In addition to the utilities serving the existing lock, there are buried power, water and sewer lines between the service mound and the public restroom facilities. It is anticipated that these utilities will not be impacted by construction. Care shall be taken when working near these utilities to prevent damage caused by construction activities.

8.6.1 Cofferdam

Currently all four proposed plans are to be built in the wet. Therefore, the need to construct a cofferdam for this project has been eliminated. It will be necessary, however, to construct a sheet pile cut-off wall to tie into one of the new landwall monoliths for Plan 3 and the 2nd phase of Plan 4. This cut-off wall will be needed to enable the dry hookup of the filling culvert to the culvert in the wall.

8.6.2 Approach Walls Temporary Cofferdam

The construction of the nose piers, the free standing pylon, the excavation under the Lower Land Wall (LLW) and Lower River Wall (LRW) Pontoons, and work related to the construction of the fixed (alternative) of the LLW and LRW would use in-the-wet construction techniques, and therefore, no cofferdams would be required for water maintenance except for the minor reconstruction work for the existing bullnose.

The modification of the bullnose includes the attachment of three stainless steel frames by bolts to the concrete of the bullnose. The frames are required as ‘carriers’ for the Ultra High Molecular Weight Polyethylene (UHMWPE) panels installed for reduced friction between the marine fenders and their rub surface.

It is anticipated that the installation of the stainless steel frames would minimize the rework of the existing bullnose concrete thus enabling the work to be performed in a skin cofferdam

installed adjacent to and sealed against the bullnose concrete. No rework of the existing bands of armor would be required (except for painting), as the frames would be fabricated to accommodate the armor bands that protrude beyond the concrete surface. Since the construction tolerances for the UHMWPE surface are tighter than the customary tolerances for the construction of the bullnose concrete, the as-built condition of the bullnose would have to be surveyed before fabricating the stainless steel frames.

8.7 PARKING LOT

The existing parking lot just to the west of the auxiliary chamber's downstream miter gate will be slightly expanded and will be paved. (See plates 1-4 through 1-8 for location)

8.8 ROADS AND ACCESS

8.8.1 Permanent Access Roads

An existing access road that borders the western edge of the project site will be improved to a 24' wide gravel access road. This road during construction will allow the contractor easy access to the downstream (northern) end of the project without having to go through the existing project area. A permanent 24' wide access road will also be constructed from the existing asphalt access road to the downstream end of the project (See plates 1-4 through 1-8). These two access roads will allow the constructor easy access to the casting yard, batch plant and laydown areas. It will also allow the contractor to loop traffic in that area and will minimize traffic on the existing asphalt access road. Upon completion of the project these roads will be used to gain easy access to the downstream end of the project and could be used by local fisherman.

8.8.2 Temporary Service Roads

Temporary service roads will be needed from the existing asphalt access and both of the proposed gravel access roads. These Temporary Service roads will be used to move heavy equipment into position for work at the harbor area, slipway and mooring dolphin construction as well as the construction of the landwall extension. The layout of these access roads will be determined by the contractor and by the Resident Engineer.

8.9 FENCING

Temporary fencing will be required between public use areas and any construction work. All of the proposed plans require that some of the existing fencing be removed during construction. Any new fencing will be designed to match existing in type and appearance in accordance with EM 1110-1-400 and ER 1130-2-400.

8.10 SIGNING

Signs will be provided where needed to regulate traffic, warn of hazardous conditions, and establish restrictions and restricted areas and to direct and inform the public. All traffic and

warning signs shall be placed and installed in accordance with the current "Manual on Uniform Traffic Control Devices for Streets and Highways" and Chapter 4 of EP 310-1-C. Informational signs and bulletin board will be provided in public use and observation areas containing project maps, emergency numbers, title 36 rules and regulations, safety tips and general information on the history, purpose and operation of the facility.

8.11 MOORING FACILITIES FOR WORK BOATS

8.11.1 Plan 1

Once the upstream landwall monoliths L-29 through L-37 are demolished, the Harbor Area will be utilized as shown on Plate (1-4).

On the downstream end of the project the six mooring dolphins near the Slipway, built for construction purposes, can be utilized as a mooring facility.

8.11.2 Plan 2

On the upstream end of the project, the landward side of the upstream landwall can be utilized as a mooring facility as it currently is being used. As shown on Plate (1-6) monoliths L-29 through L-37 will not be affected during the construction of this scheme.

On the downstream end of the project the six mooring dolphins near the Slipway, built for construction purposes, can be utilized as a mooring facility.

8.11.3 Plan 3

As far as mooring facilities for this plan see plan 1 above. (See plate 1-7)

8.11.4 Plan 4

Since the first phase of construction takes this project to the Plan 2 configuration, the mooring facilities for the upstream and downstream portions of the project will mirror those shown in Plan 2 above.

Once the second phase of construction is complete, the facilities available will be the same as those in plans 1 and 3. (See plate 1-8)

SECTION 9 HYDRAULIC DESIGN

9.1 GENERAL

Normal upper and lower pool elevations at the Greenup L&D are 515.0 and 485.0 feet, respectively, resulting in a lift of 30.0 feet. The existing filling and emptying system for the 600x110 feet, auxiliary lock chamber consists of an intake manifold situated in land wall monoliths L-23 through L-25; one- 16x18 feet culvert located in the land wall monoliths; a centrally configured bottom lateral field; and a flared outlet structured located riverward of the lower guard wall. Reverse-mounted, tainter-type, culvert valves control filling and emptying of the lock chamber. A general layout of the existing filling and emptying system is provided in Plate No. 1-1.

Two filling and emptying schemes have been considered for the proposed auxiliary lock extension. The first scheme utilizes the existing filling and emptying system, while modifying the valve schedule, to control the filling and emptying of the lock chamber. The second scheme incorporates a supplemental filling and emptying system to function concurrently with the existing system for operation of the lock chamber. Plate No. 1-4 and 1-8 provide a general layout of the without and with supplemental system, respectively. Details of the proposed schemes are contained in the following sections.

9.2 COMPONENTS

9.2.1 Without Supplemental Filling and Emptying System

The proposed auxiliary lock chamber extension will utilize the existing F/E system for filling and emptying operations. A description of the aforementioned system is discussed in the previous section. Modified cycle timing of the culvert valves will be necessary to facilitate lock operation without experiencing undesirable hawser forces. When filling or emptying a lock chamber, small oscillations develop in the water surface within the lock chamber. These oscillations will tend to induce motion in a tow within the lock chamber. As a result, the tow must be moored with hawser lines to prevent the tow from striking the miter gates. These lines must be able to resist the forces generated by the moving tow. The resisting forces generated in the line are defined as hawser forces. These forces are generally evaluated with physical hydraulic model testing. Experience has indicated that limiting the hawser forces in a model to less than five tons will provide satisfactory prototype performance. Recent advantages in numeric modeling techniques have provided additional methods for evaluating hawser forces. The numerical techniques provide satisfactory results for screening of alternatives; however, final design should be based upon the results of physical hydraulic model testing. In traditional F/E systems, the filling cycle will generate greater hawser forces than the emptying cycle. The most significant factor influencing the oscillations in the lock chamber is the rate of change of discharge (dq/dt). These factors produce the greatest hawser forces during the early part of the

filling cycle while the valve is opening.

Typically, bottom laterals for lock F/E systems are situated in the lock chamber such that a "balanced" water surface elevation is maintained during the filling and emptying operations, thereby, reducing oscillations and subsequent hawser forces. This "balanced" condition is the result of a variety of contributing factors, two of which are geometric configuration of the lateral field and culvert valve schedule. The existing bottom lateral field in the Greenup L&D auxiliary lock chamber is symmetrically located in the middle portion of the chamber. With the proposed lock extension, the existing bottom lateral field would be geometrically situated in the upper middle third of the lock chamber. Therefore, in order to oppose the adverse effects of this configuration, modifications to the existing culvert valve schedule are necessary.

9.2.2 With Supplemental Filling and Emptying System

The supplemental F/E system will operate concurrently with the existing system and will consist of an intake structure, wrap-around culvert, modified split lateral field, and outlet structure. Reverse-mounted, tainter-type culvert valves will control filling and emptying of the lock chamber. A general layout of the supplemental F/E system is provided in Plate No. 1-8. Preliminary design of the intake structure consists of four- 10x18 feet intake passages, which converge and transition to the 16x18 feet wrap-around culvert. The tops of the intake passages are at elevation 501.0, providing a submergence of 14.0 feet at normal upper pool. The 16x18 feet wrap-around culvert follows a path between the existing bridge piers to the filling valve structure, then transitioning into the lock walls. The invert elevation of the wrap-around culvert varies from 483.0 at the intake structure transition and 463.0 near the ports to bottom lateral field to 449.0 at the outlet structure. Water is passed through the main culvert to the lock chamber through a modified split lateral field. Similar to the existing F/E system, the eleven ports for entrance to the proposed bottom lateral field are situated on 24 feet center spacing with an invert elevation of 462.5. Geometric dimensions of the lateral field are identical to those of the existing F/E system. The supplemental F/E lateral field is centrally situated in the lower third of the proposed lock chamber to provide more "balanced" filling and emptying conditions. Downstream of the port entrances to the bottom lateral field, the wrap-around culvert passes through the empty valve lock monolith to the outlet structure. The outlet structure discharges riverward of the lower guard wall as shown on Plate No. 1-8. Final design of supplemental F/E components would be based upon results of physical model testing.

9.3 NUMERICAL HYDRAULIC MODEL

Numerical modeling techniques were utilized to evaluate the proposed lock extension filling and emptying system alternatives. LOCKSIM (LOCK SIMulator) is a hydraulic numerical computer model developed at the Tennessee Valley Authority's (TVA's) Engineering Laboratory for simulation of one-dimensional transient filling and emptying flow in navigation locks. In LOCKSIM, a filling and emptying system is represented by a network consisting of closed conduit and open channel components arranged in any desired combination. The geometry, hydraulic characteristics, and boundary conditions arranged in the network are described in an ASCII input file, which is read by LOCKSIM at the start of each simulation. LOCKSIM was designed as a general-purpose simulator, applicable to nearly any type of filling and emptying system. The program permits a more detailed numerical analysis of the F/E system compared with traditional methods. Distinguishing technical features of LOCKSIM

include prediction of hawser forces in the lock chamber, prediction of cavitational index, and evaluation of critical pressures and discharge anywhere within the system.

The LOCKSIM numerical model developed for evaluation of the proposed filling and emptying alternatives utilized guidelines, criteria and previous analyses provided in the following publications:

- Contract Report CHL-99-1, "Hydraulic Simulation of Navigation Lock Filling and Emptying Systems", dated January 1999.
- EM 1110-2-1604, " Hydraulic Design of Navigation Locks", dated 30 June 1995.
- TVA Report WR28-1-72—100, "Numerical Model for Navigation Lock Filling and Emptying Systems", dated May 1992.
- Miscellaneous Paper HL-89-5, "Hydraulic Design of Navigation Locks", dated September 1989.
- Technical Report HL-81-10, "Lock Culvert Valve Loss Coefficients", dated September 1981.
- BHRA Fluid Engineering Series, Volume 5, "Internal Flow Systems", dated 1978.
- Miscellaneous Paper H-5-7, "Lock Design, Sidewall Port Filling and Emptying System", dated July 1975.
- Technical Report No. 2-734, "Culvert Pressures, Greenup Lock, Ohio River, Kentucky", dated July 1966.
- Hydraulic laboratory Report No. 74, "Filling and Emptying Systems for Greenup and Markland Locks, Ohio River", dated January 1962.

Baseline conditions were established prior to conducting simulations of the proposed lock extension modifications. These baseline conditions were verified through previously performed hydraulic physical model studies, prototype data and field investigations. Proposed project features were then introduced into the numeric model to evaluate the estimated functionality of the proposed systems.

9.4 LOCK OPERATIONAL CHARACTERISTICS

9.4.1 Without Supplemental Filling and Emptying System

Filling and emptying operational characteristics were evaluated for the proposed auxiliary lock extension without a supplemental F/E system. Due to the proposed geometric alterations to the lock chamber, modifications to the culvert valve schedule were necessary to achieve favorable hawser forces. Calculations indicate that the mitergate machinery, when energized, will hold the gates closed against a differential head of 0.60 foot at normal upper and lower pool. Therefore, filling and emptying times for lock operation were limited to overfill and overempty control of 0.60 foot. The filling and emptying characteristics for the 30 feet design lift are provided in Table 19. Filling and emptying curves are provided in Plate No. 6-7 and 6-8, respectively.

Table 19 System Characteristics – W/O F/E Supplemental

VALVE CHARACTERISTICS	FILLING	EMPTYING
Time to Open Valve	6.0 minutes	6.0 minutes
Time at Full Open	10.0 minutes	8.4 minutes
Close to 60% Open	2.4 minutes	2.4 minutes
Total Valve Operation Time	18.4 minutes	16.8 minutes
DISCHARGE CHARACTERISTICS		
Peak Discharge	7980 cfs	7748 cfs
Time to Peak Discharge	5.9 minutes	6.0 minutes
FILL/EMPTY CHARACTERSTICS		
Time to Fill/Empty	16.0 minutes	16.2 minutes
Time to Extreme Elevation	18.0 minutes	18.1 minutes
Overfill/Overempty	0.60	0.55
HAWSER CHARACTERISTICS		
Maximum Chamber Slope	0.00014	0.00005
Maximum Hawser Force	4.22 tons	1.34 tons

Removal of the existing lower miter gate sill was an initial concern relative to fill/empty times, hawser forces and overall construction costs. The reduction in clearance over the sill compared with the clearance over the remainder of the lock chamber floor was thought to have a potential impact on the filling and emptying of the chamber. However, numerical model results indicate that adequate submergence is present on the lower miter gate sill such that fill/empty times are not affected. Therefore, removal of the lower miter gate sill will not be necessary. Physical, hydraulic model testing will be necessary to verify the numerical results. Plate No. 6-9 depicts the effects of valve scheduling on filling times and subsequent hawser forces for the proposed extension without a supplemental F/E system.

The piezometric head elevations at the valve wells and the vena contracta were determined using LOCKSIM for the 30 feet design lift. Piezometric head curves for the filling and empty cycles are provided in Plate No. 6-10 and 6-11, respectively. The minimum computed head at the vena contracta for the filling and empty valves are below the culvert roof elevation. This would indicate that there would be air entrainment into the lock filling and emptying system. Prior physical model study and prototype analyses performed for the Greenup L&D provided verification of the numerical computational results obtained with LOCKSIM. Research and development efforts are being conducted at the Waterways Experimentation Station (WES) for the Ohio River main stem locks, which target innovative design and construction techniques for various project components. As part of these efforts, general proposed lock extensions with and without supplemental filling and emptying systems are being evaluated. Results from these investigations will be utilized for correlation to the proposed alternatives at the Greenup L&D site. In addition, further hydraulic, physical model studies will be necessary for final design of the proposed extension without a supplemental filling and emptying system.

9.4.2 With Supplemental Filling and Emptying System

Filling and emptying operational characteristics were evaluated for the auxiliary lock extension with a supplemental F/E system. A split lateral configuration was utilized with the existing culvert supplying the transverse lateral field in the upper portion of the lock chamber and the proposed wrap-around culvert supplying the transverse lateral field in the lower portion of the lock chamber. Initially vertical lift gates (stoney gates) were proposed for the supplemental F/E system due to the fact that less space is required than with a reverse tainter valve and the monolith that is required to support this type of valve is smaller. However, the linear operating scheme of the stoney valve when incorporated with the existing reverse tainter valve produces undesirable hawser forces and unsatisfactory fill/empty times. Therefore, reverse-mounted tainter-type culvert valves were utilized for the proposed supplemental F/E system. Filling and emptying times for lock operation were limited to overfill and overempty control of 0.60 foot. The filling and emptying characteristics for the 30 feet design lift are provided in Table 20. Filling and emptying curves are provided in Plate No. 6-12 and 6-13, respectively. Through implementation of the supplemental F/E system, lock filling and emptying times would be comparable to the existing main chamber. Plate No. 6-14 depicts the effects of valve scheduling on filling times and subsequent hawser forces for the proposed lock extension with a supplemental F/E system.

Table 20 System Characteristics – With F/E Supplemental

VALVE CHARACTERISTICS	FILLING	EMPTYING
Time to Open Valve	4.0 minutes	4.0 minutes
Time at Full Open	2.8 minutes	2.8 minutes
Close to 60% Open	2.4 minutes	2.4 minutes
Total Valve Operation Time	9.2 minutes	9.2 minutes
DISCHARGE CHARACTERISTICS		
Peak Discharge	13628 cfs	13800 cfs
Time to Peak Discharge	4.0 minutes	3.9 minutes
FILL/EMPTY CHARACTERSTICS		
Time to Fill/Empty	9.1 minutes	8.9 minutes
Time to Extreme Elevation	10.55 minutes	10.3 minutes
Overfill/Overempty	0.60	0.59
HAWSER CHARACTERISTICS		
Maximum Chamber Slope	0.00009	0.00002
Maximum Hawser Force	2.50 tons	0.80 tons

The piezometric head elevations at the valve wells and the vena contracta were determined using LOCKSIM for the 30 feet design lift. Piezometric head curves for the filling and emptying cycles are provided in Plate No. 6-15 through 6-18. The minimum computed head at the vena contracta for the filling and empty valves are below the culvert roof elevation for both the existing and proposed culverts. This would indicate that there would be air entrainment into the lock filling and emptying system. Prior physical model study and prototype analyses performed for the Greenup L&D provided verification of the numerical computational results obtained with LOCKSIM. The aforementioned design efforts being conducted at WES will provide additional information relative to the proposed supplemental F/E system for the Greenup L&D extension. Site specific, hydraulic, physical model studies will be necessary for final design of the proposed extension with a supplemental filling and emptying system.

SECTION 10 STRUCTURAL DESIGN REQUIREMENTS

10.1 LOCATION AND SITE RESTRICTIONS

10.2 CONSTRUCTION TECHNIQUES AND PROCEDURES

Generalized construction techniques and procedures for each construction method are described in the following paragraphs. Detailed construction sequences are described in Section 24.2.1.

10.2.1 Lift-in Monoliths

The lift-in method of construction generally consists of pre-casting concrete blocks and wall panels, setting and connecting up to a given level with crane barges, filling void spaces with tremie concrete, and repeating the process until the construction is above water. Above water, the procedure is modified to include setting braced wall panels without additional towers. Panels are set and braced in the dry and concrete is cast in place. The principle features of this method are described below:

a) The process uses techniques common to most civil works construction. A larger number of contractors will be able to bid on contracts using this method than the more specialized float-in method.
b) Flexibility is a key feature and is incorporated at the design level. The method directly addresses the critical issue of extending an operating lock, while minimizing closure of the existing lock chambers. The lock can be closed for only a few hours as each piece is set and reopened to clear the traffic queue.
c) A second advantage is the ability to open the auxiliary chamber within a few hours of notification. The worst case would occur if the main chamber had to be closed because of an emergency while a chamber face wall panel is being set in the auxiliary chamber. In this case, the auxiliary chamber would not be available until the base tremie grout was sufficiently set to avoid being damaged by propeller turbulence.
d) This lift-in concept will require a 350 T to 400 T derrick crane (or boat) to lift the heaviest elements.
e) A large pre-cast yard will be required to cast approximately 250 pre-cast elements.
f) A slipway can be used to transfer the pre-cast elements from shore to barges for installation.

10.2.2 Float-in Monoliths

The float-in method of construction generally consists of constructing a floating shell, bracing it for stability, positioning it, sinking it, grouting the base, filling it with tremie concrete,

and completing the construction to the desired elevation. The technique has been used for some bridge piers, breakwaters, piers, and oil platform bases. The attraction of the float-in method is, like the lift-in method, the ability to build the 600-foot extension while keeping the existing lock open and operating with minimal interruptions from the construction. The principle features of this method are described below:

a) Both locks must be closed for 3 to 5 days while the monolith shell is precisely positioned, sunk in place and the base is grouted in place.
b) The base shell is pre-cast at a dry dock. It is anticipated that the decommissioned 600-foot lock at R.C. Byrd L&D (formerly Gallipolis) could beadapted for this purpose.
c) Since the design draft is 9-feet between R.C. Byrd Locks and Dam and Greenup Locks and Dam, an additional fit out dock would be required at Greenup to extend the walls and increase the draft to 22-feet.
d) Because the bottom of the channel at Greenup is rock, draft is also limited for movement from the fit out dock to the placement position. This is especially a problem when a culvert is added to the shell. Two solutions are available. One is to excavate a channel to the placement site, but this would add approximately 25,000 CY of rock excavation to the project. The other solution would be to wait for a higher pool, but this occurs only during high flows. Working in high flows would mean greater difficulties in precisely positioning and setting the shell thus extending the period for which both locks would have to be closed.

10.2.3 Drilled Caisson Landwall

Drilled caisson construction applies to the land wall extension only. This method generally consists of drilling caissons to a design depth in the rock, lifting in an "H"-shaped pre-cast wall panel to straddle the caissons, and filling the annular space with tremie concrete. The drilled caisson structure is built to elevation 500 feet. Above this elevation, the structure is completed using pre-cast panels and cast-in-place concrete. The principle features of this method are described below:

a) The volume of rock removal that would be required for the land wall construction is reduced by approximately 5,000 CY.
b) The volume of concrete for completion of the land wall is reduced by approximately 20,000 CY.
c) The construction time for drilled caissons would be shorter than other alternatives.
d) The caisson-rock interaction has been the focus of a separate study and is discussed in detail in 25.1. The rock reaches high but acceptable stress levels at design loading conditions. Deflections in the rock have been determined to slightly exceed the allowable values. Current caisson-rock interaction studies are based on simplifying conservative assumptions. It is recommended that additional studies be performed to evaluate the wall-caisson-rock interaction. It is believed that a systems approach to the analysis will show a significant reduction in the calculated deflections. Until a more detailedstudy of this problem can be conducted, this problem eliminates drilled caissons as an alternative construction method.
e) The stresses in the caisson also reach high levels requiring very heavy steel reinforcement.

10.2.4 In-the-Dry Construction

In-the-dry construction is conventional so it will not be described in detail. The fundamental procedure is to build the two miter gate monoliths using float-in or lift-in methods, build a

cofferdam from the land wall miter gate monolith to the near shore, install a bulkhead between the miter gate monoliths, dewater, and build the remaining land wall monoliths in the dry. Most major civil works projects built in water are constructed using this method. The principle features of this method are described below:

a) This method closes the auxiliary chamber for the majority of the construction period without the ability to reopen it if an emergency were to occur in the main chamber. This issue alone eliminates in-the-dry construction as a viable alternative construction method.
b) Construction is conventional.
c) The bulkhead and bulkhead sill must be designed to withstand significantly larger differential water pressures.
d) The gate monoliths would have to be constructed at lower elevations (more rock excavation) to be stable under the higher water pressures.
e) A cofferdam must be constructed from the land wall miter gate monolith to the shore.
f) Dewatering costs and the cost of the cofferdam are very high.

10.2.5 Supplemental Filling/Emptying System

The supplemental filling/emptying system starts with construction of a 1200-foot bypass culvert to be buried in a trench varying from 50 feet deep to 70 feet deep. In the next section of the system, culverts are incorporated in the land wall monoliths. Laterals extend from the land wall across the chamber at elevation 460 feet and will be constructed in the dry while the miter gate sill is being built. The last feature of the filling/emptying system is the outlet culvert and outlet structure. The outlet culvert passes through the land wall miter gate monolith and is incorporated in that structure. It then crosses the auxiliary and main lock lower approaches and goes through the downstream guard wall to the outlet structure in the river channel. The portion of the system crossing the lower approaches will be constructed in the wet. The outlet structure will be constructed in the dry.

10.3 TYPE AND CONFIGURATION OF EXTENDED LOCK CHAMBER WALLS

The three principal monolith types for this project are the land wall, the land wall miter gate monolith, and the middle wall miter gate monolith. The four construction methods considered for building each type of monolith were discussed in section 10.2.1 through 10.2.4. They are; lift-in, float-in, drilled caisson, and in-the-dry.

There is nothing requiring the entire extension project to use a single construction method. The fastest and least expensive construction will come from using the most practical method for the feature being constructed. The following paragraphs discuss the various configurations of feature and construction method.

Drilled caissons and in-the-dry construction methods are not practical for the construction of gate monoliths, particularly the middle wall miter gate monolith.

- To cast the miter gate monoliths in the dry, a cofferdam would have to be constructed around both gates. Construction of the cofferdam would require closing both the main and auxiliary locks for the time required installing the cofferdam and the time to construct the monoliths. Operationally, this is totally unacceptable. Similarly, building just the land wall and land wall miter gate monolith in the dry would be unacceptable. Construction would require

building the middle wall miter gate monolith and then building a cofferdam to the shore which would close the auxiliary lock for the duration of the project without the ability to reopen it if an emergency were to occur in the main lock chamber.

- Drilled caissons do not readily allow the incorporation of the gate machinery, gate recess, or pintle anchorage. To accommodate these features, the caisson would have to be set back at least 20 feet from the face of the wall. The recesses and anchorage for the miter gate would then have to be cast in place, probably using some type of lift-in construction. Increasing the size of the monolith to accommodate these items would eliminate the advantages of the drilled caisson method.

It is assumed both gate monoliths will be constructed using the same construction technique.

- The construction of the land wall miter gate monolith will allow the contractor to gain a level of expertise that will shorten the construction time and difficulties for the middle wall miter gate monolith. This is especially important because of the operational difficulties caused by shutting down the main lock chamber. Both locks must be shut down for at least a portion of the time required to construct the middle wall miter gate monolith. Thus, any advantage that can be accrued to shorten the shutdown of the main lock should be pursued.
- The second reason for constructing both gates using the same method is construction efficiency. The construction will proceed more smoothly and the cost will likely be lower if the construction methods are duplicated.

To select the best configuration of wall type and construction method, the advantages of each method must be understood. The following paragraphs discuss the advantages of each construction method and where it is best applied to the 600-foot extension.

10.3.1 Lift-in Miter Gate Monoliths

The lift-in technique allows the miter gate monolith to be constructed in modules. Each module is stable and permits the passage of traffic in the main chamber after a short closure period. The majority of the work can be done from the backside of the monolith, i.e. the auxiliary channel. The working equipment can be removed in a matter of hours should there be an emergency need for the auxiliary chamber and approach to be opened, such as due to a malfunction of the main lock. A detailed discussion of the construction of the middle wall miter gate monolith by lift-in construction is found in Section 24.2.1.

Construction by lift-in procedure is broken into pieces which each require closure of the main lock for 12 to 16 hours. This allows the queue of tows to be cleared and traffic to be restored before the next closure. At current traffic volume, a queue resulting from a 16-hour closure should be cleared in less than 24 hours. As discussed in 15.4, the float-in method requires closure of both locks for a minimum of 84 hours. At current traffic volume, it would take approximately 28 days to clear a queue resulting from an 84-hour closure. The difference in the disbenefit costs of creating and clearing such queues is in the tens of millions of dollars. (Calculation of the disbenefit costs is discussed elsewhere in this study, and has been provided here to assist in understanding the importance of reducing main lock closure times.)

The lift-in system is not significantly affected by the addition of the supplemental fill/empty system. The tower modules change shape and size to incorporate the culvert. The spacing of the towers is reduced to ensure the top of the tower is still above water. The technique for placement and alignment remains the same.

Lift-in is generally insensitive to the draft limitations downstream of the Greenup dam. The heaviest pieces are 350 T and can be transported on a 40' x 60' barge. No additional dredging is required for movement of the monolith pieces or the construction equipment.

Lift-in saves the cost of a dry dock (R.C. Byrd modifications) and a fit-out dock at the site. Offsetting some of this saving is the cost of setting up the large pre-cast yard at the site. An offsetting cost unique to lift-in is the need for a slipway or other means to transfer pre-cast pieces, but this will be much less than the cost of a fit-out dock.

Another significant factor leading to the preference for lift-in construction is contractor knowledge of the lift-in technique. The skills and equipment required to build by the lift-in method are common to most contractors who build civil works projects on rivers. The individual techniques required are typical of those used in most other types of construction, compared to a limited number of contractors who have experience with float-in. Therefore, a request for proposal for lift-in has the potential of attracting a larger number of qualified bidders. In addition, the successful bidder will be more familiar with the specific techniques required to accomplish lift-in construction.

Contractor familiarity is an intangible advantage for the lift-in method and would not be enough by itself to make the technique preferred over the float-in method.

10.3.2 Float-in Monoliths

Float-in construction is a good alternative to the construction methods recommended. In some ways, float-in is superior to lift-in, but the overall benefits of float-in do not outweigh the benefits of lift-in. The benefits of float-in over lift-in are discussed below.

The unit cost of concrete for float-in construction would be lower. This is due to the fact that approximately 18% of lift-in construction is pre-cast whereas less than 12% of the float-in monoliths would be pre-cast. The difference would be greater were it not for the bottom of the float-in shell, which does not exist in lift-in. The remainder of the concrete in both cases is either cast-in-place or tremie concrete and would have comparable cost.

Offsetting the reduced amount of pre-cast concrete is the need to set up a batch plant and pre-casting operation at both R.C. Byrd Locks and Dam and at Greenup Locks and Dam for the float-in method.

The very nature of the lift-in technique is that the various pieces must be assembled to produce the whole. There are significantly more connections and connection problems with lift-in than there are with float-in. Connection problems include such items as making underwater connections and making connections in relatively tight places.

The float-in method of construction allows construction of the extension while keeping the main lock open, except for relatively short duration closures during preparation and installation of the middle wall miter gate monolith. Like the lift-in method, the equipment used to build the float-in monoliths can be removed in a matter of hours to open the auxiliary lock, provided that the float-in shell is secured in position. If a segment of the land wall is being set, this could be up to three days.

The float-in method is expected to be more sensitive than the lift-in method because of the size differences of the elements being placed. The float-in method calls for the movement and setting of the entire middle wall gate extension in one piece. This piece is approximately 145 feet long and 38 feet wide. It has a hard bottom with a minimum of 18 landing points along the length. This monolith must be placed level so the walls are vertical. It must also be placed in the exact position so the walls are true with the walls of the existing chambers. Thus, overall

levelness of the excavation is important with particular emphasis at the locations of the landing points. Local humps, which would contact the bottom, must be removed so no contact is made with bottom except at landing points. Care must be taken not to damage the integrity of the shell, as it may have to be refloated to make leveling adjustments to the landing points or to its position.

The final cleaning will have to take place immediately prior to moving the monolith and setting it. Because of space limitations under the floor of the shell, it will not be practical to clean again prior to placing the first lift. The solid floor of the float-in shell also means the first lift will have to be grout instead of tremie concrete. The design values used for the float-in elements will have to take into account the likelihood the first lift will have some silt contamination.

The advantages of float-in over lift-in do not outweigh the main lock closure time difference between the two construction methods. Because of the rock bottom, draft problems also favor lift-in over float-in.

10.3.3 Drilled Caisson Landwall

While the drilled caisson method is eliminated from consideration for the miter gate monoliths, it has a significant cost advantage in construction of the land wall and should be reconsidered during the DDR phase of the project. That advantage is primarily in the volume of materials.

The total width of the drilled caisson wall is approximately 12 feet. This yields an approximate 50% reduction in concrete required for the wall. The volume of concrete required for 360 feet of gravity structure is approximately 33,000 CY and the volume required for the drilled caisson wall is 13,000 CY (including the embedded portions of the caissons). This large advantage in concrete is somewhat offset by the need for significant reinforcement in the caisson.

Significant additional savings accrue in the reduced amount of rock excavation that will be required. As compared to those methods described in 10.3.1 and 10.3.2, the drilled caisson method saves approximately 5,000 CY of rock excavation over any type of gravity wall construction.

Utilizing the drilled caisson wall will reduce overall construction time. The construction method will all take place from moderate sized barges (60’x 160’). Because of this, the barges may be moved and the auxiliary lock may be opened each weekend or, if the need is great, each night.

Because of these cost advantages, the drilled caisson wall would be a clear recommendation for the land wall. However, the current analysis shows the system as failing to meet the deflection criteria in the founding rock. This is an issue that deserves further study because of the savings that can accrue to the project.

10.3.4 In-The-Dry Construction

Although in-the-dry construction has been historically used for lock and dam construction, it does not appear to offer the advantages in cost or schedule proposed by other methods. There are two primary reasons why the in-the-dry method is least preferred for the 600-foot extension of the Greenup Locks & Dam

First, construction in the dry requires the auxiliary lock to be closed for the entire period of the construction. All other methods allow periodic opening of the auxiliary lock. In some cases using other methods, the lock could be opened daily if there was sufficient need. Dry construction does not allow this flexibility.

The second reason in-the-dry construction is the least preferred is the additional costs associated with this technique. A cofferdam must be constructed from the land wall miter gate monolith to the near bank. Additional dewatering bulkhead sections must be designed and constructed to hold water to the ten-year flood, elevation 532 feet. Maintenance bulkheads are currently designed to hold water to elevation 512 feet. This would not be adequate height to prevent flooding in the two to three year construction period. After installing the bulkhead, the enclosed area must be dewatered. The volume of dewatering will be 2.5 to 3 times the dewatering required for other construction methods. Since the site will remain dewatered in excess of two years, there is increased probability the site will be flooded at least once. Such an occurrence would have additional costs associated with shutdown, delay, dewatering, cleanup, and starting construction again.

The higher costs, due to the cofferdam, are somewhat offset by the lower cost of construction in the dry. There is also the contention argument that in-the-dry construction improves the quality of the final product. Neither of these issues is strong enough to outweigh the costs and impacts to the towing industry.

10.3.5 Recommended Configuration

The recommended configuration for the 600-foot extension project is to construct the land wall using lift-in construction. Sequential to finishing the land wall, the land wall miter gate monolith would be built using lift-in procedures. On completion of the land wall miter gate monolith, the middle wall extension and miter gate monolith would be built by the lift-in method. The downstream maintenance bulkhead sill would be constructed next. The cross over tunnel incorporated in the sill would be lifted-in. Once the bulkhead sill is cured, the bulkhead would be installed and the auxiliary chamber would be dewatered. The final phase would be construction of the miter gate sill and, depending on the alternative chosen, construction of the laterals in the dry. Plan 1 is shown in Section 26.4.1 Plates 2-1 through 2-10. Since the 600-foot extension is the same for Plans 2, 3, and 4, it is shown in Section 26.4.2 on Plates 2-11 through 2-28. The supplemental filling/emptying system is shown in Section 26.4.4 on Plates 4-1 through 4-7.

Each of the construction methods is discussed in more detail in SECTION 16. In addition, a full construction schedule has been developed for this recommended configuration for each of the alternatives and is presented in SECTION 24.

10.4 TYPE AND CONFIGURATION OF APPROACH WALLS

Four new approach walls are required for the proposed 600' lock extension. Final required approach wall lengths will be determined after completion of hydraulic model testing. For feasibility study purposes, the following preliminary approach wall lengths (including nose piers) were included in this design:

- 1,345.91' Floating Upper Middle Approach Wall
- 1,345.91' Floating Upper Riverside Approach Wall
- 1,184' Fixed or Floating Lower Landside Approach Wall
- 295' Floating Lower Riverside Approach Wall

The Upper Middle Approach Wall (UMW) will extend approximately 1,200 feet beyond the uppermost landside monolith (after twelve existing landside monoliths are demolished, as proposed). The new floating Upper Riverside Approach Wall (URW) will extend upstream from the existing fixed approach wall at this location. The new URW will extend approximately 1,200 feet beyond the new UMW. The Lower Landside Approach Wall (LLW) will extend approximately 1,200 feet beyond the proposed new Lower Middle Wall Bullnosed Monolith.

The upper approach walls and lower riverside approach wall will be composed of floating pontoons that are laterally restrained by nose piers and pylons. The following two design alternatives are being considered for the Lower Land Wall:

1. A floating pontoon concept similar to those proposed for the upstream walls, or
2. A fixed wall comprised of precast panels supported by drilled shafts.

See Plates 4-1 to 4-7 for plan views, elevations, and sections of the proposed approach walls.

10.4.1 Pontoons

The overall width of the pontoons has been based on the estimated weight of the pontoons and the required flotation characteristics such as freeboard and draft. The weight of the pontoons will depend on the required wall thicknesses, which was designed to resist barge impact forces.

The overall height of the pontoons, measured from the deck slab crown to the bottom of the keel slab, is 15 feet. The overall height of all three pontoons is assumed to be identical.

In order to prevent unintended impact on the lower part of the pontoon walls, the lower portion of the wall will be set back from the guide surface. The impact face of the pontoons will be armored from 2 feet below the water line to 7 feet above the water line and will be approximately 24.5 to 28 inches thick, depending on the design impact forces. This thickness is required to prevent punching shear failure. The landward wall of the LLW Pontoon and the riverside wall of the URW are 23 inches thick. This thickness is optimized for construction cost, embedded features, and overall strength of the pontoons. The deck slab will be a minimum of 8 inches thick and the keel slab will be a minimum of 9 inches thick.

The parapet of the LLW Pontoon was raised to an elevation 14 feet above the water in proximity to the lock chamber wall to eliminate the possibility that empty barges would ride over the parapet wall and impact the lock monolith.

The pontoon is made up of a number of pontoon segments, ranging from 380 feet to 440 feet in length, which are connected by pretensioned high strength bolts. Each pontoon segment is designed as a watertight concrete box structure that is compartmentalized by chambers. Chambers are watertight enclosed spaces created by transverse bulkheads (typically at 20-foot spacing), the segment end walls, the deck and keel slabs, and the pontoon sidewalls. Because of its watertight construction, each segment can be individually launched, towed, maneuvered, and ballasted.

The bulkheads (i.e., transverse concrete walls within the interior of the pontoon) serve four primary functions:

- They provide a skeleton for the relatively long, thin pontoon structure.
- They provide a means of tying the walls and slabs together.
- They compartmentalize the pontoon's interior space. This helps ensure pontoon flotation in case of accidental flooding.
- They provide local stiffness and strength for the required light poles and mooring points.

If, for an extraordinary reason (such as the impact by a runaway barge and tows), any chamber should be flooded, the compartmentalization of the pontoon will ensure confinement of the flooding to the damaged area. This confinement, which prevents progressive failure, is a critical feature for the survivability and redundancy of the pontoons.

Each chamber can be accessed only through the deck slab openings. The openings in the deck slab are equipped with watertight hatches and access ports. Hatches will provide access for thorough inspections and maintenance work. Access ports will be used for short inspections. For instance, they may be used for sounding of the chambers with a pole, providing fresh air supply into the confined space during inspection and repair, and pumping (in rare occasions).

The pontoon will have a concrete parapet wall on the navigation side of the pontoon and a combination concrete parapet/guardrail on the non-navigation side. Recessed ladders and mooring points will be incorporated on the navigation side of the pontoon. Line hooks and timberheads will accommodate 2-inch diameter synthetic lines.

Presently, all pontoons are anticipated to be equipped with skirts for improved navigation. This requirement will be re-examined during later design phases. The proposed skirts for the upper walls are composed of articulated stainless steel panels, which hang beneath the pontoons' keel slab. An even multiple of hinged panels will be used in order to provide better performance during low water periods. Even numbers of panels are capable of folding in a more favorable manner upon contact with the riverbed. The skirt for the LLW will be smaller in size and of simpler construction. Since the LLW Skirts add only 2 feet to the 11 feet of pontoon draft, their effectiveness should be evaluated in conjunction with future hydraulic modeling.

10.4.2 Nose Piers and Pylons

Nose piers and pylons provide lateral support for the floating pontoons while allowing the pontoons to float at varying water elevations as the pool fluctuates. Pylons are located adjacent to the existing lock structures while nose piers are located at the opposing, or leading ends, of the approach walls. Pylons may be independent, stand-alone structures or they may be protrusions or recesses at existing or new lock wall monoliths. In-the-wet construction of nose piers and pylons minimizes lock closure requirements. Nose pier and pylon details are shown in Plates 6-1 and 6-2.

There are two upper nose piers and two lower nose piers (if the Lower Land Wall is a floating wall). The Upper Middle Wall (UMW) Nose Pier Superstructure is 38 feet wide and Upper River Wall (URW) Nose Pier Superstructures are 42 feet wide. Both UMW and URW are 50 feet tall, El. 505 to El. 555. The Lower Land Wall (LLW) and Lower River Wall (LRW) Nose Pier Superstructures are 42 feet wide by 80 feet tall (El. 475 to El. 555). The UMW and URW Nose Piers protect the pontoons from runaway downbound barges, and the LLW and

LRW nose piers protect the pontoons from upbound barges up to the flood of record elevation (El. 548.8).

The superstructures will be supported by three 10-foot diameter drilled shafts arranged in a triangular pattern. After the installation of the steel base shell on the shafts, the base shell will be filled with tremie concrete to the top of the base shell. Each superstructure has three 11.5-foot diameter steel sleeves that slide over and bear on the top of three drilled shafts. The gaps between the sleeves and drilled shaft casings will be filled with grout. The top of the drilled shafts will be anchored to the superstructure so that the connection will act as fixed supports for moment, horizontal shear, and axial forces.

At their transition to the existing or new wall monoliths, the pontoons are interlocked with the pylon structures. These structures were designed to meet the following objectives:

- Provide a smooth transition between the flexible pontoons and nearly rigid existing or new monoliths.
- Minimize the construction duration, obstructions, and lock closures.
- Use features that allow in-the-wet construction thus, eliminating the need for conventional cofferdams.
- Use existing features where possible, thus, minimizing the construction cost.

There is only one stand-alone pylon. It is located at the downstream end of the new URW. The pylon superstructure is a precast concrete segment, which is 13 feet x 13 feet in cross section extending from El. 505 to El. 555. The pylon superstructure will be supported at El. 530 by a 10-foot diameter drilled shaft. The bottom portion of the pylon is overlapped with the drilled shaft to develop full structural continuity through the top of the pylon.

As proposed, the pylon structure at the transition of the LLW pontoon to the new lock extension will require a modification to the planned float-in monolith downstream of the new miter gate monolith. The modification will consist of the following:

- Below El. 537, a vertical "guide slot" at the downstream face of the new float-in monolith will accommodate a guide key for the pontoon.
- Above the new monolith, a "shield structure" will extend from El. 537 to El. 555.

If desired, the shield structure may be constructed on site (after the float-in segment has been installed) either conventionally formed or in conjunction with precast shell elements filled in situ with concrete.

The shield structure will serve two functions. It allows the guide slot to be extended to an elevation above the "probable maximum flood" elevation, and it "shields" the end of the pontoon against potential damage at flood stage. Runaway barges would be diverted from head-on collisions with the pontoon. In addition, the shield prevents debris from becoming lodged in gaps near the marine fenders. A ladder recess will be provided for maintenance access to the cable reel and other electrical installations.

The pylon structure at the transition between the UMW pontoon and the existing upstream bullnose of the Middle Lock Wall Monolith will have unique features, which allow utilization of the existing bullnose structure for the pontoon support. Here, the stainless steel brackets that are attached to the end of the pontoon overlap with the bullnose for the pontoon's lateral support. (For details, see Plate 3-1).

The taper of the pontoon end and the geometry of the bullnose allow the stainless steel brackets to be positioned in a protected recess. Therefore, only a small chance of barge impact exists at this location. This assumption appears justified as:

- The outermost part of the bracket is 1 foot-6 inches from the wall's guide surface.

- Barge tows are expected to be well aligned when approaching the end of the pontoon (which is over 1,000 feet in length).
- Impact damage to miter gates in an "open" position has been reported only very rarely and, when they occur, they are usually minor.

The required modifications to the existing structure are anticipated to be relatively small. However, during later design phases it will be determined if any structural enhancement of the existing structure will be necessary.

The modifications will include the following:

- Installation of Ultra High Molecular Weight Polyethylene (UHMWPE) panels adjacent to the marine fenders of the pontoon. This installation will require some cleaning and patch work on the armored face of the bullnose. The UHMWPE panels may be installed in conjunction with a stainless steel frame anchored in the existing concrete.
- To provide for pontoon support above El. 537 (the top of the existing wall monolith), the existing bullnose structure (or a part thereof) needs to be extended to El. 555. Presently, the exterior is expected to be cast-in-place reinforced concrete (See Plate 3-1 for details) although precast shell elements may also be used if found to be more cost efficient than conventionally formed concrete. It is anticipated that the existing structure will be of sufficient strength to tolerate the additional gravity loads and transverse loads due to the extension weight, barge impact, etc.
- A recessed ladder is proposed in order to provide personnel access to the pontoon.

10.5 IMPACT OF ADDING A SUPPLEMENTAL FILLING/EMPTYING SYSTEM

The addition of a supplemental filling/emptying system has been incorporated in the design in four different configurations; each represented by Plans 2 through 4. The alternatives and how much of the filling/emptying system they include are described in detail in SECTION 2.

- Plan 2 includes the culverts in the land wall, the laterals, outlet culvert, and the outlet structure at the time of construction of the auxiliary extension. The bypass culvert and intake are deferred until traffic demands require reduced fill times.
- Plan 3 includes all elements at the time of construction of the auxiliary extension.
- Phase 1 of Plan 4 is the same as Plan 2 with the culvert in the land wall, the laterals, outlet culvert and outlet structure. Phase 2, the addition of the bypass culvert and intake are deferred until traffic demands justify reduced fill times and the cost of future construction.

The impact on the design, by selecting any of the four options incorporating all or part of the filling/emptying system, is the same. To properly provide for the future addition of the filling/emptying system, it must be completely designed. This includes consideration of all related issues including excavation, stability, incorporation of culverts, provision for valves and hydraulic performance.

The most significant impact of the filling/emptying system is on the excavation. The addition of the culverts would increase the excavation depth for the land wall, significantly increase the depth of the land wall miter gate monolith, and would add excavation for the laterals and the outlet. The volume of rock to be removed for the filling/emptying system is estimated to be 52,000 CY for Plans 2, 3 and 4, compared to 20,000 CY for Plan 1.

A second significant impact is on construction time. The additional excavation adds approximately 6 months to the completion schedule for the contract. Additional closures for the main chamber are required to complete the installation of the outlet culvert.

Another significant impact of adding a filling/emptying system is on project cost. See SECTION 23 for details concerning the additional cost related to adding this feature to the project.

If a drilled caisson solution can be developed in later studies, the addition of a filling/emptying system will have significant impact. The removal of ten additional feet of rock would increase the bending moment in the caissons and stress in the rock significantly. Study results indicate the caisson stresses could be dealt with, but the rock deflections are much too great. This does not eliminate the drilled caissons, but would mean a significant change to the alternatives. An alternative has been developed wherein the drilled caissons would be spaced to accommodate the addition of laterals at a later date. In its simplest form, this would involve modifying the drilled caisson wall to become a gravity wall at the time the filling/emptying system is added. This would reduce initial construction cost significantly, but would increase the cost if the filling/emptying system were added.

10.6 STABILITY ANALYSES

10.6.1 Extended Lock Chamber

Stability analysis of the middle wall miter gate monolith was relatively straightforward since the width of the monolith was fixed by the two adjacent lock channels. Analysis of the land wall monoliths presented an opportunity for optimization since the loads were not the same as those on similar existing monoliths. Stability analysis of the monoliths included stability against sliding, overturning, and base uplift.

The first issue to be resolved was the elevation the monoliths are to be founded. Analysis determined the base friction was inadequate by itself to provide an adequate factor of safety unless the monoliths were founded on the sandstone and the weak layer at elevation 462-463 was eliminated. The founding elevation was set at 461 feet or nine feet below the top of rock. Because of excavations adjacent to monoliths, crossbed shear strength or equivalent passive pressure was not included in the stability analysis for sliding.

Overturning of the gate monoliths was satisfactory for all three cases; the usual, the unusual, and the extreme. Dewatering for maintenance is considered unusual loading and a seismic event is considered extreme. Rock anchors are not required for any of the new monoliths.

Stability analysis of overturning of the land wall allowed for optimization of the shape and size of the monoliths. Eight different shapes were developed varying from analysis of the existing land wall to very narrow sections requiring a large number of rock anchors. The final section selected optimized the mass for overturning without the addition of rock anchors. The volume of concrete was minimized. There is some inefficiency in the shape because of the need to build up vertical walls to a certain elevation to simplify in-the-wet construction. The principal reason the final section is narrower than the existing chamber monoliths is that the esplanade is not to be extended as part of this construction or in the foreseeable future. Thus, the soil load on the back of the monolith was reduced considerably. As shown on the loading diagrams, an allowance was made for 20 feet of construction disposal and/or sedimentation against the back of

the land wall. This is considered very conservative considering the operating tail water is elevation 485 feet.

10.6.2 Approach Walls

10.6.2.1 Barge Tow Impact Analysis

The objective of this analysis is to determine barge tow impact loads for the design of the wall face and restraint system for the Upstream Riverside Guard Wall, Upstream Middle Guide Wall and Downstream Landside Guide Wall at the Greenup Locks on the Ohio River. The methodology chosen for computing impact loads is contained in USCAE ETL 1110-2-338. The procedure is used to calculate the maximum force and energy absorbed in a barge collision with a rigid or flexible structure. The magnitude of the impact force generated by a particular collision event is dependent on the mass, including hydrodynamic added mass, of the barge tow, the approach speed, the approach angle, the barge tow moment of inertia, the damage sustained by the barge structure and the friction losses between the barge and wall. The method is based on the structural interaction mechanism of V. Minorsky. The semi-empirical mechanism that he developed correlates kinetic energy lost in collision with the volume of in-plane material damages.

Three independent probability distributions are proposed for the primary impact variables: mass, approach speed and approach angle. In this way a per event impact force and impulse probability can be estimated. An annualized extreme value distribution is computed to predict annual usual, unusual and extreme impact forces.

A beta distribution was chosen to represent the impact probabilities because it captures the essential characteristics of a lock approach procedure for impact angle and speed. These are:

- the speeds and angle are positive (> 0)
- there is an upper limit
- the distribution is asymmetric between the upper and lower bound
- normal deviations in the approach are accounted
- extreme events due to equipment or human failure are assigned discrete, but small probabilities.

The parameters of a beta distribution are: lower limit (>0), upper limit, mean value and standard deviation. The most probable value and shape of the curve are calculated from the beta distribution function.

The distributions used in the analysis are presented in the figures below. Without field data or model scale experiments, the distribution parameters are necessarily subjective. The mean values and standard deviations have been chosen based on our site visit and subsequent discussions as a best estimate of the field data.

10.6.2.1.1 <u>Impact Angle</u>

The objective with respect to impact angle is to choose a most probable impact angle and a reasonable distribution. The approach angles to the two upstream walls are limited by the proximity of the riverbank. For the Upstream Middle Guide Wall, the maximum angle is assumed to be 6 degrees, with a most probable impact angle of 2.8 degrees. For the Upstream Riverside Guard Wall, there is more clearance, and the potential for larger impact angles. The maximum angle is assumed to be 22 degrees, with a most probable impact angle of 6.6 degrees.

However, the higher approach angles are improbable, with 99.2 percent of all approaches assumed to be at 12 degrees or less.

On the approach to the Downstream Landside Guide Wall, there is no navigational restriction on the angle taken by the barge tows. The distribution is defined with a maximum impact angle of 25 degrees, and a most probable angle of 9.6 degrees. 99.1 percent of all impacts are assumed to be at an angle of 17 degrees or less.

Figure 11 and Figure 12 present the proposed distributions for impact angle.

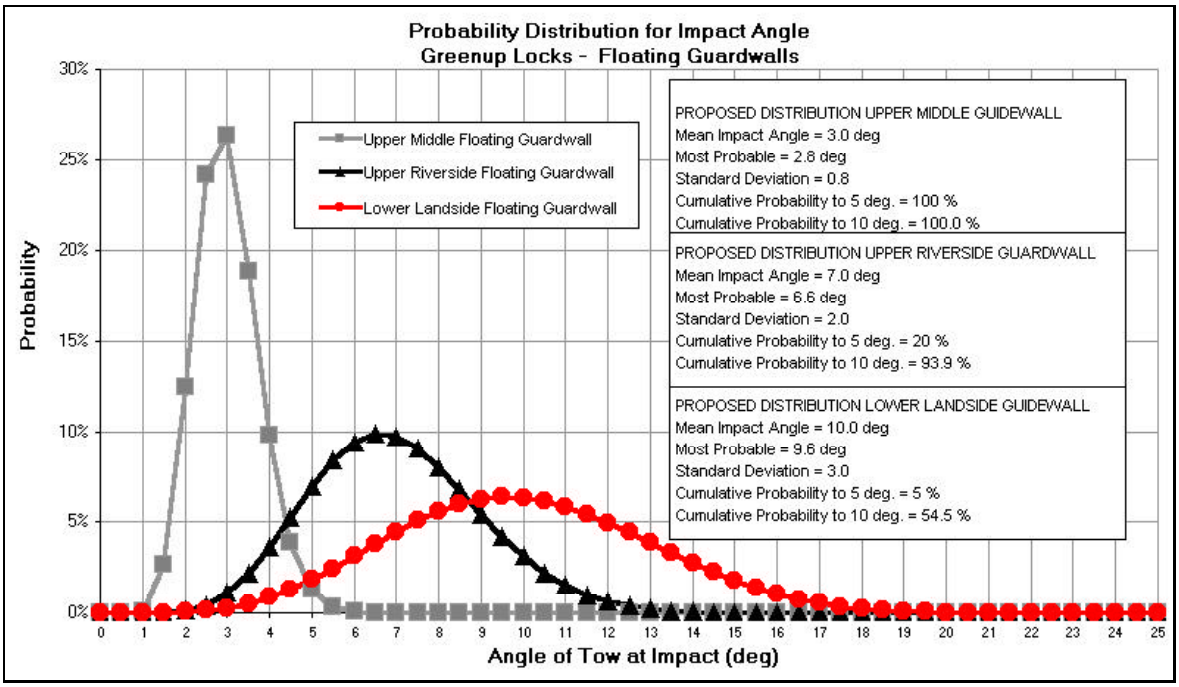


Figure 11. Probability Distribution for Impact Angle

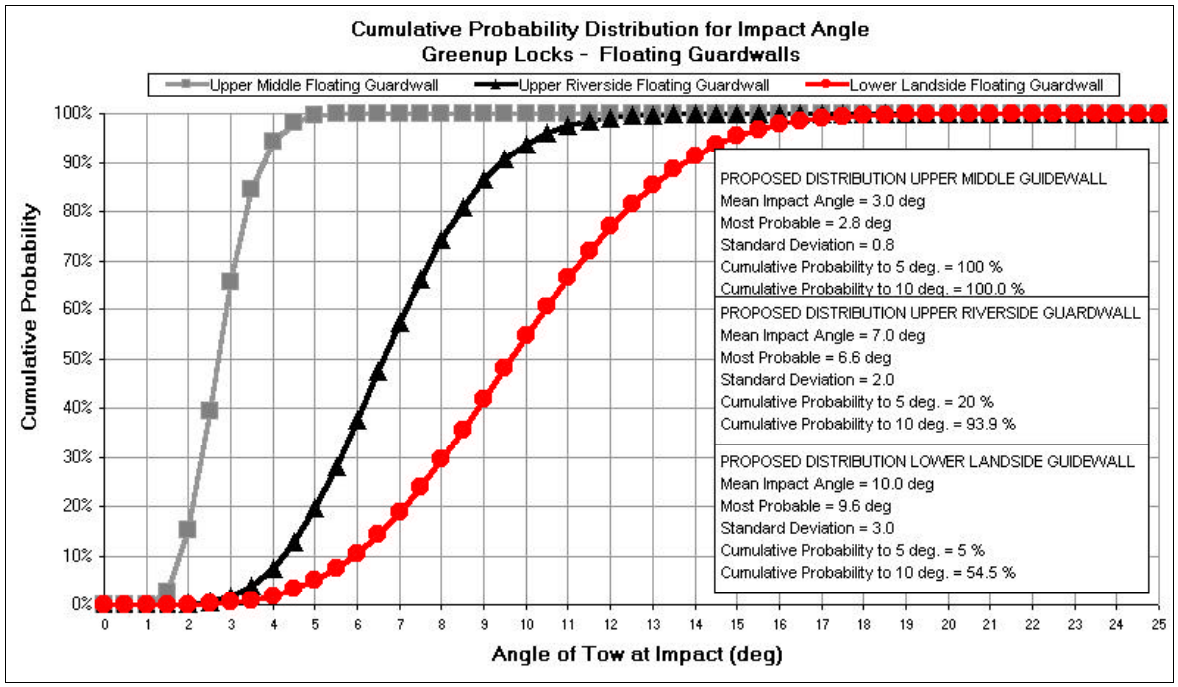


Figure 12. Cumulative Probability Distribution for Impact Angle

The mean impact angles are shown in Figure 13 with a 15-barge tow drawn to scale.

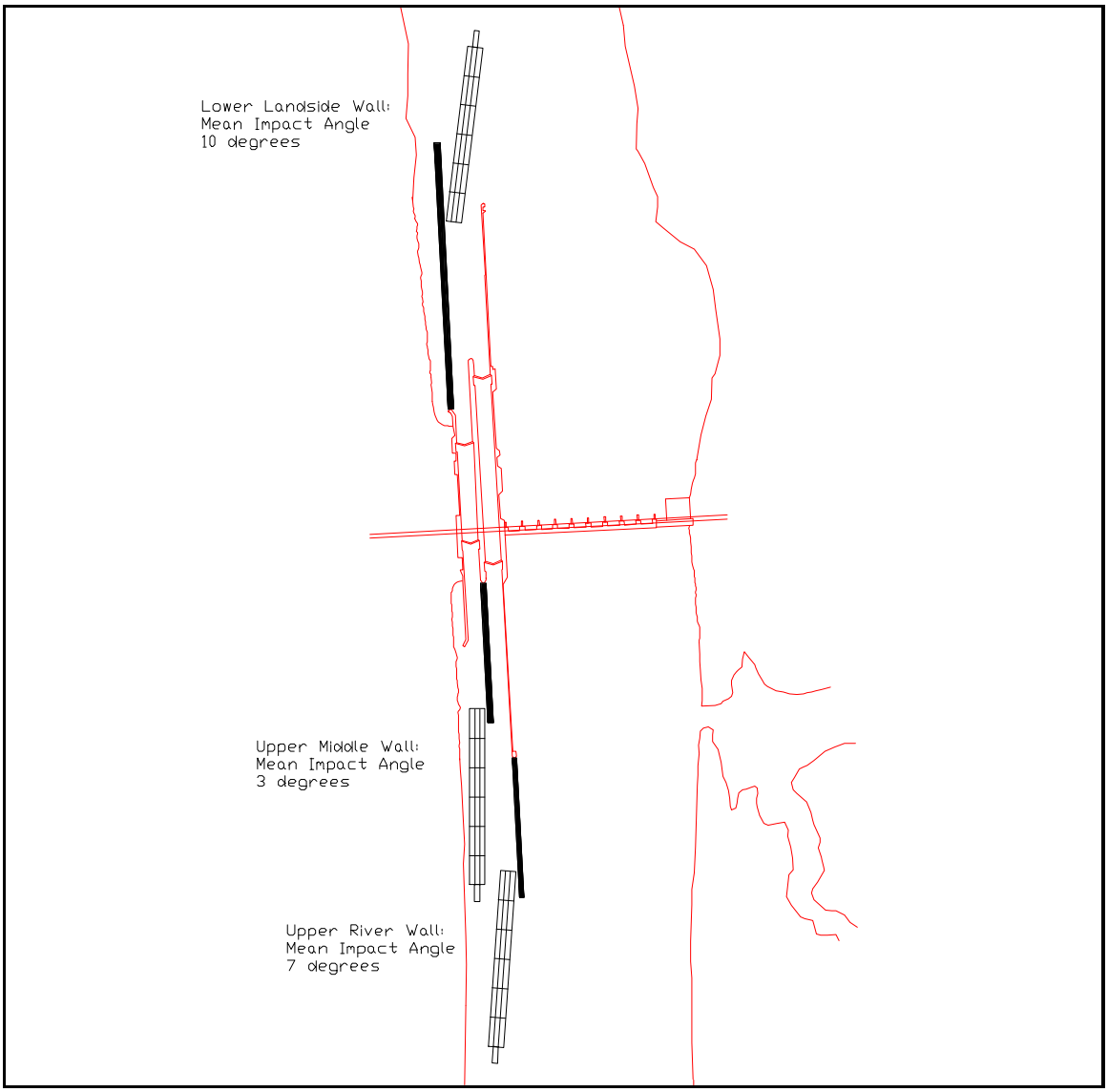


Figure 13. Mean Impact Angles

10.6.2.1.2 <u>Impact Speed</u>

For the Upstream Middle Guide Wall, the tow impact speed distribution was chosen with a most probable value of 0.8 ft/sec (slower than slow walk or 1.0 ft/sec) with 98 percent of landings slower than medium walk (3.0 ft/sec). The approach to the Upstream Riverside Wall is not quite as tight, allowing for slightly higher normal approach speeds. The most probable impact speed is assumed to be 2.2 ft/sec, with 87 percent of all landings slower than a medium walk. The approach speed to the Lower Landside Guide Wall is expected to be lower due to adverse current. The most probable impact speed is taken to be 1.5 ft/sec, with 96 percent of landings slower than a medium walk. These numbers are primarily based on observations made during the site visit and select video records.

Figure 14 and Figure 15 present the proposed beta distribution and cumulative probability curves for barge tow impact velocity for the three floating walls.

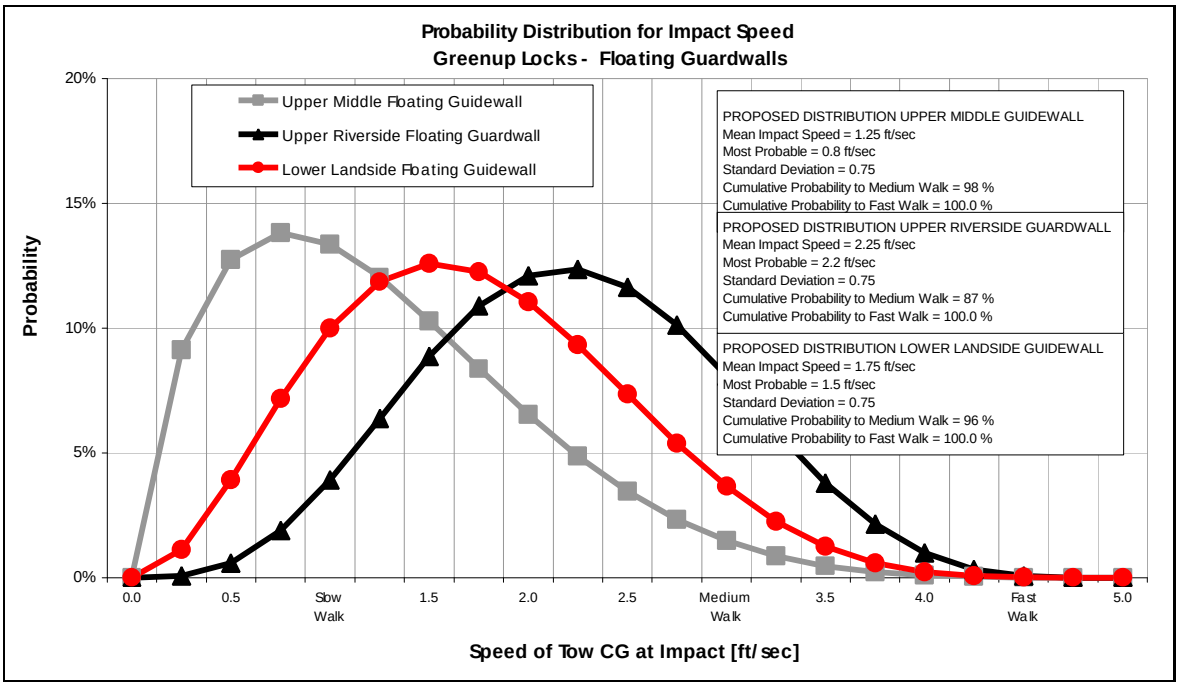


Figure 14. Probability Distribution for Impact Speed

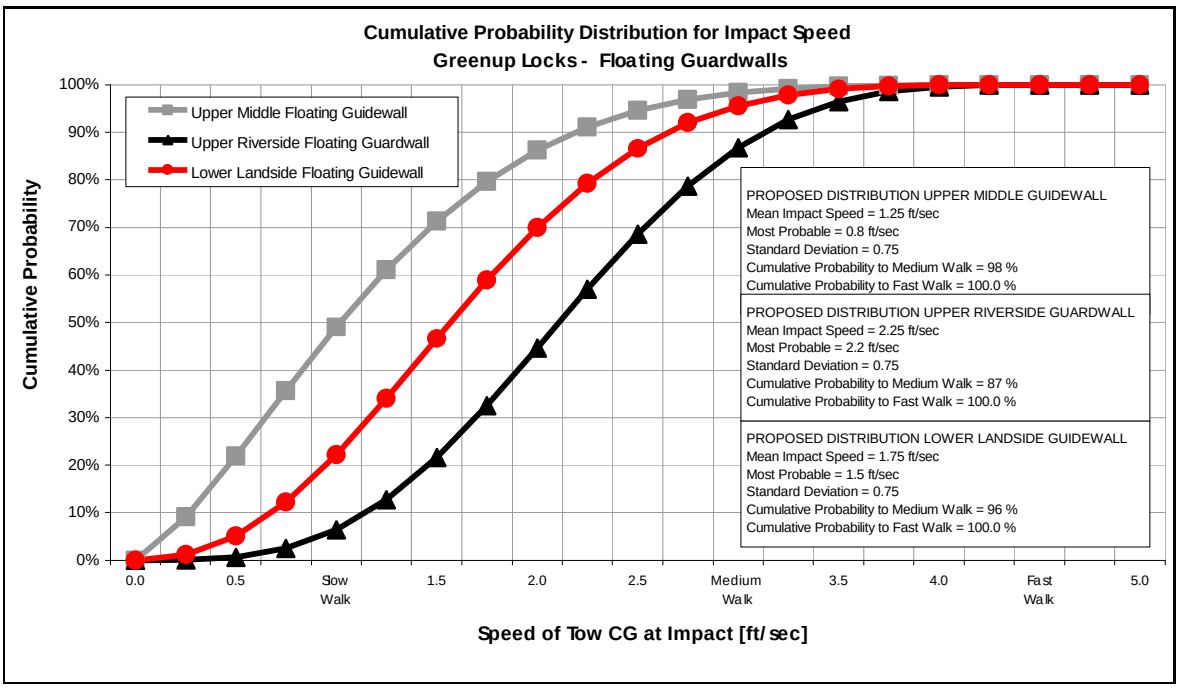


Figure 15. Cumulative Probability Distribution for Impact Speed

Measured current data in the vicinity of the three walls was limited to data taken on one day. The discharge that day was 145,000 cfs, a rate that is exceeded about 20 percent of the time. This limited data was analyzed to determine whether or not there was a significant set from the bank toward the middle of the river in the vicinity of the proposed upstream walls. A lateral current would tend to increase the impact angles, thereby increasing the impact forces. In the

immediate approach area for the Upstream Middle Wall, the average current velocity at 4.36 feet below the surface (approximately mid-draft on a laden barge) was 1.9 ft/sec flowing at an average angle of 9.4 degrees with respect to the wall, resulting in a velocity component toward the wall of 0.3 ft/sec. For the Upper River Wall, the average velocity was 2.7 ft/sec at 9 degrees to the wall, and a component into the wall of 0.42 ft/sec. The presence of the walls, with skirts extending below the surface, will tend to align the current vectors with the walls, reducing the expected lateral velocity. However, without model testing or field data from a set of representative discharge conditions, it is not possible to incorporate lateral velocity into the probabilistic model. Alternatively, the models were run with an arbitrary lateral velocity (0.0 and 0.25 ft/sec in barge coordinates) to check the sensitivity of the results to this variable. Based on the limited data, a lateral velocity of 0.25 ft/sec is considered an upper bound. Results should be considered accordingly.

The parameters of the impact angle and impact speed beta distributions are given in Table 21.

Table 21 Beta Distribution Parameters for Impact Variables

Wall (Traffic Direction)	Variable	Most Probable	Mean	Standard Deviation	Minimum	Maximum
Upper Middle (downbound)	Angle	2.8°	3.0°	±0.8°	0°	6°
	Speed	0.8 fps	1.25 fps	±0.75 fps	0 fps	5 fps
Upper Riverside (downbound)	Angle	6.6°	7.0°	±2.0°	0°	22°
	Speed	2.2 fps	2.25 fps	±0.75 fps	0 fps	5 fps
Lower Landside (upbound)	Angle	9.6°	10.0°	±3.0°	0°	25°
	Speed	1.5 fps	1.75 fps	±0.75 fps	0 fps	5 fps

10.6.2.1.3 Weight Distribution

The distribution of tow weights of barge tows arriving at the Greenup Lock and Dam from both directions was developed from the database for arriving tows compiled by the USCOE. The database included all upbound and downbound arrivals of commercial tows, from 1991 through 1998. Due to a significant increase in traffic from 1991 to 1992, 1991 data was disregarded in developing the weight distributions. The database included the number barges loaded; number barges empty; tow length; tow width; tow draft; number of cuts; tonnage; and towboat horsepower.

The Glosten Associates used the data provided to develop the distribution of weight of upbound and downbound tows shown in Figure 16 and Figure 17. The weight distributions were developed by summing the weights of the barges, the towboat and the cargo. The weight of the barges themselves is assumed to be the number of barges times 213 tons per barge (i.e. steel weight). The weight of the towboat was taken as a multiplier times the horsepower of the towboat. The multiplier was developed from a regression of known designs. This is regression is not exact, but it is a good approximation for this investigation. The cargo weight is the reported tonnage. Those lockages that were reported with a length or beam greater than the size of the new lock chamber were divided into two cuts. The first cut is assumed to be the maximum

size for the chamber. The second cut uses the remaining barges. The towboat is assumed to be part of both landings. This process resulted in a total of 22,325 upbound and 21,919 downbound barge lockages over the seven-year period beginning in 1992. Due to a trend of increasing traffic volume, the 1998 volumes were used in the analysis. The results presented are based on 3,272 landings per year on each of the two upper walls and 3,363 landings per year on the Lower Landside Wall.

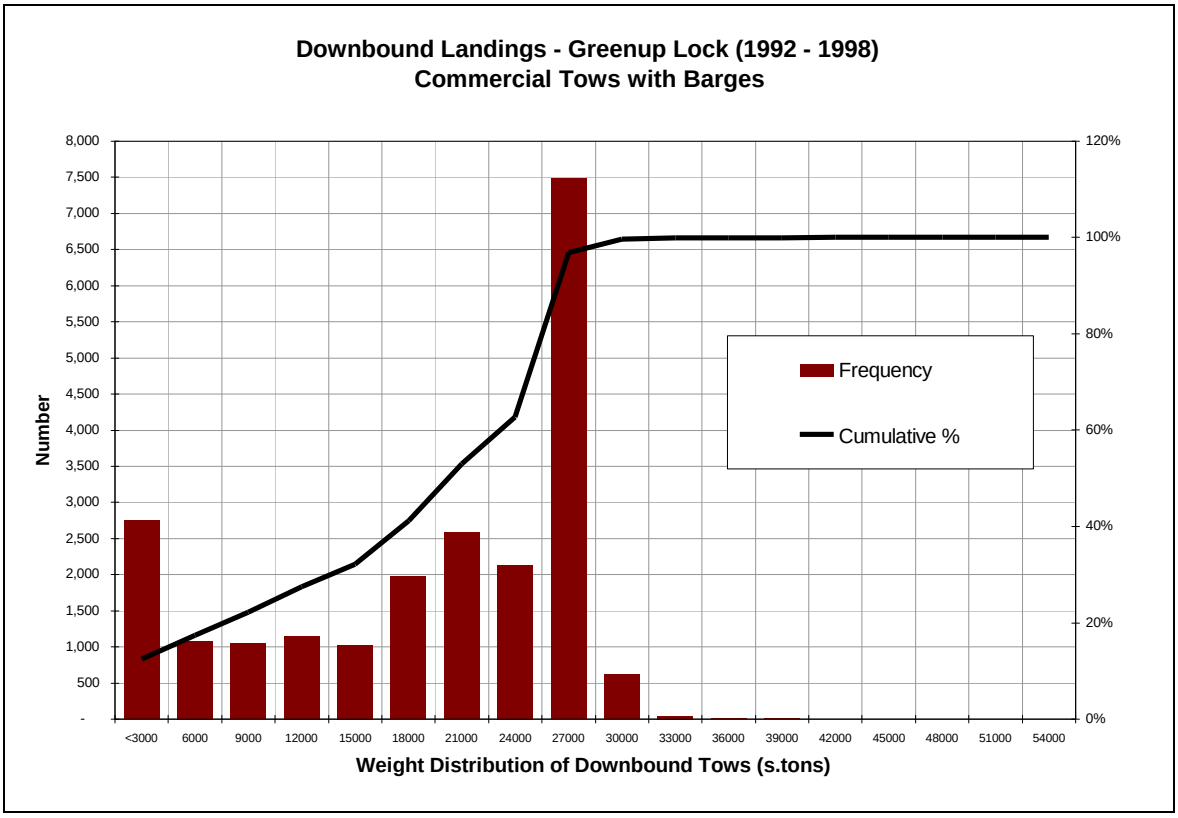


Figure 16. Histogram of Impact Weight Distribution – Downbound Landings

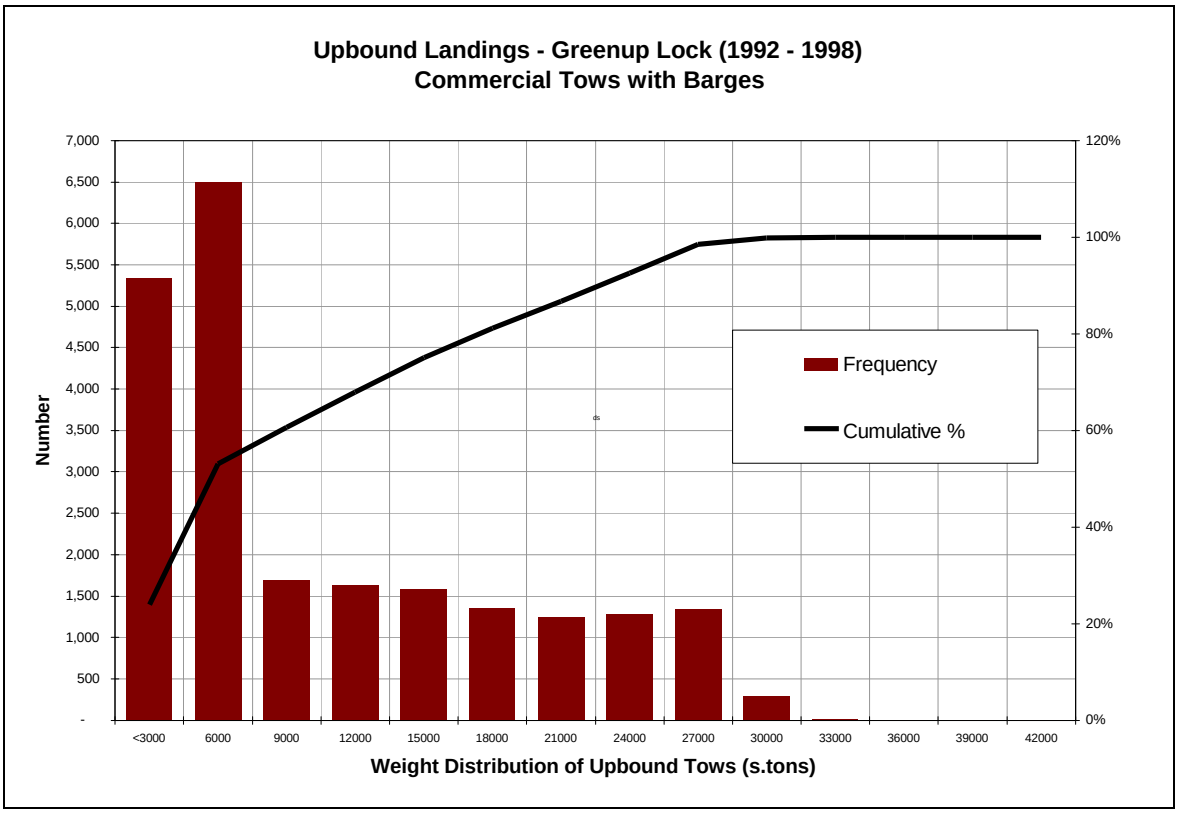


Figure 17. Histogram of Impact Weight Distribution – Upbound Landings

10.6.2.2 Impact Forces on Lower Landside Guide Wall

The normal component of impact force on the guide wall is computed using the method of USACE ETL 1110-2-338. Each combination of impact angle, impact speed and tow mass is analyzed using the ETL methodology. An event probability is computed for each impact as the product of the probabilities of the three underlying parameters. A cumulative distribution of impact force is produced simply by ordering from lowest to highest the computed impact force, while keeping track of the discrete individual case impact probabilities. The per-event probabilities are then annualized using a binomial probability transformation for repeated independent trials. The cumulative probability is the sum of all lower impact force annualized probabilities.

Figure 18 through Figure 22 show the cumulative distribution of impact force plotted on Weibull Type II extremal probability paper. The 'k' parameter of the distribution is varied to produce a best-fit least squares straight line. In this way, the distribution can be easily interpolated to find impact forces at chosen probability levels.

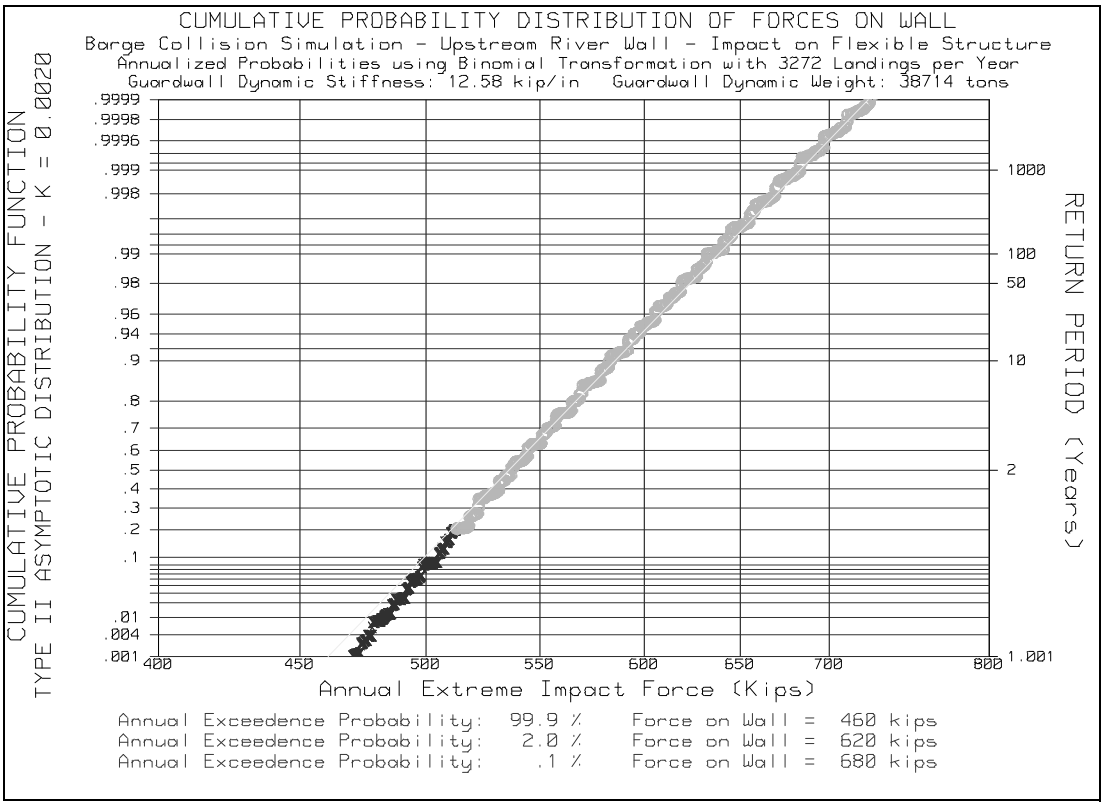


Figure 18. **Cumulative Distribution of Impact Force – Upper River Wall (no lateral set)**

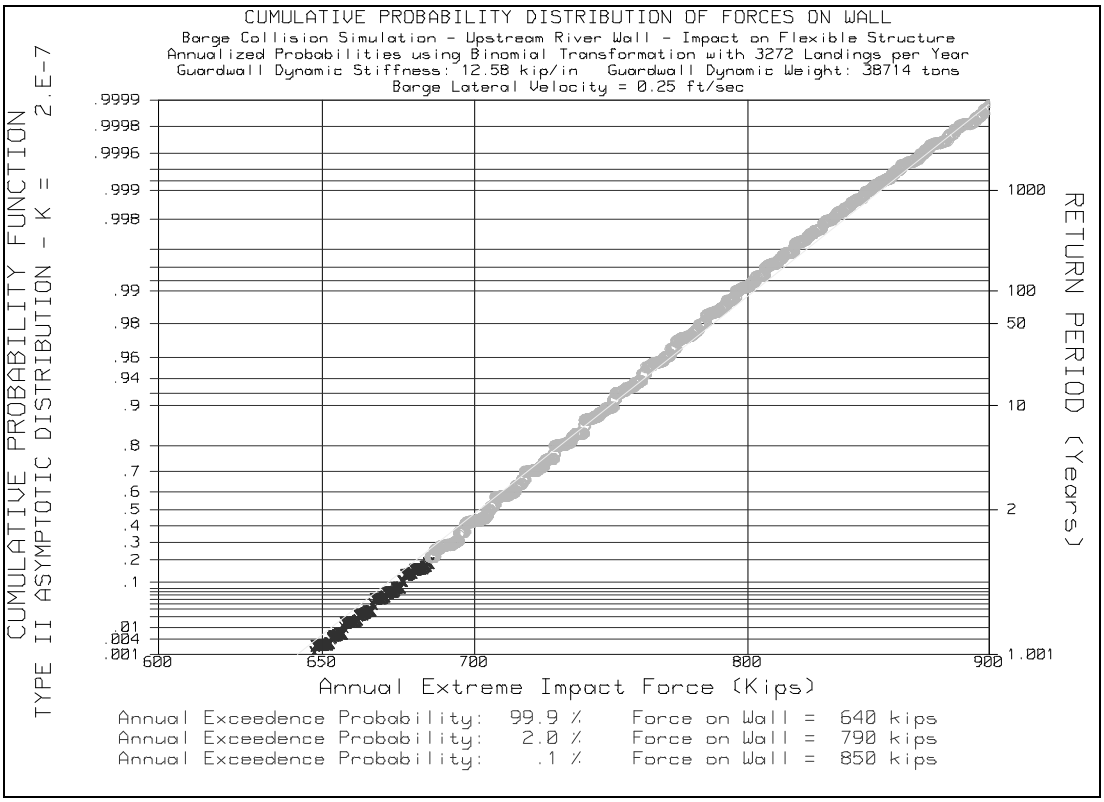


Figure 19. Cumulative Distribution of Impact Force – Upper River Wall (0.25 ft/sec lateral velocity)

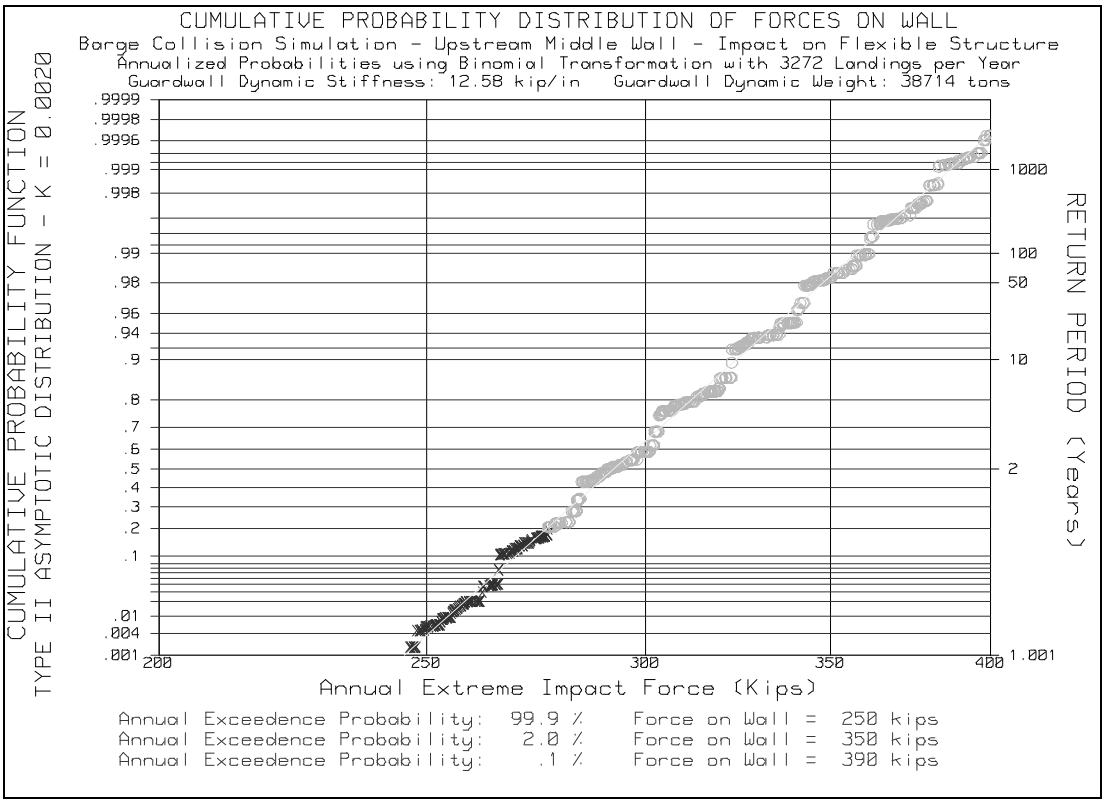


Figure 20. Cumulative Distribution of Impact Force – Upper Middle Wall (no lateral set)

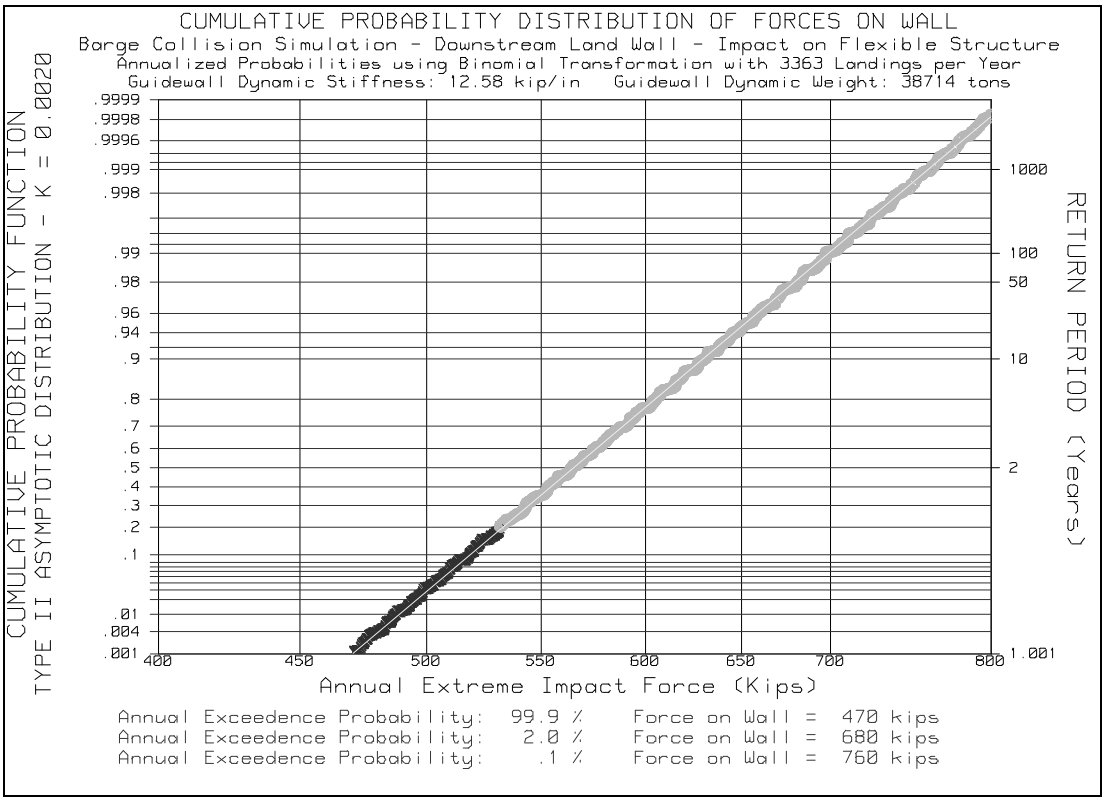


Figure 21. Cumulative Distribution of Impact Force – Lower Landside Wall (no lateral set)

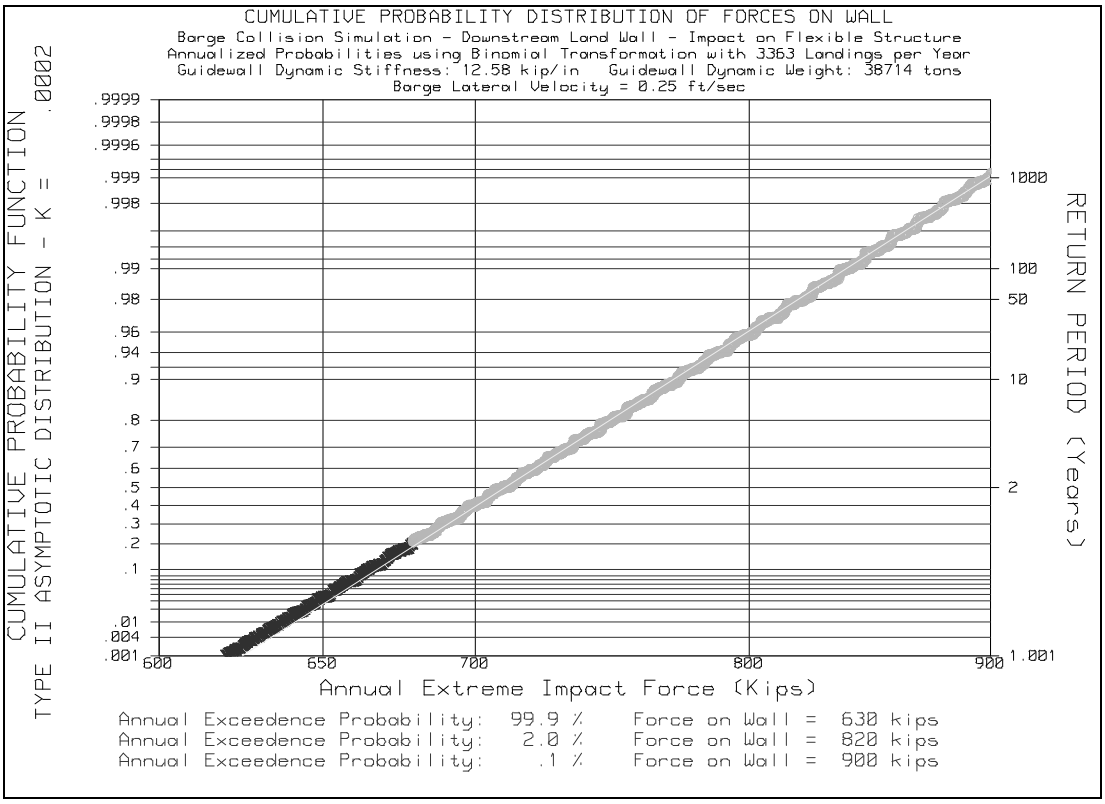


Figure 22. Cumulative Distribution of Impact Force – Lower Landside Wall (0.25 ft/sec lateral velocity)

Three impact force probabilities are chosen to represent usual, unusual and extreme events. These levels were defined as an annualized probability of exceedence of 99.9 percent, 2.0 percent and 0.1 percent, respectively. Thus, the usual event has a probability of being exceeded approaching 1 in 1 year. The unusual event has a probability of being exceeded approaching 1 in 50 years. The extreme event has a probability of being exceeded approaching1 in 1,000 years.

The usual, unusual and extreme impact forces are summarized inTable 22.

Table 22 Usual, Unusual and Extreme Impact Forces Greenup Lock and Dam

Annualized Exceedence Probability	Return Interval Years		Upstream River Wall	Upstream Middle Wall	Downstream Land Wall
Usual: 99.9%	1	Expected values	460	250	470
		Upper bound	*640*		*630*
Unusual: 2.0%	50	Expected values	620	350	680
		Upper bound	*790*		*820*
Extreme: 0.1%	1,000	Expected values	680	390	760
		Upper bound	*850*		*900*

This impact analysis assumes that the tows land on a flexible guide wall. Thus, the guide wall absorbs some of the impact energy by its own motion. The dynamic stiffness of the floating guide walls is assumed to be 12.58 kips/inch,and the dynamic weight of each wall is 38,714 tons.

Also, the tow is assumed to be a rigid mass with no internal flexibility, i.e. there is no stretching or breaking of the wires connecting the barges together and no energy absorbed in vibrations of the hull structures. Although this assumption of tow configuration rigidity is conservative, it allows for the simplifications contained in the ETL method. There is currently an active investigation at the COE Waterways Experiment Station of full-scale tests of loaded barge impacts with guide wall structures. The object of the investigation is a rewrite or modifies ETL 1110-2-338, with a possible reduction in the conservatism of the predicted loads. However, at this time, the research is incomplete and the ETL has been used as published.

10.6.2.3 Force-Impulse on Floating Guide Walls

Impact force-impulse is calculated as the integration of the force vs. time function. The shape of the force vs. time curve is not computed by the ETL method, however time domain simulations of the impact of barges with floating guide walls, carried out for the Olmsted study, showed that the impulse integration can be reasonably approximated as 2/3 of the product of the maximum force and the total impact duration. As both of these are calculated with the ETL method, the force-impulse is easily computed and the cumulative distribution function is produced in the same way as for impact forces.

The annualized cumulative distribution for impact force-impulse for the Greenup Lock floating guide walls are shown in Figure 23 through Figure 27. Usual, unusual and extreme values are given in Table 23.

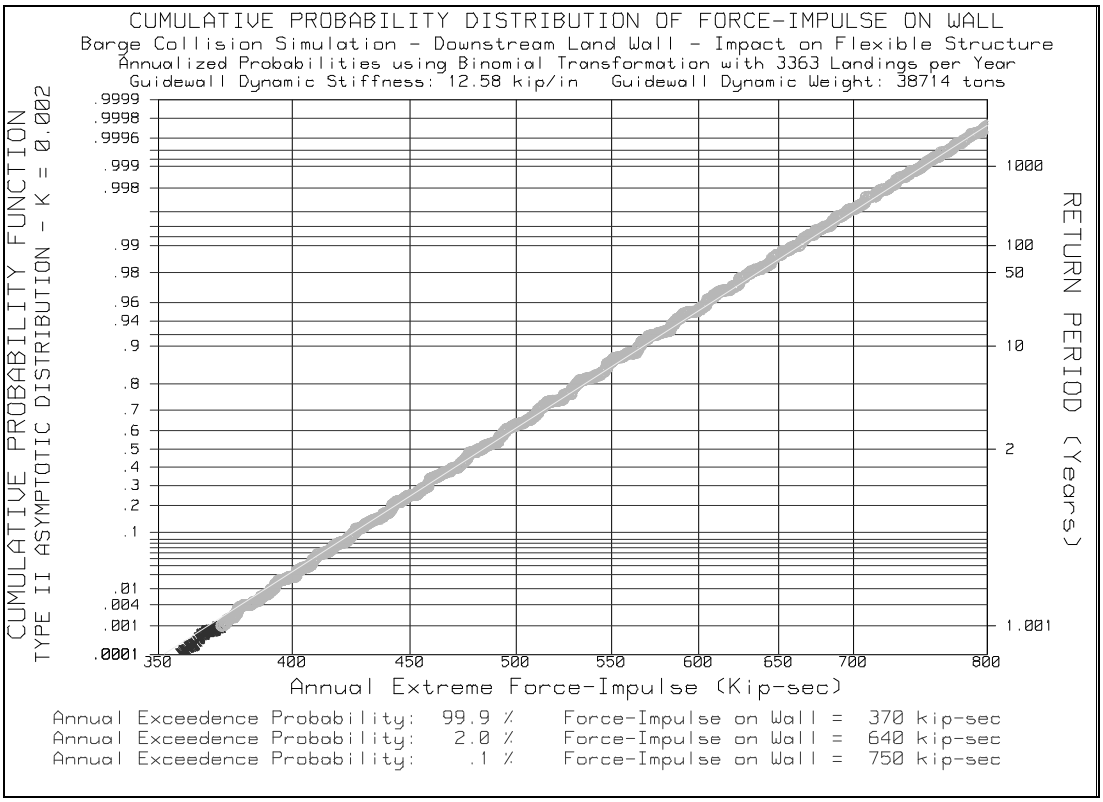


Figure 23. Cumulative Distribution of Impact Force – Impluse - Lower Landside Wall

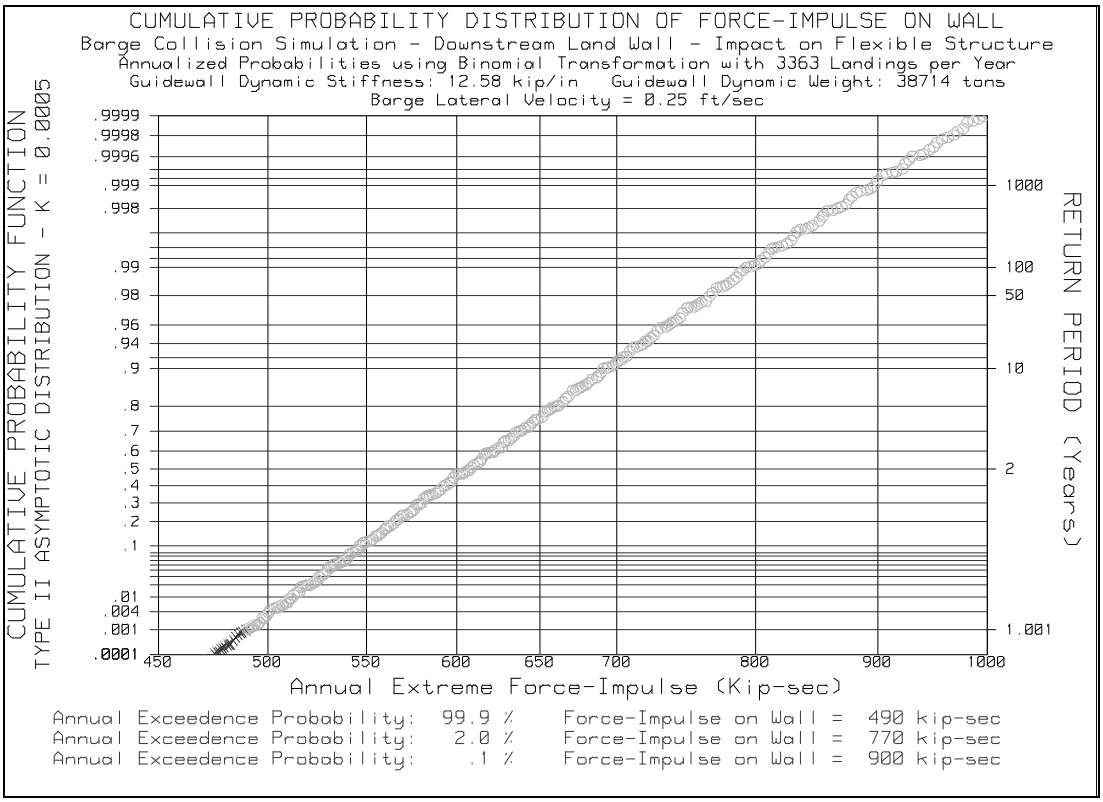


Figure 24. Cumulative Distribution of Impact Force – Impluse - Lower Landside Wall (0.25 ft/sec lateral velocity)

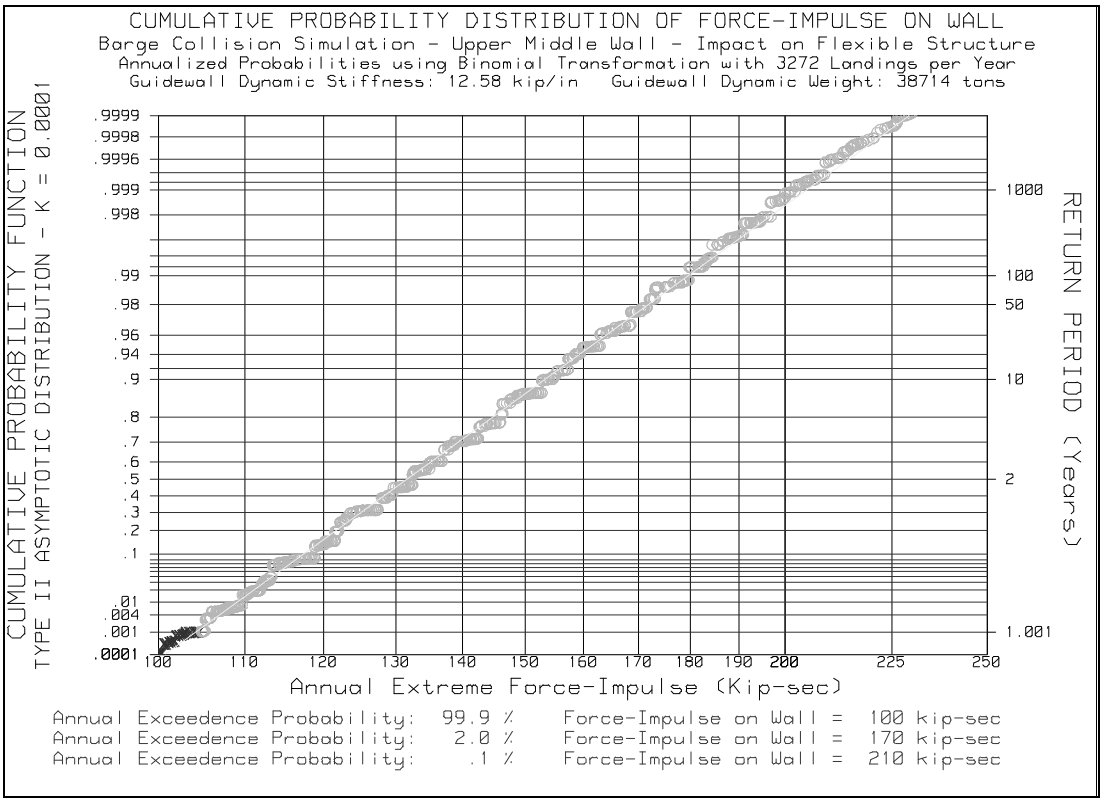


Figure 25. Cumulative Distribution of Impact Force – Impluse - Upper Middle Wall

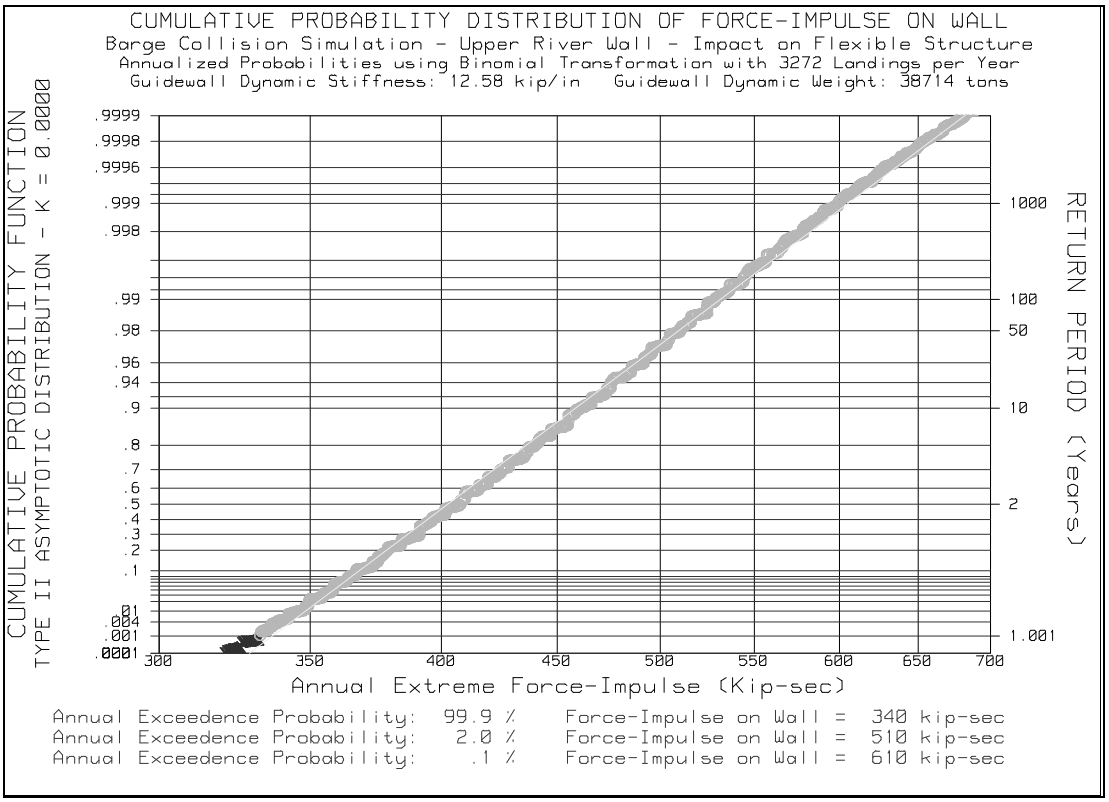
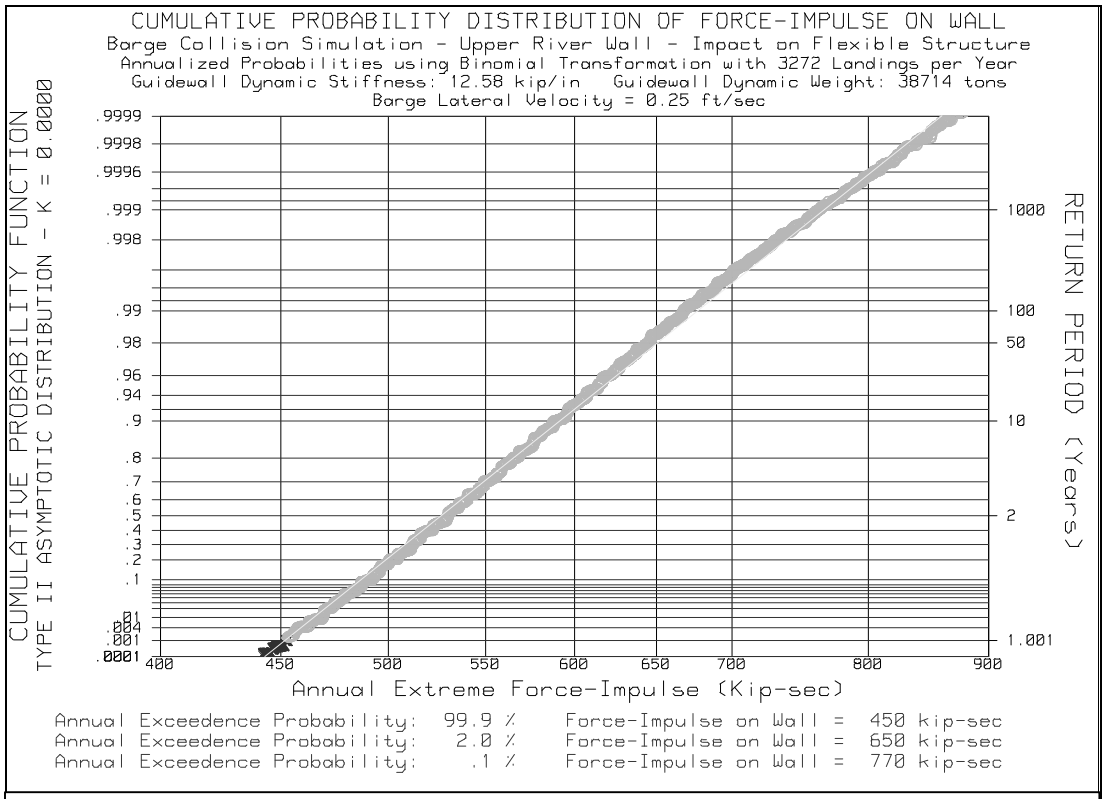


Figure 26. Cumulative Distribution of Impact Force – Impluse - Upper River Wall



Cumulative Distribution for Impact Force - Impulse– Upper River Wall (0.25 ft/sec lateral velocity)

Figure 27. Cumulative Distribution of Impact Force – Impluse - Upper River Wall (0.25 ft/sec lateral velocity)

Table 23 Usual, Unusual and Extreme Impact Force – Impulse Greenup Lock and Dam

Annualized Exceedence Probability	Return Interval Years		Upstream River Wall (kip-sec)	Upstream Middle Wall (kip-sec)	Downstream Land Wall (kip-sec)
Usual: 99.9%	1	Expected values	340	100	370
		Upper bound	*450*		*490*
Unusual: 2.0%	50	Expected values	510	170	640
		Upper bound	*650*		*770*
Extreme: 0.1%	1,000	Expected values	610	210	750
		Upper bound	*770*		*900*

10.6.3 Pontoon Flotation

The flotation characteristics of the pontoons will be evaluated with respect to their levelness, hydraulic stability, available freeboard, required draft, etc. In addition, the potential for reduction of freeboard under certain load conditions will be investigated to ensure that the pontoon would satisfy its navigational purpose under all day-to-day operational conditions.

Partial flooding of the pontoons is accounted for in the design to provide for the redundancy and resilience of the pontoons. Flooding of the chambers will be prevented by sizing the impact walls for the required collision forces, and by providing watertight hatches. Spreading of the water within the pontoon is prevented by compartmentalization. The compartmentalization is accomplished by transverse bulkheads. The bulkheads will be capable of resisting all loads incidental with flooding of the pontoon chambers. The bulkheads will be watertight, and no access is provided between the chambers.

10.6.4 Pontoon Flooding

Pontoon flooding is not a probable service condition, as the pontoons will be designed to withstand all "usual" loads associated with the navigational purpose of the approach walls. The intent of designing the pontoons for this load is to provide for survivability of the pontoon in the very unlikely event that one chamber or two adjacent chambers would be completely flooded after major damage.

As the pontoon will be designed to maintain flotation, and the pontoon concrete is designed to resist all applicable forces within the elastic range of the materials, the repair effort could be focused on the area of damage, thus, minimizing out-of-service time. In particular, the selected level of prestressing will ensure that tensile stresses stemming from the flexure of the flooded pontoon will be sufficiently resisted. In addition, tensile stresses are suppressed in order to prevent development of detrimental membrane cracks (through cracks) that would, otherwise, allow initially undamaged parts of the pontoon to be filled with water seeping through the cracks.

Flooding of one chamber at any location of the pontoon will be accounted for as a "usual load," while flooding of any two adjacent chambers will constitute an "extreme load" case.

All proposed pontoons will have a large flotation capacity. These long pontoons will have the ability to maintain overall flotation in spite of the added weight of the water contained in the one or two chambers. Depending on the location of the flooding along the longitudinal axis of the pontoon, the pontoon would deform in different flexural modes. The deflections are typically very gradual but noticeable even several hundred feet from the flooded location. In the sagged areas, the pontoon would 'lose' freeboard.

The loss of freeboard, easily detectable by normal inspection of the bands of the wall armor relative to the water line, would alert the Operation Staff at an early stage enabling mobilization of equipment (pumps, for instance) and preparation for repair work.

The maximum loss of freeboard (adjacent to the flooded cells) is anticipated to be about 3.5 feet when two chambers are flooded. This loss should be compared to the design freeboard of 3.5 feet at the pontoon shoulder. This loss of freeboard is acceptable, temporarily, as the waterline would be still more than 16 inches below the watertight hatches. The watertight hatches and the compartmentalization of the pontoon combined would prevent flooding in any additional compartments.

10.7 STRESS ANALYSES

10.7.1 Pontoon Design

10.7.1.1 Design Loads and Special Considerations

The numerous types of loads, load factors, and load combinations for the analysis and design of the pontoons are discussed in SECTION 6.

Satisfactory performance, low maintenance, and durability of the structure will depend on the watertightness of the pontoons. It is essential that quality assurance measures be employed in the design, detailing, and construction, in order to achieve this objective. Some aspects of design and construction, which are intended to improve watertightness, are referenced below:

- Prestressing of the pontoon and closely spaced conventional reinforcement for prevention or limitation of cracks, both during the construction and in service.
- Wet-curing of concrete to preclude development of shrinkage cracks.
- Rigorous reduction of construction joints and pour lines by using a workable concrete mix, thus, maintaining a high placement rate.
- Thorough preparation of cured concrete at the interface when construction joints are unavoidable. It is anticipated that such preparation will include hydroblasting (pressurized water jetting) techniques.

Crack prevention and crack control are given a very high priority in the pontoon design in order to accomplish the following objectives:

- Provide lowest possible permeability.
- Prevent reinforcement corrosion and corrosion caused deterioration/spalling of the concrete.
- Prevent concrete deterioration through hydrodynamic jetting (material loss caused by flushing and jetting of the water entrapped in a 'working' crack).
- Minimize freeze-thaw deterioration.
- Provide esthetically pleasing appearance.

10.7.1.2 Pontoon Reinforcement

10.7.1.2.1 <u>Prestressing.</u>

All pontoon segments are longitudinally prestressed for strength and crack control. The level of prestress is anticipated to be in the 1,450-psi range. This requirement will be refined and verified by analysis. These levels of precompression will provide sufficient structural strength in lateral bending (i.e. bending about both the horizontal and vertical axes). Prestressing prevents the pontoon concrete from experiencing "working" cracks. These types of cracks open and close in a volatile manner, depending upon their response to load application. Preventing these cracks improves the life span and the required maintenance effort for the pontoons.

10.7.1.2.2 <u>Conventional Reinforcing</u>

Closely spaced reinforcing will be provided in both the longitudinal and transverse directions. This reinforcement ties the structure together, allowing the various components of the pontoon to accommodate their associated loads that include:

- Hydrostatic pressure on the keel slab.

- Barge impact and hydrostatic pressure on the walls.
- Maintenance vehicles and small cranes on the deck slab.

In addition, conventional reinforcing reduces the potential for development of temperature and shrinkage cracks during the construction of the pontoon segments.

10.7.1.3 Pontoon Integration Joints

Integration joints enable the pontoon approach wall to be constructed in segments while providing structural continuity and strength along the entire length of the pontoon. The pontoons are between approximately 1,135 to 1,298 feet in length. Thus, the anticipated pontoon segments will be approximately 380 feet long for the lower approach wall and approximately 440 feet long for both upper approach walls. Since the integration joints constitute a significant cost, the cost for each additional joint was balanced against the additional cost of providing a larger casting bed for the construction of longer pontoon segments. Integration of pontoon segments will be accomplished with pretensioned bolts, providing a clamping force at the interface between the segments adequate for providing for the structural continuity of the pontoons from end-to-end.

10.7.1.4 Preliminary Pontoon Analyses

10.7.1.4.1 <u>Synopsis</u>

The purpose of the following paragraphs is to present the analyses, design parameters, and design objectives to be considered for the underlying feasibility design phase. The analysis was prepared with the understanding that the results of this study will provide the basis for future design phases.

Although the proposed Greenup Locks pontoons generally resemble their 'prototype models' at the Olmsted site, a multitude of differences exist, including different design loads, different overall geometry and features (length, width, height, skirts), variations in member sizes, and different guide and support systems.

The insight gained during the design of the pontoons for the Olmsted Locks and Dam project were used as initiation points for the pontoon design at Greenup Locks. The differences noted above evolved in the design process by tailoring the design to different site conditions, different seismicity of the site, extension of existing lock versus new lock construction, and assuming different barge collision loads. The presented design has been optimized to best meet Greenup Lock specific conditions.

The freeboard, which begins at the waterline and extends to the top of the deck slab, is selected to place the strength of the deck slab in the alignment (elevation) of the most probable barge collision. Below the deck slab, the collision load will be resisted by the pontoon impact wall. The parapet extends upward from the deck slab for full coverage of the guide surface. The entire guide surface is armored with conventional steel armor elements.

Puncture of the pontoon impact walls will be resisted by adjusting the thickness of the walls to resist barge collision forces, taking into account the barge headlog and bow corner geometry and stiffness, as explained in Section10.7.1.5.2

The underlying mechanics of the collision, which is complex in nature, was adapted for the pontoon design. Since the thickness of the impact walls significantly influences the construction cost of the pontoon, particular effort was made to capture the mechanics of the collision accurately. The sought accuracy provided the required balance between meeting required strength requirements and maintaining cost efficient construction.

10.7.1.4.2 Terminology

Generally, the consequence of the load application will be applied to the pontoon both locally and globally. 'Local' refers to the immediate vicinity of the load application. For instance, in the case of a barge collision, the effect on the pontoon wall that is impacted would be considered a local effect. In this case, local effects may include one-way or two-way ('punching') shear forces, flexural moments, and localized deflections in pontoon walls in proximity of the collision.

The collision of the barge would also generate a series of reactions, which affect the pontoon in its entirety. For instance, the pontoon would undergo varying rigid body motions and would flex in different ('global' or end-to-end) bending modes. It will also move and flex in one direction first and then rebound. Incidental with the pontoon motions, the marine fenders would engage (and again disengage) at the support surfaces. These responses constitute 'global' effects. Generally, the collective response of the pontoon parts will be termed a 'global' response.

The distinction between local and global effect is not limited to the collision loads only. Essentially, all loads will have local and global effects. The difference will be in the quantity and proportion of local versus global effects. Note that the term 'effects' is used to refer to all structural reactions and consequences including motions, deflections, development of stress and strain states in parts and members, etc.

Other examples that would require the distinction include the following:

- The effect of the line (mooring) forces on the timberheads would be local. By contrast, the pontoon would be required to resist those forces in flexure, and the fenders would transfer the forces to the fixed structure. These pontoon reactions to the load may be several hundred feet apart from the line exerting the force. Therefore, these effects will be referred to as 'global'.
- Partial flooding of the pontoon would exert forces into the pontoon bulkheads of the flooded chambers. This effect would be local. The weight of the water collected in the chambers would cause the pontoon to deform globally (i.e., end-to-end) to compensate for the added gravity force. The resulting deformation of the pontoon may be 'felt' at locations 1,000 feet or more apart from the flooded chamber. The effects incidental with the overall flexure (membrane stresses in the slabs and walls, vertical shear in the walls, etc.) would be global
- Temperature load may cause flexural moments in the deck slabs. These flexural moments would be more or less confined to the deck slab and would not cause overall deformations in the pontoon. This local effect stands in contrast to the temperature load consisting of the difference in the temperatures of the water and air surrounding the pontoon. This temperature difference would cause the pontoon to deflect in a global flexural mode. The associated global effects include significant 'membrane' (i.e., tensile or compressive) stresses in the pontoon. This load may be the most demanding (with respect to the required strength of the pontoon and the level of prestress necessary to suppress the tensile membrane stresses).

10.7.1.4.3 Design Approach

Past experience from the design of the Olmsted Approach Walls was used to simplify the preliminary design of the pontoons at the Greenup Locks & Dam site. The global dynamic response of the pontoons to the barge collision falls in this category. The global response of the pontoon to the barge collision load is primarily governed by the inertia of the colliding bodies.

Some loads were judged to contribute little to the overall strength demand. Those loads were accounted for at this stage 'by inspection'. Seismic loads transmitted to the pontoon by the fixed structures (and to a lesser degree by the body of water) fall in this category.

Some pontoon feature sizes were adapted using insight gained by previous detailed analyses, including those conducted in conjunction with the Olmsted project. Examples of those features include the geometry of the pontoon's deck and keel slabs. The slab thickness was optimized for all applicable loads, local effects (i.e., effects in proximity of the acting loads such as service equipment on the pontoon deck and hydrostatic head pressing against the keel slab), and for accommodation of several layers of conventional reinforcement, prestressing ducts, and sufficient concrete cover.

10.7.1.5 Pontoon Wall Design

10.7.1.5.1 Design Collision Forces

The probability-based analysis of barge tow impacts with the approach wall pontoons will be discussed in Section 10.10 of this report. The results are compiled below in Table 24.

Table 24 Collision Loads

Annualized Exceedence Probability	Recurrence Periods in Years	Load/ Performance Category	URW & LLW Pontoon Collision		UMW Pontoon Collision	
			Force kips	Impulse kip-sec.	Force kips	Impulse kips-sec.
99.9%	1	Usual	500	400	300	100
2.0%	50	Unusual	700	650	350	170
0.1%	1000	Extreme	800	750	400	210

The table values are the component of the force and impulse vectors 'normal' to the guide surface of the pontoons. The tangential component of the vectors will not affect the pontoon wall strength. These forces are based on the probabilities related to the prevailing barge weights, approach velocities and approach (alignment) angles, collision energy absorbed by plastic deformation of the barge bow corner and by the ability of the pontoon to yield in the instant of impact.

The magnitude of the collision force depends on the pontoon's response to the collision. As the pontoon yields at the instance of the collision, the impact force is reduced. Conversely, impact on a (non-yielding) fixed wall would constitute the upper bound for the transfer of force. The ability of the pontoons to yield depends on several factors including the pontoon stiffness and mass, fendering and support system, location of the impact, and the interaction of the pontoon with its surrounding water. The influence of these parameters on the collision process was estimated for calculating the design collision forces.

The mechanism of the barge impact, particularly those impacts causing significant deformation of the barge hull in proximity to the impact 'point', is very complex. Therefore, an attempt was made to capture the major characteristics of this mechanism in the analytical idealizations with respect to the footprint of the impact. This is discussed further in Section 10.10.

10.7.1.5.2 Footprint of the Barge Bow Corner Collision

The required flexural, shear, and punching shear strength of pontoon walls will not only depend on the impact force magnitude but will also depend on the size ofthe area (footprint) over which the force is distributed at the interface between the barge and the pontoon wall.

Increasing the footprint and spreading the collision force over larger parts of the impact wall will reduce the damage to the pontoon. In the collision process, the rate of the increase of the footprint and spreading of the collision force depends on both the magnitude of the force transferred between the colliding bodies (i.e., barge and pontoon), and the plastic deformations sustained by the barge's bow corner transferring the collision force. Both the bow corner geometry and stiffness may be subjected to significant changes during the 0.8 to 1.5 second anticipated duration for the transfer of design collision force.

The design footprint is not only used for the punching shear analysis but also for the analyses related to the flexure of the walls and parapets.

10.7.1.5.3 Required Thickness of the Pontoon Walls

The walls have been designed for site specific barge collision loads. The impact walls above the haunch are 28 inches for the Upper River Wall and Lower Land Wall Pontoons and 24-1/2 inches for the Upper middle Wall Pontoons. This thickness is reduced by 5 inches below the haunch, where the probability of direct barge impact is small.

Although the barge collision force is a significant parameter in determining the thickness of the pontoon walls, other considerations may also govern the design. Some of these considerations are outlined below:

- Counterballast of the pontoon by balancing the pontoon weight by the weight of concrete and gravel ballast.
- Space for conventional reinforcement, prestressing ducts, and skirt pipes.
- Adequate thickness for concrete placement and consolidation in 14 feet high wall forms.
- Adequate strength for the pontoon transportation (delivery journey) and maneuvering during its final installation.
- Accommodate membrane tensile and compressive stresses that stem from the pontoon's global bending.

10.7.1.6 Environmental Forces

Cross current forces, drag forces induced by the current, wind, and wave forces, will be addressed in this section. See 10.9.2 for a discussion of temperature loads.

10.7.1.6.1 Cross Current Flow Thrust and Flow Drag

Preliminary evaluation of the flow characteristics, after the completion of the proposed lock extension, suggests that cross current velocities will warrant the installation of skirts under the pontoons. For the feasibility level design, the flow restrictions have been assumed as outlined below:

- From El 515 to El. 495 for URW and UMW.
- From El. 485 to EL. 472 for the LLW.

Future analyses will incorporate more accurate current thrust (pressure) and drag forces when more accurate flow information will become available.

10.7.1.6.2 Wind

For wind loading, the pressure associated with the 70 miles per hour 'fastest mile speed' (at 33 feet above ground) was used for determination of the strength demand of the pontoon. Since, per the UBC, this wind velocity is based on an annual exceedence probability of merely 2 percent, the level of wind pressure used to satisfy the strength requirements will be subjected to reduction factors in the Usual and Unusual load categories. For details, see information contained in the load combination tables.

The exposure of the pontoon to the onset wind would be largest assuming empty barges mooring at the pontoon. Therefore, a 975-foot long barge configuration was assumed to exert additional wind forces into the pontoons. The wind-exposed height of the pontoon is 7 feet (i.e., freeboard and parapet height). This height was increased by 5 feet over the extent of 975 feet accounting for the moored barge tow. The maximum tension in the pontoon walls (280-psi) due to the assumed wind load is within allowable design values.

Refined, site specific, wind pressure information is not anticipated to be required as the pontoon design is not particularly sensitive to wind load variations.

10.7.1.6.3 Wave

The force of the wave on the pontoon depends on a variety of parameters including the height of the wave, wave length (or period) onset angle, etc. It has been assumed that the wind-generated waves will not control the design. The estimated site-specific wind velocities and fetch will be used to estimate height of design waves and the consequent force on the pontoon during future design phases.

10.7.2 Nose Pier and Pylon Design

The computer analysis program GT STRUDL has been used for modeling the nose pier superstructure, and the program LPILE has been used to model the drilled shafts below the riverbed. The 4,000-kip and 2,500-kip barge impact loads, applied parallel to the approach wall at El. 538 and El. 552.8, respectively, will be the nose pier drilled shaft governing design load cases. The 1,000-kip load, applied perpendicular to the approach wall at El. 538, will not govern the shaft design, but may be the governing load condition for the superstructure cantilever wing design at the nose pier ends.

Although an analysis of the buoyancy effect may be required in the final design as part of the nose pier shaft stability check, it has been neglected in this preliminary shaft analysis. Buoyancy will affect only the shaft uplift resistance calculation. It will not significantly affect any other shaft design parameters.

The drilled shafts were designed so that they would not exceed their yield moment capacity. This ensures that the shafts will not yield under any load combination and minimizes the possibility of foundation repair after any foreseeable event. The strength design method, in which the demand forces are factored by the load factors, will be used. The shaft yield moment capacity will also be determined using the EIPILE computer program provided by the Corps of Engineers.

Shafts have been analyzed and designed as "long piles." The important characteristics of long pile action are low pile tip soil pressure and two zero displacements along the pile.

Drilled shaft embedment lengths will be designed to ensure that long pile behavior characteristics occur for all load combinations. This will also minimize the chance for any permanent shaft displacements.

All drilled shaft steel casings below the superstructures are permanently immersed in the water and soil. Therefore, the possibility of casing corrosion is very low. For this reason, the steel casing corrosion consideration has been neglected in the casing design.

In order to use permanent casing with 10-foot diameter drilled shaft in the rock layer; an oversized 11-foot or 12-foot diameter hole must be drilled into the rock. After the 10-foot diameter permanent steel casing is installed in the hole, the gap between the casing and hole must be filled with grout to seal the gap for positive lateral load transfer from the shaft to the rock.

When the nose pier is exposed to the design head-on barge impact load of 4,000 kips, the structural response of the nose pier would include the tendency of the lead drilled shaft (i.e., the one in proximity to the impacted side) to withdraw from its anchorage in the rock and soil. Of course, the selfweight of the shaft and friction between the shaft casing and its surrounding rock and soil would provide some resistance to the withdrawal.

The estimated resistance, however, appears to be minute when compared with the pulling force. Therefore, the design provides a slide mechanism to separate the superstructure from the drilled shaft, thus preventing a pullout of the drilled shaft. It is noteworthy that the slide mechanism would not activate during the normal or operational use of the facility but only under extreme collision loads.

This approach does not result in any problems due to shaft axial forces. However, it will cause significant upward and horizontal displacements at the top of nose pier. The maximum front shaft displacements at the top of UMW nose pier are about 1-inch upward and 3.5-inches horizontally, which are acceptable temporary displacements for the extreme load condition. Even though the structure may not rebound completely to its original position after the extreme barge collision, the nose pier misalignment will be small and will not affect the approach wall operation. For reference, temporary vertical and horizontal displacements of the Olmsted Locks and Dam Nose Piers were estimated to be approximately 3 inches upward and 12 inches lateral when exposed to 4,000 kips.

This boundary condition also will cause large shaft bending moments and shears in the shafts. The maximum bending moment will occur below the rock layer and it is a conservative design assumption for the drilled shafts.

10.8 SEISMIC ANALYSES

10.8.1 Extended Lock Chamber Walls

The seismic analysis for this project was limited to a pseudo-static analysis. The site is in Zone 1 as defined by the Uniform Building Code 1997 (UBC). Calculation of all the factors in the UBC, which are multiplied against the mass of the structure, yielded a pseudo-static composite coefficient of 0.024. Because this analysis is preliminary and because of the critical nature of this type of structure to the economy, stability was checked using a composite factor of 0.15. All shapes of monoliths considered here were well within the criteria of EC 1110-2-291 using this composite factor.

Because the factor used in the analysis was so conservative and the results were well within the design criteria, a more detailed analysis does not appear to be required for this site.

10.8.2 Approach Walls

The project site is located in Seismic Zone 1 according to Figure 1 of ER 1110-2-1806, Earthquake Design and Analysis for Corps of Engineers Projects; and therefore, the earthquake loading will not govern the nose pier and pylon drilled shaft design by inspection. For the feasibility study stage in the design, only the barge collision impact loads have been used as the governing load case for the nose pier and pylon design.

The drilled shafts for the LLW Fixed Wall Alternative will be governed by the earthquake loading. "Retaining and Flood Walls", EM 1110-2-2502, Section 3-26, Earthquake Forces, has been used to determined the earthquake forces.

The OBE (Operating Basis Earthquake) seismic coefficient for Zone 1 is 0.05g and it is the same as the seismic coefficient shown on AASHTO seismic contour map. The horizontal acceleration coefficients of kh = 0.05g for the OBE and kh = 0.10g for the MDE (Maximum Design Earthquake) have been used in the feasibility study.

The OBE will not govern the drilled shaft design by inspection. The drilled shafts for the LLW Fixed Wall Alternative have been analyzed for the MDE only in the feasibility study.

10.9 THERMAL STRESS ANALYSIS

10.9.1 Extended Lock Chamber Walls

A level one thermal analysis has been completed for the project elements. This analysis method is considered preliminary in nature and should be supplemented by a level three Non-linear Incremental Structural Analysis (NISA) in the DDR phase.

As a result of the level one analysis, it was found the middle gate monolith could be poured without joints. The restrictions on this conclusion are the use of a Type II cement content at 376 lb/cy, and limiting initial placement temperature to 62° F. If placement is expected to be at higher temperatures, one joint should be added to the monolith.

Using the same assumptions as above for the land wall, it is recommended the joints be placed no further apart than 90 feet. This is valid for placement temperatures up to 70° F. If placement temperatures are expected to be higher than 70° F then joint spacing will have to be reduced.

10.9.2 Approach Walls

10.9.2.1 Design Temperature Profiles

Two temperature profiles will be used for the evaluations related to the pontoons at the Greenup L&D site. The temperature profiles differ significantly when winter conditions and summer conditions are investigated. The variation includes both the maximum (and minimum) values and the temperature gradients. The term 'gradient' refers to the <u>change</u> in the concrete temperature over the height of the pontoon.

In lieu of more accurate (i.e., site specific temperature) data, temperature profiles previously developed for the Olmsted lock location were used in the temperature related analyses (see Section 25.2 for additional discussion). This approach was judged appropriate (during the feasibility phase) for the geographic proximity of the two projects, and comparable ambient

conditions. This approach should be reexamined and, if required, site-specific profiles should be developed during future design phases.

In the context of this discussion, the term 'ambient' refers to essentially two media (air and water) and four 'spheres' or zones of the pontoon. The temperature distribution on a typical cross section of the pontoon will be essentially dominated by the varying temperature of the surrounding media and the proximity of the pontoon members to different zones. The following zones may be distinguished:

- Keel slab and submerged walls
- Walls above the waterline
- Deck slab
- Confined space within the pontoon chambers

The temperature of the exterior layer of the deck slab may vary depending on the intensity of the sunshine and the wind speeds. The increased temperature of the deck slab is, however, limited to about one inch or two, and the average temperature of the deck slab would vary only marginally. The effect of the sunshine on the deck slab is relevant to the local behavior of the deck slab, e.g., for inducing a flexural moment into the slab 'plate'. The local effect will not be addressed further in this section since the global response of the pontoon is sensitive to the average deck slab temperature as opposed to the temperature gradient within the (depth of) the slab.

During the design of the Olmsted pontoons site specific temperature profiles were developed based on actual measurements performed at the John Day (Oregon) Floating Guide Wall. In addition, the records of water and air temperatures at the Olmsted project site were analyzed and site-specific extreme differences between the air and water temperatures were identified. The temperature profiles obtained at the Oregon site were adjusted and calibrated to match both the geometry and (project) site-specific temperatures.

The (Olmsted, Illinois) project specific temperature range was minus 14 to plus 108 degrees Fahrenheit for the air and 37 to 87 degrees Fahrenheit for the river water. Relevant to the pontoon design are extreme differences between the temperature of the water and the temperature of the air rather than the extreme values of the media taken separately. Therefore, the temperature records measured during several seasons were scrutinized for the maximum relative differences between the temperature of the river water and the air temperature during the same periods.

The developed temperature profiles indicate that the temperature profiles--and therefore, the distribution of the temperature strains within the typical pontoon cross-section-- are extremely nonlinear. This circumstance will be significant when evaluating analysis tools and methods for pontoon related structural evaluations.

10.9.2.2 Pontoon Stresses

The temperature gradient load can induce significant tensile and compressive stresses into the pontoon slabs, and shear stresses into the pontoon walls. The shear stresses are easily controllable for the thickness of the pontoon walls. Compressive stresses are not anticipated to govern the design although their magnitude should approach the admissible limits set by the design criteria. The membrane tension is critical to the watertightness of the pontoons because they may cause cracks to develop.

These potential 'membrane' cracks (termed to distinguish from the flexural cracks that are v-shaped) would be through cracks. These cracks would be open through the wall allowing the

water to drain through the pontoon slabs or walls. It is critical that the design accounts for this potential and provides a sufficient level of compressive prestress of the concrete pontoon to prevent membrane crack development.

The nonlinear nature of the temperature gradient related stresses caused by the temperature difference between the water and air, should be computed by idealizing the cellular shaped pontoons by plate-shell finite elements in a computer simulation during the DM phase of this project.

In the feasibility computations, the design relevant maximum tensile stresses were estimated by calibrating the results obtained during the design of the Olmsted pontoons taking the following factors into account: a) pontoon width, b) pontoon length, flexural pontoon stiffness (relative to an horizontal axis), draft, freeboard, and the applicable summer and winter temperature profiles.

It was found that the temperature gradient load could induce significant tensile and compressive stresses into the pontoon slabs, impart some shear stresses into the pontoon walls, and cause minor flexural and membrane stresses in the bulkheads. When exposed to the winter temperature gradient, the maximum tensile stress of about 900 psi occurs in the deck slab. Summer temperature gradient causes tensile stress of about 300 psi in the keel slab. The induced tensile stresses can be suppressed effectively and at reasonable cost by prestressing the pontoons in the longitudinal direction.

Compressive membrane stresses in the slabs are not anticipated to govern the design although their magnitude should approach the admissible limits set by the design criteria. The shear stresses in the walls are easily controllable for the substantial thickness of the walls. The bending of the bulkheads would follow the non-uniform temperature strains and the shear lag of central parts of the slabs versus the parts in proximity to the longitudinal walls. The membrane stresses in the bulkheads are related to the expansion of the deck slab (or alternatively contraction of the keel slab) in the transverse direction. The associated stresses can be accommodated with a reasonable level of conventional reinforcement.

All pontoons will be prestressed to a level sufficient to suppress even extreme tensile stresses of the temperature load. However, where this load appears in combination with other large loads, the design criteria will allow accumulated tensile stresses below the concrete rupture stress of approximately 460-psi.

This approach appears justified, as extreme temperature loads exist only during very short periods throughout the year. Therefore, the joint probability that unusual or extreme barge collisions would occur in presence of such extreme temperature conditions would be very small.

It is anticipated that the required level of prestress can be provided for the three pontoons within a practical and economical range.

10.10 ADDITIONAL STUDIES, TESTS AND ANALYSES

10.10.1 Extended Lock Chamber Walls

Two additional studies are recommended for the DDR phase.

Because of the significant potential cost savings, it is recommended that Drilled Caissons be given further consideration. The analysis resulting from this study (See Section 25.1) indicates the caissons are causing strain in the rock just in excess of the values considered allowable. This analysis has treated the caisson as a single system independent of the superstructure with

superstructure loads carried directly into and supported fully by the caissons. In reality, this will not be the case. Once the tremie concrete is poured against the rock, some of the load will transfer to the rock directly without transferring through the caisson. To model the interaction between the rock and the total structural system will require a complex finite element model to be constructed. The potential benefits justify this effort in the DDR phase.

The second analysis recommended for the DDR phase is a level three thermal analysis (NISA) of the mass concrete pours. Because of the lack of actual design parameters and because of time constraints, analysis for this phase has been limited to level one thermal analysis. The higher level of analysis is justified for a project of this scope. The NISA may also show some significant savings in reinforcing steel by demonstrating lower levels of stress from all loading conditions including thermal stresses.

SECTION 11 MECHANICAL & ELECTRICAL DESIGN REQUIREMENTS

11.1 PLAN 1 - AUXILIARY LOCK EXTENSION (NOT CAPABLE OF E/F ENHANCEMENT)

Definition: This scheme utilizes the existing empty/fill system in the Auxiliary Lock, moves the lower miter gates downstream, and lengthens the auxiliary lock to 1200 feet by extending the middle and landwalls downstream.

11.1.1 Mechanical Features

This level of improvement requires relocating the miter gate machinery and hydraulic control manifolds for both leaves, 600 feet downstream to new miter gate machinery recesses. Relocate downstream the miter gate latches and actuators for both leaves. Extend the power piping in trenches to the relocated machines Provide new embedded metals for both miter gate machinery and latches. Extend air and raw water 600 feet downstream. Install bubblers in miter gate recesses. Provide manhole access to air and raw water.

11.1.2 Electrical Features

This level of improvement requires relocating the control station on the downstream extension of the middle wall nearer the relocated gates. Provide raceways/cable trays in trenches to electrical equipment on new lockwalls. Provide necessary lighting, conduits and signal lights on new lockwalls and approach walls. The commercial electric power service comes to the project through a reinforced, concrete, underground duct bank, which is located on the south side, downstream end of the project. The duct bank is almost perpendicular to the lockwall and enters the land wall monolith at approx. station 4+35B. The commercial electric power service will not be impacted by this scheme.

11.2 PLAN 2 - AUXILIARY EXTENSION WITH MODIFICATIONS

Definition: This scheme utilizes the existing fill system in the Auxiliary Lock and lengthens the lock to 1200 feet by extending the middle and landwalls downstream. Move the lower miter gates downstream. It includes an empty valve in the new land wall extension, an emptying culvert, new laterals in the new lock walls and the outlet for discharge of the lock chamber at the riverside of the river wall. The wraparound culvert is not constructed. Culvert valve machinery is required for this scheme. The chamber will be emptied using two culvert valves (one new, one old) and filled using the one existing valve.

11.2.1 Mechanical Features

This level of improvement requires relocating 600 feet downstream both lower miter gate machines and hydraulic control manifolds. Relocate downstream the miter gate latches and actuators for both leaves. Extend the power piping in trenches to the controls for the relocated miter gate machines. Provide new embedded metals for both miter gate machines and latches. Fabrication and installation of one culvert valve machine and control manifolds would be required. Extend hydraulic power piping in trenches to the culvert valve machine. Extend air and raw water 600 feet downstream. Install bubblers in miter gate recesses. Provide manhole access to air and raw water.

11.2.2 Electrical Features

This level of improvement requires relocating the control station on the downstream extension of the middle wall nearer the relocated gates. Provide raceways/cable trays in trenches to electrical equipment on the new lockwall. Provide necessary lighting, conduits and signal lights on new lockwalls. Provide raceways/cable trays to provide wiring to the new culvert valve machinery. Provide new electrical control for the additional culvert valve. It is anticipated that the commercial electric power service, described in the AUXILIARY EXTENSION scheme, will not be impacted. If it is determined that the service will be impacted, the plans and specs will be prepared to require that the service be temporarily rerouted as necessary for construction, then reinstalled.

11.3 PLAN 3 - AUXILIARY EXTENSION WITH CULVERT

Definition: This scheme utilizes the existing empty/fill system in the Auxiliary Lock and lengthens the lock to 1200 feet by extending the middle and landwalls downstream. Move the lower miter gates downstream. An additional empty/fill system is provided for the extension.

11.3.1 Mechanical Features

Beginning phase relocate the miter gate machinery and hydraulic control manifolds for both leaves 600 feet downstream to the new miter gate machinery recesses. Relocate downstream the miter gate latches and actuators for both leaves. Extend the power piping in trenches to the relocated machines. (Provide trenches to the culvert valve machinery locations.) Provide new embedded metals for both miter gate machinery and latches. *Later phase* requires fabrication and installation of two culvert valve machines and control manifolds. Extend hydraulic power piping in trenches to the culvert valve machines. Extend air and raw water 600 feet downstream. Install bubblers in miter gate recesses. Provide manhole access to air and raw water.

11.3.2 Electrical Features

Beginning phase requires relocating the control station on the downstream extension nearer the relocated miter gates. Provide raceways/cable trays to electrical equipment on new lockwalls. Provide necessary lighting, conduits and signal lights on new lockwalls. *Later phase* will provide raceways/cable trays to provide wiring to the new culvert valve machinery. Provide new electrical control for the additional culvert valves. The commercial electric power service,

described in the AUXILIARY EXTENSION scheme, will have to be temporarily rerouted for construction of the wraparound culvert, and then reinstalled.

11.4 PLAN 4 – AUXILIARY EXTENSION - PHASED CONSTRUCTION

Definition: This scheme has the same configuration as the AUXILIARY EXTENSION WITH CULVERT with the installation of certain portions of the empty/fill system phased in later.

11.4.1 Mechanical Features

Beginning phase relocate the miter gate machinery and hydraulic control manifolds for both leaves 600 feet downstream to the new miter gate machinery recesses. Relocate downstream the miter gate latches and actuators for both leaves. Extend the power piping in trenches to the relocated machines. (Provide trenches to the culvert valve machinery locations.) Provide new embedded metals for both miter gate machinery and latches. *Later phase* requires fabrication and installation of two culvert valve machines and control manifolds. Extend hydraulic power piping in trenches to the culvert valve machines. Extend air and raw water 600 feet downstream. Install bubblers in miter gate recesses. Provide manhole access to air and raw water.

11.4.2 Electrical Features

Beginning phase requires relocating the control station on the downstream extension nearer the relocated miter gates. Provide raceways/cable trays to electrical equipment on new lockwalls. Provide necessary lighting, conduits and signal lights on new lockwalls. *Later phase* will provide raceways/cable trays to provide wiring to the new culvert valve machinery. Provide new electrical control for the additional culvert valves. The commercial electric power service will be impacted as described in the AUXILIARY EXTENSION WITH CULVERT scheme above. The service will be temporarily rerouted for construction of the wraparound culvert, and then reinstalled, as in the AUXILIARY EXTENSION WITH CULVERT scheme.

SECTION 12 HAZARDOUS AND TOXIC WASTE

12.1 SCOPE OF STUDY

In accordance with Corps of Engineers regulations, Phase I Hazardous, Toxic, and Radioactive Waste (HTRW) investigations shall be performed onall properties to be purchased for project construction. These investigations identify past and present land use through regulatory record searches, site history investigations, and physical surveys. If Phase I data identifies areas containing suspectedhazardous or toxic contaminants, a Phase II HTRW investigation should be performed to identify and delineate the types and levels of contamination in these areas.

12.2 SUMMARY OF HTRW INVESTIGATION

Property proposed for construction, staging, borrow or spoil a reas on the Kentucky side of Greenup Locks and Dam was investigated on the basis of current and previous land usage, the ownership history of the property, interviews with local residents and public officials, regulatory agency records and public documents, and visual inspection of the subject property. This level of investigation was intended to determine the possible presence of HTRW contamination.

Historical research into prior ownership and use of the properties did not reveal any previously identifiedpotential for contamination, such as the presence of an industrial facility or landfill. Most of the properties have their origins as farmland. Search of regulatory records revealed no incident that would pose an environmental risk to any of the subjecttracts. Site inspections and personal interviews revealed that none of the properties in this study were found to have HTRW concerns related to underground (UST) and aboveground (AST) storage tanks.

During the site investigation, a considerable amount of refuse was observed near the CSX railroad tracks and in the wooded area downstream from the dam. The refuse consists of cardboard and paper products, cans, plastic bags with household garbage, small household appliances, hoses, wood products, and discarded tires. This refuse was left by individuals living in the area and not by the Corps of Engineers.

12.3 CONCLUSION AND RECOMMENDATIONS

Based upon the information obtained during the HTRW investigation, no tract was determined to contain any HTRW concerns, nor were any adjacent tracts observed to contain any HTRW concerns that would significantly impact these tracts during construction. Though the refuse does not pose an HTRW concern, it is recommended that the refuse is removed and disposed of in a state permitted sanitary landfill prior to construction activities. Efforts should be made to discourage further dumping of refuse on the property. No further environmental investigation on these tracts is recommended

SECTION 13 ENVIRONMENTAL ENGINEERING

13.1 USE OF ENVIRONMENTALLY RENEWABLE MATERIALS

13.2 DESIGN OF POSITIVE ENVIRONMENTAL ATTRIBUTES INTO THE PROJECT

13.3 ENVIRONMENTALLY BENEFICIAL O&M

Current Operations and Maintenance (O&M) practices at Greenup Lock & Dam require annual clearing of vegetation from the banks of the Ohio River within Corps property boundaries. This technique requires the spraying of riparian areas to eliminate trees and other woody vegetation along the banks of the river. Mechanical clearing becomes necessary wherever woody vegetation escapes less intensive control techniques. The result is an ongoing O&M responsibility and a conspicuous break in the otherwise wooded riparian corridor of the Ohio River at the Greenup project.

A section of wooded riparian habitat at the Greenup site would be disturbed as part of the lock extension project. This disturbance includes the only segment of wooded riparian habitat remaining on the Greenup site and is located downstream of the existing auxiliary chamber. These impacts would be mitigated largely through an engineered change in the O&M practices for bank stabilization at the Greenup site. State-of-the-art bio-engineered bank protection in this area and other shoreline areas within the Greenup project boundaries would allow for a modification of current bank clearing activities. Woody vegetation would be used to provide a sustained, low maintenance alternative that protects the bank and provides a continuous wooded riparian corridor across the Greenup site. Methods may include riprap below ordinary low water, geotextile, and geotextile/woody plant combinations.

Current O&M for floodplain lands west of the service mound involves semi-annual mowing of pasture grasses and forbs. This maintains an open meadow type habitat with regular disturbances from mowing. Much of the open land would be impacted during construction for either dredge spoil disposal or contractor lay-down. The establishment of warm season grasses/forbs on this site would improve the habitat structurally and reduce the need for regular mowing to maintain its open context. Plans call for in-situ mitigation for open areas disturbed during construction of the auxiliary extension. This mitigation would include native and warm season re-vegetation and require a change in the maintenance of the area from semi-annual mowing for hay to an annual or biennial mowing requirement. The result would be an improved and increasingly uncommon warm season pasture community with a less intensive disturbance cycle.

13.4 BENEFICIAL USES OF SPOIL OR OTHER PROJECT REFUSE

Quantities of rock and concrete rubble would be produced during various phases of construction for the auxiliary extension at Greenup. The particulars of these excavation and blasting requirements are outlined in SECTION 8 of this appendix. Disposal of gravel, cobble and boulder sized fragments often follow finer grained dredge material into nuisance spoil sites. For the Greenup project, this material would be well used in an overall bio-engineered matrix for bank protection wherever possible. Further, this coarse "spoil" lends itself well to use as aquatic habitat structures where quantities permit. Such beneficial use thereby maximizes the product for environmental enhancements. The Greenup project, being situated on the Ohio River, would be ideal to employ this material as firm aquatic habitat structures in the increasingly uniform, canalized river habitat. Proposed uses include "T"-shaped rubble dikes placed on otherwise featureless bars within the Greenup and Meldahl pools, or a set of long parallel dikes within the tailwaters of Greenup Lock & Dam.

13.5 ENERGY SAVINGS FEATURES OF THE DESIGN

13.6 MAINTENANCE OF THE ECOLOGICAL CONTINUITY IN THE PROJECT WITH THE SURROUNDING AREA AND WITHIN THE REGION

Bank disturbance would be required for all of the lock extension alternatives addressed in this appendix. Such activities may include simple clearing and grubbing or more involved bank dressing or slope modifications. The final stabilization of these disturbed riverbanks would be vital to the long-term function of the project. The sustainability and longevity of any bank stabilization/protection approach would also be essential to reducing future O&M expenses.

Final stabilization approaches for the Greenup project would employ modern bioengineering techniques that consider riverbank conditions above and below the project and offer long-term service. Bio-engineered bank protection for Greenup would allow the connection of an otherwise intact wooded riparian corridor across the project.

13.7 CONSIDERATION OF INDIRECT ENVIRONMENTAL COSTS AND BENEFITS

13.8 INTEGRATION OF ENVIRONMENTAL SENSITIVITY INTO ALL ASPECTS OF THE PROJECT

The construction of the auxiliary chamber at Greenup would require temporary closures of both the main chamber and auxiliary during brief periods. Navigation traffic would queue for as much as 24 hours during these time periods in spite of efforts to minimize traffic impacts during

project planning. Queuing tows result in negative economic and environmental effects through the expense of the idle tow and the damage the idle tow does to nearby habitats. Current conditions require waiting tows to "nose" into the shoreline, with engines running, in order to maintain their position against river currents. To mitigate the environmental affects of construction queues, the Corps would develop mooring sites in the downstream approach to Greenup as part of the project. Mooring facilities would allow queuing tows to avoid sensitive near-shore and gravel bar habitats while waiting to lock through Greenup. This may also mitigate some of the expense to industry of maintaining river position during the queue.

Downstream habitats would also be threatened by suspended sediment produced during in-water excavation for the auxiliary extension. Large quantities of sediment could entrain in the water column, travel downstream, and severely impact mussel beds and fish spawning habitats located on gravel bars within a mile of Greenup. Contractor specifications would require that state of the art sediment controls and turbidity retention devices be employed throughout in-water operations. However, monitoring of downstream water quality would also be conducted to ensure the effectiveness of these efforts. Actions would be taken whenever suspended sediment conditions below Greenup exceeded background levels outside of the construction work limits.

During later phases of project planning, specifications would be made for the disposition of contractor lay-down, spoilage and stockpile areas at Greenup. These activities stand to impact the terrestrial environment within the project boundaries. Final decisions as to the area required and exact locations would be deferred until more details are available. For the purposes of minimizing terrestrial habitat impacts however, plans would call for the use of disturbed, open, and non-wooded areas before less disturbed, wooded habitats would be considered for these purposes.

13.9 ENVIRONMENTAL REVIEW GUIDE FOR OPERATIONS (ERGO)

13.10 INCORPORATION OF ENVIRONMENTAL COMPLIANCE MEASURES INTO THE PROJECT DESIGN

13.11 ENVIRONMENTALLY SENSITIVE CONSTRUCTION TECHNIQUES

The construction sequence for the auxiliary extension provides for the dewatering of areas isolated from the river and where groundwater intercepts excavations for the fill/empty culverts. This dewatering effluent may contain extremely large suspended sediment load that would be detrimental if discharged to the ecosystem of the Ohio River. The Corps would require the use of state-of-the-art treatment technologies to minimize suspended sediments from reaching sensitive Ohio River habitats. Protection would be especially key for gravel bars downstream of the project, within one mile, that are known to harbor large mussel communities and provide fish spawning sites. Plans would call for the treatment of discharge waters if necessary, in order to

maintain suspended sediment loads at or below background levels downstream of the construction work limits.

Excavation and blasting "in-the-wet" would be minimized as another means of reducing aquatic impacts from turbidity and suspended sediment downstream of the project. Current plans call for early construction of the auxiliary extension to be pursued with an emphasis on isolating the extended chamber area downstream of the existing auxiliary chamber. This would allow the bedrock excavation for the lateral field to be pursued in a dry, dewatered environment.

During work below the existing auxiliary chamber, rare flood events may inundate the dewatered work area. Contractor specifications would ensure worker safety and the protection of water quality in the event of an emergency flood event in the dewatered work area. This would provide for the rapid removal of all equipment, personnel, and quantities of supplies that may degrade water quality should they be released in floodwaters. Further, contractor stockpiles within the dewatered area would be limited to allow timely removal under such circumstances.

SECTION 14 ENVIRONMENTAL RESTORATION

14.1 PROJECT IMPACTS TO HABITAT AT GREENUP L&D

Construction of the proposed lock improvements would result in unavoidable direct losses of both terrestrial and aquatic habitat. Direct habitat losses would result primarily from land clearing, dredging, blasting, and excavation activities. All terrestrial habitats within the CWL are considered exposed to removal or other adverse impacts. Approximately 17 acres of backwater aquatic habitat and approximately 1 acre of upper riverine aquatic habitat would also be lost to dredging, rock excavation, and blasting activities.

Table 25 Project Impacts to Habitat

Habitat Type	Estimated Acreage Loss	Description of Impacts
Riparian Forest	47 acres	Land clearing for dredge spoil pile, batch concrete plant, construction laydown and access
Open Field	83 acres	Land clearing for construction laydown and access
River Bank	9 acres	Construction of landwall extension, filling culvert, construction access
Total Terrestrial	**139 acres**	
Backwater	17 acres	Dredging, rock excavation And blasting for landwall extension
Upper Riverine	1 acre	Dredging, rock excavation and blasting for fill culvert
Lower Riverine	0 acres	No direct habitat losses anticipated
Total Aquatic	**18 acres**	

Proposed instream construction activities including dredging, excavation, and blasting would result in some direct loss of fish individuals. Blasting impacts may also damage or destroy fish eggs. Minimal fish losses are anticipated due to the use of controlled blasting techniques and the relatively confined nature of proposed instream activities; however, some loss of fish individuals is inevitable.

Anticipated adverse impacts resulting from projected increases in navigation traffic consist primarily of increased velocity and substrate disturbances to fish from additional tow passages and increases in the number of juvenile fish entrained in propellers. Restoration for impacts due to increased navigation traffic will be addressed through an area wide strategy in Meldahl pool.

14.2 ENVIRONMENTAL COMMITMENTS

14.2.1 Avoidance

Actions may be taken during the construction of the Greenup and Myers lock improvements projects to completely avoid adverse impacts to the environment, instead of minimizing them, as discussed in Section B below. The following actions are avoidance commitments:

1. With respect to the lock improvements projects, the clearing of habitat used for nesting and the disposal of dredged and excavated materials during nesting season likely would pose the greatest risks to migratory birds. In an effort to protect nesting migratory bird species and their eggs, the Corps would try to schedule the removal of vegetation typically used by migratory birds for nesting. However, if such scheduling is not possible or if unforeseen construction delays occur, the Corps would implement mechanisms to discourage migratory birds from nesting within the proposed project site. If migratory birds nest in the construction area, appropriate coordination with USFWS to determine appropriate remedial action may be implemented.

2. Similar to the migratory birds issue, trees would not be cut between April 15 and September 15 in order to avoid impacts to the Indiana bat and the evening bat.

14.2.2 Minimization

Throughout the Greenup and Myers L&D lock improvements construction, measures would be taken to minimize the adverse impacts to environmental resources and human health and safety. Table 26 lists the resource areas along with the potential impacts and minimization measures that would be used during the construction process.

Table 26 Minimization Measures Used During Construction of Greenup and Myers L&D Lock Improvements

Resource Area	Impact → Action Taken To Minimize
Soils and Geology	• Erosion → Silt fencing • Erosion → Anchored straw bales • Erosion → Temporary seeding • Turbidity → Turbidity curtains • Shoreline damage from toe-ins → Floating mooring buoys
Water Resources	• Runoff/Sedimentation → Silt fencing • Runoff/Sedimentation → Anchored straw bales • Runoff/Sedimentation → Check dams and mud boards • Turbidity → Turbidity curtains • Contamination during dredging → Containment, proper • disposal
Biological Resources	• Contamination during dredging → Containment, proper disposal • Turbidity (harm filter feeders) → Turbidity curtains • Shoreline habitat damage from toe-ins → Mooring buoys • Fish kills → Use controlled blasting techniques • Damage to water control structure (Myers) → bank stabilization
Human Health and Safety	• Potential diving and blasting accidents → Use of diving plans, blasting plans, and Safety and Health Requirements Manual • Navigation accidents → Restriction of towboat traffic during blasting • Public injury → Fencing and signage
Socioeconomics	• Damage to surrounding structures → Use instrumentation to detect damaging vibration
Transportation	• Potential for vehicular accidents → Use of public roads during non-peak hours

14.3 ENVIRONMENTAL RESTORATION STRATEGY

14.3.1 Terrestrial Restoration

Restoration objectives for direct terrestrial habitat losses call for rectification or compensation of impacted habitats with replacement habitats of at least equal HU value when compared to without project conditions. The "without project conditions" assume a continued maturity of the site's terrestrial and aquatic habitats over 50 years, with no impacts from construction and no restoration action taken. Replacement or substitute habitats pursued under a "with project condition" would be designed to support project restoration goals of enhancing ecological diversity and locating restorative measures close to the site of impact and on COE-controlled lands. The following is a description of the proposed terrestrial restoration plan. This approach was developed through rigorous technical screening for habitat values, construction feasibility and economic costs. The following plan was found to offer to greatest gain in habitat values for the money and meet the restoration objective of a one to one or better replacement of habitat values for target species.

The terrestrial habitat restoration plan would result in a net gain in habitat values over the 50-year study period with the construction and restoration project. Restoration of existing woodland and openfield habitat types results in a net total cumulative HMU value of 2258.74 HMUs and 41.07 net average annual HMUs (AAHMUs) when compared to "without project" values. To achieve these gains in habitat, the proportion of woodland habitat would increase slightly for the site at the expense of openfield habitats. Field habitats are the common landuse for the Ohio River floodplain near Greenup Lock & Dam and more readily provide high value to openfield target species. Thus providing a means to improve relatively uncommon and slow developing woodland values on the restricted Greenup site.

Table 27 Habitat Target Species- Terrestrial

Riparian Forest	Open Field	River Bank
White-tailed deer	White-tailed deer	White-tailed deer
Northern raccoon	Northern raccoon	Northern raccoon
Red-tailed hawk	Red-tailed hawk	Beaver
Wood thrush	Eastern meadowlark	Belted kingfisher
Red-eyed vireo	Meadow vole	Red-eyed vireo
Pileated woodpecker	Eastern cottontail	
Eastern box turtle		

14.3.1.1 Riparian Forest Plantings

As mentioned an estimated 47 acres of riparian forest habitat may be eliminated through land clearing for construction laydown, access and disposal. Habitat values would need to be replaced for species identified for this habitat type. This would require the establishment of

approximately 68 acres riparian forest communities and appropriate management. Pioneer species (e.g. black locust, cottonwood) are expected to colonize readily from existing seed banks or nearby seed sources and would not need to be planted. The following is a list of woody plant species that would be planted for value to target species identified for the riparianwoodland community:

silver maple (*Acer saccharinum*)
sycamore (*Platanus occidentalis*)
red maple (*Acer rubrum*)
green ash (*Fraxinus pennsylvanica*)
shellbark hickory (*Carya lacinosa*)
buckeye (*Aesculus glabra)*
sweet gum (*Liquidambar styraciflua*)
black walnut (*Juglans nigra*)
American elm (*Ulmus americana*)
pin oak (*Quercus palustris*)
box elder (*Acer negundo*)
shagbark hickory (*Carya ovata*)
butternut (*Juglans cinerea*)
black cherry (*Prunus serotina*)

Planting would be in groups of three to four seedlings spaced approximately 10 feet apart. Plantings would generally be random by species and could be phased over a period of several years. Plant success must be monitored for at least the first 2 years after planting.

A number of active management and maintenance measures are proposed over the long term to optimize habitat values in areas proposed to be reforested. Proposed management and maintenance measures would focus on adding, accelerating, or maintaining habitat features and values which would not be expected to develop during the course of natural succession or which would develop more slowly in the absence of intervention. Key proposed management and maintenance actions are summarized below.

- Plant fast-growing canopy species (e.g. sycamore, silver maple) to maximize forest growth rates and thereby accelerate attainment of optimum tree height, trunk diameter, and canopy closure.
- Plant and manage for at least four large mast (acorns, hickory nuts) trees per acre.
- Install or preserve snags, stumps, and downed logs at establishment to accelerate availability of nest sites and food sources to species such as pileated woodpecker and raccoon.
- If necessary girdle or cut pioneer tree species at approximately 5-year intervals to replace and establish additional snags, logs, and stumps.
- Manage for approximately 30 percent shrub crown cover in the understory. The preferred shrub distribution pattern is scattered, dense clumps.
- Maintain a woodland size of greater than or equal to 50 acres to favor interior forest-dwelling species such as wood thrush, pileated woodpecker, and warblers.

14.3.1.2 Open Field Plantings

Approximately 83 acres of frequently maintained open field habitat might be impacted during construction of the proposed improvements. Open Field habitat areas are currently dominated by common introduced pasture grass species such as Italian ryegrass, orchard grass, and timothy. Habitat values for the target species identified for this area would be required. Approximately 62 acres of open field habitats with active management strategies is capable of meeting this objective. Introduction of shrub cover and native grass species, in particular warm season grasses such as big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), Indian grass (*Sorghastrum nutans*), and switch grass (*Panicum virgatum*) would enhance species diversity and habitat structure in this habitat type. Site preparation would consist of plowing and disking to create a good seedbed, and prior application of herbicide to control initial weed growth. Seeding could be broadcast or accomplished with a seed drill. Maintenance would consist primarily of controlled mowings and possibly controlled burning to encourage and maintain desired species. Optimized management strategies would include the following:

- Plant and manage for approximately 20 percent shrub cover in dense, well-distributed clumps throughout the Open Field habitat.
- Seed and manage for approximately 80 percent herbaceous cover, with at least 80 percent in grasses.
- Maintain an optimal average annual height of 12 inches for herbaceous vegetation.
- Mow selected areas, for example, at habitat edges and along roads, to provide short grass (4 inches or less) in spring months for cottontail breeding.
- Preserve or install perch sites for meadowlark (e.g., fence posts, earthen mounds, utility line or poles) at an optimum spacing of 100 feet or less.

14.3.1.3 Riverbank Stabilization

Approximately 4,000 linear feet (lf) of river bank habitat totaling an estimated 9 acres would be impacted as a result of construction of the landwall extension and culvert features. Restoration options for this habitat type are limited by the need for reliable bank stabilization measures and current operations and maintenance (O&M) practices that preclude the establishment of mature trees on banks in operations areas. Use of soil bioengineering techniques in combination with standard structural bank stabilization measures offers the potential to restore habitat values while meeting O&M requirements. Soil bioengineering techniques would employ easily rooted shrub species such as willows (*Salix* spp.) rather than trees, and are amenable to periodic maintenance to preserve a shrubby condition. The plan would use a combination of riprap stabilization at the toe of slope and joint plantings, live fascines, and brushmattressing to stabilize upper slopes. Current habitat values are proximate to this proposed "shrubby" condition. Habitat values for target species can be met on the projected site, totally 9 acres of bank treatment. See plates 8-1 through 8-4 for details.

Individual live stakes planted in riprap joints and backfilled contribute to stabilization by preventing washout of fines, dissipating wave energy, and removing excess soil moisture. Live fascines consist of a series of contour trenches filled with bundles of live branch cuttings from easily rooting shrub species. A row of vertically oriented live stakes could also be placed along the downslope edge of each trench. Brushmattressing also uses bundles of livebranch cuttings but these are placed and anchored over the stream bank in a continuous matress-like layer rather

than in trenches. One or more live fascine trenches could be installed at the downslope edge of the brushmatress to ensure stability. Brushmatressing provides immediate protective cover and promotes rapid establishment of vegetation. The final disposition of the bioengineered stabilization would depend upon detailed design at a later phase of the project. Habitat values for target species would be preserved for any significant departure from the proposed plan.

Shrub species could be used to construct proposed bioengineering measures. The following is a proposed list:

Eastern baccharis	*(Baccharis halimifolia)*	Coyote willow	*(Salix exigua)*
red-osier dogwood	*(Cornus sericea ssp sericea)*	Prairie willow	*(Salix humilis)*
Balsam popular	*(Populus balsamifera)*	Sandbar willow	*(Salix interior)*
Eastern cottonwood	*(Populus deltoides)*	Shining willow	*(Salix lucida)*
Swamp rose	*(Rosa palustris)*	Yellow willow	*(Salix lutea)*
Virginia rose	*(Rosa virginiana)*	Black willow	*(Salix nigra)*
Allegheny rose	*(Rosa allegheniensis)*	Pupleosier willow	*(Salix purpurea)*
red raspberry	*(Rubus idaeus ssp. stirgosus)*	American elder	*(Sambucus canadensis)*
Peachleaf willow	*(Salix amygdaloides)*	red elderberry	*(Sambucus racemosa)*
bebb's willow	*(Salix bebbiana)*	Snowberry	*(Symphoricarpos albus)*
Pussy willow	*(Salix discolor)*	Arrowwood	*(Viburnum dentatum)*
Hubblebush viburnam	*(Viburnum lantanoides)*		

14.3.2 Aquatic Environmental Restoration

The objective of the aquatic habitat restoration plan is to maintain current habitat values or improve them cumulatively for the project life. This requires a plan that meets or slightly exceeds the net habitat values currently observed in the Greenup system for the 50 years following construction. In order to address the potential for cumulatively significant human activities impacting the Ohio River, all projected impacts would be mitigated. The following is a description of the proposed aquatic restoration plan. This approach was developed through rigorous technical screening for habitat values, construction feasibility and economic costs. The following plan was found to offer to greatest gain in habitat values for the money andmeet the restoration objective of a one to one or better replacement of habitat values for target species.

The aquatic restoration plan shows a slight net gain in HMUs when compared to without project conditions during the 50-year study period. Tailwater dikes and constructed shallows are proposed to compensate for site-specific habitat impacts. These show a net gain of 2.11 HMUs over the without project condition during the study period. Similar gains would be expected for T-dikes and notched-dikes proposed as restoration for traffic effects in the Greenup and Meldahl pools.

14.3.2.1 Tailwater Dikes

The tailwater dike structures would consist of two 1,000-foot parallel dikes in the restricted tailwater zone below the Greenup Dam. The baseline habitat type in this area is Lower Riverine. The dikes would be continuous structures of rock and rubble with undulating widths and heights to maximize surface area. (See plate 8-7 for details of dike configuration.) A gravel skirt would be employed along portions of the dikes for invertebrate colonization. Final height and configuration of the dikes would depend on hydraulic and operational considerations undertaken during the detailed design phase of the project. However, modifications to the analyzed design would necessarily preserve habitat values for target species.

Table 28 Habitat Target Species- Aquatic

Backwater	Upper Riverine	Lower Riverine
Eastern gizzard shad	Eastern gizzard shad	Eastern gizzard shad
Northern largemouth bass	Flathead catfish	White bass
Northern bluegill sunfish		Northern bluegill sunfish
Smallmouth buffalofish		

Constructed shallows would also be integrated with the overall design for biostabilization of impacted bank areas to work in concert with tailwater dikes in the replacement of site-specific habitat losses. Approximately 1.3 acres of protected shallows would be constructed at the toe of impacted shorelines. Timber bundles or other “soft” breaks would be the most operationally friendly and cost-effective means of constructing a protective offshore “berm” to deflect wave energy. This would also encourage deposition and subsequent establishment of aquatic and emergent vegetation behind these constructed berms. Timber bundles would be constructed of planks or large branches bound together with wire or other suitable material and anchored into the bank. Cover structures such as constructed fish ledges, submerged brush, rootwads, or boulders could also be placed in these areas to enhance their habitat value, but are not assumed in the generalized design or habitat value accounting. Final dimensions and placement of constructed shallows features will be determined during detailed design of bank bioengineering treatments and based on a detailed assessment of future shoreline conditions.

14.3.2.2 T-Dike and Notch Dike Fields

Area wide restoration would include the construction of T-dike and notch dike fields (a dike field is a series of dikes) for compensation of fish mortality and fish reproduction impacts. The T-dike field would be located along the right descending band of the Ohio River between

River Miles 357.0 and 358.0 pending detailed navigation studies. The notch dike field would be placed along the right descending bank of the Ohio River between River Miles 366.5 and 368.5. Several alternative locations have been considered. These sites represent the best combination of navigation safety, proximity to tributary streams, clean substrates, public accessibility and low potential for threatened or endangered species impacts.

In general, the dikes would be constructed of stone or rubble material positioned perpendicular to the riverbank. The T-dikes would be up to 50 feet long with a 3 to 1 slope and constructed at a minimum of 10 feet below normal pool elevation. The notch dikes would be up to 70 feet long with a 3 to 1 slope and constructed at a minimum of 10 feet below normal pool elevation. The notch width should be at least 18 feet. (See plates 8-5 and 8-6 for details of configuration.)

SECTION 15 ENGINEERING DETERMINATION OF REAL ESTATE NEEDS

Currently, it appears that all areas needed for the construction are currently owned by the Government.

SECTION 16 CONSTRUCTION PROCEDURE

16.1 NEAR SITE WORK STATION

There are two near site workstations, which will be required for construction of the 600-foot extension. A large contractor area will be needed at the Greenup site for all construction methods. A fit-out area in the river adjacent to the bank will also be required for all construction methods.

16.1.1 Contractor Lay Down Area at Greenup

There is a large amount of ground available for contractor lay down at Greenup. This allows the contractor to do things on site, which will reduce his cost and make his operation more efficient.

The first of these is the construction of a dedicated batch plant. Because of the volume of concrete to be placed, this is an essential item. Associated with the batch plant would be a large pre-casting yard. Fewer than 20 of the 250+ pre-cast items are unique. For the others, the contractor will be able to take advantage of repetition and use assembly lines to improve production rates.

Also, related to the concrete operation, the contractor will need storage space for large quantities of aggregate, sand, and cement. It is expected most of this material will arrive by barge and will be stockpiled on site.

A staging area will be required for the large number of embeds to cast in the wall panels. These include wall armor, corner armor, mooring bits, ladders, etc. Later in the project, this area will be used for finish items such as guardrail, light poles, and fixtures.

Temporary stockpile area will have to be set aside to accommodate the large volume of earth removed during construction of the bypass culvert, if Plan 3 chosen for construction.

The size of the pre-cast elements will necessitate having large handling equipment on the site to move them to the river for installation.

Finally, the contractor will have to provide for the needs of a large labor force. This will include sanitation facilities, and POV parking. Job administration will require at least four job trailers plus additional locking containers for small tools and supplies.

16.1.2 Fit-Out Pier/Mooring Facility at Greenup

A large part of the contractor's work will be from barges. Again, the contractor will be able to take advantage of the large amount of space available at Greenup. The dredging plan calls for a space approximately 800'x150' to be dredged to the top of rock.

Six mooring dolphins will be built along the dredged length to tie up contractor barges. The dolphins will be capable of securing the contractors equipment during off time (weekends, holidays) and during emergency shutdowns. Emergency shutdowns may include flooding conditions or emergency closure of the main lock. The contractor will provide temporary floating walkways for access to the barges.

Near the north end of the dredged area, a slipway will be constructed. This will be constructed as a concrete ramp on the slope of the existing bank. The ramp will be cut into the bank somewhat to reduce the slope. The ramp will be equipped with winches, trolleys and rails to permit lowering pre-cast elements to water level for transfer to work barges.

16.2 EXISTING LOWER LANDWALL END MONOLITHS

The existing lower land wall end monoliths will be demolished/reused in one of two configurations depending on which alternative is selected for construction.

If Plan 1 is selected, only the end monolith L-1 needs to be demolished. The demolition will include the small wedge shaped mass between L-1 and L-2. Stability analysis shows the existing monoliths L-2 through L-5 can be stabilized using multi-strand rock anchors.

If any of the other alternatives are chosen, the culvert will need to be incorporated in the extension wall. Hydraulic analysis has established minimum straight lengths of culvert just before and just after the laterals. To get the required leading straight section, the last horizontal radius must occur in existing monoliths L-4 and L-5. It is not practical to modify these existing culverts with retrofit culverts, so monoliths L-1 though L-5 must be demolished for Plans 2 through 4. New monoliths will be built in their place, which incorporate the needed culvert sections and meet current stability criteria.

16.3 LIFT-IN-CONSTRUCTION

The lift-in method of construction generally consists of pre-casting concrete blocks and wall panels, setting and connecting up to a given level with crane barges, filling void spaces with tremie concrete, and repeating the process up to the next level. The process uses techniques common to most civil works construction.

The basic concept is illustrated on Plates 2-3 through 2-10 for Plan 1 and on Plates 2-12 through 2-29 for Plans 2 through 4. The middle wall gate structure is the critical structure for this extension and is chosen to illustrate the method with step-by-step sections on Plates 2-33 through 2-40. The same basic elements and procedures shown for the middle wall gate structure are used for the land wall and land wall gate structures. The two principal elements of the method are the central blocks and the shape defining wall panels.

The blocks and wall panels elements are constructed in a pre-cast yard. Because of the large amount of space available for contractor laydown at the Greenup site and the large amount of pre-casting to be done, it is expected the contractor will build a pre-cast plant at the site. Ideally, the pre-cast plant will produce blocks and panels at a slightly faster pace than they will be required for installation. All embedsare installed at the pre-cast plant. Wall panels will incorporate wall armor and required attachment hardware for mooring bitts and other features. The geometry of the panels will include recesses for floating bitts, fixed bitts, ladders, and dewatering bulkheads. When an adequate stock of cured blocks and panels is on hand, placement can begin.

The first elements to be placed are the central core blocks. The blocks have been sized to meet several criteria. It is desirable to have the top of the blocks above water so they can be leveled using visual survey. As seen on Plate 2-35, the blocks have been sized to have a top at elevation 499 ft or above. The blocks must be heavy enough to provide stability to the walls when the panels are attached. Heavy crane barges with the ability to work in the lock channels

(110-ft.) are generally restricted to 350T to 400T. Therefore the blocks have been sized to weigh less than 350T. To maximize stability and minimize the number of blocks to be set, the blocks have been designed with hollow cores.

Hydraulic jacks are incorporated in the blocks at the corners to be used for leveling the blocks after they are in place. The jack's pads and a portion of the legs are sacrificial and will use environmentally safe fluid. The jacks are the sized for a 100 T working load. The controls for the jacks are located at the top of the blocks to permit leveling without hazardous underwater work such as shimming on pads. The jack cylinders are also mounted at the top of the blocks to facilitate removal after the base level of grout is set. The jack cylinders can then be reused on later blocks.

Wall attachment corbels are cast as integral parts of the blocks. The corbels are designed to permit the wall panel to be attached with a horizontal tolerance of +/- 12 inches. The combination of the jacks and the wall attachment tolerances give the contractor substantial flexibility in placement of the blocks. This speeds the placement procedure considerably.

The placement flexibility also accounts for the expected lack of uniformity of the rock excavation surface. The jacks are selected for a 36-inch extension. Therefore, the surface of the bottom of the excavation need only be level to a tolerance of two feet from high to low point. Variances from this tolerance can be permitted if they do not occur in the near proximity of the jack landing locations. Some local leveling may be required at the expected jack landing locations. Humps, which would contact the bottom of the blocks or wall panels, will have to be trimmed down before placement begins. This will need to be established by the bathymetric survey discussed in Section 8.2.1.

By separating the blocks and the wall panels into two construction elements, the contractor is able to place the blocks approximately 8 foot back from the face of the lock chamber. At least two crane barges of the required capacity have been verified to have the reach to make this lift from the backside of the wall (auxiliary chamber). This reach allows placement with minimal disruption to main chamber traffic. The reach of the cranes is shown on Plates 2-33 and 2-34. The main lock can be closed either when the block is suspended over the placement location or when it is in the act of being moved to that position. The block is set, leveled, and checked for position tolerance. Then the base of the block is sandbagged in preparation for the first lift of concrete. When it meets these criteria, the main lock can be reopened for traffic.

The hollow cores of the stability blocks are grouted full and allowed to set before wall panels are placed. Once the bottom of the block is sealed with concrete and it is set, the cells of the block can be filled with tremie concrete. The cells are small enough that they may be filled in a continuous operation without concern for the heat of hydration. The main lock chamber does not need to be closed during placement of tremie in the block cells.

Placement continues with the placement of wall panels and concrete bulkheads at the ends of the panel. Prior to installing a wall panel, the contractor must trim the compression strut. From his survey, the contractor will know the exact position of the block and will know the desired final position for the wall panel. Using this data, the contractor will trim the compression strut so the bottom of the wall is held in the correct position. Installation proceeds when the contractor has a wall panel ready to be moved to position or when the traffic queue is cleared, whichever occurs later. Wall panels are sized to provide maximum coverage while weighing less than 125T. The 350T cranes are verified to have a 90-foot reach from the edge of the barge with a 150T load, which is more than adequate to work from the auxiliary chamber. The wall will be set at the edge of the lock chamber to extend the chamber wall. Therefore, the lock must

be closed before the wall is swung into position. The panel is set on the support corbels and initial support connections made. It is then positioned to be true with the lock and vertical. When the wall panel is in this position, connections will be locked down by welding to embedded plates in the corbels. This welding will be above water.

It is desirable to place tremie concrete at the base of the wall prior to allowing traffic to pass. However, if a long queue has developed, it is possible to delay the base lift of concrete until the queue has been cleared. Prior to placing the base tremie concrete, the wall panel is vulnerable to damage from barge impact and will remain vulnerable even after the base is grouted. The risk of damage is far outweighed by the benefit of the abbreviated lock closure times. If damage were to occur, the worst case would be delay until a replacement panel could be set.

Tremie concrete is poured up to the top of rock, approximate elevation 470 foot after the base layer of concrete is poured, and a protective panel will be laid in the main chamber. The purpose of the panel is to protect the green concrete from being washed out when tugs pass in the vicinity. The main lock chamber will have to be closed during this grouting operation. This is the last time the lock will have to be closed to traffic for this module.

When the base grout is set (approximately 24 hours), tremie concrete may be placed in the annular space between the wall panel and the block. The annular space has been designed to be small enough that this tremie operation may proceed continuously without concern for heat of hydration. This operation may take place while traffic is passing in the adjacent lock.

The remainder of the monolith structure is constructed by repeating this procedure until all of the first level walls adjacent to the main lock are set and grouted. Construction of the auxiliary chamber side of the monoliths can proceed without interruption for main chamber traffic. The auxiliary chamber side of the monolith is more complicated than the main chamber side due to offsets and anchorage for the miter gate. This should not be a problem since the contractor will be able to perform the work at a slower pace without interruptions to allow tow traffic to pass.

By the time the construction reaches the upper level, it will essentially be a cast-in-place operation. Forming for the gate equipment and upper anchorage will be relatively straightforward.

This discussion and the exhibit drawings have focused on the middle wall due to the time critical nature of constructing that structure. It is anticipated that construction of the land wall gate monoliths will be done before beginning the middle wall monoliths. The land wall will be built first, then the land wall gate, and finally the middle wall gate. In this way, the contractor can become comfortable with the procedures without being under time pressure. All of the workers will be familiar with their responsibilities and the middle wall should proceed with minimal difficulties.

16.4 FLOAT-IN CONSTRUCTION

The float-in method of construction generally consists of constructing a floating shell, bracing it for stability, positioning and anchoring it, sinking it, grouting the base, filling it with tremie concrete, and completing the construction to the desired elevation. The principal elements of a float-in structure are the concrete shell, ballast tanks, internal bracing, and partition walls.

Adaptation of float-in technology to the Greenup 600-foot extension project is made somewhat easier by the proximity of the RC Byrd Locks and Dam. RC Byrd is the next dam

upstream from Greenup. The decommissioned 600 foot lock chamber at RC Byrd is available for use as a dry-dock to construct the floating shell. If this facility were not available, the project would have to absorb the cost of constructing a dry-dock at or near the project site.

The disadvantage of using RC Byrd to construct the float-in shell is the completed shell must be floated down the river to the site to be installed. The statutory draft between these two facilities is only 9 foot. However, the design criterion sets the draft at 11 foot. It is believed the contractor can schedule the move from RC Byrd to Greenup at a time when he can be assured of an 11-ft. draft with no real impact on his schedule.

A second disadvantage is the RC Byrd chamber is closed with a permanent cofferdam at the downstream end. This means float-in shells built at RC Byrd will have to be locked through at both RC Byrd and at Greenup. This is not viewed as a major disadvantage, but does add to the project risk.

It is desirable to have the walls of the float-in module as high as possible when the module is sunk in final position. The project has established a target height that will put the top of wall at elevation 507 feet. The purpose of setting the top of the shell wall at elevation 507 feet is twofold. First, it is desirable to have the subsequent construction be out of the water after the shell is filled with concrete. Second, it is desirable for the top of the wall to be high enough to limit the chance a barge could ride over the wall and break the wall after it has been sunk in place.

It is not possible to achieve that kind of wall height at RC Byrd without extensive use of secondary floatation to keep the draft to less than 11 feet. A combination of floatation and tall walls would require much more internal bracing and the module would be less stable during the move to Greenup. Therefore, a three-stage construction has been envisioned in which an initial shell is designed for the 11-ft. draft. This structure is moved to a fit-out area adjacent to the 600-foot extension on the downstream side of Greenup. At the fit-out area, the walls are built up. The shell is then floated to and sunk in position. The third phase is to build up the monoliths to the final elevation in place.

Before beginning construction of the float-in shell at RC Byrd, the lock there must be modified to act as a dry-dock. The length and width of the chamber at RC Byrd is sufficient to build the shells for both the land wall gate and the middle wall gate simultaneously. If it were decided to construct the whole project using the float-in method, the land wall shell would be built in a separate operation before the gate monoliths were built. In either case, construction would be very similar.

To save weight and increase the strength, the bottom and walls of the float-in shell would be prestressed. The walls have been designed to be 12 inches thick. Because of the symmetry of the shape, the walls of the land wall section are built up higher than the walls for a gate section. Symmetry of the shape means it will be more naturally stable when floating and will require less ballast or supplemental floatation. Preliminary design has determined the walls for a land wall section can be 28 foot high and still achieve an 11-foot draft. Since the gate shell is asymmetrical in both horizontal directions, the walls can only be 24 feet tall with an 11-foot draft. All required wall armor and recesses are cast in the shell walls at RC Byrd.

After the section is built to the optimum height for an 11-ft. draft, it is moved to the fit-out area at Greenup. The fit-out area consists of a large area next to the existing south bank, which has been dredged to the top of rock. The initial shell is floated to this area, sunk in place, and tied off to shore anchors. Sinking the shell at the fit-out area serves several purposes. First, it is a more stable platform to work on than the floating shell. Second, it permits a test of the landing

point system. Third, it avoids the need to construct a pier or dock to moor the shell to while the walls are being extended. Material to extend the walls to the second height will be moved to the shell by a combination of construction barges and gangways.

The prime limitation on how high to build the wall at the fit-out area is, again, draft. Since the bottom of the channel is rock, it is not economical to over dredge a channel from fit-out to the final position. An examination of the tail water stage-duration curves shows significant variability, even within a given month. The project could take advantage of the highest tail water to move the second stage shell to position, but high tail water generally means higher energy and more turbulence. High energy and turbulence such as eddy currents will make final positioning more difficult. The compromise solution is to plan the construction so the move can take place in late April to early May. By waiting until then and designing for an 18-foot draft, the contractor has better than 80% chance the tail water will be at or above the needed elevation. The water level is generally in recession, so the energy and turbulence will not be as high as they would be earlier in the year. The walls can be built up to 47 ft. at the fit-out and the draft will not exceed 18 feet. Wall armor and required recesses and embedments are built in as the walls are raised. Bracing is added to keep the walls stable during the move and setting.

Since the gate monolith is built as a single unit shell, it will be approximately 145 ft. long. This means the excavation must be level to within +/- 1 foot of the target setting elevation over the entire length. Since the shell has a hard bottom, all humps over 18 inches above the target elevation must be removed. The bottom should be cleaned just prior to the move because it will not be possible to clean sedimentation below the bottom of the shell subsequent to placement of the base grout.

Concrete landing pedestals will be constructed on the bottom after cleaning. The pedestal is pyramid shaped with a flat top to receive the corresponding point on the shell. The pedestals must be constructed so the top elevation of each one is at the same elevation +/-0.05 ft. This close tolerance is necessary for proper installation of the shell without having to refloat it for shimming or other fine-tuning of the level. To achieve this close tolerance, the pedestals will have to be constructed by divers inside a casing or box in which clear water can be circulated.

The middle wall gate shell is the only monolith that has a critical placement sequence. It is recommended the land shells be placed prior to the middle gate so the contractor is familiar with any potential problems likely to occur while positioning and setting the shell.

The middle gate shell is refloated, stabilized and moved near its final position before the main lock is closed to traffic. The shell is then moved into final position. Because of the short distance of the move, the draft of the built up shell is designed for a margin of one foot of water under it. There is no flexibility in the final position. Once the shell has been sunk, it cannot be moved or adjusted without refloating it. The final position must be true with the existing chamber walls. It must also be vertical. The shell will be sunk by filling it with water. The shell will be filled at the highest pumping rates until it is within two feet of being on the bottom. At this point, the filling will be slowed as final position adjustments are made. The final foot of sinking will proceed slowly as position is continually checked and rechecked. When the landing points contact the bottom of the shell, sufficient additional water will be pumped to ensure the shell is not buoyant. Final leveling of the shell will then be checked. If additional level or position adjustments are needed, the shell will have to be pumped until it becomes buoyant again. Divers will be used throughout this process to provide visual verification of the mating of the landing pedestals.

When the final position and level of the shell is satisfactory, additional ballast will be added to ensure the position is held. At this stage, it would be possible to open the main lock to traffic to clear the queue. The risk of allowing traffic at this stage is that barge contact could either damage a wall or shift the shell. If this were to happen, it would create a great amount of difficulty. The damaged wall would have to be repaired so the shell could be refloated and repositioned. Because of the severity of the consequences of such an accident, it is recommended the main lock remain closed until the base grout can be placed. The base grout would be pumped into the space below the bottom of the shell through a series of access ports with relief vents further downstream of the pumping to permit the cement to force out all 'air' pockets. These ports and vents would have been cast in during the original shell bottom construction. The tremie would be filled up to approximate elevation 470 ft., the top of rock. This would lock in the position of the shell. Pre-cast panels could be placed on top of the exposed tremie in the main lock to protect it from being washed out when the lock is reopened to traffic. This would permit the reopening of the lock several hours earlier than if the tremie were allowed to set.

The lock would then be reopened and the shell would be filled with tremie concrete. Until the shell is full, there would still be some danger of damage to a wall from barge contact, but the consequence at that time would only be repair or replacement of a section of wall. The tremie operation would proceed in stages to allow dissipation of the heat of hydration. When sufficient tremie concrete is placed to ensure the shell was firmly ballasted, the shell could be pumped dry and all work from that point would be in the dry.

The gate monolith would be built up to the final elevation of 537 ft. by adding pre-cast panels and pouring concrete behind them. Recesses for the miter gate machinery and anchorage would all be formed and cast in the dry.

This discussion has focused on the middle wall due to the time critical nature of constructing that structure. It is anticipated that construction of the land wall gate monoliths will be done before beginning the middle wall monoliths. If the land wall is to be constructed using float-in, it will be built first, then the land wall gate, and finally the middle wall gate. In this way, the contractor can become comfortable with the procedures without being under time pressure. All of the workers will be familiar with their responsibilities and the middle wall should proceed with minimal difficulties.

16.5 DRILLED CAISSON CONSTRUCTION

As discussed in Section 10.2.3, the drilled caisson solution is not technically feasible according to current analysis and criteria. However, it presents the opportunity for significant savings if further study determines it to be acceptable. Therefore, the method and its principle features are described here.

Drilled caisson construction applies to the land wall monolith only. The drilled caisson method generally consists of drilling 10-foot diameter caissons at 14-foot center-to-center spacing to a design depth within the rock, capable of withstanding the service loads to be applied during construction and upon completion of the land wall. The wall is completed with an "H" shaped pre-cast member set on the caisson. This construction is favorable due to the reduction in the volume of rock removal that would be required for the land wall constructions and the reduction in volume of concrete for completion of the land wall.

The basic concept of the drilled caisson is illustrated on Plates 2-39 and 2-40, Section 26.4.2. Prior to the arrival of the drilling contractor, the overburden dredging will be completed down to the top of rock at Elevation 470. In addition, the top 2 -feet of weathered rock (Elevation 468) would be removed at a 14-foot width along the drilled caisson. The drilling contractor will come out on the first barge rig to drive an 11-foot diameter steel casing a sufficient depth in to the rock to allow the auger-bit to drill a 10-foot diameter core hole approximately 15 feet into the siltstone and sandstone (Elevation 455). Upon completion of the drilling of the first "hole", including removal and disposal of all spoil material, as directed by the COE, an additional barge will float in to fill the hole with concrete and rebar cages. Each caisson will be completed at Elevation 500, with an additional 5 feet of rebar cage extending to Elevation 505 $\pm$ for continuation of wall with cast-in-place concrete to Elevation 537.

It is intended that the drilling of the 26 holes and the pouring of the concrete caisson will occur almost simultaneously for the length of the 364-foot land wall. In addition, the pre-cast "H"-shaped panels to be placed on the caisson will be cast concurrently (or before dredging is completed) in the fit-up area to ensure full-strength panels during placement. Upon completion of the first couple of caissons to Elevation 500, the pre-cast "H"-shaped panels will be lifted into place by a third barge and attached to the caissons. Tremie concrete will then fill the void between the caisson and the pre-cast panels. Divers may be required to ensure that the tremie concrete seals the pre-cast panels into the rock layer and around the caisson.

After placement of several of the "H"-shaped panels has been completed, braced panels and cast in place concrete will be used complete the land wall from the top of the caissons (elevation 500) to the top of the finished monolith (elevation 537).

16.6 IN-THE-DRY CONSTRUCTION

In-the-dry construction is conventional so it will not be described in detail. The fundamental procedure is to build the two gate monoliths, build a cofferdam from the land wall gate to the near shore, install a bulkhead between the gates, dewater, and build the remaining land wall monoliths in the dry.

The first difference with this method would be in the sequence of the rock excavation. There would be no need to perform underwater rock excavation for the entire site. Instead, the rock would only be removed for the two gate structures and for the dewatering bulkhead using underwater techniques. The remainder of the required rock excavation would be done in the dry after dewatering.

A new bulkhead would have to be designed to dewater the site for in-the-dry construction. The current dewatering bulkhead is designed for a top elevation of 512 foot Use of this elevation would be unacceptable as the site would be flooded several times a year. Design of a bulkhead for elevation 532-ft. may also require modification of the design of the gate monoliths to accommodate the significantly larger force.

Once the site is dewatered and construction is begun, there would be no possibility of opening the auxiliary gate without great expense.

Once the site is dewatered, the land wall between the existing wall and new land wall gate would be built. The construction would use familiar techniques and procedures. The gravity walls would be formed and raised to finished elevation 537 ft.

16.7 GATE AND BULKHEAD SILLS

The construction of the gate and bulkhead sills begins with construction of the outer bulkhead sill and crossover tunnel in the wet. After dewatering the lock chamber, the miter gate sill and inside bulkhead sill would be constructed in the dry.

The primary reason it is desired to construct the miter gate sill in the dry is the need for a close tolerance finish for the top of the miter gate sill. Several methods were examined for construction of the sill and the tunnel including, float-in as one piece, float-in as separate pieces, and lift-in core blocks. All of these methods were viable but the connection to the gate monoliths was a concern. All methods envisioned were technically difficult, hazardous to underwater workers, and expensive. In-the-dry construction eliminates the connection problems and makes the construction and finishing of the sill itself easier and less expensive as well.

The outer bulkhead sill is constructed by placing three support blocks; one at each monolith and one at the center of the channel. Two 59-ft. concrete sections incorporating the crossover tunnel and the bulkhead seal would then be lowered onto the supports and leveled by shimming. This concept is shown on Plates 2-30 through 2-32. The mass of the sill would then be poured with tremie concrete. When the sill concrete was set and had obtained its design strength, the bulkheads would be installed and the chamber would be dewatered.

Construction of the crossover tunnel would be different for lift-in than for float-in. For lift-in, the elbow under the monolith could be set and tremied in place when that portion of the monolith is constructed (Plate 2-29). The joint would then be in the horizontal section in the channel itself.

Construction of the tunnel under the float-in shell would be more difficult. The utility tunnel elbow could not be incorporated in the original construction of the shell because it would eliminate 7-8 feet of the much-needed draft. Therefore, a knockout panel would be provided in the bottom of the shell and the elbow would be constructed as part of the bulkhead sill. That portion of the bulkhead sill either would be constructed prior to the gate monolith or would be 'slipped' under the monolith. Sand bags or other methods would be required to seal between the bottom of the shell and the perimeter of the tunnel trench during the placement of the base lift of tremie concrete for the shell. This would prevent concrete in the base lift from filling the trench. After dewatering, the knockout panel would be removed and the elbow could be formed and connect to the bottom of the shell. Once the tunnel is built, the mass of the bulkhead sill would be poured and finished.

16.8 IMPACT ON CONSTRUCTION OF ADDING A SUPPLEMENTAL FILLING/EMPTYING SYSTEM

As discussed in earlier sections, the assumption of the study to this level was that there would be no supplemental filling/emptying system. This section discusses the construction implications of the addition of a supplemental filling and emptying system at the time of the construction of the extension. The supplemental filling/emptying system is shown in plan on Plate 4-1.

The first feature of the system is a bypass culvert to reach the new 600-foot extension. The proximity of the Highway 7 bridge pier behind the land wall prevents a bypass from being constructed in that space. The bypass is routed south to pass in the span between two bridge piers. Construction of this bypass requires a 50 to 70 foot deep trench be dug along the

alignment shown on the plan. A total of 351,000 CY of earth is to be excavated from this trench. See Plates 4-1 through 4-3 in Section 26.4.4. Only about one third of this volume will have to be stockpiled and handled twice. For the remainder, the earth excavated at part of the trench can be hauled directly back to the part where the culvert is cured and dumped there as fill. Thus, the fill can follow the excavation across the site, separated by the forming, casting, and curing of the culvert in the bottom.

The section of the culvert passing the Highway bridge piers requires special treatment. There is sufficient space to lay back the excavation for all of the excavation except at the bridge piers. At the piers, open cut would undermine the bridge supports. Therefore, the excavation must be supported for the bottom 20 ft. for a length of 200 feet centered on the bridge. The excavation support has been determined to be PZ 27-sheet pile driven four feet into rock. To accomplish this, it will have to be predrilled and grouted. A single row of anchors is required to brace the sheets. The anchors are 60 T capacity soil anchors installed at 6-ft spacing. The support system is shown on Plate 4-2.

The second feature of the filling/emptying system is the culvert and lateral system. The culvert would be constructed within the land wall monoliths and the laterals would pass out the face of the monoliths. Since the invert of the laterals needs to be at approximate elevation 462.5 feet. The monoliths would have to be founded at elevation 458. In addition, the physical size of the monoliths must increase to create more mass to meet stability criteria.

The hydraulic analysis requires a minimum straight section before discharging into the laterals. Because of this additional length, the existing landwall monoliths L-1 through L-5 will have to be demolished so the culvert meets the flow requirements. The new monoliths replacing L-1 through L-5 would also have to be founded at the new lower elevation, elevation 458 feet.

Construction of the laterals would also require a large chamber section to be excavated to at least elevation 459 ft., adding approximately 18,000 CY of rock excavation for this portion of the feature alone. The required rock excavation would be more than doubled for the whole project without the system and does not include the additional rock excavation required for the monoliths.

The excavation of the chamber for the laterals will have a secondary cost by increasing the instability of the existing middle wall monoliths. Additional measures will likely be required to stabilize those features.

The final element of the supplement filling/emptying system is the outlet. To have minimal impact on traffic, the current plan calls for routing the discharge to the main river channel on the far side of the river wall. The discharge culvert would be incorporated in of the land wall gate monolith and will pass downstream of the middle wall extension. To pass under the navigation channel, the land wall gate monoliths will need to be founded at elevation 445 and becomes more massive. A vertical transition section is required in the land wall just before the gate to lower the outlet culvert.

The culvert can be incorporated in the lift-in scheme more easily than it can in the float-in. See Plates 2-23 through 2-29. For the float-in gate monolith, the culvert would require knockout panels for access on the sides. The culvert itself would have to pass above the floor of the monolith shell, requiring an additional 23 ft. of rock excavation more than that already described. Including the culvert in float-in shell also creates serious problems with draft for the shell. This has been discussed in more detail in SECTION 10. With lift-in, the culvert can rest directly on top of the rock and be incorporated into the lift-in wall blocks directly.

The supplemental system will not be completed or put in operation until after the new lock chamber is operational. At that time, the existing main lock can be closed while the culvert is extended across that channel and through the existing river guard wall.

The outlet structure will have to be constructed in the river channel on the outside of the river wall. This is a massive structure and will be constructed in the dry. Because of the pattern of bracing, the majority of the excavation will take place in the wet prior to erecting the dewatering cofferdam. The final excavation of the last piece of culvert from the outlet structure to the cross channel culvert will be done in the dry. It is important that this section not be completed until the last section of cross channel culvert is set and fully cured. By doing this, the excavation under the existing guard wall can be safely accomplished in the dry. To build the outlet structure, an internally braced sheet pile enclosure will be built to dewater the site. The enclosure will utilize a modified box pile configuration constructed of PZ 40 sheets and filled with sand. The walls will be cross-braced with W14x90s. The outlet and final culvert section will be cast in place in the dry. See Plate 4-4.

If construction of the supplemental filling/emptying system is to be deferred to a future project, the full design of the system will still need to be completed at the time of the extension design. The design must address the concerns presented in this discussion and the discussion in SECTION 10.

16.9 APPROACH WALLS

The pontoons have been designed such that they can be fabricated in standard graving dock sites. The lengths have been limited to approximately 400'. This allows the pontoons to be built in stages in smaller or multiple construction sites. Their draft, width and length have been limited such that they can be transported virtually anywhere within the inland river system. Transportation costs suggest that the pontoons can be constructed anywhere along the inland river system within 500 to 1,000 miles of the site. The pontoon segments have not been designed for an ocean voyage, but it is conceivable that the pontoons could be transported by submersible barge. This technique was used to fabricate the Ford Island Bridge for the U. S. Navy. The pontoons were fabricated in Seattle and shipped by submersible barge to Pearl Harbor, Hawaii.

There are a number of construction site alternatives. It is not anticipated that they would be constructed at the Greenup site to minimize construction and operational impacts to the site. It is anticipated that the pontoons would be constructed at a site where the logistics, materials supply and means to launch or float the completed segments were favorable. Potential pontoon construction facilities include existing or project specific constructed graving docks, dry docks. However, the pontoons could also be constructed on submersible barges or constructed on shore and skidded into the water. It is also possible that the pontoons could be constructed at Gallipolis. This lock could be rebuilt to serve as a graving dock for construction of the pontoons.

16.9.1 Pontoons

Each pontoon segment can be constructed on a casting bed in a graving yard, and construction will include the following:

- Construct the keel slab
- Construct all the walls

- Construct the deck slab
- Prestress the concrete segment
- Construct parapets
- Launch segment and ballast for float-out
- Float out segment from the graving yard.

The construction techniques and prestressing of concrete will minimize crack development, minimize construction joints, and provide strength, durability, and water integrity. Once afloat, the segments will be measured to document their "as-built" flotation characteristics and, if necessary, corrective ballasting will beadded.

Whether or not the segments will be transported to the lock site directly for pontoon integration and outfitting, or transported to an off-site location first, will be left up to the Contractor.

However, some viable locations for the integration and outfitting of the pontoons have been identified. The most prominent and suitable of these locations is the Auxiliary Lock Chamber at the Greenup site. If the Contractor desires to use this location, some or all of the outfitting work to be performed at this site would include the following:

- Fine ballasting of the pontoon segments.
- Cleaning of the exterior concrete at the integration joint.
- Integration of the pontoon's segments via pre-tensioned bolts.
- Installation of parts of the pontoons' guide and restraining system such as guide keys and restrainer brackets. (See note below on clearance considerations.)
- Installation of features related to the power supply, electrical installations including cable tensioning reels, light poles, and communication devices.
- Personnel access and safety items, guard rails, etc.

Note: As the clearance between the nose piers and other fixed structures is limited, some parts of the guide and restraining system will be installed after the pontoons have been maneuvered into their permanent locations.

The final installation will be a critical phase of the construction as the pontoons will be maneuvered between the fixed structures, temporarily lashed and secured, and then locked in place permanently by installation of the restrainer bracket and/or guide key. Control of tolerances will be crucial for the successful placement of a pontoon in its final position.

Restraining brackets and guide keys are stainless steel structures that are bolted to the end of the pontoon by pre-tensioned bolts. Although it is not necessary to remove the pontoons for maintenance, temporary removal is possible.

Marine fenders may be installed at any construction stage. They are either attached to the brackets and guide keys or to the pontoon's end wall with stainless steel bolts, screws, and ferrules embedded in concrete.

See Plate 3-10 for pontoon construction and installation details.

16.9.2 Nose Piers and Pylons

The nose pier consists of a foundation composed of three drilled shafts and a superstructure. The drilled shaft foundation allows in-the-wet construction of the nose pier.

The drilled shaft consists of a permanent steel casing containing a cage of reinforcing steel and tremie concrete. At its exterior face, the permanent casing is equipped with brackets capable

of retaining a steel ring plate collar. The collar plate is equipped with a compression seal to close the gap between the base shell and the shaft casings.

The superstructure consists of a structural steel base shell that is anchored upon the upper portion of the drilled shafts and is filled completely with concrete.

The base shell serves two purposes; it forms the fresh concrete during construction and functions as wall armor during the service life of the navigation lock. It is comprised of an outer shell resembling the superstructure geometry, three (approximately 11 foot-6 inch diameter) inner sleeves aligned with the foundation-drilled shafts, and a steel bottom plate for supporting fresh concrete. The inner sleeves are equipped with steel brackets that allow the base shell to rest upon the steel casing of the drilled shafts.

See Plate 3-11 for nose pier construction sequence details.

16.9.2.1 Proposed Construction Sequences

The following descriptions are related to the in-the-wet construction of the Upper Middle Wall (UMW) Nose Pier, shown on Plate 3-9. Note that the actual construction method may vary from the proposed construction sequences, depending on the contractor's preference. URW Nose Pier, LLW Nose Pier, and Pylon construction sequences will be similar to the UMW Nose Pier construction described herein.

16.9.2.1.1 <u>Drilled Shaft Construction Sequence</u>

1. Erect a work platform at a safe elevation above the water line using a “spud” barge or a trestle.
2. Install a positioning and alignment template for installation of the drilled shaft casings. Secure the template by temporary steel piles, penetrating the riverbed.
3. Install a 12-foot diameter temporary casing through the template. When completely installed, the tip of the temporary casing penetrates the rock material about 2 feet. Select the length of the temporary casing so that several feet of the casing would project above the waterline.
4. Drill/excavate riverbed material and rock within the temporary casing to the final shaft tip elevation and lower the permanent casing within the temporary casing.
5. Pressure grout between the permanent casing and the rock, beginning from the shaft tip elevation upward to the top of the rock elevation. Remove the temporary casing.
6. Install the reinforcing cage inside the permanent casing, and place tremie concrete continuously inside the permanent casing until filled completely.
7. Repeat work until all three shafts are constructed.
8. Allow the tremie concrete to attain the required minimum strength (determined by the design) before removing the template and temporary piles.
9. Construct the superstructure after the drilled shaft concrete has attained design strength.

16.9.2.1.2 <u>Nose Pier Superstructure Construction Sequence</u>

1. Install the collar plate on the brackets attached to the exterior face of the permanent casing.
2. Lower the base shell upon the shafts until the brackets come to rest upon the top of the steel casing.
3. Shim as required for final alignment of the superstructure.

4. Fill annular space between the drilled shaft casings and the inner sleeves with pressurized grout.
5. Place concrete in the base shell in 8-foot lifts (first lift ≤ 5 feet). Allow the concrete to attain a compressive strength of not less than 2,000 psi, and repeat lifts until the base shell is completely filled with concrete.

SECTION 17 FLOOD EMERGENCY PLAN

The 600-foot lock extension will require dewatering the auxiliary chamber for construction activities. This will be accomplished by installing 42 feet of lock maintenance bulkheads, from elevation 470 to elevation 512, in the new bulkhead recess on the downstream side of the new downstream miter gate. The Huntington District currently has 4-foot bulkhead units designed to resist a 42-foot hydrostatic load and 6-foot units designed to resist a 30-foot hydrostatic load. For plan 1, construction activities will be limited to construction of the miter gate sill and miter gate work. This will require approximately four months of work. For plans 2, 3, and 4 construction activities will consist of construction of the miter gate sill, miter gate workand construction of the laterals. This will require approximately four months of work.

The dewatering of the auxiliary chamber should be scheduled during the summer months, July through October, when the lower pool is historically lower. The top of the bulkheads, elevation 512, is less than the expected 99% chance exceedence flood elevation of 519.2. Table 29 shows the percent of time for each month the lower pool is below elevation 512 feet.

Table 29 Greenup Locks and Dam Lower Gage

Time Period	Expected Percentage Below Elevation 512
January	94%
February	89%
March	80%
April	89%
May	92%
June	98%
July	98%
August	99%
September	99%
October	99%
November	98%
December	94%
Annual	95%

Note: Greenup Lower Gage Zero Elevation 473.00

While the auxiliary chamber is dewatered for construction activities, the lower pool level will be monitored and forecasts for lower pool crests will be made. If the lower pool is forecasted to crest above elevation 512, the contractor will be notified. There will be adequate time to evacuate personnel and some equipment. Depending on river conditions and weather, in

some instances there will be adequate time to remove all equipment from the dewatered auxiliary chamber. The construction contract will contain restrictions such as times of the year when the auxiliary chamber may be dewatered. The contract will also contain provisions for damages to be paid to the contractor for flooding the auxiliary chamber. Flooding the chamber will result in lost time to the contract, dewatering the chamber again, cleanup and may or may not result in flooding of equipment.

SECTION 18 CONSTRUCTION MATERIALS

18.1 CONCRETE

18.1.1 Concrete Requirements

Construction of the lock extension at Greenup Lock and Dam requires conventional cast-in-place concrete, mass concrete, tremie concrete, and pre-cast concrete. The concrete will be subjected to a variety of climatic conditions. The climate of the Greenup County, Kentucky area is temperate and includes the usual seasonal variations in temperature. The temperatures in the area generally vary seasonally from a minimum of about (minus) -24° F to a maximum of approximately 108° F. The mean annual temperature is 57° F. The concrete will be subjected to hot, humid temperatures in the summer months and sub-freezing temperatures in the winter months. For the purpose of concrete design, the project area is considered to be in the severe weather region, as defined by CRD-C 133-94, "Standard Specifications for Concrete Aggregates," and the concrete will be designed accordingly. Quality requirements for concrete will be in compliance with EM 1110-2-2000, "Standard Practice for Concrete." The maximum size coarse aggregate to be specified for mass concrete will be 3 inches. The strength will be determined by the water-cement ratio.

18.1.2 Sources of Cement

Type II low-alkali Portland cement, including the requirements for low heat and flash set, in accordance with ASTM C-150-85a, "Portland Cement," will be designated for use in construction of most major structures of the Greenup project. The low alkali requirement may be dropped depending on the aggregate sources. The source of cement can be selected from a pre-approved list of commercial cement producers, which will be provided by Waterways Experiment Station (WES). If a source is selected for use, which is not on the pre-approved list, the Corps of Engineers will test the source prior to construction.

18.1.3 Sources of Pozzolan

Fly Ash (Class F pozzolan) is the only pozzolan that will be required for use in construction of the project. Fly ash will be obtained commercially and is readily available for transport to the project. There are several fossil fuel power plants within a 50-mile radius of Greenup Locks and Dam, which are potential sources of fly ash.

18.1.4 Sources of Concrete Aggregate

18.1.4.1 Coarse Aggregate

A commercial limestone source will most likely be used due to quality requirements, thermal restrictions and economics. Several quality limestone sources in Kentucky, accessible by truck, are located within a 40-mile radius of the project and produce aggregate from the Newman formation of Mississippian age. Aggregate producers in Ohio that are accessible by truck or rail produce aggregate from the Greenfield and Peebles formations. Several other limestone quarries capable of producing suitable aggregate are accessible by barge within about 200 miles by river. These suppliers, located in Kentucky, Indiana and Illinois, produce aggregate from the Paoli, St. Genevieve, and St. Louis Formations of Mississippian Age. Commercial sources of natural gravel aggregate will also be given consideration. However, these sources are normally high in chert content and will probably not be able to supply 3-inch size stone in sufficient quantities.

18.1.4.2 Fine Aggregate

Fine aggregate will probably be obtained from a commercial source of natural sand and gravel. The project has several sources within 40 to 80 miles, which are accessible by truck. There are also several sources that are within 60 miles by river of the project and are accessible by barge. Most of these sources provide alluvial material. Material is obtained from the present Ohio, Kanawha, or Scioto River Valley flood plains or old river terraces. Material that is dredged from an active river system will not be allowed unless suitably processed.

Manufactured limestone sand will also be considered for use as fine aggregate. This material can be obtained from most of the limestone producers mentioned above in paragraph "Coarse Aggregate."

18.1.5 Approved Material Sources

Sources of cement, pozzolan and concrete aggregate, which are selected to be used in construction of the project, must be approved in accordance with EM 1110-2-2000, "Standard Practice for Concrete." WES continually updates a list of pre-approved pozzolan and cement sources. A number of commercial aggregate sources have been tested in Division laboratories for similar district projects. Additional testing of several other sources, as well as updating of previously tested sources, is planned prior to construction. Information on all aggregate sources investigated will be provided in the Design Memorandum.

18.2 STONE SLOPE PROTECTION

18.2.1 Quality of Stone Slope Protection

The stone slope protection (SSP) must be durable and of a suitable quality to insure permanent protection of the slopes on which it will be placed. The stone will be subjected to the usual seasonal changes of weather and temperature. SSP at or near the water surface will be subjected to freezing water and sub-freezing temperatures in the winter months. It must provide adequate protection against drawdown and waves caused by tows. The SSP will consist of

tough, durable, massively bedded rock cemented with calcium or silica. Quality requirements for SSP will be based on laboratory test results from the following tests: freeze-thaw, wet-dry, specific gravity, Los Angeles Abrasion, and other applicable tests as discussed in ASTM D4992-94.

18.2.2 Sources of Stone Slope Protection

Several commercial sources of limestone SSP are accessible to Greenup by truck or barge. Limestone products of Kentucky and Indiana areas are produced from Mississippian Age limestones and dolomites. Quality SSP is also available from southeastern Ohio. The Ohio quarries produce stone from the Silurian Greenfield Dolomite and Pennsylvanian-Aged Vanport Limestone of the Conemaugh Series. Since material for SSP can be obtained commercially, no quarry site investigations or core drilling are planned at this time. However, this does not preclude the development of a local stone quarry near the site by the contractor. Most of the local stone, which would be available for quarrying near Greenup, is part of the Borden Formation of Lower Mississippian age. Any source designated for use as SSP will be thoroughly investigated and undergo a program of laboratory testing prior to approval.

SECTION 19 OPERATION AND MAINTENANCE

19.1 O&M MANUAL

19.1.1 Approach Walls

During final design, an Operations and Maintenance (O & M) Manual will be prepared for the approach walls. This document will focus on particular features of the approach walls. Longevity and low maintenance of the new structures were particular objectives of the Design Team. Therefore, no significant maintenance effort is anticipated. The recommendations rendered herein should be re-examined, modified, and expanded as appropriate. At a minimum, re-examination is recommended after the two to three years of service.

19.1.2 Approach Wall Components

Both floating and fixed (or earth bound) approach walls are included in this analysis. Floating approach walls consist of pontoons, pylons, and nose piers. The fixed alternative for the Lower Land Wall is constructed of precast panels and a cast-in-place concrete cap both supported by drilled shafts at about 30-foot spacing.

19.1.3 Fixed Approach Wall

The operation and maintenance requirements for the fixed alternative closely resembles those of the existing fixed walls and lock walls, and therefore will be discussed only briefly. Precast and cast-in-place concrete elements are durable and require minimal maintenance efforts. Similarly, little maintenance is anticipated for the stainless steel fasteners and other galvanized hardware and parts such as handrails, ladders, and the like.

Access to portions of the drilled shaft casings exposed to the elements is limited and they should be designed with a corrosion and abrasion allowance commensurate with the design life of the facility.

The mooring features, ladder recess armor, and bands of wall armor will be maintained following policy and guidelines established for the existing facility. The cap beam supports the electrical features including light poles, and provides staff access. Damage to these features may occur during extreme flood events above the max operating pool. Cleanup and repair may be required.

Potential for sediment deposition in the navigation channel in proximity to the fixed wall is still under investigation. Remedial techniques would include dredging. The requirement for this or other techniques may be further scrutinized in the final design phase in the light of the hydraulic testing performed by WES.

19.1.4 Floating Approach Walls

The O & M Manual for the pontoons and their fixed guide and shield structures should address the following:

- Pontoon watertight integrity.
- Pontoon access hatches and ports.
- Pontoon flotation at extreme (low water versus flood) elevations.
- Marine fenders and rubbing interfaces of stainless steel and UHMW panels.
- Pontoon vertical and horizontal motions.
- Pontoon articulated stainless steel skirts.
- Marine growth.
- Bottoming out of the skirts (and less likely bottoming out of the pontoons) in presence of excessive sediment accumulation.
- Lodging of substantial drift or debris.

Additional information should be included for the following:

- Periodic inspection and maintenance of jib cranes and fall protection devices.
- Periodic inspection and maintenance of electrical features including light poles, light fixtures, cable tensioning reels, electrical cabinets, receptacles, grounding lines, communication lines and devices, etc.
- Periodic inspection and maintenance for access features such as step-over platforms, ladders, hand and guardrails, navigation lights, etc.
- Nose pier and pylon stone protection should be sounded at the same intervals scheduled for sounding the navigation channels. Moderate scour at the mud-line should not pose any immediate problem for the drilled shafts; however, any loss of stone protection should be documented for future evaluations.

19.1.4.1 Sediment Deposits & Drift Wood

Excessive sedimentation of the river andlarge drift or debris in proximity to the pontoons would be a maintenance concern particularly at times of low water elevation. At low water elevation, the potential exists that a pontoon or its skirts may be affected by sediment accumulation, deposit of a root ball or other large objects, under the pontoons. It is anticipated that periodic inspections and dredging of the navigation channels (at typical intervals for maintaining the necessary draft) would prevent damage such as:

- Excessive (i.e., non-elastically) bending of the skirt panels.
- Dislodgment (i.e., separation from the pontoon).
- Shearing off hinges and fastener hardware.

- High stress conditions when the pontoon bottoms out either on the riverbed or on substantial debris lodged between the riverbed and the keel slab.

It is anticipated that water flow patterns in proximity to the approach walls would flush accumulating silt deposit, thus eliminating the potential that the skirts would bottom out. This assumption should be re-examined in the light of the results of the physical model tests (conducted by WES) during future design phases. It is recommended that the O & M Manual contain provisions for both proactive (i.e., periodic or preventive) and impromptu measures.

Impromptu measures should address access alternatives, staff requirements, tools, equipment, and materials required. Periodic or preventive measures should include sounding the navigation channels and under the pontoons. The frequency of soundings may be adjusted (e.g., seasonally) in response to the sediment and debris deposition rates and the probability of low or floodwater elevations. On occasions when evidence of substantial debris exists, additional sounding and removal effort may be warranted.

19.1.4.2 Debris Collection in the Proximity of the Marine Fenders

Fenders (or other debris control features) are installed near the corners at each end of the pontoons to restrict the entrance of small drift and debris in the gap between the pontoons and earth-supported structures. Small debris may enter this area and be lodged, however, and should be removed periodically.

19.1.4.3 Guide Keys & Marine Fenders

The guide keys, fenders, and fender rubbing surfaces comprised of Ultra-High-Molecular-Weight Polyethylene (UHMW is a self-lubricating non-stick polymer.) or stainless steel panels at the interface between the fenders and concrete should be inspected visually for signs of wear and tear, dents, marine growth, etc. This in-place inspection should be hands-on, however, optical aids may be used to inspect less accessible areas of the UHMW panels.

Initial inspections should be performed annually. The annual inspection interval may be revised to once every two or three years if warranted by experience. Fender replacement will be required approximately every ten to fifteen years.

19.1.4.4 Pontoon Watertightness, Draft, Freeboard, Heel Angle & Alignment

No weekly or monthly hands-on inspection of the pontoons for watertightness is anticipated. The staff should note any signs of unusual behavior. For this, the staff should record or note the 'normal' pontoon freeboard. Change in pontoon draft could be indicative of water accumulation in one or more pontoon chambers, and the cause should be investigated.

Detailed inspection of the pontoon chambers should be scheduled annually during the first three years of service. The frequency of inspection should then be re-examined and potentially revised -- if warranted by experience-- to once every three to five years.

Direct hands-on inspection should be made if damage (e.g., cracks or puncture of the pontoon impact walls, puncture of the keel slab and the like) to the pontoon is obvious or suspected, e.g., unusual flotation characteristics of the pontoon, or vessel impact sufficient to cause damage to the vessel.

19.1.4.5 Periodical Inspections of the Pontoon Interior

Periodic in-depth inspection of the pontoon compartments is recommended every year for the first three to five years. This inspection frequency may be revised based on experience gained.

During the initial phase of service,hands-on inspection is recommended for about 5 percent to 10 percent of all compartments, and about 50 percent of all segment-joint compartments. In addition, all compartments that are suspected to have suffered unusually high levels of barge impact should be on the inspection schedule.

Integration joints should be visually inspected from the pontoon top and sides for any signs for 'working' of the joint. The term 'working' is used here to indicate opening and closing of cracks at the interface between two pontoon segments. This interface is pre-compressed by pretensioned bolts to prevent separation of the segments for all design load conditions.

Thus the focus of the inspection should be the integrity of the grout and absence of opening and closing of cracks through the joint (best detected by looking for any sign of water flushing (or jetting) through cracks incidental with the pontoon's flexural oscillations.

19.1.4.6 Carbon Steel Exposed to Weathering

The pontoon wall armor, line hooks, timberheads, and ladder recess armor will require periodic painting, comparable to the painting requirements for the existing approach walls.

19.1.4.7 Skirts

Skirts are made of stainless steel material. Very infrequent reattachment or replacement of skirting panels may be required. Periodic indirect inspection of the skirting panels may be accomplished by measuring the variation of flow velocity (using a vane anemometer or other measuring device to measure the cross current velocity) along the length of the approach walls. A sudden change in velocity may indicate a damaged or missing skirting panel. If further inspection is warranted, a diver or remote camera may then be required.

19.2 STAFFING RECOMMENDATIONS

19.3 DREDGING RECOMMENDATIONS

SECTION 20 ACCESS ROADS

A 20-foot wide bituminous concrete access roadway provides access to the existing esplanade and visitor and public use facilities. Since this is an operating project, entry to the existing facilities must be maintained during construction.

For Plans 1, 2 and 4 there will be little impact if any to the existing access to the project. For Plan 3, however, temporary gravel access roadways will be constructed and maintained to gain access to the esplanade area. This is due to the construction of the Bypass culvert.

At the completion of the project, any portion of the permanent bituminous access that has been damaged due to construction will be replaced. For Plan 3 as shown on Plate 1-8, that will include all of the existing esplanade area, the existing parking lot, and the access up to the picnic area. All of this pavement will be removed or damaged during the construction of the bypass culvert.

Additionally, a permanent 24-foot gravel access roadway will be constructed and maintained from the existing bituminous concrete access road to the proposed near site workstation. This access starts near the entrance to the government's property and follows the western boundary of the property line for approximately 2,500-feet. It will then head due east for approximately 500-feet and then will fork to either the north for another 1,500-feet or turn back to the south to head back towards the existing bituminous access near the picnic area. This gravel access will be used during construction to allow the contractor easy access to the casting yard, batch plant and laydown area as well as the slipway. It will also cut down on heavy traffic of the existing bituminous access during construction.

SECTION 21 CORROSION MITIGATION

21.1 FLOATING APPROACH WALLS

The pontoon wall armor elements, line hooks, timber heads, andthe ladder recess armor will be fabricated using appropriate grades of carbon steel material. They will be painted for corrosion protection, and repainted as part of the planned maintenance.

Ladders in the pontoon chambers, ladders attached to the end walls of the pontoons, stairs above the pontoon deck, guard rails, sway bridges, hatch frames, interior bearing plates for segment joint bolts, and the anchorage chain will be fabricated from carbon steel materials and hot-dipped galvanized. The restrainer brackets and impact shields, embedded girders, embedded plates, embedded ferrules and pipe sleeves (except those grouted inside) receiving bolts, embedded pipes accepting the skirt wire rope, gudgeon and pintle used for attachment of the skirt to the pontoons, wire ropes holding the skirts, skirt panels, anchor bolts for light poles, temporary supports for precast bulkheads, headed studs and bolts (in contact with stainless steel materials) debris fender brackets, etc. will be made of a variety of stainless steel grades. Selection of various grades of steel (including stainless steel) will be made to minimize galvanic action by metals that are connected either directly or by an electrolyte (water).

Corrosion control for the reinforcing steel in the concrete portions of the structure is accomplished during the design of the structural elements. For concrete, corrosion control is crack control. The Corps Engineer Manual, EM-1110-2-2104, *Strength Design for Reinforced Concrete Hydraulic Structures* provides design guidelines for crack control in reinforced concrete structures. The EM requires that the factored load combinations be multiplied by a hydraulic factor, H_f. Increasing the required ultimate strength capacity results in the structural element "working" in a stress range, which is well below its cracking capacity. The EM also states that the inclusion of the hydraulic factor precludes the usual checks on the crack control parameter, z, used by the American Concrete Institute. For buildings, z is limited to 175 kips/in for interior exposure and 145 kips/inch for exterior exposure. For environmental concrete structures (or hydraulic structures), z is limited to 115 kips/inch. This provides for crack widths, which are applicable to environmental engineering concrete structures. For severe conditions, z should be limited to 95 kips/inch. Immersion in the Ohio River is not considered a severe condition. Therefore, during design, z will be limited to 115 kips/inch.

Corrosion protection for the floating portions of the approach walls lock is aided by longitudinally post-tensioning the pontoons. The presence of a post-tensioning force has several desirable affects relative to crack and corrosion control. The primary effect is that precompression of the section eliminates tension cracks. A secondary effect is decreased permeability of the concrete. This is a by-product of the concrete mix design. Concrete for post-tensioned sections usually has higher compressive strength, lower water/cement ratio, and lower permeability than concrete for mild reinforced sections.

21.2 LOCK WALLS

This plan considers materials selection, protective coatings, and cathodic protection as means of controlling corrosion. Water resistivity at this project is in the 3,000 to 3,500 ohm-cm range. Where possible, materials will be selected to minimize corrosion due to dissimilar metals such as carbon steel with corrosion resistant steel (CRS). Vinyl paint systems will provide primary corrosion prevention. Large CRS items will also be painted as a means of minimizing the corrosion effects of CRS.

Miter gates will incorporate CRS quoin and miter blocks and CRS wall quoin. A local cathodic protection system will be provided for each gate leaf to offset the corrosive effects of this mass of CRS. Magnesium marine anodes will be provided in each compartment below water level on each side of each gate leaf, at both quoin and miter ends. Anodes will be mounted on threaded studs welded to the gate for ease of replacement.

SECTION 22 PROJECT SECURITY

A Project Physical Security Plan is in place for the Greenup Locks & Dam project, and it is in accordance with Security Engineering Manuals TM 5-853-1, -2, -3, and -4. This plan outlines in-place site precautions as well as responses to be taken as a result of threats to the facility.

The locks and dam are manned 24 hours a day, seven days a week at this site. Limited applications of fencing and area lighting have been used. With the 600' lock extension, this approach will be continued and closed-circuit television (CCTV), intended for the purpose of lock operations, will also be available for limited assessment use. As stated in Volume 3 of the Security Engineering Manual, "although the use of CCTV for surveillance purposes is not recommended, it is recommended as an assessment tool." (p. 2-18)

Adequate lighting is required for the CCTV and for general area lighting. Per Volume 3, "Although lighting itself does not provide security, it helps to assess aggressor activities. The primary purpose of lighting is to illuminate an area so that visual assessment of that area can be made either by a guard or by CCTV. Security lighting also acts as a psychological deterrent to potential aggressors." (p. 2-16)

In addition, there is limited fencing at the site, including some fencing with barbed wire outriggers. Again, as described in Volume 3 of the Security Engineering Manual, fences "… are used as protective measures against project-specific threats. Fencing is not a reliable security barrier because it provides little delay and can be breached in seconds. Fences are most appropriately used to define boundaries and to deter the casual intruder from penetrating a secure area (by mistake or intentionally). A fence will assist in controlling and screening authorized access into a secure area." (p. 2-7) Fences used at the project site were placed and will be continued to be used in this manner, in order to achieve the boundary and screening goals described in the manual. During construction, additional fencing will be required to control and restrict access to construction areas, including those areas which are normally open to the public.

SECTION 23 COST ESTIMATES

23.1 METHODOLOGY

23.1.1 Cost Methodology

23.1.1.1 General

The Current Working Estimate has been prepared to an equivalent price level of October 1, 1999. The preparation of the cost estimate is in accordance with guidelines and policies included in "ER 1110-1-1300 - Cost Engineering Policy and General Requirements", "ER 1110-2-1302 - Engineering and Design - Civil Works Cost Engineering", and "EI 01D010 - Construction Cost Estimates dated 1 September 1997". The estimate was completed using the latest guidance from OCE concerning implementation of the Civil Works Breakdown Structure (CWBS) and Chart of Accounts. The Baseline Cost Estimate was prepared using MCACES Gold version 5.30 by applying crews to work items and obtaining material and supply quotes from respective vendors/contractors where possible for significant cost items.

23.1.1.2 Direct Costs

Direct costs are based on anticipated equipment, labor and materials necessary to construct this type of innovative lock extension and historical costs from other lock and dam projects in the area including Winfield, R.C. Byrd (Gallipolis) and Marmet. Historical cost references were used to develop anticipated costs for those portions of the lock construction where design information was not yet developed. Direct costs are calculated independent of the Contractor assigned to perform the tasks. Following formulation of the direct cost a determination is made as to whether the work is performed by the Prime Contractor or a Subcontractor. The markups associated with the Prime Contractor and Subcontractors are discussed below in "Indirect Costs".

23.1.1.3 Indirect Costs

23.1.1.3.1 <u>Prime Contractor</u>

23.1.1.3.1.1 Field Overhead

The indirect costs for field overhead are included as a percentage equivalent to 9% of the direct costs. Specific costs for mobilizing the site-specific plant (concrete batch plant), tow haulage, and equipment necessary to construct the lock modifications are also part of the field overhead costs but are detailed in the estimate. The value of 9% represents the anticipated prime contractor field overhead costs for such items as project supervision, contractor quality control, contractor field office supplies and temporary facilities, personal protective equipment, field

The cost estimate includes a percentage applied as 4% of direct cost for home office overhead expense. Home office overhead includes such items as office rental/ownership costs, utilities, office equipment ownership/maintenance, office staff (managers, accountants, clerical, etc.), insurance, and miscellaneous. The range of home office overhead can be quite broad, and depends largely on the Contractor's annual volume of work.

23.1.1.3.1.3 Profit

Profit has been calculated using 8.5 percent to cover the contractors return on investment and to cover the contractor's risk.

23.1.1.3.1.4 Bond

The Prime Contractor's Payment and Performance Bond cost is calculated using the Class A bond table in MCACES Ver. 5.30. The bond table uses a decreasing percentage of cost based upon graduated project cost methodology. The bond cost for the project is 0.5%.

23.1.1.3.2 <u>Subcontractors</u>

23.1.1.3.2.1 Overhead

All subcontractor markups are set to 15% of direct cost to account for the combined markups for field overhead, home office overhead, and bond cost. The exception is where the subcontractor has provided a quoted price including overhead. For discussion of these costs see the appropriate sections under 1.1.3.1.

23.1.1.3.2.2 **Profit**

All subcontractor profit margins are set to 10% of direct cost. The exception is where the subcontractor has provided a quoted price including profit. For discussion of these costs see the appropriate sections under 1.1.3.1.

23.1.1.4 Labor - Wage Determination

The cost estimate uses Kentucky Davis Bacon Wage Rates for the county of Greenup. Included for support are the current wage rates as published per General Decision KY990027 for heavy construction. These rates are effective, for the October 1, 1999 price level. It is probable given the magnitude of the project that a project-specific labor agreement will be entered into by the successful Contractor and representative labor unions. It is anticipated that maritime wage modifiers will be applicable for work on and over the water. The estimator has determined through analysis that an overall modifier of ten percent on labor for the entire project is representative of the maritime labor premium that will be required for the project.

23.1.1.5 Crews

Project specific crews have been developed for use in estimating the direct costs of construction for those items not estimated using quotes or historical cost information. Crewmembers consist of selected complements of labor classifications and equipment pieces assembled to perform specific tasks. Productivity has been assigned to each crew reflective of the expected output per unit of measure for the specific activities listed in the cost estimate. The default crew productivity for all crews is one (1.0), representing one hour of productivity for every one-hour work period.

23.1.1.6 Quantities

The civil site work quantity takeoffs were provided by the Army Corps of Engineers' Engineering Construction branch, Design Civil branch, and checked for reasonableness. The structural quantities for this design were prepared by the A/E design firms of Black & Veatch and INCA, and were checked for reasonableness.

23.1.1.7 Rationale for Contingency Values

Contingencies were assigned by the Cost and Project engineer based on the risk or uncertainty of each individual bid item estimated. Higher contingencies were assigned to the items that had the least design development or a higher anticipated risk factor associated with construction, such as the Floating Walls and Lift-In Monoliths. Contingency is applied at Level 5 (Bid Item) of the cost estimate in order to more definitively determine the level of risk associated with the determinate scope of the lower level cost item. This allows the estimator greater freedom to apply more liberal contingencies to high risk cost items while maintaining lower contingencies on lower risk cost items. Table 30 contains the subjective analysis mechanism that was formulated to illustrate the rationale for the included contingencies.

Table 30 Contingency Development

		Weighted Risk Factors				
		Difficulty of Construction	Totality of Design	Pricing Confidence	Market Confidence	Total Factor
	Weight	35	25	25	15	100
	Range of Values	.05 - .40	.05 - .40	.05 - .40	.05 - .40	.05 - .40
Bid Item						
Example 1		0.30	0.30	0.30	0.30	0.30
Example 2		0.22	0.10	0.20	0.10	0.17
Example 3		0.10	0.10	0.10	0.10	0.10

In accordance with the "Range of Values" this system establishes a minimum and maximum contingency of 5% and 40%, respectively. Those items in the estimate using the minimum or maximum values can be viewed as having been weighted at the minimum or maximum values, respectively, in all categories. "Weighting" is done subjectively by the cost estimator using this rationale to determine the contingency placed at the Bid Item level. All contingencies used in the cost estimate are between the ranges of values indicated (5% to 40%). Applied contingency at the bid item level can be viewed in the Second View Summary for each alternative.

23.1.1.8 Fully Funded Cost Estimate

The Fully Funded Cost Estimate is presented in Excel Version 7.0 spreadsheet format to allow for future adjustments by the Government should they become necessary. It incorporates the Plan 3 (the preferred alternative selected by the Government) cost estimate and associated preliminary project schedule.

23.1.2 Major assumptions made in the Cost Estimate

The following are the major assumptions made in preparing the cost estimate;

1. Construction of the land wall would be Lift-In constructed in the wet.
2. Casting of the blocks and panels could be match cast with the tolerance that would allow the miter gate to operate.
3. Gate Monolith assembly would use methods to connect the panels to the block structure in a timely and economic manner that reflect safe working conditions.
4. The downstream Guidewall could be of the Float-In type.
5. All down time given by the A&E firm, Black & Veatch, to be true at this 90% design level.
6. No Real Estate would be needed to construct this lock extension.
7. The project account "30 Engineering & Design" was collected from each branch for the Construction Cost estimate.
8. The project account "31 Construction Management (Supervision & Administration)" was collected from each branch for the Construction Cost estimate.

23.1.3 Project cost Accounts

The Greenup 600' Lock Extension project contains the following feature accounts:

23.1.3.1 (01) Lands and Damages

At the present level of design, it is not anticipated that any costs will be attributable to this account. This account is thus absent from the estimates prepared for the various alternatives.

23.1.3.2 (02) Relocations

This cost represents an allowance for the relocation of the existing buried power line to the project. The service will require relocation to a temporary overhead configuration during construction and subsequent re-bury following completion of lock modifications. This allowance is also intended to cover costs associated with protecting the existing raw water service and other existing site utilities during construction. At present there is insufficient information to determine a developed cost for this feature of work. The relocations cost allowance should be reviewed following receipt of additional field information presently under analysis. It is anticipated that the cost allowance contained in the estimate will be sufficient to satisfy project requirements.

23.1.3.3 (05) Locks

This cost is for the construction of an additional 600' lock using hollow float-in concrete section construction methodology. The scope of work and costs associated therewith vary in accordance with the construction alternatives as described in the body of this report.

23.1.3.4 (06) Fish & Wildlife

As civil design plans have only recently become available, the state-of-the-art mitigation plan does not yet contain feasibility level costs or incremental analysis to back-up a recommended approach. The cost estimates reference the concepts that have been screened and

are currently undergoing feasibility level design. It is anticipated that completed designs, costs, incremental analysis and recommendations will be available shortly for inclusion in the Preliminary Draft EIS.

23.1.3.5 (19) Buildings, Grounds, and Utilities

This cost includes site work for tot lot and picnic areas. Items include water/sewer lines, asphalt pavement, picnic shelters, flagpole, lights, picnic grills, waste receptacles, and picnic tables. Design documents are not currently available for these features.

23.1.3.6 (30) Planning, Engineering, and Design

The work covered under this account includes project planning, preliminary, final design, plan preparation, specification preparation, engineering during construction, advertise, open bids, and award contract. The cost for this account is based on collected data from each branch that will participate.

23.1.3.7 (31) Construction Management

The work covered under this account includes supervision, contract administration, construction administration, technical management activities, and District office supervision and administration costs. . The cost for this account is based on collected data from each branch that will participate.

23.2 PROJECT DESCRIPTION

05.00.01 Mobilization/Demobilization & Preparatory Work

The contractor will mobilize the equipment and construct the plant that will support the construction of the 600' Lock extension. This is visualized as the necessary site clearing and grubbing, construction of the carpentry shop, mechanic shop, site staging area (for Lift-in and floating walls), concrete batch plant, and field offices to support construction of the project. Transportation of the floating walls from RCB Lock & Dam dry dock to Greenup Lock & Dam staging site was included as part of this item, as well as, project and safety signs.

05.00.03 Care & Diversion of Water

Under this item the contractor will construct systems to facilitate the proper construction techniques as set forth by the Contractor and approved by the Corps of Engineers. This shall include de-watering the lock chamber, stone slope protection, sheet pile cut-off walls, and cofferdams as necessary to facilitate construction per the design documents.

05.00.10 Earthwork for Structures

<u>Earthwork and Backfill</u>

Earthwork for the project addressed by this study may be placed in three categories:

4. Soil excavation for the Supplemental Filling And Emptying Culvert
5. Dredging for the Fit-Out Area
6. Rock excavation for the Lock Extension.

Excavation for the Supplemental Filling and Emptying Culvert

The Supplemental Filling and Emptying System is composed of five separate elements for the purposes of excavation. The elements are the Intake Structure, Bypass Culvert, the Laterals, the Outlet Culvert, and the Outlet Structure. Drawings of the Supplemental Fill/Emptying System are in Section 26.4, Plates 4 through 7.

The Intake Structure will be excavated in the dry after a cutoff wall is constructed from the existing land wall to the existing riverbank. Excavation will use conventional excavators and will stop at approximate elevation 480 where the structure will be founded on soil.

Excavation for the bypass culvert will proceed from the Intake toward the Chamber Extension. The majority of the excavation will be cut and cover with excavation sides sloped at 2H:1V. The culvert will be cast-in-place in the bottom of the excavation. At its deepest point, the excavation will be approximately 70 feet deep and will be over 55 feet deep over most of its length. The completed culvert will be covered with the excavated material. A total of 350,000 CY of earth will be excavated for construction of the bypass culvert.

The existing state highway bridge piers present a problem to the excavation for the Bypass Culvert since the cut slope would undermine the piers. Therefore, an anchored sheet pile wall will support the bottom 22 feet of the excavation. The wall will be founded at elevation 466 and will have a top at elevation 497. The rock at elevation 470 will have to be pre-drilled to achieve the required penetration into sound rock. One row of anchors will be required at elevation 488. The wall will act as a cantilevered wall for excavation to elevation 485. The anchors will be 60 ton (design load) soil anchors at 6-foot spacing along the wall. Approximately 70 anchors will be required. For additional details, refer to Plate 4-4.

The excavation for the laterals will be entirely in rock. The bottom of the excavation will be at elevation 460 feet requiring the removal of approximately 13,000 CY of rock. The excavation will be done in the wet concurrent with excavation for the Chamber Extension.

Likewise, the excavation for the Outlet Culvert will be entirely in rock. A trench 25 feet deep by 22 feet wide will be required for the Outlet Culvert. A total of 6,000 CY of rock will be removed in two phases. The first phase will be the half of the trench that crosses the Auxiliary Chamber. The first phase will be excavated concurrently with excavation for the extension. The second phase will be the main chamber crossing and will extend halfway under the existing guardwall. This phase will be delayed until the Auxiliary Chamber Extension is operational and passing traffic. Then the main chamber can be closed and the outlet extended across that chamber.

Excavation for the outlet structure will be entirely in rock. The excavation will be approximately 60 feet x 60 feet with an average depth of 13 feet resulting in approximately 2,000 CY of rock removal. This excavation will include the tie-in under the remaining half of the guard wall. A braced cofferdam will be constructed around the outlet structure and the excavation will be in the dry. This excavation will not require closure of either of the lock chambers.

23.2.1.1 Dredging for Fit-Out Area

Overburden soils are dredged to clear the top of the rock for the Fit-Out Area. The limits of the Fit-Out Area and the associated dredging are shown on Plate 2-11. The dredge limits shown assume the navigation channel is dredged to the top of rock at elevation 470 feet. Therefore, dredging the channel will not be required for this project. The purpose of the dredging shown on the drawings is to remove the overburden soils to the top of rock back to the toe of the existing fill area slope. The slope is not to be disturbed. This dredged area will be available to the contractor for the transfer of blocks and wall panels from the shore to barges. It can also be used for mooring construction barges. The estimated quantity of dredging is 15,000 CY of soil. This is based on an average thickness of 3 feet of soil removal over the entire dredged area.

23.2.1.2 Rock Excavation for the Lock Extension

Various section views of the different wall types show the rock excavation at the base of each wall type. Construction includes the complete extension with a supplemental fill and empty system including the intake structure, bypass culvert and outlet structure. A total of 52,000 CY of rock must be removed.

23.2.1.3 Earthwork for the Lower Land Wall (LLW)

Excavation of topsoil and rock (sandstone) material is required for floating walls for the full length of the approach wall. The excavation is about 46 feet wide and 4 to 5 feet deep centered under the pontoon footprint.

It is anticipated that upon construction completion, the riverbed elevation in proximity to the LLW would be filled to grade (with the natural silt and sand found in the riverbed material in proximity to the construction site) to El. 469.0 which is the design depth of the navigation channel. The grading is required to prevent entrapment of bulky debris such as down drifting logs and root balls in the otherwise depressed area.

The dredging of the alluvial deposits of the riverbed and of the riverbank would require conventional equipment such as self-loading scraper pans, backhoes, trucks, and dozers. Draglines or other suitable equipment may be required for saturated riverbed material with very soft consistency. Most dredging can be carried out independently of other operations, in which case the rate of production will be relatively high.

Whether or not the borrow material would balance or exceed the amount of the alluvial deposits required for grading of the riverbed under the LLW pontoon will be deferred to future design stages. If excess material should be encountered, the material may be stockpiled temporarily near the excavation site or directly loaded onto a barge. No land surface transport would be required for the disposal traffic.

The removal of the sandstone rock is anticipated to require blasting. An underwater hydraulic breaker ram or chisel, however, may accomplish the removal of about 2 feet of the top layer of weathered sandstone (if sufficiently fractured). At this stage it has not been determined whether the contractor will adopt blasting alone or a combination of varying techniques. Because of the required integration of sequential activities (such as removing the rock material in 'bites' of the bucket, with teeth), the blasting is expected to slow down the removal work appreciably. Depending on the size of the material excavated, the material may be used near the site for shoreline and scour protection or hauled off site by barges.

For blasting the rock, the sandstone will be drilled and shot underwater by a drill barge using the OD method of casing. Holes will be loaded (for detonation) immediately upon completion of drilling of the individual hole, which will be placed about 7-foot on center each way. Typically, one or two lines will be shot at a time to keep an open face. The drill barge will drill and shoot 14 – 16 holes/shift. Then the clamshell crane barge, with a heavy-duty bucket and teeth, will excavate the sandstone.

23.2.1.4 Rock Excavation Beneath Lower Land and River Walls

Alluvial deposits will be dredged to elevation 570 beneath the Lower River Walls. The possibility exists that after a flood event occurs, trees or other hard debris could be lodged beneath the floating walls. This debris could potentially cause the floating walls to break if these objects were trapped between the rock and the wall as the pontoon lowered onto the lodged object after the high water event. As a precaution against possible pontoon damage rock will be excavated 3' outside of the perimeter of the footprint to elevation 460. If any hard object, such as a tree root ball, were trapped beneath the wall it would be crushed when the river elevation went back down to normal elevations.

23.2.1.5 Rock Excavation for Deep Foundations

Rock excavation of sandstone and siltstone materials incidental with the construction of the drilled shafts (serving as deep foundations for the nose piers and pylons) will be accomplished by specialty contractors. A probable construction scenario using a permanent steel casing and a temporary steel casing is depicted on Plate No. 3-12 entitled: Nose Pier Construction Sequence.

23.2.1.6 Disposal

Expansion of the 600' lock will require removal of approximately 350,000 cubic yards of common excavation and dredging and approximately 100,000 cubic yards of rock excavation and concrete demolition.

Excavated rock from the site will be used to construct dikes and T-dikes for aquatic habitat. Specific locations for the dikes and the number of T-Dikes will be determined once the quantity of rock available from excavation is known within a smaller range. All excavated material, except suitable backfill, course materials suitable for creation of environment design features and demolition debris, will be spoiled in disposal areas 1 through 3 as shown on plates 1-4 through 1-8.

23.2.1.7 Spoil Site #1

This site is located on the southwestern-most portion of the government's property. It is currently seeded with grass and is a large depression along the permanent access road. This site should be the first area utilized for spoil and contoured to a final grade as shown on plates 1-4 through 1-8. It will hold approximately 44,000 CY of spoil.

23.2.1.8 Spoil Site #2

This site is located across the main access road and to the east of Spoil Site #1. This area is currently covered with grassy-type vegetation. This spoil site will be the 2nd area utilized for spoil. This spoil site should be contoured as shown on plates 1-4 though 1-8. The spoil will

provide fill at this site to increase the size of usable recreational area near the picnic shelters. This site will hold approximately 105,000 CY of spoil.

23.2.1.9 Spoil Site #3

This area is located on the northern-most portion of the project's property. It is currently covered by trees. The site will require clearing and grubbing over the entire area prior to its use as a spoil site. This area should be the last area utilized as a spoil area. It will be filled to an elevation as needed. It can hold up to approximately 150,000 CY of spoil (if needed).

05.00.41 Gates, Stoplogs and Assembly Equipment, and 05.00.57 Lock Gates Embed Metals

The construction of the gate and bulkhead sills begins with construction of the outer bulkhead sill and crossover tunnel in the wet. After dewatering the lock chamber, the miter gate sill and inside bulkhead sill would be constructed in the dry.

The primary reason it is desired to construct the miter gate sill in the dry is the need for a close tolerance finish for the top of the miter gate sill. The assumption was made to use in-the-dry construction to eliminate the connection problems and make the construction and finishing of the sill itself easier and less expensive.

The outer bulkhead sill is constructed by placing three support blocks, one at each monolith and one at the center of the channel. Two 59-ft. concrete sections incorporating the crossover tunnel and the bulkhead seal would then be lowered onto the supports and leveled by shimming. This concept is shown on Plates 2-30 through 2-32. The mass of the sill would then be poured with tremie concrete. When the sill concrete has set and has obtained its design strength, the bulkheads would be installed and the chamber would be dewatered.

Construction of the crossover tunnel would be different for lift-in than for float-in. For lift-in, the elbow under the monolith could be set and tremie-placed when that portion of the monolith is constructed (Plate 2-29). The joint would then be in the horizontal section in the channel itself.

Construction of the tunnel under the float-in shell would be more difficult. The utility tunnel elbow could not be incorporated in the original construction of the shell because it would eliminate 7-8 feet of the much-needed draft. Therefore, a knockout panel would be provided in the bottom of the shell and the elbow would be constructed as part of the bulkhead sill. That portion of the bulkhead sill either would be constructed prior to the gate monolith or would be 'slipped' under the monolith. Sand bags or other methods would be required to seal between the bottom of the shell and the perimeter of the tunnel trench during the placement of the base lift of tremie concrete for the shell. This would prevent concrete in the base lift from filling the trench. After dewatering, the knockout panel would be removed and the elbow could be formed and connected to the bottom of the shell. Once the tunnel is built, the mass of the bulkhead sill would be poured and finished.

05.00.61 Guide-Guard Walls, Upper & Lower

Gallipolis is an abandoned lock that the Corps currently owns. For this report, it was assumed that this lock could be rebuilt to serve as a graving dock for pontoon construction. Each

pontoon segment would be constructed on a casting bed, and construction will include the following:

1. Construct the keel slab.
2. Construct all the walls.
3. Construct the deck slab.
4. Prestress the concrete segment.
5. Construct parapets.
6. Launch segment and ballast for float-out.
7. Float out segment from the graving yard.

The pre-cast, prestressing technique for casting concrete was used to fabricate the pontoons, which would minimize construction joints. The pontoons would then be floated, and the segments would be measured to document their "as-built" flotation characteristics and, if necessary, corrective ballasting will be added.

Segments will be transported to the lock site directly for pontoon integration and outfitting in the Auxiliary Lock Chamber at the Greenup site. Outfitting work to be performed at this site will include the following:

1. Fine ballasting of the pontoon segments.
2. Cleaning of the exterior concrete at the integration joint.
3. Integration of the pontoon's segments via pre-tensioned bolts.
4. Installation of parts of the pontoons' guide and restraining system such as guide keys and restrainer brackets. (See note below on clearance considerations.)
5. Installation of features related to the power supply, electrical installations including cable tensioning reels, light poles, and communication devices.
6. Personnel access and safety items, guard rails, etc.

The final installation will be a critical phase of the construction as the pontoons will be maneuvered between the fixed structures, temporarily lashed and secured, and then locked in place permanently by installation of the restrainer bracket and/or guide key. Control of tolerances will be crucial for the successful placement of a pontoon in its final position. Restraining brackets and guide keys are stainless steel structures that are bolted to the end of the pontoon by pre-tensioned bolts. Although it is not necessary to remove the pontoons for maintenance, temporary removal is possible. Marine fenders may be installed at any construction stage. They are either attached to the brackets and guide keys or to the pontoon's end wall with stainless steel bolts, screws, and ferrules embedded in concrete.

PLATE (1-1) 05.00.61. Nose Piers and Pylons

The nose pier consists of a foundation composed of three drilled shafts and a superstructure. The drilled shaft foundation allows in-the-wet construction of the nose pier.

The drilled shaft consists of a permanent steel casing containing a cage of reinforcing steel and tremie concrete. At its exterior face, the permanent casing is equipped with brackets capable of retaining a steel ring plate collar. The collar plate is equipped with a compression seal to close the gap between the base shell and the shaft casings.

The superstructure consists of a structural steel base shell that is anchored upon the upper portion of the drilled shafts and is filled completely with concrete.

The base shell serves two purposes; it forms the fresh concrete during construction and functions as wall armor during the service life of the navigation lock. It is comprised of an outer shell resembling the superstructure geometry, three (approximately 11 foot-6 inch diameter) inner sleeves aligned with the foundation-drilled shafts, and a steel bottom plate for supporting fresh concrete. The inner sleeves are equipped with steel brackets that allow the base shell to rest upon the steel casing of the drilled shafts.

See Plate 3-11 for Nose Pier construction sequence details.

Proposed Construction Sequences

The following descriptions are related to the in-the-wet construction of the Upper Middle Wall (UMW) Nose Pier, shown on Plate 3-9. Note that the actual construction method may vary from the proposed construction sequences, depending on the contractor's preference. URW Nose Pier, LLW Nose Pier, and Pylon construction sequences will be similar to the UMW Nose Pier construction described herein.

Drilled Shaft Construction Sequence

10. Erect a work platform at a safe elevation above the water line using a “spud” barge or a trestle.
11. Install a positioning and alignment template for installation of the drilled shaft casings. Secure the template by temporary steel piles, penetrating the riverbed.
12. Install a 12-foot diameter temporary casing through the template. When completely installed, the tip of the temporary casing penetrates the rock material about 2 feet. Select the length of the temporary casing so that several feet of the casing would project above the waterline.
13. Drill/excavate riverbed material and rock within the temporary casing to the final shaft tip elevation and lower the permanent casing within the temporary casing.
14. Pressure grout between the permanent casing and the rock, beginning from the shaft tip elevation upward to the top of the rock elevation. Remove the temporary casing.
15. Install the reinforcing cage inside the permanent casing, and place tremie concrete continuously inside the permanent casing until filled completely.
16. Repeat work until all three shafts are constructed.
17. Allow the tremie concrete to attain the required minimum strength (determined by the design) before removing the template and temporary piles.
18. Construct the superstructure after the drilled shaft concrete has attained design strength.

Nose Pier Superstructure Construction Sequence

1. Install the collar plate on the brackets attached to the exterior face of the permanent casing.
2. Lower the base shell upon the shafts until the brackets come to rest upon the top of the steel casing.
3. Shim as required for final alignment of the superstructure.

4. Fill annular space between the drilled shaft casings and the inner sleeves with pressurized grout.
5. Place concrete in the base shell in 8-foot lifts (first lift ≤ 5 feet). Allow the concrete to attain a compressive strength of not less than 2,000 psi, and repeat lifts until the base shell is completely filled with concrete.

05.00.62 Remove Existing Monolith L1-L5 & L29-L37

The culvert will need to be incorporated in the extension wall. Hydraulic analysis has established minimum straight lengths of culvert just before and after the laterals. To get the required leading straight section, the last horizontal radius must occur in existing monoliths L-4 and L-5. It is not practical to modify these existing culverts with retrofit culverts, so monoliths L-1 though L-5 must be demolished. New monoliths will be built in their place, which incorporate the needed culvert sections and meet revised stability criteria.

05.00.63 Lock Structure

23.2.1.10 Lift-in Monoliths

The lift-in method of construction generally consists of pre-casting concrete blocks and wall panels, setting and connecting up to a given level with crane barges, filling void spaces with tremie concrete, and repeating the process until the construction is above water. Above water, the procedure is modified to include setting braced wall panels without additional towers. Panels are set and braced in the dry and concrete is cast in place. The principle features of this method are described below:

g) The process uses techniques common to most civil works construction. A larger number of contractors will be able to bid on contracts using this method than the more specialized float-in method.
h) Flexibility is a key feature and is incorporated at the design level. The method directly addresses the critical issue of extending an operating lock, while minimizing closure of the existing lock chambers. The lock can be closed for only a few hours as each piece is set and reopened to clear the traffic queue.
i) A second advantage is the ability to open the auxiliary chamber within a few hours of notification. The worst case would occur if the main chamber while a chamber had to be closed because of an emergency while a chamber face wall panel is being set in the auxiliary chamber. In this case, the auxiliary chamber wouldnot be available until the base tremie grout was sufficiently set to avoid being damaged by propeller turbulence.
j) This lift-in concept will require a 350 T to 400 T derrick crane (or boat) to lift the heaviest elements.
k) A large pre-cast yard will be required to cast approximately 250 pre-cast elements.

A slipway was used to transfer the pre-cast elements from shore to barges for installation.

The basic concept is illustrated on Plates 2-12 through 2-29. The middle wall gate structure is the critical structure for this extension and is chosen to illustrate the method with step-by-step sections on Plates 2-33 through 2-40.

05.00.64 Filling and Emptying System

The Supplemental Filling/Emptying System starts with construction of the Intake Structure. The Intake Structure will be excavated in the dry after a cutoff wall is constructed from the existing land wall to the existing riverbank. Excavation will use conventional excavators and will stop at approximate elevation 480 where the structure will be founded on soil. The next feature of the system includes construction of a 1200-ft. bypass culvert to be buried in a trench varying from 50 feet deep to 70 feet deep. In the next section of the system, culverts are incorporated in the construction of the land wall monoliths. Laterals extend from the land wall across the chamber at elevation 460-foot and will be constructed in the dry while the miter gate sill is being built. The last features of the filling/emptying system are the outlet culvert and outlet structure. The outlet culvert passes through the land wall gate monolith and is incorporated in that structure. It then crosses the auxiliary and main lock channels and goes through the downstream river guard wall to the outlet structure in the river channel. The portion of the system crossing the locks will be constructed in the wet. The outlet structure will be constructed in the dry after the installation and dewatering of a steel sheetpile cofferdam occurs.

05.00.66 Power and Lighting System

23.2.1.11 Mechanical Features

The initial work includes relocating the miter gate machinery and hydraulic control manifolds for both leaves 600 feet downstream to the new miter gate machinery recesses. It also includes downstream relocation of the miter gate latches and actuators for both leaves, extending the power piping in trenches to the relocated machines (provide trenches to the culvert valve machinery locations), and providing new embedded metals for both the miter gate machinery and latches. Later work requires fabricating and installing two culvert valve machines and control manifolds, extending hydraulic power piping in trenches to the culvert valve machines, extending air and raw water 600 feet downstream, installing bubblers in miter gate recesses, and providing manhole access to air and raw water.

23.2.1.12 Electrical Features

The initial work requires relocating the control station on the downstream extension nearer the relocated miter gates, providing raceways/cable trays to electrical equipment on new lock walls, and providing necessary lighting, conduits and signal lights on new lock walls. Later work will provide raceways/cable trays for wiring to the new culvert valve machinery and new electrical controls for the additional culvert valves. The commercial electric power service will have to be temporarily re-routed for construction of the wraparound culvert, then reinstalled.

05.00.99 Site Work

23.2.1.13 Near Site Work Station

Two near-site work areas will be required for construction support. A large contractor area will be needed at the Greenup site. A fit-out area in the river adjacent to the bank will also be required.

23.2.1.14 Contractor Lay Down Area at Greenup

There is a large amount of ground available for contractor lay down at Greenup. This allows the contractor to setup operations on site, which will reduce his cost and make his operation more efficient.

The first of these is the construction of a dedicated batch plant. Due to the volume of concrete to be placed, this is an essential item. Associated with the batch plant would be a large pre-casting yard. Fewer than 20 of the 250+ pre-cast items are unique. For the others, the contractor will be able to take advantage of repetition and use assembly lines to improve production rates. The size of the pre-cast elements will necessitate having large handling equipment on the site to move them to the river for installation.

Also related to the concrete operation, the contractor will need storage space for large quantities of aggregate, sand, and cement. It is expected that most of this material will arrive by barge and will be stockpiled on site.

A staging area will be required for the large number of embeds to cast in the wall panels. These include wall armor, corner armor, mooring bits, ladders, etc. Later in the project, this area will be used for finish items such as guardrail, light poles, and fixtures.

A temporary stockpile area will have to be set aside to accommodate the large volume of earth removed during construction of the bypass culvert.

Finally, the contractor will have to provide for the needs of a large labor force. This will include sanitation facilities, and POV parking. Job administration will require at least four job trailers plus additional locking containers for small tools and supplies

23.2.1.15 Fit-Out Pier/Mooring Facility at Greenup

A large part of the contractor's work will be from barges. Again, the contractor will be able to take advantage of the large amount of space available at Greenup. The dredging plan calls for a space approximately 800'x150' to be dredged to the top of rock.

Six mooring dolphins will be built along the dredged length to tie up contractor barges. The dolphins will be capable of securing the contractors equipment during off time (weekends, holidays) and during emergency shutdowns. Emergency shutdowns may include flooding conditions or emergency closure of the main lock. The contractor will provide temporary floating walkways for access to the barges.

Near the north end of the dredged area, a slipway will be constructed. This will be constructed as a concrete ramp on the slope of the existing bank. The ramp will be cut into the

bank somewhat to reduce the slope. The ramp will be equipped with winches, trolleys and rails to permit lowering precast elements to water level for transfer to work barges.

Demonstration Project for Mooring Cells

This demonstration project consists of two different styles of fixed mooring cells. The first is based on the lift-in design used to construct the chamber wall. This plan uses the same central tower design with four hanging wall panels (one on each side) to form the sides of the mooring cell. The second style-mooring cell will be used to simulate the construction of a prototype bullnose. This cell design is based on Mississippi River Lock and Dam No. 24 Downstream Protection Cell. The basic design is to place a cylindrical steel can into the water and fill it with tremie concrete. In the Downstream Protection Cell, the internal cracking caused by thermal expansion was not an issue. However, it does become an issue in the design of our bullnoses. These cells will have to support the forces generated from the proposed floating approach wall, some of which are almost 1400-ft long.

05.00.99 Dry Dock @ Gallipolis Dry Dock RCB

Construction Sequence for Dry Dock:

1. Remove silt and sediment from lock chamber floor.
2. Inspect and set poiree dam on the existing poiree sill.
3. Dewater lock chamber.
4. Fill chamber with 19' of sand and construct seepage collection system.
5. Drill and set steel dowels in the existing poiree sill.
6. Face-up downstream poiree sill, 11' extension.
7. Place 1' concrete cap on sand fill.
8. Cut bulkhead slots and install embedded metals in lock walls for bulkhead shoes.
9. Cast-in-place a bulkhead seal across the poiree sill.
10. Install bulkheads.
11. Re-water between the poiree dam and the bulkheads.
12. Remove poiree dam.

23.3 REPORT FINDINGS

23.3.1 Cost Summaries

Table 31 presents the cost summaries for each of the four alternatives. Cost information to the sub-feature level can be found in Appendix E. Detailed cost information (to the line item level) can be found in an electronic format on the diskettes, which accompany this report.

Table 31 Alternatives Cost Summary

Alternative	Cost
Plan 1 – AUXILIARY EXTENSION CAPAB	$141,883,000
Plan 2 – AUXILIARY EXTENSION MODIFIED	$149,441,000
Plan 3 – AUXILIARY EXTENSION WITH CULVERT*	**$175,590,000**
Plan 4 – AUXILIARY EXTENSION FUTURE/PHASED	$173,515,000

23.3.2 Vendor quotes

The scope of services contained in Work Order 10 required that the contractor's narrative make reference to "historical cost data, vendor quotes, and other data used to prepare the cost estimate". The Cost Engineer used (the data in the government's files at the Huntington District), the government prepared estimates generally contained detailed notes which described how such information was utilized in the government's estimates. The team reviewed all such notes and found no apparent inadequacies consistent with the level of design.

23.3.3 Quantity review

Quantities for major work items were independently evaluated and provided to the Government for comparison with those provided by EC-DC, Inca, and Black & Veatch. The Government provided final quantities to be incorporated into the cost estimates as prepared by EC-DC, Inca, and Black & Veatch.

23.3.4 Fully funded estimate

The fully funded cost estimate utilizes index projections as developed from the OMB factors as referenced in publication EM 1110-2-1304 Appendix A published September 1998. The Government provided a general project schedule for use in developing the fully funded cost estimates. *** ***A meeting was held to coordinate the final cost estimates that will be used for J.T. Myers/Greenup Final Interim Report as part of the Ohio River Mainstem System Study (ORMSS). The meeting was held 19-20 January 2000 at the Louisville District. The basic purpose of the meeting was to ensure that the sufficient baseline costs are being used for the projects that are being presented for both J.T. Myers and Greenup in the Final Interim Report. A Fully Funded Cost Estimate has been prepared for Plans 3, the Government preferred alternative and reflects the unit cost agreed on at the a -fore mentioned meeting. Additionally, the meeting ensured a seamless process between the change s and the independent technical review (ITR) since several ITR members from Nashville District were in attendance at the meeting.***

Table 32 Plan 3 – Fully Funded Project Cost by Fiscal Year

Table 5-1, Civil Works Const. Cost Index (CWCCIS)
Composite Index, Sheets 3 of 4 and 4 of 4.

Greenup Locks & Dam
Indiana and Kentucky
Plan 3 - Auxiliary Extension with Culvert
Fully Funded Project Cost by Fiscal Year

ACC NO	ITEM DESCRIPTION	Oct-99 COST	10/00-9/01 FY01	10/01-9/02 FY02	10/02-9/03 FY03	10/03-9/04 FY04	10/04-9/05 FY05	10/05-9/06 FY06	10/06-9/07 FY07	10/07-9/08 FY08	10/08-9/09 FY09	FULLY FUNDED
	OMB FACTOR	538.82	538.82	552.83	567.20	581.95	597.08	612.60	628.53	644.87	661.64	
02.-.	Relocation	$500,000	-	-	-	-	500,000.00	-	-	-	-	
	FULLY FUNDED		$0	$0	$0	$0	$554,063	$0	$0	$0	$0	$554,063
	Contingency	$100,000	$0	$0	$0	$0	$100,000	$0	$0	$0	$0	
	FULLY FUNDED		$0	$0	$0	$0	$110,813	$0	$0	$0	$0	$110,813
	OMB FACTOR	514.73	514.73	528.11	541.84	555.93	570.38	585.21	600.43	616.04	632.06	
05.-.	Locks	$119,582,240	-	-	9,017,238.00	-	-	37,230,057.00	49,515,951.00	23,819,004.00	-	
	FULLY FUNDED		$0	$0	$9,492,161	$0	$0	$42,327,826	$57,760,112	$28,507,099	$0	$138,087,198
	Contingency	$19,147,730	$0	$0	$1,443,857	$0	$0	$5,961,346	$7,928,586	$3,813,943	$0	
	FULLY FUNDED		$0	$0	$1,519,903	$0	$0	$6,777,610	$9,248,656	$4,564,609	$0	$22,110,778
	OMB FACTOR	516.55	516.55	529.98	543.76	557.90	572.41	587.29	602.56	618.22	634.30	
06.-.	Fish & Wildlife Facilities	$4,554,020	-	-	-	-	-	2,277,010.00	-	2,277,010.00	-	
	FULLY FUNDED		$0	$0	$0	$0	$0	$2,588,840	$0	$2,725,183	$0	$5,314,023
	Contingency	$1,080,870	$0	$0	$0	$0	$0	$540,435	$0	$540,435	$0	
	FULLY FUNDED		$0	$0	$0	$0	$0	$614,446	$0	$646,806	$0	$1,261,252
	OMB FACTOR	504.18	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	619.11	
19.-.	Buildings, Grounds & Utilities	$644,240	-	-	-	-	-	136,236.00	113,530.00	394,474.00	-	
	FULLY FUNDED		$0	$0	$0	$0	$0	$154,892	$132,434	$472,120	$0	$759,446
	Contingency	$137,170	$0	$0	$0	$0	$0	$29,007	$24,173	$83,990	$0	
	FULLY FUNDED		$0	$0	$0	$0	$0	$32,979	$28,198	$100,522	$0	$161,699
	OMB FACTOR	504.18	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	619.11	
30.-.	Engineering & Design	$18,087,000	2,496,006.00	3,436,530.00	2,984,355.00	2,532,180.00	1,808,700.00	1,627,830.00	1,085,220.00	1,085,220.00	1,030,959.00	
	FULLY FUNDED		$2,496,006	$3,525,889	$3,141,570	$2,734,883	$2,004,286	$1,850,737	$1,265,918	$1,298,829	$1,265,971	$18,318,118
	Contingency	$1,808,700	$249,601	$343,653	$298,436	$253,218	$180,870	$162,783	$108,522	$108,522	$103,096	
	FULLY FUNDED		$249,601	$352,589	$314,157	$273,488	$200,429	$185,074	$126,592	$129,883	$126,597	$1,831,813
	OMB FACTOR	504.18	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	619.11	
31.-.	Supervision & Administration	$9,043,500	-	-	-	-	904,350.00	2,260,875.00	3,165,225.00	2,713,050.00	-	
	FULLY FUNDED		$0	$0	$0	$0	$1,002,143	$2,570,468	$3,692,260	$3,247,072	$0	$10,511,943
	Contingency	$904,350	$0	$0	$0	$0	$90,435	$226,088	$316,523	$271,305	$0	
	FULLY FUNDED		$0	$0	$0	$0	$100,214	$257,047	$369,227	$324,707	$0	$1,051,195
	TOTAL PROJECT COST	$175,589,810	$2,745,607	$3,878,478	$14,467,791	$3,008,371	$3,971,948	$57,359,919	$72,623,397	$42,016,830	$1,392,568	$200,072,341

Table 33 Plan 3 - Fully Funded Estimate

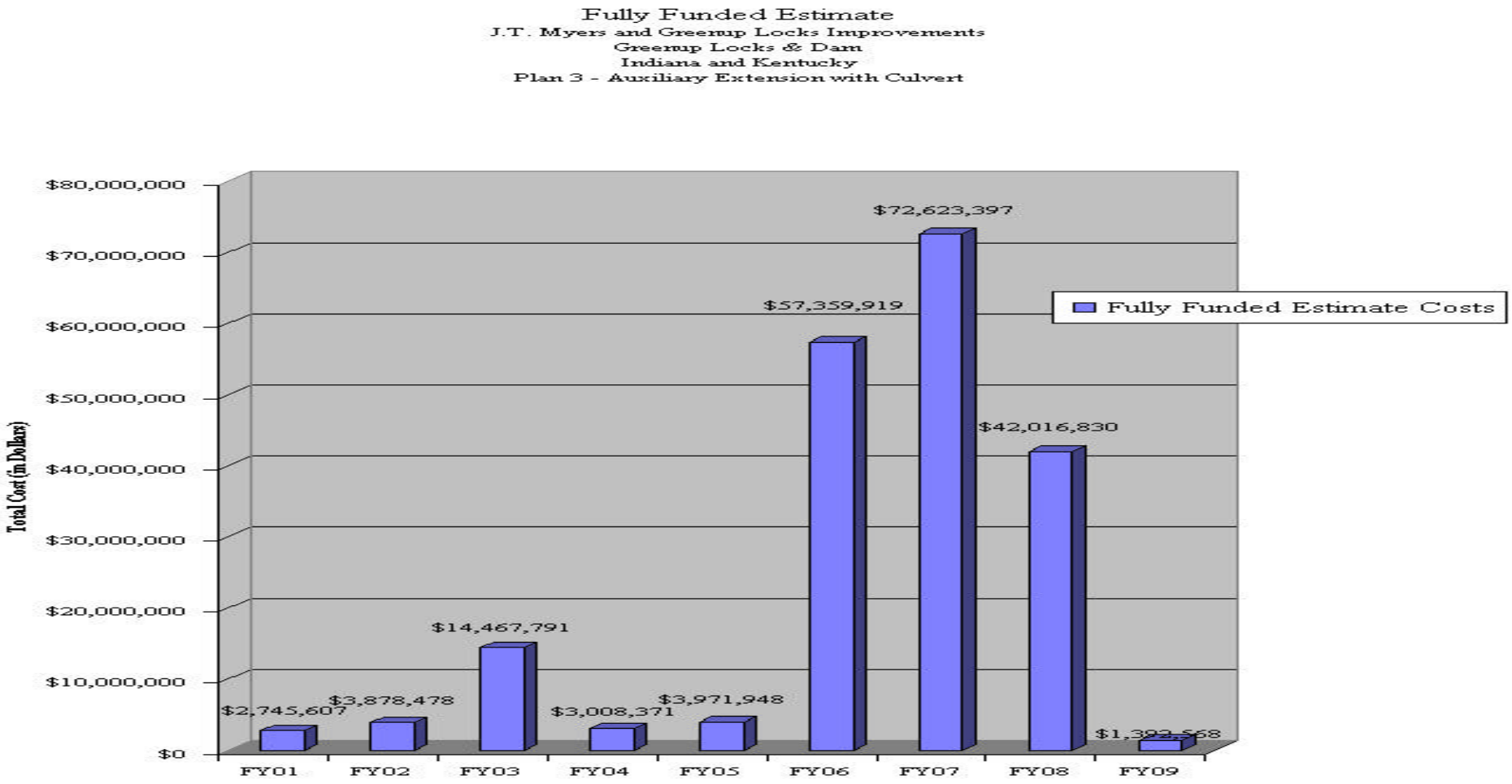


Table 34 Plan 4 – Fully Funded Project Cost by Fiscal Year

Reference:

Table 5-1, Civil Works Const. Cost Index (CWCCIS)
Composite Index, Sheets 3 of 4 and 4 of 4.

U.S. Army Engineer District, Huntington
Ohio River Main Stem Systems Study (ORMSS)
J.T. Myers and Greenup Locks Improvements
Greenup Locks & Dam
Indiana and Kentucky
Plan 4 - Auxiliary Extension -- Future Phased
Fully Funded Project Cost by Fiscal Year

ACC NO	ITEM DESCRIPTION	Oct-98 COST	10/00-9/01 FY01	10/01-9/02 FY02	10/02-9/03 FY03	10/03-9/04 FY04	10/04-9/05 FY05	10/05-9/06 FY06	10/06-9/07 FY07	10/07-9/08 FY08	10/28-9/29 FY28	10/29-9/30 FY29	FULLY FUNDED
	OMB FACTOR	511.85	538.82	552.83	567.20	581.95	597.08	612.60	628.53	644.87	1077.51	1105.53	
02.-.	Relocation	$500,000	-	-	-	-	500,000.00	-	-	-	-	-	
	FULLY FUNDED		$0	$0	$0	$0	$583,257	$0	$0	$0	$0	$0	$583,257
	Contingency	$100,000	$0	$0	$0	$0	$100,000	$0	$0	$0	$0	$0	
	FULLY FUNDED		$0	$0	$0	$0	$116,651	$0	$0	$0	$0	$0	$116,651
	OMB FACTOR	488.97	514.73	528.11	541.84	555.93	570.38	585.21	600.43	616.04	1029.33	1056.09	
05.-.	Locks	$96,565,540	-	-	-	-	5,586,564.00	38,193,815.50	39,439,495.00	13,345,695.50	-	-	
	FULLY FUNDED		$0	$0	$0	$0	$6,516,687	$45,711,194	$48,429,670	$16,813,879	$0	$0	$117,471,430
	Contingency	$21,468,100	$0	$0	$0	$0	$1,241,985	$8,491,110	$8,768,045	$2,966,967	$0	$0	
	FULLY FUNDED		$0	$0	$0	$0	$1,448,767	$10,162,346	$10,766,708	$3,738,001	$0	$0	$26,115,822
	OMB FACTOR	490.70	516.55	529.98	543.76	557.90	572.41	587.29	602.56	618.22	1032.98	1059.84	
06.-.	Fish & Wildlife Facilities	$3,000,000	-	-	-	-	-	1,500,000.00	-	1,500,000.00	-	-	
	FULLY FUNDED		$0	$0	$0	$0	$0	$1,795,262	$0	$1,889,810	$0	$0	$3,685,072
	Contingency	$600,000	$0	$0	$0	$0	$0	$300,000	$0	$300,000	$0	$0	
	FULLY FUNDED		$0	$0	$0	$0	$0	$359,052	$0	$377,962	$0	$0	$737,014
	OMB FACTOR	478.95	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	1008.25	1034.46	
19.-.	Buildings, Grounds & Utilities	$417,910	-	-	-	-	-	68,670.00	57,225.00	292,015.00	-	-	
	FULLY FUNDED		$0	$0	$0	$0	$0	$82,186	$70,270	$367,904	$0	$0	$520,360
	Contingency	$91,800	$0	$0	$0	$0	$0	$15,084	$12,570	$64,145	$0	$0	
	FULLY FUNDED		$0	$0	$0	$0	$0	$18,053	$15,435	$80,815	$0	$0	$114,303
	OMB FACTOR	478.95	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	1008.25	1034.46	
30.-.	Engineering & Design	$15,072,520	3,014,504.00	3,014,504.00	3,014,504.00	3,014,504.00	3,014,504.00	-	-	-	-	-	
	FULLY FUNDED		$3,173,301	$3,255,815	$3,340,469	$3,427,326	$3,516,449	$0	$0	$0	$0	$0	$16,713,360
	Contingency	$1,507,250	$301,450	$301,450	$301,450	$301,450	$301,450	$0	$0	$0	$0	$0	
	FULLY FUNDED		$317,330	$325,581	$334,047	$342,732	$351,644	$0	$0	$0	$0	$0	$1,671,334
	OMB FACTOR	478.95	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	1008.25	1034.46	
31.-.	Supervision & Administration	$7,536,260	-	-	-	-	-	2,637,691.00	2,637,691.00	2,260,878.00	-	-	
	FULLY FUNDED		$0	$0	$0	$0	$0	$3,156,858	$3,238,971	$2,848,437	$0	$0	$9,244,266
	Contingency	$753,630	$0	$0	$0	$0	$0	$263,771	$263,771	$226,089	$0	$0	
	FULLY FUNDED		$0	$0	$0	$0	$0	$315,688	$323,899	$284,845	$0	$0	$924,432
	OMB FACTOR	478.95	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	1008.25	1034.46	
30A.-.	E&D (for future culvert system)	$2,592,510	388,876.50	388,876.50	388,876.50	388,876.50	388,876.50	-	-	-	648,127.50	-	
	FULLY FUNDED		$409,362	$420,006	$430,927	$442,131	$453,628	$0	$0	$0	$1,364,390	$0	$3,520,444
	Contingency	$259,250	$38,888	$38,888	$38,888	$38,888	$38,888	$0	$0	$0	$64,813	$0	
	FULLY FUNDED		$40,937	$42,001	$43,093	$44,214	$45,363	$0	$0	$0	$136,440	$0	$352,048
	OMB FACTOR	478.95	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	1008.25	1034.46	
31A.-.	S&A (for future culvert system)	$1,296,250	-	-	-	-	-	-	-	-	648,125.00	648,125.00	
	FULLY FUNDED		$0	$0	$0	$0	$0	$0	$0	$0	$1,364,385	$1,399,853	$2,764,238
	Contingency	$129,630	$0	$0	$0	$0	$0	$0	$0	$0	$64,815	$64,815	
	FULLY FUNDED		$0	$0	$0	$0	$0	$0	$0	$0	$136,444	$139,991	$276,435
	OMB FACTOR	478.95	504.18	517.29	530.74	544.54	558.70	573.22	588.13	603.42	1008.25	1034.46	
64.-.	Phased Filling & Emptying System	$17,283,370	-	-	-	-	-	-	-	-	10,346,069.00	6,720,851.00	
	FULLY FUNDED		$0	$0	$0	$0	$0	$0	$0	$0	$21,779,777	$14,516,028	$36,295,805
	Contingency	$4,339,430	$0	$0	$0	$0	$0	$0	$0	$0	$2,597,644	$1,687,441	
	FULLY FUNDED		$0	$0	$0	$0	$0	$0	$0	$0	$5,468,367	$3,644,619	$9,112,986
	TOTAL PROJECT COST	$173,515,000	$3,940,930	$4,043,403	$4,148,536	$4,256,403	$13,032,446	$61,600,639	$62,844,953	$26,401,653	$30,249,803	$19,700,491	$230,219,257

Table 35 Plan 4 - Fully Funded Estimate

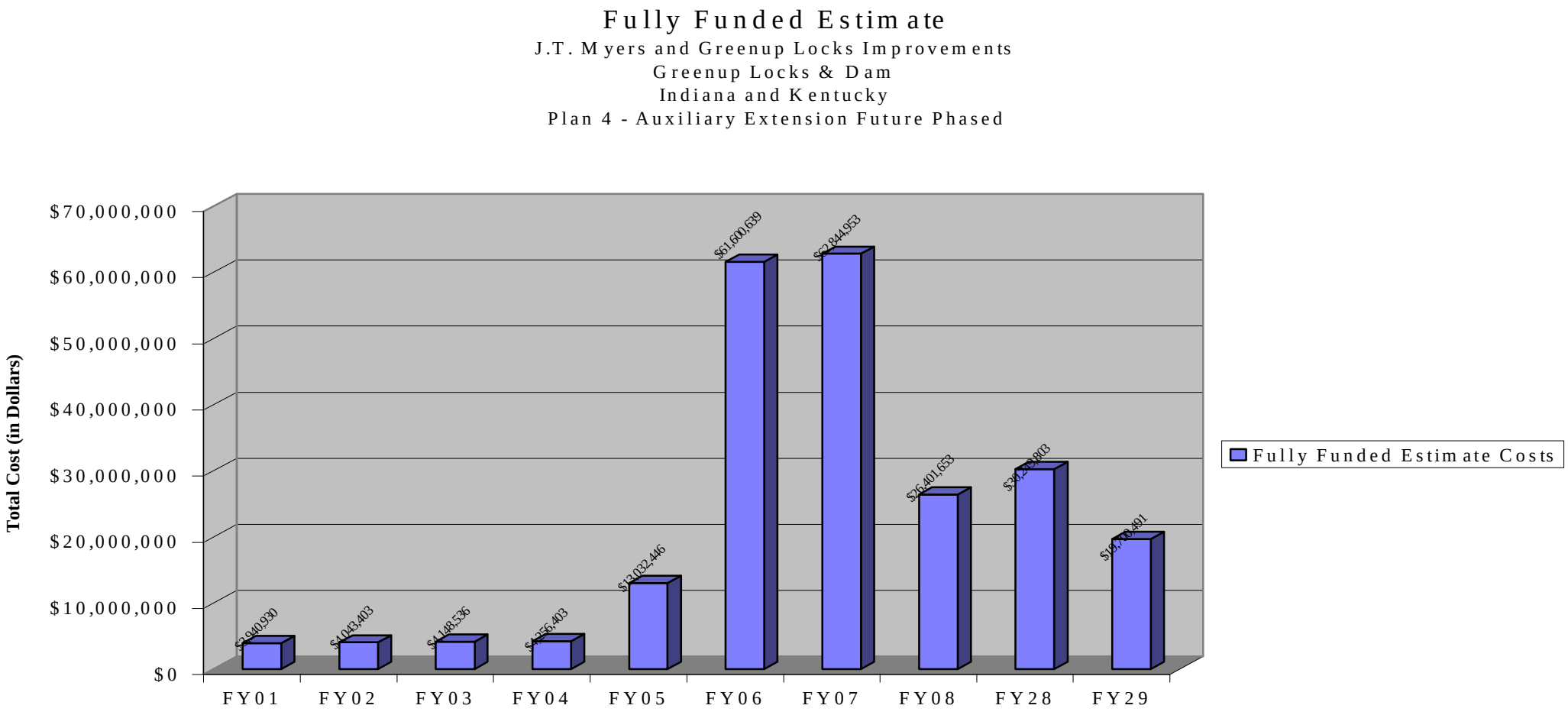


Table 36 Plan 1 Auxiliary Extension Summary Cost

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON, WV					
BASELINE ESTIMATE (M-CACES) FOR					
GREENUP LOCK & DAM 600' PLAN 1 AUX. LOCK EXTENSION /CAPABLE, KY					
PROJECT SUMMARY COST					
ACCOUNT	ACCOUNT	ESTIMATED	CONTINGENCY		1-Oct-99
NUMBER	NAME	COST	(%)	AMOUNT	COST
		---	---	---	---
01.-.-.-	LANDS AND DAMAGES	$0	0%		$0
02.-.-.-	RELOCATIONS	$500,000	20%	$100,000	$600,000
05.-.-.-	LOCKS	$92,392,140	23%	$20,794,790	$113,187,000
06.-.-.-	FISH & WILDLIFE FACILITIES	$3,000,000	20%	$600,000	$3,600,000
19.-.-.-	BUILDINGS, GROUNDS, & UTILITIES	$521,070	22%	$112,440	$634,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN (15%)	$14,461,982	10%	$1,446,198	$15,908,000
31.-.-.-	CONSTRUCTION MANAGEMENT (7.5%)	$7,230,991	10%	$723,099	$7,954,000
	TOTAL PROJECT COSTS:	$118,106,182	20%	$23,776,527	**$141,883,000**

23.4 PLAN 1 – AUXILIARY EXTENSION 2ND VIEW BACKUP

QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
02 Relocation						
02. 02 Relocation						
02. 02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
05 Locks						
05. 01 Mob, Demob & Preparatory Work						
05. 01. 10 MOB.& DEMOB.AND PREP. WORK	1.00	JOB	912,880	91,290	10.0%	1,004,170	1004172
05. 01. 20 SIGNS	1.00	JOB	4,430	890	20.0%	5,320	5315.71
05. 01 Mob, Demob & Preparatory Work	1.00	JOB	917,310	92,170	10.0%	1,009,490	1009488
05. 02 Drainage						
05. 02. 10 Concrete Lined Ditch	160.00	LF	13,790	4,140	30.0%	17,920	112.02
05. 02. 50 Catch Basins 4' Depth	1.00	EA	0	0	%	0	
05. 02. 60 15" RCP	80.00	LF	5,240	1,570	30.0%	6,810	85.16
05. 02. 70 15" Headwalls	2.00	EA	1,100	330	30.0%	1,430	715.86
05. 02 Drainage	1.00	JOB	20,130	6,040	30.0%	26,170	26167.03
05. 03 Care and Diversion of Water						
05. 03. 90 Channel & SSP Lining	14000.00	CY	2,363,600	709,080	30.0%	3,072,680	219.48
05. 03.100 Cut-off Wall PS 27.5	14204.00	LF	401,120	120,340	30.0%	521,450	36.71
05. 03 Care and Diversion of Water	1.00	JOB	2,764,720	829,420	30.0%	3,594,140	3594135
05. 04 Permanent Access Roads & Parking						
05. 04.000 <<< Not Identified >>>	14204.00	LF	0	0	%	0	
05. 04 Permanent Access Roads & Parking	1.00	JOB	0	0	%	0	
05. 10 Earthwork for Structures						
05. 10.240 Strip & Stockpile Topsoil	21000.00	CY	27,870	8,360	30.0%	36,230	1.73
05. 10.242 Clearing and Grubbing	19.00	ACR	35,580	10,680	30.0%	46,260	2434.86
05. 10.250 Replace Topsoil from Stockpile	21000.00	CY	22,290	6,690	30.0%	28,980	1.38
05. 10.260 Haul Roads 12" Aggregate	6000.00	SY	82,210	24,660	30.0%	106,870	17.81
05. 10 Earthwork for Structures	1.00	JOB	167,960	50,390	30.0%	218,350	218346.33
05. 11 Foundation Work						
05. 11.330 Drilling Weep Holes	6100.00	LF	36,860	11,060	30.0%	47,920	7.86
05. 11.340 Preliminary Cleanup	4000.00	SY	25,440	7,630	30.0%	33,070	8.27
05. 11.350 Final Found.Cleanup	4000.00	SY	21,200	6,360	30.0%	27,560	6.89
05. 11 Foundation Work	1.00	JOB	83,490	25,050	30.0%	108,540	108537.38

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 18 Utilities, Lines, & Services							
05. 18.360 Fuel Storage & Dispen. System	1.00	JOB	32,020	6,400	20.0%	38,420	38420.29
05. 18.370 Hydraulic System	1.00	JOB	774,900	154,980	20.0%	929,880	929877.46
05. 18 Utilities, Lines, & Services	1.00	JOB	806,910	161,380	20.0%	968,300	968297.75
05. 22 Temporary Service Roads							
05. 22.380 Aggregate Road 12"Depth	3574.00	SY	50,330	10,070	20.0%	60,400	16.90
05. 22.390 Aggregate Path 8"Depth	1320.00	SY	13,110	2,620	20.0%	15,730	11.92
05. 22 Temporary Service Roads	1.00	JOB	63,440	12,690	20.0%	76,130	76129.00
05. 24 Buildings, Residences, etc.							
05. 24.400 Resident Engineer Office	1.00	EA	362,640	72,530	20.0%	435,170	435172.72
05. 24.410 Concrete Steps W/O Railing	100.00	LF	13,460	2,690	20.0%	16,160	161.57
05. 24 Buildings, Residences, etc.	1.00	JOB	376,110	75,220	20.0%	451,330	451329.57
05. 41 Gates,Stoplogs,& Ass.Equipmen							
05. 41.430 Mitergates Emb.Metal.	2.00	EA	960,050	192,010	20.0%	1,152,060	576030.00
05. 41.431 Removal of Mitergates and Reset	2.00	EA	46,310	9,260	20.0%	55,580	27787.78
05. 41.432 Construct New Assembly Pier	1.00	JOB	1,343,850	537,540	40.0%	1,881,400	1881396
05. 41 Gates,Stoplogs,& Ass.Equipmen	1.00	JOB	2,350,220	738,810	31.4%	3,089,030	3089031
05. 57 Lock Gate Embed Metals							
05. 57.440 DS Miter Gate	1.00	JOB	2,954,000	1,033,900	35.0%	3,987,900	3987900
05. 57 Lock Gate Embed Metals	1.00	JOB	2,954,000	1,033,900	35.0%	3,987,900	3987900
05. 61 Guide-Guard Walls, Upper & Lower							
05. 61.450 US Middle Floating Wall (UMW)	1300.00	LF	10,088,210	2,017,640	20.0%	12,105,850	9312.19
05. 61.460 US River Floating Wall (URW)	1297.00	LF	9,844,030	1,968,810	20.0%	11,812,840	9107.82
05. 61.470 DS LL Floating Wall (LLW)	1136.00	LF	8,507,850	1,701,570	20.0%	10,209,420	8987.17
05. 61.475 DS Guidewall Floating Wall (LRW)	249.00	LF	2,430,390	486,080	20.0%	2,916,470	11712.72
05. 61.480 Nose Piers	4.00	EA	13,989,130	2,797,830	20.0%	16,786,950	4196738
05. 61.490 Pylons	2.00	EA	1,702,590	340,520	20.0%	2,043,110	1021557
05. 61 Guide-Guard Walls, Upper & Lower	3982.00	LF	46,562,200	9,312,440	20.0%	55,874,640	14031.80
05. 62 Demo,Lock walls Up & Dn Stream							
05. 62.480 Exca. Wet Earth & Haul	20530.00	CY	327,170	98,150	30.0%	425,330	20.72
05. 62.490 Remove Existing Monolith L1	3500.00	CY	455,420	136,620	30.0%	592,040	169.51
05. 62.500 Remove Existing Monolith L2	2950.00	CY	0	0	%	0	
05. 62.510 Remove Existing Monolith L3	2900.00	CY	0	0	%	0	
05. 62.520 Remove Existing Monolith L4	3050.00	CY	0	0	%	0	
05. 62.530 Remove Existing Monolith L5	3600.00	CY	0	0	%	0	
05. 62.540 Downstream Steel & Wall Armor	1.00	JOB	16,770	5,030	30.0%	21,790	21794.53
05. 62.550 H-Beam Piles Upstream	319.00	EA	147,600	44,280	30.0%	191,880	601.52
05. 62.560 Remove Existing Monolith L29-L37	11505.00	CY	1,180,170	354,050	30.0%	1,534,220	133.35
05. 62.570 Upstream Steel & Wall Armor	1.00	JOB	33,530	10,060	30.0%	43,590	43589.05
05. 62 Demo,Lock walls Up & Dn Stream	1.00	JOB	2,160,660	648,200	30.0%	2,808,860	2808856

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 63 Lock Structure							
05. 63.590 Floating Mooring Bitt	4.00	EA	599,400	119,880	20.0%	719,280	179820.56
05. 63.600 Rock Excavation for Laterals	13000.00	CY	0	0	%	0	
05. 63.610 Ladders Rung, Machinery Reces.	775.00	LB	6,830	1,370	20.0%	8,190	10.57
05. 63.620 Grab Bars	44.00	EA	4,940	990	20.0%	5,930	134.77
05. 63.630 Ladders Safety Cages Material	92.00	LF	7,210	1,440	20.0%	8,650	94.07
05. 63.640 Ladders Safety Devices	4.00	EA	6,750	1,350	20.0%	8,100	2025.71
05. 63.650 Sump Well Gratings and Frames	5.00	EA	5,860	1,170	20.0%	7,030	1406.37
05. 63.660 Sump Pump Disch. Cover & Frame	1.00	EA	1,220	240	20.0%	1,460	1458.15
05. 63.670 Drain Cover and Frame	1.00	EA	960	190	20.0%	1,150	1154.96
05. 63.680 Pipe Trench Cover & Frame	4000.00	SF	155,680	31,140	20.0%	186,810	46.70
05. 63.700 Aluminum Grating	1.00	JOB	307,170	61,430	20.0%	368,600	368599.81
05. 63.710 Steel, Castings, Corner Caps	2100.00	LB	47,340	9,470	20.0%	56,810	27.05
05. 63.720 Steel, Ladders Lock Walls	550.00	LF	30,350	6,070	20.0%	36,420	66.21
05. 63.800 Steel Gages	2.00	EA	8,260	1,650	20.0%	9,910	4953.45
05. 63.860 Concrete in Lock Floor Paving	1225.00	CY	298,100	89,430	30.0%	387,530	316.35
05. 63.861 Concrete in Laterals,	4302.00	CY	921,820	276,550	30.0%	1,198,370	278.56
05. 63.862 CIP Concrete in Sills	6700.00	CY	1,417,550	425,270	30.0%	1,842,820	275.05
05. 63.863 Tremie Concrete in Sills	1100.00	CY	102,890	30,870	30.0%	133,760	121.60
05. 63.864 Precast Concrete in Sills	200.00	CY	47,210	14,160	30.0%	61,370	306.86
05. 63.865 Tunnel and Slab Precast Concrete	173.00	CY	95,190	28,560	30.0%	123,750	715.31
05. 63.895 Line Hooks	20.00	EA	22,450	4,490	20.0%	26,950	1347.28
05. 63.900 Check Posts	2.00	EA	3,310	660	20.0%	3,970	1983.71
05. 63.905 Steel, Ladders Lock Walls	1.00	EA	27,790	5,550	20.0%	33,340	33342.55
05. 63.910 Corner Armor	643.00	LF	43,330	8,670	20.0%	52,000	80.87
05. 63.915 Wall Armor	2090.00	LF	153,000	30,600	20.0%	183,600	87.85
05. 63.934 Monoliths L1-L5 & M1, Lift-In	93150.00	CY	15,297,120	3,059,420	20.0%	18,356,540	197.06
05. 63 Lock Structure	1.00	JOB	19,611,720	4,210,620	21.5%	23,822,340	23822338
05. 64 Filling and Emptying System							
05. 64.101 Shoring for excavation	11200.00	SF	0	0	%	0	
05. 64.102 US Cut-Off Wall	12670.00	SF	0	0	%	0	
05. 64.271 Exca. Dry Earth & Haul	350000.00	CY	0	0	%	0	
05. 64.291 Culvert, Rock Exc	8000.00	CY	0	0	%	0	
05. 64.690 Screens and Nose Plates at	1.00	JOB	0	0	%	0	
05. 64.777 Special Construction for Outlet-	1.00	JOB	1,076,510	481,350	44.7%	1,557,860	1557863
05. 64.841 Concrete CIP - Bypass Culvert	6850.00	CY	0	0	%	0	
05. 64.842 Concrete Thrust Block Culvert	2000.00	CY	0	0	%	0	
05. 64.843 Concrete Outlet Culvert	2850.00	CY	1,336,960	267,390	20.0%	1,604,350	562.93
05. 64.844 Wells for Dewatering	520.00	EA	0	0	%	0	
05. 64.845 Ice & Debris Floating Boom	1.00	EA	0	0	%	0	
05. 64.935 Drilled Caissons for Wingwall	9.00	EA	0	0	%	0	
05. 64.960 Sealing Diaphragms and Embedded	2.00	EA	51,720	15,520	30.0%	67,240	33619.81
05. 64.965 Tainer Val.Oper.Mach&Emb.Metal	2.00	EA	731,250	219,370	30.0%	950,620	475309.88
05. 64 Filling and Emptying System	1.00	JOB	3,196,440	983,630	30.8%	4,180,070	4180073

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 66 Power and Lighting Systems							
05. 66.970 Electrical Work	1.00	JOB	0	0	%	0	
05. 66 Power and Lighting Systems	1.00	JOB	0	0	%	0	
05. 68 Compressed Air System							
05. 68.985 Compressed Air Piping System	1.00	JOB	198,020	59,410	30.0%	257,430	257429.78
05. 68 Compressed Air System	1.00	JOB	198,020	59,410	30.0%	257,430	257429.78
05. 76 Pumping Machinery & Appurten.							
05. 76.990 Extension Raw Water Pump & Pipe	1.00	JOB	32,490	9,750	30.0%	42,240	42235.62
05. 76.991 Raw Water Piping	1.00	JOB	110,840	33,250	30.0%	144,090	144086.52
05. 76 Pumping Machinery & Appurten.	1.00	LS	143,320	43,000	30.0%	186,320	186322.14
05. 99 Associated General Items							
05. 99.993 Truck 4x4, 9 Passenger C.D.	1.00	EA	29,110	1,460	5.0%	30,570	30566.99
05. 99.994 Instrumentation	1.00	JOB	967,250	48,360	5.0%	1,015,610	1015612
05. 99.995 Truck 4x4, 3/4 Ton, 8800GVW Op.D	1.00	EA	28,130	1,410	5.0%	29,540	29540.78
05. 99.996 Truck 2x4 Shortbed C.D.	2.00	EA	52,360	2,620	5.0%	54,980	27489.18
05. 99.997 Truck 4x4 Longbed C.D.	1.00	EA	24,470	1,220	5.0%	25,690	2569247
05. 99.99A Fit-Out Area	1.00	JOB	864,350	339,290	39.3%	1,203,640	1203636
05. 99.99B Dry Dock @ RCB	1.00	JOB	6,000,000	1,500,000	25.0%	7,500,000	7500000
05. 99.99C Silt Fence (Erosion& Sediment)	10000.00	LF	123,470	30,870	25.0%	154,340	15.43
05. 99.99D Straw Bales (Dike and Ditch)	660.00	EA	8,250	2,060	25.0%	10,310	15.62
05. 99.99E Mudboards 25'Width x 20'Long	2.00	EA	9,200	2,300	25.0%	11,500	5752.22
05. 99.99F Temporary Seeding(Erosion &Sed.)	50.00	ACR	103,600	25,900	25.0%	129,500	2589.91
05. 99.99G Permanent Seeding	50.00	ACR	111,890	27,970	25.0%	139,870	2797.35
05. 99.99H Environmental Protection	1.00	JOB	346,690	86,670	25.0%	433,360	433356.33
05. 99.99I Janitorial Services	1.00	JOB	137,810	34,450	25.0%	172,260	172260.59
05. 99.99J As-Built Drawing	1.00	JOB	104,740	26,190	25.0%	130,930	130930.48
05. 99.99K Helper Boats	3.30	MO	400,000	100,000	25.0%	500,000	151515.15
05. 99.99M Harbor Area Items	1.00	JOB	704,160	281,660	400%	985,820	985823.61
05. 99 Associated General Items	1.00	JOB	10,015,490	2,512,430	25.1%	12,527,910	12527915
05 Locks	1.00	JOB	92,392,140	20,794,70	0 22.5%	113,186,940	113186936
06 Fish & Wildlife							
06. 06 Fish & Wildlife							
06. 06. 06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
06. 06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
19 Buildings, Grounds, & Utilities							
19. 18 UTILITIES, LINES and SERVICES							
19. 18.99I 2"D. PVC Water Line ++	1000.00	LF	10,050	2,010	20.0%	12,060	12.06
19. 18.99J 4"D. PVC Sewer Line ++	200.00	LF	2,410	48	20.0%	2,890	14.44
19. 18.99K Lighting ++	2.00	EA	5,220	1,040	20.0%	6,270	3134.99
19. 18 UTILITIES, LINES and SERVICES	1.00	JOB	17,680	3,540	20.0%	21,220	21220.74

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
19. 22 PARKING LOTS AND SERVICE ROADS							
19. 22.000 <<< Not Identified >>>	1828.00	SY	0	0	%	0	
19. 22.100 Aggregate Road 12"Depth	18000.00	SY	228,900	45,780	20.0%	274,680	15.26
19. 22.99L Crush Aggregate 4"Depth Cl I ++	216.00	CY	8,320	1,660	20.0%	9,990	46.24
19. 22.99M #57 Aggregate Base 4"Depth ++	216.00	CY	8,450	1,690	20.0%	10,140	46.95
19. 22.99N Bituminous Prime Coat ++	500.00	GAL	1,090	220	20.0%	1,300	2.61
19. 22.99O 2"Bitum. Concrete Base Course ++	200.00	TON	11,590	2,320	20.0%	13,910	69.53
19. 22.99P 1"Bitum.Concrete Wearing Course+	100.00	TON	6,430	1,290	20.0%	7,710	77.14
19. 22.99Q 6"D.PVC Pref. Pipe Underdrain ++	650.00	LF	13,530	2,710	20.0%	16,240	24.98
19. 22.99R Filter Fabric ++	2000.00	SY	7,880	1,580	20.0%	9,460	4.73
19. 22.99S Exca.& Haul Road & Parkinglot ++	2000.00	CY	8,430	1,690	20.0%	10,120	5.06
19. 22.99T Disposal Exca. Material ++	2545.40	CY	2,630	530	20.0%	3,150	1.24
19. 22.99U Prepare Subbase	1828.00	SY	34,810	6,960	20.0%	41,770	22.85
19. 22 PARKING LOTS AND SERVICE ROADS	1.00	JOB	332,060	66,410	20.0%	398,470	398467.22
19. 23 FENCE							
19. 23.99U Farm Fence 4'High, 3 Strand ++	9850.00	LF	63,420	19,030	30.0%	82,440	8.37
19. 23 FENCE	1.00	JOB	63,420	19,030	30.0%	82,440	82442.21
19. 27 BUILDINGS, PUBLIC USE							
19. 27.99V Picnic Shelter 25'X40' ++	6.00	EA	18,800	5,640	30.0%	24,440	4073.71
19. 27 BUILDINGS, PUBLIC USE	1.00	JOB	18,800	5,640	30.0%	24,440	24442.26
19. 72 DAY USE AREA							
19. 72.90A Tot Lot ++	1.00	EA	22,960	4,590	20.0%	27,550	27549.26
19. 72.90B Asphalt Paving ++	400.00	SY	7,520	1,500	20.0%	9,020	22.56
19. 72.90C Flag Pole ++	1.00	EA	12,530	2,510	20.0%	15,040	15041.39
19. 72.90D Concrete Picnic Table & Seat 7'L	12.00	EA	19,560	3,910	20.0%	23,470	1955.67
19. 72.90E Pine Picnic Table & Seat 8'L ++	30.00	EA	16,930	3,390	20.0%	20,320	677.30
19. 72.90F Raised Castiron Picnic Grill ++	15.00	EA	6,600	1,320	20.0%	7,920	527.77
19. 72.90G Waste Receptacle ++	20.00	EA	3,010	600	20.0%	3,610	180.61
19. 72 DAY USE AREA	1.00	JOB	89,110	17,820	20.0%	106,930	106931.46
19 Buildings, Grounds, & Utilities	1.00	JOB	521,070	112,440	21.6%	633,500	633503.89
30 Engineering & Design							
30. 30 Engineering & Design							
30. 30. 30 Engineering & Design	1.00	JOB	14,461,980	1,446,200	10.0%	15,908,180	15908180
30. 30 Engineering & Design	1.00	JOB	14,461,980	1,446,200	10.0%	15,908,180	15908180
30 Engineering & Design	1.00	JOB	14,461,980	1,446,200	10.0%	15,908,180	15908180
31 S&A							
31. 31 S&A							
31. 31. 31 S&A	1.00	JOB	7,230,990	723,100	10.0%	7,954,090	7954090
31. 31 S&A	1.00	JOB	7,230,990	723,100	10.0%	7,954,090	7954090
31 S&A	1.00	JOB	7,230,990	723,100	10.0%	7,954,090	7954090
Plan 1 Aux. Lock Ext	1.00	EA	118,106,180	23,776,530	20.1%	141,882,710	141882710

Table 37 Plan 2 Auxiliary Extension W/Modifications Summary Cost

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON, WV					
BASELINE ESTIMATE (M-CACES) FOR					
GREENUP LOCK & DAM 600' PLAN 2 AUX. LOCK EXTENSION /MODIFICATIONS, KY					
PROJECT SUMMARY COST					
ACCOUNT	**ACCOUNT**	**ESTIMATED**		**CONTINGENCY**	**1-Oct-99**
NUMBER	**NAME**	**COST**	**(%)**	**AMOUNT**	**COST**
		---	---	---	---
01.-.-.-	LANDS AND DAMAGES	$0	0%		$0
02.-.-.-	RELOCATIONS	$500,000	20%	$100,000	$600,000
05.-.-.-	LOCKS	$97,675,230	22%	$21,761,690	$119,437,000
06.-.-.-	FISH & WILDLIFE FACILITIES	$3,000,000	20%	$600,000	$3,600,000
19.-.-.-	BUILDINGS, GROUNDS, & UTILITIES	$521,070	22%	$112,440	$634,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN (15%)	$15,254,445	10%	$1,525,445	$16,780,000
31.-.-.-	CONSTRUCTION MANAGEMENT (7.5%)	$7,627,223	10%	$762,722	$8,390,000
	TOTAL PROJECT COSTS:	$124,577,968	20%	$24,862,297	**$149,441,000**

23.5 PLAN 2 – AUXILIARY EXTENSION W/MODIFICATIONS 2ND VIEW BACKUP

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
02 Relocation							
02. 02 Relocation							
02. 02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
05 Locks							
05. 01 Mob, Demob & Preparatory Work							
05. 01. 10 MOB.& DEMOB.AND PREP. WORK	1.00	JOB	907,020	90,700	10.0%	997,720	997718.18
05. 01. 20 SIGNS	1.00	JOB	4,430	890	20.0%	5,320	5315.71
05. 01 Mob, Demob & Preparatory Work	1.00	JOB	911,450	91,590	10.0%	1,003,030	1003034
05. 02 Drainage							
05. 02. 10 Concrete Lined Ditch	160.00	LF	13,790	4,140	30.0%	17,920	112.02
05. 02. 50 Catch Basins 4' Depth	1.00	EA	0	0	%	0	
05. 02. 60 15" RCP	80.00	LF	5,240	1,570	30.0%	6,810	85.16
05. 02. 70 15" Headwalls	2.00	EA	1,100	330	30.0%	1,430	715.86
05. 02 Drainage	1.00	JOB	20,130	6,040	30.0%	26,170	26167.03
05. 03 Care and Diversion of Water							
05. 03. 90 Channel & SSP Lining	14000.00	CY	2,363,600	709,080	30.0%	3,072,680	219.48
05. 03.100 Cut-off Wall PS 27.5	14204.00	LF	401,120	120,340	300%	521,450	36.71
05. 03 Care and Diversion of Water	1.00	JOB	2,764,720	829,420	30.0%	3,594,140	3594135
05. 04 Permanent Access Roads & Parking							
05. 04.000 <<< Not Identified >>>	14204.00	LF	0	0	%	0	
05. 04 Permanent Access Roads & Parking	1.00	JOB	0	0	%	0	
05. 10 Earthwork for Structures							
05. 10.240 Strip & Stockpile Topsoil	21000.00	CY	27,870	8,360	30.0%	36,230	1.73
05. 10.242 Clearing and Grubbing	19.00	ACR	35,590	10,680	30.0%	46,260	2434.86
05. 10.250 Replace Topsoil from Stockpile	21000.00	CY	22,290	6,690	30.0%	28,980	1.38
05. 10.260 Haul Roads 12" Aggregate	6000.00	SY	82,210	24,660	30.0%	106,870	17.81
05. 10 Earthwork for Structures	1.00	JOB	167,960	50,390	30.0%	218,350	218346.33
05. 11 Foundation Work							
05. 11.330 Drilling Weep Holes	6100.00	LF	36,860	11,060	30.0%	47,920	7.86
05. 11.340 Preliminary Cleanup	4000.00	SY	25,440	7,630	30.0%	33,070	8.27
05. 11.350 Final Found.Cleanup	4000.00	SY	21,200	6,360	30.0%	27,560	6.89
05. 11 Foundation Work	1.00	JOB	83,490	25,050	30.0%	108,540	108537.38

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 18 Utilities, Lines, & Services							
05. 18.360 Fuel Storage & Dispen. System	1.00	JOB	32,020	6,400	20.0%	38,420	38420.29
05. 18.370 Hydraulic System	1.00	JOB	774,900	154,980	20.0%	929,880	929877.46
05. 18 Utilities, Lines, & Services	1.00	JOB	806,910	161,380	20.0%	968,300	968297.75
05. 22 Temporary Service Roads							
05. 22.380 Aggregate Road 12"Depth	3574.00	SY	50,330	10,070	20.0%	60,400	16.90
05. 22.390 Aggregate Path 8"Depth	1320.00	SY	13,110	2,620	20.0%	15,730	11.92
05. 22 Temporary Service Roads	1.00	JOB	63,440	12,690	20.0%	76,130	76129.00
05. 24 Buildings, Residences, etc.							
05. 24.400 Resident Engineer Office	1.00	EA	362,640	72,530	20.0%	435,170	435172.72
05. 24.410 Concrete Steps W/O Railing	100.00	LF	13,460	2,690	20.0%	16,160	161.57
05. 24 Buildings, Residences, etc.	1.00	JOB	376,110	75,220	20.0%	451,330	451329.57
05. 41 Gates,Stoplogs,& Ass.Equipmen							
05. 41.430 Mitergates Emb.Metal.	2.00	EA	960,050	192,010	20.0%	1,152,060	576030.00
05. 41.431 Removal of Mitergates and Reset	2.00	EA	46,310	9,260	20.0%	55,580	27787.78
05. 41.432 Construct New Assembly Pier	1.00	JOB	1,343,850	537,540	40.0%	1,881,400	1881396
05. 41 Gates,Stoplogs,& Ass.Equipmen	1.00	JOB	2,350,220	738,810	31.4%	3,089,030	3089031
05. 57 Lock Gate Embed Metals							
05. 57.440 DS Miter Gate	1.00	JOB	2,954,000	1,033,900	35.0%	3,987,900	3987900
05. 57 Lock Gate Embed Metals	1.00	JOB	2,954,000	1,033,900	35.0%	3,987,900	3987900
05. 61 Guide-Guard Walls, Upper & Lower							
05. 61.450 US Middle Floating Wall (UMW)	1300.00	LF	10,088,210	2,017,640	20.0%	12,105,850	9312.19
05. 61.460 US River Floating Wall (URW)	1297.00	LF	9,844,030	1,968,810	20.0%	11,812,840	9107.82
05. 61.470 DS LL Floating Wall (LLW)	1136.00	LF	8,507,850	1,701,570	20.0%	10,209,420	8987.17
05. 61.475 DS Guidewall Floating Wall (LRW)	249.00	LF	2,430,390	486,080	20.0%	2,916,470	11712.72
05. 61.480 Nose Piers	4.00	EA	13,989,130	2,797,830	20.0%	16,786,950	4196738
05. 61.490 Pylons	2.00	EA	1,702,590	340,520	20.0%	2,043,110	1021557
05. 61 Guide-Guard Walls, Upper & Lower	3982.00	LF	46,562,200	9,312,440	20.0%	55,874,640	14031.80
05. 62 Demo,Lock walls Up & Dn Stream							
05. 62.480 Exca. Wet Earth & Haul	20530.00	CY	327,170	98,150	30.0%	425,330	20.72
05. 62.490 Remove Existing Monolith L1	3500.00	CY	455,420	136,620	30.0%	592,040	169.15
05. 62.500 Remove Existing Monolith L2	2950.00	CY	292,990	87,900	30.0%	380,890	129.12
05. 62.510 Remove Existing Monolith L3	2900.00	CY	288,030	86,410	30.0%	374,430	129.12
05. 62.520 Remove Existing Monolith L4	3050.00	CY	302,920	90,880	30.0%	393,800	129.12
05. 62.530 Remove Existing Monolith L5	3600.00	CY	357,550	107,270	30.0%	464,820	129.12
05. 62.540 Downstream Steel & Wall Armor	1.00	JOB	16,770	5,030	30.0%	21,790	21794.53
05. 62.550 H-Beam Piles Upstream	319.00	EA	147,600	44,280	30.0%	191,880	601.52
05. 62.560 Remove Existing Monolith L29-L37	11505.00	CY	0	0	%	0	
05. 62.570 Upstream Steel & Wall Armor	1.00	JOB	33,530	10,060	30.0%	43,590	43589.05
05. 62 Demo,Lock walls Up & Dn Stream	1.00	JOB	2,221,980	666,590	30.0%	2,888,570	2888575

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 63 Lock Structure							
05. 63.590 Floating Mooring Bitt	4.00	EA	599,400	119,880	20.0%	719,280	179820.56
05. 63.600 Rock Excavation for Laterals	13000.00	CY	274,210	82,260	30.0%	356,480	27.42
05. 63.610 Ladders Rung, Machinery Reces.	775.00	LB	6,830	1,370	20.0%	8,190	10.57
05. 63.620 Grab Bars	44.00	EA	4,940	990	20.0%	5,930	134.77
05. 63.630 Ladders Safety Cages Material	92.00	LF	7,210	1,440	20.0%	8,650	94.07
05. 63.640 Ladders Safety Devices	4.00	EA	6,750	1,350	20.0%	8,100	2025.71
05. 63.650 Sump Well Gratings and Frames	5.00	EA	5,860	1,170	20.0%	7,030	1406.37
05. 63.660 Sump Pump Disch. Cover & Frame	1.00	EA	1,220	240	20.0%	1,460	1458.15
05. 63.670 Drain Cover and Frame	1.00	EA	960	190	20.0%	1,150	1154.96
05. 63.680 Pipe Trench Cover & Frame	4000.00	SF	155,680	31,140	20.0%	186,810	46.70
05. 63.700 Aluminum Grating	1.00	JOB	307,170	61,430	20.0%	368,600	368599.81
05. 63.710 Steel, Castings, Corner Caps	2100.00	LB	47,340	9,470	20.0%	56,810	27.05
05. 63.720 Steel, Ladders Lock Walls	550.00	LF	30,350	6,070	20.0%	36,420	66.21
05. 63.800 Steel Gages	2.00	EA	8,260	1,650	20.0%	9,910	4953.45
05. 63.860 Concrete in Lock Floor Paving	1225.00	CY	298,100	89,430	30.0%	387,530	316.35
05. 63.861 Concrete in Laterals,	4302.00	CY	921,820	276,550	30.0%	1,198,370	278.56
05. 63.862 CIP Concrete in Sills	6700.00	CY	1,417,550	425,270	30.0%	1,842,820	275.05
05. 63.863 Tremie Concrete in Sills	1100.00	CY	102,890	30,870	30.0%	133,760	121.60
05. 63.864 Precast Concrete in Sills	200.00	CY	47,210	14,160	30.0%	61,370	306.86
05. 63.865 Tunnel and Slab Precast Concrete	173.00	CY	95,190	28,560	30.0%	123,750	715.31
05. 63.895 Line Hooks	20.00	EA	22,450	4,490	20.0%	26,950	1347.28
05. 63.900 Check Posts	2.00	EA	3,310	660	20.0%	3,970	1983.71
05. 63.905 Steel, Ladders Lock Walls	1.00	EA	27,790	5,560	20.0%	33,340	33342.55
05. 63.910 Corner Armor	643.00	LF	43,330	8,670	20.0%	52,000	80.87
05. 63.915 Wall Armor	2090.00	LF	153,000	30,600	20.0%	183,600	87.85
05. 63.934 Monoliths L1-L5 & M1, Lift-In	93150.00	CY	20,785,010	4,157,000	20.0%	24,942,010	267.76
05. 63 Lock Structure	1.00	JOB	25,373,820	5,390,460	21.2%	30,764,290	30764286
05. 64 Filling and Emptying System							
05. 64.101 Shoring for excavation	11200.00	SF	0	0	%	0	
05. 64.102 US Cut-Off Wall	12670.00	SF	0	0	%	0	
05. 64.271 Exca. Dry Earth & Haul	350000.00	CY	0	0	%	0	
05. 64.291 Culvert, Rock Exc	8000.00	CY	169,690	50,910	30.0%	220,590	27.57
05. 64.690 Screens and Nose Plates at	1.00	JOB	0	0	%	0	
05. 64.777 Special Construction for Outlet-	1.00	JOB	1,076,510	481,350	44.7%	1,557,860	1557863
05. 64.841 Concrete CIP - Bypass Culvert	6850.00	CY	0	0	%	0	
05. 64.842 Concrete Thrust Block Culvert	2000.00	CY	0	0	%	0	
05. 64.843 Concrete Outlet Culvert	2850.00	CY	1,336,960	267,390	20.0%	1,604,350	562.93
05. 64.844 Wells for Dewatering	520.00	EA	0	0	%	0	
05. 64.845 Ice & Debris Floating Boom	1.00	EA	0	0	%	0	
05. 64.935 Drilled Caissons for Wingwall	9.00	EA	0	0	%	0	
05. 64.960 Sealing Diaphragms and Embedded	2.00	EA	51,720	15,520	30.0%	67,240	33619.81
05. 64.965 Tainer Val.Oper.Mach&Emb.Metal	2.00	EA	731,250	219,370	30.0%	950,620	475309.88
05. 64 Filling and Emptying System	1.00	JOB	3,366,130	1,034,540	30.7%	4,400,660	4400664
05. 66 Power and Lighting Systems							
05. 66.970 Electrical Work	1.00	JOB	0	0	%	0	
05. 66 Power and Lighting Systems	1.00	JOB	0	0	%	0	

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 68 Compressed Air System							
05. 68.985 Compressed Air Piping System	1.00	JOB	198,020	59,410	30.0%	257,430	257429.78
05. 68 Compressed Air System	1.00	JOB	198,020	59,410	30.0%	257,430	257429.78
05. 76 Pumping Machinery & Appurten.							
05. 76.990 Extension Raw Water Pump & Pipe	1.00	JOB	32,490	9,750	30.0%	42,240	42235.62
05. 76.991 Raw Water Piping	1.00	JOB	110,840	33,250	30.0%	144,090	144086.52
05. 76 Pumping Machinery & Appurten.	1.00	LS	143,320	43,000	30.0%	186,320	186322.14
05. 99 Associated General Items							
05. 99.993 Truck 4x4, 9 Passenger C.D.	1.00	EA	29,110	1,460	5.0%	30,570	30566.99
05. 99.994 Instrumentation	1.00	JOB	967,250	48,360	5.0%	1,015,610	1015612
05. 99.995 Truck 4x4, 3/4 Ton, 8800GVW Op.D	1.00	EA	28,130	1,410	5.0%	29,540	29540.78
05. 99.996 Truck 2x4 Shortbed C.D.	2.00	EA	52,360	2,620	5.0%	54,980	27489.18
05. 99.997 Truck 4x4 Longbed C.D.	1.00	EA	24,470	1,220	5.0%	25,690	25692.47
05. 99.99A Fit-Out Area	1.00	JOB	864,350	339,290	39.3%	1,203,640	1203636
05. 99.99B Dry Dock @ RCB	1.00	JOB	6,000,000	1,500,000	25.0%	7,500,000	7500000
05. 99.99C Silt Fence (Erosion& Sediment)	10000.00	LF	123,470	30,870	25.0%	154,340	15.43
05. 99.99D Straw Bales (Dike and Ditch)	660.00	EA	8,250	2,060	25.0%	10,310	15.62
05. 99.99E Mudboards 25'Width x 20'Long	2.00	EA	9,200	2,300	25.0%	11,500	5752.22
05. 99.99F Temporary Seeding(Erosion &Sed.)	50.00	ACR	103,600	25,900	25.0%	129,500	2589.91
05. 99.99G Permanent Seeding	50.00	ACR	111,890	27,970	25.0%	139,870	2797.35
05. 99.99H Environmental Protection	1.00	JOB	346,690	86,670	25.0%	433,360	433356.33
05. 99.99I Janitorial Services	1.00	JOB	137,810	34,450	25.0%	172,260	172260.59
05. 99.99J As-Built Drawing	1.00	JOB	104,740	26,190	25.0%	130,930	130930.48
05. 99.99K Helper Boats	3.30	MO	400,000	100,000	25.0%	500,000	151515.15
05. 99.99M Harbor Area Items	1.00	JOB	0	0	%	0	
05. 99 Associated General Items	1.00	JOB	9,311,330	2,230,770	24.0%	11,542,090	11542091
05 Locks	1.00	JOB	97,675,230	21,761,690	22.3%	119,436,920	119436917
06 Fish & Wildlife							
06. 06 Fish & Wildlife							
06. 06. 06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
06. 06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
19 Buildings, Grounds, & Utilities							
19. 18 UTILITIES, LINES and SERVICES							
19. 18.99I 2"D. PVC Water Line ++	1000.00	LF	10,050	2,010	20.0%	12,060	12.06
19. 18.99J 4"D. PVC Sewer Line ++	200.00	LF	2,410	480	20.0%	2,890	14.44
19. 18.99K Lighting ++	2.00	EA	5,220	1,040	20.0%	6,270	3134.99
19. 18 UTILITIES, LINES and SERVICES	1.00	JOB	17,680	3,540	20.0%	21,220	21220.74

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
19. 22 PARKING LOTS AND SERVICE ROADS							
19. 22.000 <<< Not Identified >>>	1828.00	SY	0	0	%	0	
19. 22.100 Aggregate Road 12"Depth	18000.00	SY	228,900	45,780	20.0%	274,680	15.26
19. 22.99L Crush Aggregate 4"Depth Cl I ++	216.00	CY	8,320	1,660	20.0%	9,990	46.24
19. 22.99M #57 Aggregate Base 4"Depth ++	216.00	CY	8,450	1,690	20.0%	10,140	46.95
19. 22.99N Bituminous Prime Coat ++	500.00	GAL	1,090	220	20.0%	1,300	2.61
19. 22.99O 2"Bitum. Concrete Base Course ++	200.00	TON	11,590	2,320	200%	13,910	69.53
19. 22.99P 1"Bitum.Concrete Wearing Course+	100.00	TON	6,430	1,290	20.0%	7,710	77.14
19. 22.99Q 6"D.PVC Pref. Pipe Underdrain ++	650.00	LF	13,530	2,710	20.0%	16,240	24.98
19. 22.99R Filter Fabric ++	2000.00	SY	7,880	1,580	20.0%	9,460	4.73
19. 22.99S Exca.& Haul Road & Parkinglot ++	2000.00	CY	8,430	1,690	20.0%	10,120	5.06
19. 22.99T Disposal Exca. Material ++	2545.40	CY	2,630	530	20.0%	3,150	1.24
19. 22.99U Prepare Subbase	1828.00	SY	34,810	6,960	20.0%	41,770	22.85
19. 22 PARKING LOTS AND SERVICE ROADS	1.00	JOB	332,060	66,410	20.0%	398,470	398467.22
19. 23 FENCE							
19. 23.99U Farm Fence 4'High, 3 Strand ++	9850.00	LF	63,420	19,030	30.0%	82,440	8.37
19. 23 FENCE	1.00	JOB	63,420	19,030	30.0%	82,440	82442.21
19. 27 BUILDINGS, PUBLIC USE							
19. 27.99V Picnic Shelter 25'X40' ++	6.00	EA	18,800	5,640	30.0%	24,440	4073.71
19. 27 BUILDINGS, PUBLIC USE	1.00	JOB	18,800	5,640	30.0%	24,440	24442.26
19. 72 DAY USE AREA							
19. 72.90A Tot Lot ++	1.00	EA	22,960	4,590	20.0%	27,550	27549.26
19. 72.90B Asphalt Paving ++	400.00	SY	7,520	1,500	20.0%	9,020	22.56
19. 72.90C Flag Pole ++	1.00	EA	12,530	2,510	20.0%	15,040	15041.39
19. 72.90D Concrete Picnic Table & Seat 7'L	12.00	EA	19,560	3,910	20.0%	23,470	1955.67
19. 72.90E Pine Picnic Table & Seat 8'L ++	30.00	EA	16,930	3,390	20.0%	20,320	677.30
19. 72.90F Raised Castiron Picnic Grill ++	15.00	EA	6,600	1,320	20.0%	7,920	527.77
19. 72.90G Waste Receptacle ++	20.00	EA	3,010	600	20.0%	3,610	180.61
19. 72 DAY USE AREA	1.00	JOB	89,110	17,820	20.0%	106,930	106931.64
19 Buildings, Grounds, & Utilities	1.00	JOB	521,070	112,440	21.6%	633,500	633503.89
30 Engineering & Design							
30. 30 Engineering & Design							
30. 30. 30 Engineering & Design	1.00	JOB	15,254,450	1,525,440	10.0%	16,779,890	16779890
30. 30 Engineering & Design	1.00	JOB	15,254,450	1,525,440	10.0%	16,779,890	16779890
30 Engineering & Design	1.00	JOB	15,254,450	1,525,440	10.0%	16,779,890	16779890
31 S&A							
31. 31 S&A							
31. 31. 31 S&A	1.00	JOB	7,627,220	762,720	10.0%	8,389,950	8389945
31. 31 S&A	1.00	JOB	7,627,220	762,720	10.0%	8,389,950	8389945
31 S&A	1.00	JOB	7,627,220	762,720	10.0%	8,389,950	8389945
Plan2 Aux.Lock Ext/Modifications	1.00	EA	124,577,970	24,862,290	20.0%	149,440,260	149440255

Table 38 Plan 3 Auxiliary Extension With Culvert Cost Summary

BASELINE ESTIMATE (M-CACES) FOR
GREENUP LOCK & DAM 600' PLAN 3 AUX. LOCK EXTENSION / WITH CULVERTS, KY
PROJECT SUMMARY COST

ACCOUNT NUMBER	ACCOUNT NAME	ESTIMATED COST	(%)	CONTINGENCY AMOUNT	1-Oct-99 COST
		-	-	-	-
01.-.-.-	LANDS AND DAMAGES	$0	0%		$0
02.-.-.-	RELOCATIONS	$500,000	20%	$100,000	$600,000
05.-.-.-	LOCKS	$119,582,240	16%	$19,147,730	$138,730,000
06.-.-.-	FISH & WILDLIFE FACILITIES	$4,554,020	24%	$1,080,870	$5,635,000
19.-.-.-	BUILDINGS, GROUNDS, & UTILITIES	$644,240	21%	$137,170	$781,000
30.-.-.-	PLANNING, ENGINEERING AND DE SIGN (15%)	$18,087,000	10%	$1,808,700	$19,896,000
31.-.-.-	CONSTRUCTION MANAGEMENT (7.5%)	$9,043,500	10%	$904,350	$9,948,000
	TOTAL PROJECT COSTS:	$152,411,000	15%	$23,178,820	**$175,590,000**

23.6 PLAN 3 – AUXILIARY EXTENSION WITH CULVERT 2ND VIEW BACKUP

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
02 Relocation							
02. 02 Relocation							
02. 02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
05 Locks							
05. 01 Mob, Demob & Preparatory Work							
05. 01. 10 MOB.& DEMOB.AND PREP. WORK	1.00	JOB	933,750	93,380	10.0%	1,027,130	1027127
05. 01. 20 SIGNS	1.00	JOB	4,040	810	20.0%	4,850	4848.62
05. 01 Mob, Demob & Preparatory Work	1.00	JOB	937,790	94,180	10.0%	1,031,980	1031975
05. 02 Drainage							
05. 02. 10 Concrete Lined Ditch	1810.00	LF	159,620	47,890	30.0%	207,500	114.64
05. 02. 50 Catch Basins 4' Depth	1.00	EA	3,370	1,010	30.0%	4,390	4386.54
05. 02. 60 15" RCP	200.00	LF	13,610	4,080	30.0%	17,690	88.45
05. 02. 70 15" Headwalls	6.00	EA	3,400	1,020	30.0%	4,420	737.03
05. 02 Drainage	1.00	JOB	180,000	54,000	30.0%	234,000	234003.00
05. 03 Care and Diversion of Water							
05. 03. 90 Channel & SSP Lining	3000.00	CY	463,830	69,570	15.0%	533,400	177.80
05. 03 Care and Diversion of Water	1.00	JOB	463,830	69,570	15.0%	533,400	533402.19
05. 04 Permanent Access Roads & Parking							
05. 04.110 1"Bitum. Conc. Wearing Course	98.00	CY	12,910	2,580	20.0%	15,490	158.06
05. 04.120 2"Bitum. Conc. Base Course	196.00	CY	23,270	4,650	20.0%	27,920	142.47
05. 04.130 Prime Coat .28Gal/SY	900.00	GAL	2,000	400	20.0%	2,400	2.67
05. 04.140 4"Crushed Aggregate Class I	378.00	CY	16,180	3,240	20.0%	19,410	51.36
05. 04.150 4" No 57 Aggregate	378.00	CY	16,410	3,280	20.0%	19,690	52.10
05. 04.160 Plastic Filter Fabric	3500.00	SY	8,540	1,710	20.0%	10,240	2.93
05. 04.170 6"Perf. Pipe Under Drain	1700.00	LF	31,850	6,370	20.0%	38,220	22.48
05. 04.180 Prepare Subase Esplanade	3200.00	SY	10,040	2,010	20.0%	12,050	3.76
05. 04 Permanent Access Roads & Parking	1.00	JOB	121,200	24,240	20.0%	145,430	145434.10
05. 10 Earthwork for Structures							
05. 10.240 Strip & Stockpile Topsoil	21000.00	CY	29,110	4,370	15.0%	33,470	1.59
05. 10.242 Clearing and Grubbing	19.00	ACR	32,410	4,860	15.0%	37,270	1961.47

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 10.250 Replace Topsoil from Stockpile	21000.00	CY	23,290	3,490	15.0%	26,780	1.28
05. 10.260 Haul Roads 12" Aggregate	6000.00	SY	83,470	12,520	15.0%	95,990	16.00
05. 10 Earthwork for Structures	1.00	JOB	168,270	25,240	15.0%	193,510	193512.89
05. 11 Foundation Work							
05. 11.330 Drilling Weep Holes	6100.00	LF	35,100	5,270	15.0%	40,370	6.62
05. 11.340 Preliminary Cleanup	4000.00	SY	24,100	3,610	15.0%	27,710	6.93
05. 11.350 Final Found.Cleanup	4000.00	SY	20,080	3,010	15.0%	23,090	5.77
05. 11 Foundation Work	1.00	JOB	79,280	11,890	15.0%	91,170	91169.22
05. 18 Utilities, Lines, & Services							
05. 18.360 Fuel Storage & Dispen. System	1.00	JOB	32,800	4,920	15.0%	37,720	37719.37
05. 18.370 Hydraulic System	1.00	JOB	793,840	119,080	15.0%	912,910	912913.34
05. 18 Utilities, Lines, & Services	1.00	JOB	826,640	124,000	15.0%	950,630	950632.71
05. 22 Temporary Service Roads							
05. 22.380 Aggregate Road 12"Depth	3574.00	SY	51,110	10,220	20.0%	61,340	17.16
05. 22.390 Aggregate Path 8"Depth	1320.00	SY	13,320	2,660	20.0%	15,980	12.11
05. 22 Temporary Service Roads	1.00	JOB	64,440	12,890	20.0%	77,320	77322.53
05. 24 Buildings, Residences, etc.							
05. 24.400 Resident Engineer Office	1.00	EA	371,810	74,360	20.0%	446,170	446169.51
05. 24.410 Concrete Steps W/O Railing	100.00	LF	14,080	2,820	20.0%	16,900	168.99
05. 24 Buildings, Residences, etc.	1.00	JOB	385,890	77,180	20.0%	463,070	463068.48
05. 41 Assembly Pier							
05. 41.430 Mitergates Emb.Metal.	2.00	EA	960,050	192,010	20.0%	1,152,060	576030.00
05. 41.431 Removal of Mitergates and Reset	2.00	EA	49,800	9,960	20.0%	59,760	29877.83
05. 41.432 Construct New Assembly Pier	1.00	JOB	1,360,400	544,160	40.0%	1,904,550	1904555
05. 41 Assembly Pier	1.00	JOB	2,370,240	746,130	31.5%	3,116,370	3116370
05. 57 Lock Gate Embed Metals D/S							
05. 57.440 DS Miter Gate	1.00	JOB	2,954,000	886,200	30.0%	3,840,200	3840200
05. 57 Lock Gate Embed Metals D/S	1.00	JOB	2,954,000	886,200	30.0%	3,840,200	3840200
05. 61 Guide-Guard Walls, Upper & Lower							
05. 61.450 US Middle Floating Wall (UMW)	1300.00	LF	9,379,810	1,406,970	15.0%	10,786,790	8297.53
05. 61.460 US River Floating Wall (URW)	1297.00	LF	8,740,760	1,311,110	15.0%	10,051,870	7750.09
05. 61.470 DS LL Floating Wall (LLW)	1136.00	LF	7,545,770	1,131,870	15.0%	8,677,640	7638.76
05. 61.475 DS Guidewall Floating Wall (LRW)	249.00	LF	2,206,960	331,040	15.0%	2,538,000	10192.78
05. 61.480 Nose Piers	4.00	EA	14,334,240	2,150,140	15.0%	16,484,380	4121095
05. 61.490 Pylons	2.00	EA	1,765,270	264,790	15.0%	2,030,060	1015028
05. 61 Guide-Guard Walls, Upper & Lower	3982.00	LF	43,972,810	6,595,920	15.0%	50,568,730	12699.33

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 62 Demo,Lock walls Up & Dn Stream							
05. 62.480 Exca. Wet Earth & Haul	20530.00	CY	328,330	49,250	15.0%	377,580	18.39
05. 62.490 Remove Existing Monolith L1	3500.00	CY	350,290	52,540	15.0%	402,830	115.09
05. 62.500 Remove Existing Monolith L2	2950.00	CY	295,240	44,290	15.0%	339,530	115.09
05. 62.510 Remove Existing Monolith L3	2900.00	CY	290,240	43,540	15.0%	333,770	115.09
05. 62.520 Remove Existing Monolith L4	3050.00	CY	305,250	45,790	15.0%	351,040	115.09
05. 62.530 Remove Existing Monolith L5	3600.00	CY	360,300	54,040	15.0%	414,340	115.09
05. 62.540 Downstream Steel & Wall Armor	1.00	JOB	16,390	2,460	15.0%	18,850	18849.31
05. 62.550 H-Beam Piles Upstream	319.00	EA	152,380	22,860	15.0%	175,240	549.34
05. 62.560 Remove Existing Monolith L29-L37	11505.00	CY	910,750	136,610	15.0%	1,047,360	91.04
05. 62.570 Upstream Steel & Wall Armor	1.00	JOB	32,780	4,920	15.0%	37,700	37698.61
05. 62 Demo,Lock walls Up & Dn Stream	1.00	JOB	3,041,940	456,290	15.0%	3,498,230	3498231
05. 63 Lock Structure							
05. 63.590 Floating Mooring Bitt	8.00	EA	614,790	92,220	15.0%	707,010	88376.26
05. 63.610 Ladders Rung, Machinery Reces.	775.00	LB	7,060	1,060	15.0%	8,120	10.48
05. 63.620 Grab Bars	44.00	EA	5,120	770	15.0%	5,890	133.77
05. 63.630 Ladders Safety Cages Material	92.00	LF	7,300	1,100	15.0%	8,400	91.26
05. 63.640 Ladders Safety Devices	4.00	EA	7,320	1,100	15.0%	8,420	2103.82
05. 63.650 Sump Well Gratings and Frames	5.00	EA	5,950	890	15.0%	6,840	1368.79
05. 63.660 Sump Pump Disch. Cover & Frame	1.00	EA	1,240	190	15.0%	1,430	1429.37
05. 63.670 Drain Cover and Frame	1.00	EA	980	150	15.0%	1,120	1124.88
05. 63.680 Pipe Trench Cover & Frame	4000.00	SF	175,310	26,300	15.0%	201,610	50.40
05. 63.700 Aluminum Grating	1.00	JOB	324,760	48,710	15.0%	373,470	373473.19
05. 63.710 Steel, Castings, Corner Caps	2100.00	LB	48,890	7,330	15.0%	56,220	26.77
05. 63.720 Steel, Ladders Lock Walls	550.00	LF	31,140	4,670	15.0%	35,810	65.10
05. 63.800 Steel Gages	2.00	EA	9,120	1,370	15.0%	10,480	5242.08
05. 63.860 Concrete in Lock Floor Paving	1225.00	CY	307,490	46,120	15.0%	353,610	288.66
05. 63.861 Reinforcing for Sills	30000.00	LB	15,760	2,360	15.0%	18,120	0.60
05. 63.862 CIP Concrete in Sills	6700.00	CY	1,332,390	199,860	15.0%	1,532,250	228.69
05. 63.863 Tremie Concrete in Sills	1100.00	CY	104,470	15,670	15.0%	120,140	109.22
05. 63.864 Precast Concrete in Sills	200.00	CY	73,030	10,950	15.0%	83,980	419.90
05. 63.865 Tunnel and Slab Precast Concrete	173.00	CY	98,320	14,750	15.0%	113,070	653.56
05. 63.895 Line Hooks	20.00	EA	22,690	3,400	15.0%	26,090	1304.52
05. 63.900 Check Posts	2.00	EA	3,470	520	15.0%	3,990	1993.77
05. 63.905 Steel, Ladders Lock Walls	1.00	EA	28,540	4,280	15.0%	32,820	32823.06
05. 63.910 Corner Armor	643.00	LF	44,830	6,720	15.0%	51,550	80.18
05. 63.915 Wall Armor	2090.00	LF	163,370	24,500	15.0%	187,870	89.89
05. 63.930 Rock Excavation	29000.00	CY	622,800	93,420	15.0%	716,220	24.70
05. 63.934 CIP Concrete for Lift-In Const.	48100.00	CY	9,272,240	1,390,840	15.0%	10,663,070	221.69
05. 63.935 Tremie Concrete for Lift-In Cons	31050.00	CY	4,451,790	667,770	15.0%	5,119,560	164.88
05. 63.936 Precast Conc for Lift-In Const.	14000.00	CY	7,010,420	1,051,560	15.0%	8,061,980	575.86
05. 63.940 Wall Embeds	1210000.00	LB	1,735,870	173,590	10.0%	1,909,450	1.58
05. 63 Lock Structure	1.00	JOB	26,526,430	3,892,170	14.7%	30,418,600	30418602

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 64 Filling and Emptying System							
05. 64. 03 Laterals	4302.00	CY	1,081,890	162,280	15.0%	1,244,170	289.21
05. 64. 15 Outlet Structure	700.00	CY	1,165,180	524,330	45.0%	1,689,510	2413.59
05. 64.100 Cut-off Wall PS 27.5	14204.00	LF	415,620	124,690	30.0%	540,310	38.04
05. 64.101 Shoring for excavation	11200.00	SF	403,420	40,340	10.0%	443,760	39.62
05. 64.102 US Cut-Off Wall	12670.00	SF	324,960	97,490	30.0%	422,450	33.34
05. 64.271 Exca. Dry Earth & Haul	350000.00	CY	2,852,400	427,860	15.0%	3,280,260	9.37
05. 64.291 Culvert, Rock Exc	23000.00	CY	494,460	98,890	20.0%	593,350	25.80
05. 64.690 Screens and Nose Plates at	1.00	JOB	444,280	88,860	20.0%	533,140	533140.43
05. 64.840 Ice & Debris Floating Boom	1.00	EA	1,025,720	205,140	20.0%	1,230,870	1230870
05. 64.841 CIP Concrete - Bypass Culvert	6850.00	CY	3,216,800	482,520	15.0%	3,699,320	540.05
05. 64.842 CIP Concrete - Thrust Blocks	1600.00	CY	433,030	64,950	15.0%	497,980	311.24
05. 64.843 Tremie Concrete - Outlet Culvert	2800.00	CY	602,440	90,370	15.0%	692,810	247.43
05. 64.844 Wells for Dewatering	520.00	EA	2,443,770	488,750	20.0%	2,932,520	5639.46
05. 64.845 Precast Conc - Outlet Culvert	900.00	CY	685,090	137,020	20.0%	822,110	913.45
05. 64.860 Reinforcing - Valve Structure	400000.00	LBS	210,310	42,060	20.0%	252,370	0.63
05. 64.935 Intake Structure & Wingwalls	1.00	JOB	2,152,820	322,920	15.0%	2,475,750	2475747
05. 64.960 Sealing Diaphragms and Embedded	2.00	EA	53,200	15,960	30.0%	69,160	34577.87
05. 64.965 Tainer Val.Oper.Mach&Emb.Metal	2.00	EA	749,120	224,740	30.0%	973,865	486927.25
05. 64 Filling and Emptying System	1.00	JOB	18,754,510	3,639,180	19.4%	22,393,680	22393682
05. 66 Power and Lighting Systems							
05. 66.970 Electrical Work	1.00	JOB	3,356,560	503,480	15.0%	3,860,040	3860045
05. 66 Power and Lighting Systems	1.00	JOB	3,356,560	503,480	15.0%	3,860,040	3860045
05. 68 Compressed Air System							
05. 68.985 Compressed Air Piping System	1.00	JOB	202,860	30,430	15.0%	233,290	233292.36
05. 68 Compressed Air System	1.00	JOB	202,860	30,430	15.0%	233,290	233292.36
05. 76 Pumping Machinery & Appurten.							
05. 76.990 Extension Raw Water Pump & Pipe	1.00	JOB	33,280	4,990	15.0%	38,280	38275.48
05. 76.991 Raw Water Piping	1.00	JOB	113,540	17,030	15.0%	130,580	130576.51
05. 76 Pumping Machinery & Appurten.	1.00	LS	146,830	22,020	15.0%	168,850	168851.99

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 99 Associated General Items							
05. 99.993 Truck 4x4, 9 Passenger C.D.	1.00	EA	29,470	1,470	5.0%	30,940	30943.26
05. 99.994 Instrumentation	1.00	JOB	987,800	49,390	5.0%	1,037,190	1037186
05. 99.995 Truck 4x4, 3/4 Ton, 8800GVW Op.D	1.00	EA	28,480	1,420	5.0%	29,900	29904.41
05. 99.996 Truck 2x4 Shortbed C.D.	2.00	EA	53,000	2,650	5.0%	55,660	27827.56
05. 99.997 Truck 4x4 Longbed C.D.	1.00	EA	24,770	1,240	5.0%	26,010	26008.73
05. 99.99A Fit-Out Area	1.00	JOB	902,720	354,420	39.3%	1,257,140	1257138
05. 99.99B Dry Dock @ RCB	1.00	JOB	6,000,000	0	%	6,000,000	6000000
05. 99.99C Silt Fence (Erosion& Sediment)	10000.00	LF	110,860	16,630	15.0%	127,490	12.75
05. 99.99D Straw Bales (Dike and Ditch)	660.00	EA	7,930	1,190	15.0%	9,120	13.81
05. 99.99E Mudboards 25'Width x 20'Long	2.00	EA	8,520	1,280	15.0%	9,790	4897.07
05. 99.99F Temporary Seeding(Erosion &Sed.)	50.00	ACR	106,700	16,010	15.0%	122,710	2454.11
05. 99.99G Permanent Seeding	50.00	ACR	115,060	17,260	15.0%	132,310	2646.27
05. 99.99H Environmental Protection	1.00	JOB	336,480	50,470	15.0%	386,950	386954.66
05. 99.99I Janitorial Services	1.00	JOB	133,550	20,030	15.0%	153,580	153576.98
05. 99.99J As-Built Drawing	1.00	JOB	106,030	10,600	10.0%	116,640	116637.11
05. 99.99K Helper Boats	3.30	MO	400,000	40,000	10.0%	440,000	133333.33
05. 99.99M Harbor Area Items	1.00	JOB	837,070	334,830	40.0%	1,171,900	1171902
05. 99.99N Lock Wall Demonstration Project	1.00	JOB	3,059,420	607,640	19.9%	3,667,060	3667059
05. 99.99O Lock Wall Demonstration Project	1.00	JOB	1,780,880	356,180	20.0%	2,137,060	2137059
05. 99 Associated General Items	1.00	JOB	15,028,730	1,882,710	12.5%	16,911,440	16911444
05 Locks	1.00	JOB	119,582,240	19,147,730	16.0%	138,729,970	138729970
06 Fish & Wildlife							
06. 06 Fish & Wildlife							
06. 06. 01 Timber Bundles	1820.00	LF	42,100	8,420	20.0%	50,520	27.76
06. 06. 03 Live Stakings	16000.00	SF	36,970	7,390	20.0%	44,370	2.77
06. 06. 05 Filter Fabric	16000.00	SY	82,980	16,600	20.0%	99,580	6.22
06. 06. 07 Brush Mattress	38500.00	SF	203,470	40,690	20.0%	244,160	6.34
06. 06. 09 Live Fascines	48000.00	SF	220,140	44,030	20.0%	264,170	5.50
06. 06. 11 Tailwater Dikes	53000.00	CY	1,226,390	245,280	20.0%	1,471,660	27.77
06. 06. 13 T-Dikes and Notch Dike Fields	45000.00	CY	1,041,270	208,250	20.0%	1,249,520	27.77
06. 06. 90 Channel & SSP Lining	11000.00	CY	1,700,700	510,210	30.0%	2,210,910	200.99
06. 06 Fish & Wildlife	1.00	JOB	4,554,020	1,080,870	23.7%	5,634,890	5634889
06 Fish & Wildlife	1.00	JOB	4,554,020	1,080,870	23.7%	5,634,890	5634889

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
19 Buildings, Grounds, & Utilities							
19. 18 UTILITIES, LINES and SERVICES							
19. 18.99I 2"D. PVC Water Line ++	1000.00	LF	9,200	1,840	20.0%	11,040	11.04
19. 18.99J 4"D. PVC Sewer Line ++	200.00	LF	2,240	450	20.0%	2,690	13.46
19. 18.99K Lighting ++	2.00	EA	5,250	1,050	20.0%	6,290	3147.36
19. 18 UTILITIES, LINES and SERVICES	1.00	JOB	16,680	3,340	20.0%	20,020	20021.83
19. 22 PARKING LOTS AND SERVICE ROADS							
19. 22.100 Aggregate Road 12"Depth	18000.00	SY	232,470	46,490	20.0%	278,960	15.50
19. 22.99L Crush Aggregate 4"Depth Cl I ++	216.00	CY	20,270	4,050	20.0%	24,320	112.59
19. 22.99M #57 Aggregate Base 4"Depth ++	216.00	CY	20,580	4,120	20.0%	24,690	114.31
19. 22.99N Bituminous Prime Coat ++	500.00	GAL	2,670	530	20.0%	3,200	6.41
19. 22.99O 2"Bitum. Concrete Base Course ++	200.00	TON	28,490	5,700	20.0%	34,190	170.96
19. 22.99P 1"Bitum.Concrete Wearing Course+	100.00	TON	15,810	3,160	20.0%	18,970	189.67
19. 22.99Q 6"D.PVC Pref. Pipe Underdrain ++	650.00	LF	46,880	9,380	20.0%	56,250	86.54
19. 22.99R Filter Fabric ++	2000.00	SY	18,590	3,720	20.0%	22,310	11.16
19. 22.99S Exca.& Haul Road & Parkinglot ++	2000.00	CY	19,900	3,980	20.0%	23,880	11.94
19. 22.99T Disposal Exca. Material ++	2545.40	CY	6,130	1,230	20.0%	7,360	2.89
19. 22.99U Prepare Subbase	1828.00	SY	42,340	8,470	20.0%	50,810	27.79
19. 22 PARKING LOTS AND SERVICE ROADS	1.00	JOB	454,120	90,820	20.0%	544,950	544945.52
19. 23 FENCE							
19. 23.99U Farm Fence 4'High, 3 Strand ++	9850.00	LF	64,200	19,260	30.0%	83,460	8.47
19. 23 FENCE	1.00	JOB	64,200	19,260	30.0%	83,460	83457.03
19. 27 BUILDINGS, PUBLIC USE							
19. 27.99V Picnic Shelter 25'X40' ++	6.00	EA	19,030	5,710	30.0%	24,740	4123.86
19. 27 BUILDINGS, PUBLIC USE	1.00	JOB	19,030	5,710	30.0%	24,740	24743.13
19. 72 DAY USE AREA							
19. 72.90A Tot Lot ++	1.00	EA	23,240	4,650	20.0%	27,890	27888.38
19. 72.90B Asphalt Paving ++	400.00	SY	7,610	1,520	20.0%	9,140	22.84
19. 72.90C Flag Pole ++	1.00	EA	12,690	2,540	20.0%	15,230	15226.54
19. 72.90D Concrete Picnic Table & Seat 7'L	12.00	EA	19,800	3,960	20.0%	23,760	1979.75
19. 72.90E Pine Picnic Table & Seat 8'L ++	30.00	EA	17,140	3,430	20.0%	20,570	685.64
19. 72.90F Raised Castiron Picnic Grill ++	15.00	EA	6,680	1,340	20.0%	8,010	534.26
19. 72.90G Waste Receptacle ++	20.00	EA	3,050	610	20.0%	3,660	182.84
19. 72 DAY USE AREA	1.00	JOB	90,210	18,040	20.0%	108,250	108247.73
19 Buildings, Grounds, & Utilities	1.00	JOB	644,240	137,170	21.3%	781,420	781415.24

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
30 Engineering & Design							
30. 30 Engineering & Design							
30. 30. 30 Engineering & Design	1.00	JOB	18,087,000	1,808,700	10.0%	19,895,700	19895700
30. 30 Engineering & Design	1.00	JOB	18,087,000	1,808,700	10.0%	19,895,700	19895700
30 Engineering & Design	1.00	JOB	18,087,000	1,808,700	10.0%	19,895,700	19895700
31 S&A							
31. 31 S&A							
31. 31. 31 S&A	1.00	JOB	9,043,500	904,350	10.0%	9,947,850	9947850
31. 31 S&A	1.00	JOB	9,043,500	904,350	10.0%	9,947,850	9947850
31 S&A	1.00	JOB	9,043,500	904,350	10.0%	9,947,850	9947850
Plan3 Aux.Lock Ext W/Culvert	1.00	EA	152,411,000	23,178,820	15.2%	175,589,820	175589824

Table 39 Plan 4 Auxiliary Extension Phased Cost Summary

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON, WV					
BASELINE ESTIMATE (M-CACES) FOR					
GREENUP LOCK & DAM 600' PLAN 4 AUX. LOCK EXTENSION --FUTURE / PHASED, KY					
PROJECT SUMMARY COST					
ACCOUNT NUMBER	**ACCOUNT NAME**	**ESTIMATED COST**	**(%)**	**CONTINGENCY AMOUNT**	**1-Oct-99 COST**
		---	---	---	---
01.-.-.-	LANDS AND DAMAGES	$0	0%		$0
02.-.-.-	RELOCATIONS	$500,000	20%	$100,000	$600,000
05.-.-.-	LOCKS	$96,565,540	22%	$21,468,100	$118,034,000
06.-.-.-	FISH & WILDLIFE FACILITIES	$3,000,000	20%	$600,000	$3,600,000
19.-.-.-	BUILDINGS, GROUNDS, & UTILITIES	$417,910	22%	$91,800	$510,000
30.-.-.-	PLANNING, ENGINEERING AND DESIGN (15%	$15,072,518	10%	$1,507,252	$16,580,000
31.-.-.-	CONSTRUCTION MANAGEMENT (7.5%)	$7,536,259	10%	$753,626	$8,290,000
	PHASE 1 PROJECT COSTS:	$123,092,226	20%	$24,520,778	**$147,614,000**
05.-.-.-	Lock Filling & Emptying System	$17,066,920	25%	$4,296,140	$21,363,000
19.-.-.-	BUILDINGS, GROUNDS, & UTILITIES	$216,450	20%	$43,290	$260,000
30	Engineering & Design(15%)	$2,592,505.50	10%	$259,251	$2,852,000
31	Construction Management(7.5%)	$1,296,252.75	10%	$129,625	$1,426,000
	PHASE 2 PROJECT COSTS:	$21,172,128	22%	$4,728,306	**$25,901,000**
All	**PHASE 1 & 2 TOTAL PROJECT COSTS:**	$144,264,355	20%	$29,249,083	**$173,515,000**

Plan 4 - Auxiliary Extension Future / Phased 2nd View Backup

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
02 Relocation							
02. 02 Relocation							
02. 02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02. 02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
02 Relocation	1.00	JOB	500,000	100,000	20.0%	600,000	600000.00
05 Locks							
05. 01 Mob, Demob & Preparatory Work							
05. 01. 10 MOB.& DEMOB.AND PREP. WORK	1.00	JOB	912,880	91,290	10.0%	1,004,170	1004172
05. 01. 20 SIGNS	1.00	JOB	4,430	890	20.0%	5,320	5315.71
05. 01 Mob, Demob & Preparatory Work	1.00	JOB	917,310	92,170	10.0%	1,009,490	1009488
05. 02 Drainage							
05. 02. 10 Concrete Lined Ditch	160.00	LF	13,770	4,130	30.0%	17,900	111.89
05. 02. 60 15" RCP	80.00	LF	5,230	1,570	30.0%	6,810	85.06
05. 02. 70 15" Headwalls	2.00	EA	1,100	330	30.0%	1,430	715.03
05. 02 Drainage	1.00	JOB	20,110	6,030	30.0%	26,140	26136.91
05. 03 Care and Diversion of Water							
05. 03. 90 Channel & SSP Lining	14000.00	CY	2,363,600	709,080	30.0%	3,072,680	219.48
05. 03.100 Cut-off Wall PS 27.5	14204.00	LF	400,250	120,070	30.0%	520,320	36.63
05. 03 Care and Diversion of Water	21700.00	CY	2,763,850	829,150	30.0%	3,593,000	165.58
05. 04 Permanent Access Roads & Parking							
05. 04.000 <<< Not Identified >>>	14204.00	LF	0	0	%	0	
05. 04 Permanent Access Roads & Parking	1.00	JOB	0	0	%	0	
05. 10 Earthwork for Structures							
05. 10.240 Strip & Stockpile Topsoil	21000.00	CY	27,870	8,360	30.0%	36,230	1.73
05. 10.242 Clearing and Grubbing	19.00	ACR	35,590	10,680	30.0%	46,260	2434.86
05. 10.250 Replace Topsoil from Stockpile	21000.00	CY	22,290	6,690	300%	28,980	1.38
05. 10.260 Haul Roads 12" Aggregate	6000.00	SY	82,210	24,660	30.0%	106,870	17.81
05. 10 Earthwork for Structures	1.00	JOB	167,960	50,390	30.0%	218,350	218346.33
05. 11 Foundation Work							
05. 11.330 Drilling Weep Holes	6100.00	LF	36,860	11,060	30.0%	47,920	7.86
05. 11.340 Preliminary Cleanup	4000.00	SY	25,440	7,630	30.0%	33,070	8.27
05. 11.350 Final Found.Cleanup	4000.00	SY	21,200	6,360	30.0%	27,560	6.89
05. 11 Foundation Work	1.00	JOB	83,490	25,050	30.0%	108,540	108537.38

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 18 Utilities, Lines, & Services							
05. 18.360 Fuel Storage & Dispen. System	1.00	JOB	32,020	6,400	20.0%	38,420	38419.02
05. 18.370 Hydraulic System	1.00	JOB	774,870	154,970	20.0%	929,850	929846.78
05. 18 Utilities, Lines, & Services	1.00	JOB	806,890	161,380	20.0%	968,270	968265.79
05. 22 Temporary Service Roads							
05. 22.380 Aggregate Road 12"Depth	3574.00	SY	50,330	10,070	20.0%	60,400	16.90
05. 22.390 Aggregate Path 8"Depth	1320.00	SY	13,110	2,620	20.0%	15,730	11.92
05. 22 Temporary Service Roads	1.00	JOB	63,440	12,690	20.0%	76,130	76129.00
05. 24 Buildings, Residences, etc.							
05. 24.400 Resident Engineer Office	1.00	EA	362,640	72,530	20.0%	435,160	435163.98
05. 24.410 Concrete Steps W/O Railing	100.00	LF	13,460	2,690	20.0%	16,150	161.48
05. 24 Buildings, Residences, etc.	1.00	JOB	376,090	75,220	20.0%	451,310	451312.08
05. 41 Gates,Stoplogs,& Ass.Equipmen							
05. 41.430 Mitergates Emb.Metal.	2.00	EA	960,050	192,010	20.0%	1,152,060	576030.00
05. 41.431 Removal of Mitergates and Reset	2.00	EA	46,310	9,260	20.0%	55,580	27787.78
05. 41.432 Construct New Assembly Pier	1.00	JOB	1,343,850	537,540	40.0%	1,881,400	1881396
05. 41 Gates,Stoplogs,& Ass.Equipmen	1.00	JOB	2,350,220	738,810	31.4%	3,089,030	3089031
05. 57 Lock Gate Embed Metals							
05. 57.440 DS Miter Gate	1.00	JOB	2,954,000	1,033,900	35.0%	3,987,900	3987900
05. 57 Lock Gate Embed Metals	1.00	JOB	2,954,000	1,033,900	35.0%	3,987,900	3987900
05. 61 Guide-Guard Walls, Upper & Lower							
05. 61.450 US Middle Floating Wall (UMW)	1300.00	LF	10,088,210	2,017,640	20.0%	12,105,850	9312.19
05. 61.460 US River Floating Wall (URW)	1297.00	LF	9,844,030	1,968,810	20.0%	11,812,840	9107.82
05. 61.470 DS LL Floating Wall (LLW)	1136.00	LF	8,507,850	1,701,570	20.0%	10,209,420	8987.17
05. 61.475 DS Guidewall Floating Wall (LRW)	249.00	LF	2,430,390	486,080	20.0%	2,916,470	11712.72
05. 61.480 Nose Piers	4.00	EA	13,989,130	2,797,830	20.0%	16,786,950	4196738
05. 61.490 Pylons	2.00	EA	1,702,590	340,520	20.0%	2,043,110	1021557
05. 61 Guide-Guard Walls, Upper & Lower	3982.00	LF	46,562,200	9,312,440	20.0%	55,874,640	14031.80
05. 62 Demo,Lock walls Up & Dn Stream							
05. 62.480 Exca. Wet Earth & Haul	20530.00	CY	327,170	98,150	30.0%	425,330	20.72
05. 62.490 Remove Existing Monolith L1	3500.00	CY	455,420	136,620	30.0%	592,040	169.15
05. 62.500 Remove Existing Monolith L2	2950.00	CY	292,990	87,900	30.0%	380,890	129.12
05. 62.510 Remove Existing Monolith L3	2900.00	CY	288,030	86,410	30.0%	374,430	129.12
05. 62.520 Remove Existing Monolith L4	3050.00	CY	302,920	90,880	30.0%	393,800	129.12
05. 62.530 Remove Existing Monolith L5	3600.00	CY	357,550	107,270	30.0%	464,820	129.12
05. 62.540 Downstream Steel & Wall Armor	1.00	JOB	16,770	5,030	30.0%	21,790	21794.53
05. 62.550 H-Beam Piles Upstream	319.00	EA	147,600	44,280	30.0%	191,880	601.52
05. 62.570 Upstream Steel & Wall Armor	1.00	JOB	33,530	10,060	30.0%	43,590	43589.05
05. 62 Demo,Lock walls Up & Dn Stream	1.00	JOB	2,221,980	666,590	30.0%	2,888,570	2888575

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 63 Lock Structure							
05. 63.590 Floating Mooring Bitt	4.00	EA	599,400	119,880	20.0%	719,280	179820.56
05. 63.610 Ladders Rung, Machinery Reces.	775.00	LB	6,830	1,370	20.0%	8,190	10.57
05. 63.620 Grab Bars	44.00	EA	4,940	990	20.0%	5,930	134.77
05. 63.630 Ladders Safety Cages Material	92.00	LF	7,210	1,440	20.0%	8,650	94.07
05. 63.640 Ladders Safety Devices	4.00	EA	6,750	1,350	200%	8,100	2025.71
05. 63.650 Sump Well Gratings and Frames	5.00	EA	5,860	1,170	20.0%	7,030	1406.37
05. 63.660 Sump Pump Disch. Cover & Frame	1.00	EA	1,220	240	20.0%	1,460	1458.15
05. 63.670 Drain Cover and Frame	1.00	EA	960	190	20.0%	1,150	1154.96
05. 63.680 Pipe Trench Cover & Frame	4000.00	SF	155,680	31,140	20.0%	186,810	46.70
05. 63.700 Aluminum Grating	1.00	JOB	307,170	61,430	20.0%	368,600	368599.81
05. 63.710 Steel, Castings, Corner Caps	2100.00	LB	47,340	9,470	20.0%	56,810	27.05
05. 63.720 Steel, Ladders Lock Walls	550.00	LF	30,350	6,070	20.0%	36,420	66.21
05. 63.800 Steel Gages	2.00	EA	8,260	1,650	20.0%	9,910	4953.45
05. 63.860 Concrete in Lock Floor Paving	1225.00	CY	298,100	89,430	30.0%	387,530	316.35
05. 63.861 Concrete in Laterals,	4302.00	CY	921,820	276,550	30.0%	1,198,370	278.56
05. 63.862 CIP Concrete in Sills	6700.00	CY	1,417,550	425,270	30.0%	1,842,820	275.05
05. 63.863 Tremie Concrete in Sills	1100.00	CY	102,890	30,870	30.0%	133,760	121.60
05. 63.864 Precast Concrete in Sills	200.00	CY	47,210	14,160	30.0%	61,370	306.86
05. 63.865 Tunnel and Slab Precast Concrete	173.00	CY	95,190	28,560	30.0%	123,750	715.31
05. 63.895 Line Hooks	20.00	EA	22,450	4,490	20.0%	26,950	1347.28
05. 63.900 Check Posts	2.00	EA	3,310	660	20.0%	3,970	1983.71
05. 63.905 Steel, Ladders Lock Walls	1.00	EA	27,790	5,560	20.0%	33,340	33342.55
05. 63.910 Corner Armor	643.00	LF	43,330	8,670	20.0%	52,000	80.87
05. 63.915 Wall Armor	2090.00	LF	153,000	30,600	20.0%	183,600	87.85
05. 63.934 Monoliths L1-L5 & M1, Lift-In	93150.00	CY	20,785,010	4,157,000	20.0%	24,942,010	267.76
05. 63 Lock Structure	1.00	JOB	25,099,610	5,308,200	21.1%	30,407,810	30407809
05. 64 Filling and Emptying System							
05. 64.291 Culvert, Rock Exc	21000.00	CY	441,460	132,440	30.0%	573,890	27.33
05. 64.777 Special Construction for Outlet-	1.00	JOB	1,076,510	481,350	44.7%	1,557,860	1557863
05. 64.841 Concrete CIP - Bypass Culvert	6850.00	CY	932,160	186,430	20.0%	1,118,590	163.30
05. 64.960 Sealing Diaphragms and Embedded	1.00	EA	51,720	15,520	30.0%	67,240	67237.40
05. 64.965 Tainer Val.Oper.Mach&Emb.Metal	1.00	EA	365,610	109,680	30.0%	475,290	475294.20
05. 64 Filling and Emptying System	1.00	JOB	2,867,460	925,420	32.3%	3,792,880	3792876
05. 66 Power and Lighting Systems							
05. 66.970 Electrical Work	1.00	JOB	0	0	%	0	
05. 66 Power and Lighting Systems	1.00	JOB	0	0	%	0	

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
05. 99 Associated General Items							
05. 99.993 Truck 4x4, 9 Passenger C.D.	1.00	EA	29,110	1,460	5.0%	30,570	30566.99
05. 99.994 Instrumentation	1.00	JOB	967,250	48,360	5.0%	1,015,610	1015612
05. 99.995 Truck 4x4, 3/4 Ton, 8800GVW Op.D	1.00	EA	28,130	1,410	5.0%	29,540	29540.78
05. 99.996 Truck 2x4 Shortbed C.D.	2.00	EA	52,360	2,620	5.0%	54,980	27489.18
05. 99.997 Truck 4x4 Longbed C.D.	1.00	EA	24,470	1,220	5.0%	25,690	25692.47
05. 99.99A Fit-Out Area	1.00	JOB	864,210	339,240	39.3%	1,203,450	1203453
05. 99.99B Dry Dock @ RCB	1.00	JOB	6,000,000	1,500,000	25.0%	7,500,000	7500000
05. 99.99C Silt Fence (Erosion& Sediment)	10000.00	LF	123,470	30,870	25.0%	154,340	15.43
05. 99.99D Straw Bales (Dike and Ditch)	660.00	EA	8,250	2,060	25.0%	10,310	15.62
05. 99.99E Mudboards 25'Width x 20'Long	2.00	EA	9,200	2,300	25.0%	11,500	5752.22
05. 99.99F Temporary Seeding(Erosion &Sed.)	50.00	ACR	103,480	25,870	25.0%	129,350	2586.93
05. 99.99G Permanent Seeding	50.00	ACR	111,770	27,940	25.0%	139,710	2794.13
05. 99.99H Environmental Protection	1.00	JOB	346,690	86,670	25.0%	433,360	433356.33
05. 99.99I Janitorial Services	1.00	JOB	137,810	34,450	25.0%	172,260	172260.59
05. 99.99J As-Built Drawing	1.00	JOB	104,740	26,190	25.0%	130,930	130930.48
05. 99.99K Helper Boats	3.30	NO	400,000	100,000	25.0%	500,000	151515.15
05. 99 Associated General Items	1.00	JOB	9,310,940	2,230,660	24.0%	11,541,600	11541598
05 Locks	1.00	JOB	96,565,540	21,468,100	22.2%	118,033,650	118033647
06 Fish & Wildlife							
06. 06 Fish & Wildlife							
06. 06. 06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
06. 06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
06 Fish & Wildlife	1.00	JOB	3,000,000	600,000	20.0%	3,600,000	3600000
19 Buildings, Grounds, & Utilities							
19. 18 UTILITIES, LINES and SERVICES							
19. 18.99I 2"D. PVC Water Line ++	1000.00	LF	10,050	2,010	20.0%	12,060	12.06
19. 18.99J 4"D. PVC Sewer Line ++	200.00	LF	2,410	480	20.0%	2,890	14.44
19. 18.99K Lighting ++	2.00	EA	5,220	1,040	20.0%	6,270	3134.99
19. 18 UTILITIES, LINES and SERVICES	1.00	JOB	17,680	3,540	20.0%	21,220	21220.74
19. 22 PARKING LOTS AND SERVICE ROADS							
19. 22 PARKING LOTS AND SERVICE ROADS	1.00	JOB	228,900	45,780	20.0%	274,680	274680.10
19. 23 FENCE							
19. 23.99U Farm Fence 4'High, 3 Strand ++	9850.00	LF	63,420	19,030	30.0%	82,440	8.37
19. 23 FENCE	1.00	JOB	63,420	19,030	30.0%	82,440	82442.21
19. 27 BUILDINGS, PUBLIC USE							
19. 27.99V Picnic Shelter 25'X40' ++	6.00	EA	18,800	5,640	30.0%	24,440	4073.71
19. 27 BUILDINGS, PUBLIC USE	1.00	JOB	18,800	5,640	30.0%	24,440	24442.26

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
19. 72 DAY USE AREA							
19. 72.90A Tot Lot ++	1.00	EA	22,960	4,590	20.0%	27,550	27549.26
19. 72.90B Asphalt Paving ++	400.00	SY	7,520	1,500	20.0%	9,020	22.56
19. 72.90C Flag Pole ++	1.00	EA	12,530	2,510	20.0%	15,040	15041.39
19. 72.90D Concrete Picnic Table & Seat 7'L	12.00	EA	19,560	3,910	20.0%	23,470	1955.67
19. 72.90E Pine Picnic Table & Seat 8'L ++	30.00	EA	16,930	3,390	20.0%	20,320	677.30
19. 72.90F Raised Castiron Picnic Grill ++	15.00	EA	6,600	1,320	20.0%	7,920	527.77
19. 72.90G Waste Receptacle ++	20.00	EA	3,010	600	20.0%	3,610	180.61
19. 72 DAY USE AREA	1.00	JOB	89,110	17,820	20.0%	106,930	106931.46
19 Buildings, Grounds, & Utilities	1.00	JOB	417,910	91,800	22.0%	509,720	509716.77
30 Engineering & Design							
30. 30 Engineering & Design							
30. 30. 30 Engineering & Design	1.00	JOB	15,072,520	1,507,250	10.0%	16,579,770	16579770
30. 30 Engineering & Design	1.00	JOB	15,072,520	1,507,250	10.0%	16,579,770	16579770
30 Engineering & Design	1.00	JOB	15,072,520	1,507,250	10.0%	16,579,770	16579770
31 S&A							
31. 31 S&A							
31. 31. 31 S&A	1.00	JOB	7,536,260	753,630	10.0%	8,289,880	8289885
31. 31 S&A	1.00	JOB	7,536,260	753,630	10.0%	8,289,880	8289885
31 S&A	1.00	JOB	7,536,260	753,630	10.0%	8,289,880	8289885
30A E&D (FOR FUTURE CULVERT SYSTEM)							
30A. 30 Engineering & Design							
30A. 30. 30 Engineering & Design	1.00	SUM	2,592,510	259,250	10.0%	2,851,760	2851757
30A. 30 Engineering & Design	1.00	SUM	2,592,510	259,250	10.0%	2,851,760	2851757
30A E&D (FOR FUTURE CULVERT SYSTEM)	1.00	SUM	2,592,510	259,250	10.0%	2,851,760	2851757
31A S&A (FOR FUTURE CULVERT SYSTEM)							
31A. 31 S&A							
31A. 31. 31 S&A FOR FUTURE CULVERT SYSTEM	1.00	SUM	1,296,250	129,630	10.0%	1,425,880	1425878
31A. 31 S&A	1.00	SUM	1,296,250	129,630	10.0%	1,425,880	1425878
31A S&A (FOR FUTURE CULVERT SYSTEM)	1.00	SUM	1,296,250	129,630	10.0%	1,425,880	1425878

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
640 Phased Filling & Emptying System							
640. 01 Mob, Demob & Preparatory Work							
640. 01. 10 MOB.& DEMOB.AND PREP. WORK	1.00	JOB	912,880	91,290	10.0%	1,004,170	1004172
640. 01. 20 SIGNS	1.00	JOB	4,430	890	20.0%	5,320	5315.71
640. 01 Mob, Demob & Preparatory Work	1.00	JOB	917,310	92,170	10.0%	1,009,490	1009488
640. 04 Permanent Access Roads & Parking							
640. 04.110 1"Bitum. Conc. Wearing Course	98.00	CY	12,600	2,520	20.0%	15,120	154.28
640. 04.120 2"Bitum. Conc. Base Course	196.00	CY	22,710	4,540	20.0%	27,260	139.06
640. 04.130 Prime Coat .28Gal/SY	900.00	GAL	1,950	390	20.0%	2,350	2.61
640. 04.140 4"Crushed Aggregate Class I	378.00	CY	15,780	3,160	20.0%	18,940	50.10
640. 04.150 4" No 57 Aggregate	378.00	CY	16,010	3,200	20.0%	19,210	50.83
640. 04.160 Plastic Filter Fabric	3500.00	SY	8,450	1,690	20.0%	10,140	2.90
640. 04.170 6"Perf. Pipe Under Drain	1700.00	LF	31,170	6,230	20.0%	37,410	22.00
640. 04.180 Prepare Subase Esplanade	3200.00	SY	9,540	1,910	20.0%	11,440	3.58
640. 04 Permanent Access Roads & Parking	1.00	JOB	118,210	23,640	20.0%	141,860	141857.94
640. 10 Earthwork for Structures							
640. 10.240 Strip & Stockpile Topsoil	500.00	CY	660	200	30.0%	860	1.73
640. 10.250 Replace Topsoil from Stockpile	500.00	CY	530	160	30.0%	690	1.38
640. 10.260 Haul Roads 12" Aggregate	54000.00	SY	732,870	219,860	30.0%	952,730	17.64
640. 10.280 Exca. Wet Earth & Haul	3500.00	CY	71,650	21,500	30.0%	93,150	26.61
640. 10.290 Rock Exc	25000.00	CY	844,430	253,330	30.0%	1,097,760	43.91
640. 10.320 Spread All Dumped Material	28500.00	CY	127,360	38,210	30.0%	165,570	5.81
640. 10 Earthwork for Structures	1.00	JOB	1,777,510	533,250	30.0%	2,310,770	2310766
640. 22 Parking Lots & Service Roads							
640. 22.99L Crush Aggregate 4"Depth Cl I ++	216.00	CY	19,770	3,950	20.0%	23,720	109.82
640. 22.99M #57 Aggregate Base 4"Depth ++	216.00	CY	20,070	4,010	20.0%	24,080	111.50
640. 22.99N Bituminous Prime Coat ++	500.00	GAL	2,610	520	20.0%	3,130	6.25
640. 22.99O 2"Bitum. Concrete Base Course ++	200.00	TON	27,810	5,560	20.0%	33,380	166.88
640. 22.99P 1"Bitum.Concrete Wearing Course+	100.00	TON	15,430	3,090	20.0%	18,510	185.14
640. 22.99Q 6"D.PVC Pref. Pipe Underdrain ++	650.00	LF	46,060	9,210	20.0%	55,280	85.04
640. 22.99R Filter Fabric ++	2000.00	SY	18,520	3,700	20.0%	22,230	11.11
640. 22.99S Exca.& Haul Road & Parkinglot ++	2000.00	CY	19,790	3,960	20.0%	23,750	11.87
640. 22.99T Disposal Exca. Material ++	2545.40	CY	6,170	1,230	20.0%	7,400	2.91
640. 22.99U Prepare Subbase	1828.00	SY	40,210	8,040	20.0%	48,260	26.40
640. 22 Parking Lots & Service Roads	1.00	JOB	216,450	43,290	20.0%	259,740	259737.19
640. 62 Demo Lock Walls, Up & Dn Stream							
640. 62.560 Remove Existing Monolith L29-L37	9100.00	CY	1,180,170	354,050	30.0%	1,534,220	168.60
640. 62 Demo Lock Walls, Up & Dn Stream	1.00	JOB	1,180,170	354,050	30.0%	1,534,220	1534223

	QUANTITY	UOM	CONTRACT	TOTAL	ROW%	TOTAL	UNIT
640. 64 Filling and Emptying System							
640. 64.101 Shoring for excavation	11200.00	SF	386,060	38,610	10.0%	424,670	37.92
640. 64.102 US Cut-Off Wall	12670.00	SF	308,790	92,640	30.0%	401,420	31.68
640. 64.271 Exca. Dry Earth & Haul	350000.00	CY	2,816,230	844,870	30.0%	3,661,090	10.46
640. 64.291 Culvert, Rock Exc	2000.00	CY	44,250	13,280	30.0%	57,530	28.77
640. 64.690 Screens and Nose Plates at	1.00	JOB	434,390	86,880	20.0%	521,270	521265.43
640. 64.842 Concrete Thrust Block Culvert	2000.00	CY	274,770	54,950	20.0%	329,720	164.86
640. 64.843 Concrete Bypass Culvert	2850.00	CY	1,336,960	267,390	20.0%	1,604,350	562.93
640. 64.844 Wells for Dewatering	520.00	EA	2,414,050	482,810	20.0%	2,896,860	5570.89
640. 64.845 Ice & Debris Floating Boom	1.00	EA	481,720	96,340	20.0%	578,060	578062.99
640. 64.935 Drilled Caissons for Wingwall	9.00	EA	1,826,270	456,570	25.0%	2,282,830	253647.99
640. 64.960 Sealing Diaphragms and Embedded	2.00	EA	51,720	15,520	30.0%	67,240	33618.70
640. 64.965 Tainer Val.Oper.Mach&Emb.Metal	1.00	EA	365,610	109,680	30.0%	475,290	475294.20
640. 64 Filling and Emptying System	1.00	JOB	10,740,810	2,559,530	23.8%	13,300,340	13300335
640. 68 Compressed Air System							
640. 68.985 Compressed Air Piping System	1.00	JOB	198,020	59,400	30.0%	257,420	257421.28
640. 68 Compressed Air System	1.00	JOB	198,020	59,400	30.0%	257,420	257421.28
640. 76 Pumping Machinery & Appurten.							
640. 76.990 Extension Raw Water Pump & Pipe	1.00	JOB	32,490	9,750	30.0%	42,230	42234.23
640. 76.991 Raw Water Piping	1.00	JOB	110,830	33,250	30.0%	144,080	144081.76
640. 76 Pumping Machinery & Appurten.	1.00	LS	143,320	43,000	30.0%	186,320	186315.99
640. 99 Associated General Items							
640. 99.99A Wharf	1.00	JOB	1,000,000	250,000	25.0%	1,250,000	1250000
640. 99.99M Harbor Area Items	1.00	JOB	836,210	334,480	40.0%	1,170,690	1170689
640. 99 Associated General Items	1.00	JOB	1,836,210	584,480	31.8%	2,420,690	2420689
640.020 Drainage							
640.020. 50 Catch Basins 4' Depth	1.00	EA	3,300	990	30.0%	4,290	4285.64
640.020. 60 15" RCP	120.00	LF	7,850	2,360	30.0%	10,210	85.06
640.020. 70 15" Headwalls	4.00	EA	2,200	660	30.0%	2,860	715.03
640.020.100 Concrete Lined Ditch	1650.00	LF	142,010	42,600	30.0%	184,610	111.89
640.020 Drainage	1.00	JOB	155,360	46,610	30.0%	201,970	201965.51
640 Phased Filling & Emptying System	1.00	JOB	17,283,370	4,339,430	25.1%	21,622,800	21622800
Plan4 Aux.Lock Ext-Future/Phased	1.00	EA	144,264,360	29,249,090	20.3%	173,513,450	173513453

SECTION 24 SCHEDULES FOR DESIGN AND CONSTRUCTION

24.1 PLANS AND SPECIFICATIONS SCHEDULE

24.1.1 Lock Wall Extension

The design schedule has not been developed at this time. It is expected development of final plans and specifications will take approximately 18 months from authorization to final acceptance. The schedule will include appropriate submittals and reviews at 35%, 65%, 95% and Construction Issue.

24.1.2 Approach Walls

It is anticipated that plans and specifications for the floating approach walls will require approximately 200 engineering drawings and will take approximately 16 months from notice to proceed to completion of the contract documents. It is anticipated that development of plans and specifications may follow the following schedule.

Work Phase	Days After NTP
Quality Control Plan Submittal	30
35 Percent Review Submittal	160
65 Percent Review Submittal	240
95 Percent Review Submittal	330
BCOP Review Submittal	390
Final Submittal	465

24.2 CONSTRUCTION SCHEDULE

24.2.1 Lock Wall Extension

Four construction schedules are submitted with this report. The first schedule is an hourly schedule for the critical construction period of the middle gate monoliths. The intent of this schedule is to show in detail how the critical main chamber shutdowns are managed.

The other four schedules are weekly construction schedules for the four alternatives. The alternatives are discussed in detail in SECTION 2.

- Plan 1 is the extension with no provisions for a supplemental fill/empty system.
- Plan 2 includes the culverts in the land wall, the laterals, outlet culvert, and outlet structure. The bypass culvert and intake are deferred until reduced fill times are deemed necessary.

- Plan 3 includes all elements at the time of the extension construction.
- Plan 4 is the same as Plan 2, however costs for constructing the addition of the bypass culvert and intake when deemed necessary are included.

The total construction schedule shows as much detail as is possible for the current stage of the design. The schedules follow this page.

24.2.2 Approach Walls

The construction schedule for the approach walls is predicated upon the availability of a suitable graving dock site. In this case, we assume that the availability of the two decommissioned locks at Galipolis will be used for fabrication and construction of the individual pontoon segments. It is anticipated that construction will proceed through two construction seasons with a winter shutdown of approximately two months.

Construction of the drilled shafts will proceed on an independent track parallel with the fabrication of the pontoons such that the drilled shafts; nose piers and anchor pylons are completed prior to pontoon fabrication. This will allow the pontoons to be transported to the site and installed immediately without need for significant storage and the associated costs and potential for damage.

Construction of the precast pontoon segments is a critical path item and drives the overall completion schedule. This construction schedule is included in sections 24.4 to 24.7 for the various plan alternatives.

24.2.3 Assumptions made for current Cost Estimate

The following assumptions were made in preparing the following construction schedule:

While lock is open: 8-hour workdays and 5 day work weeks

While lock is closed: 20-hour workdays and 7 day work weeks

Production rates:

1000 c.y./day for dredging
500 c.y./day for rock excavation w/low level blasting
1500 c.y./day for backfill
400 c.y./day for concrete demolition
60 c.y./day for precast concrete for float-in structures
1200 c.y./day for gate bay monolith mass concrete pour
1700 c.y./day for lock wall monolith concrete pour.

Many "effective production rates" were reduced from those given above to account for weather days during the construction period.

Durations for rock excavation and concrete demolition assume low level blasting will be allowed.

The 600' lock will be shut down during shaft construction of the upper middle approach wall. The shut down will be sequenced as alternating five day shut downs and two days open.

The 1200' lock will remain open during most of the construction of the riverside approach wall by working from the riverside. If a crane is used, its boom will extend over the navigation channel. However, the boom will be approximately 50 to 100 feet above ground level and can quickly swing away from the channel while barges pass through the lock. While the shaft concrete is curing, it is partially protected by oversized steel casing with sand between this casing and the concrete. However, a helper tug would be required to guide the tows through the

lock during the drilled shaft construction to ensure controlled navigation of the lock and protect the integrity of the concrete shaft.

The 600' lock will remain open during most of the construction of the lower landside approach wall by working from the landside and using similar methods to those listed in item 6 above

Helper tug services have been assumed required during many phases of the construction in order to assure smooth operation of the locks. In general, the criteria used to determine the necessity of the helper tug was as follows:

When construction activity is in or is very close to the navigation channel.

When structural elements would be damaged by scraping or minor impacts from the tows.

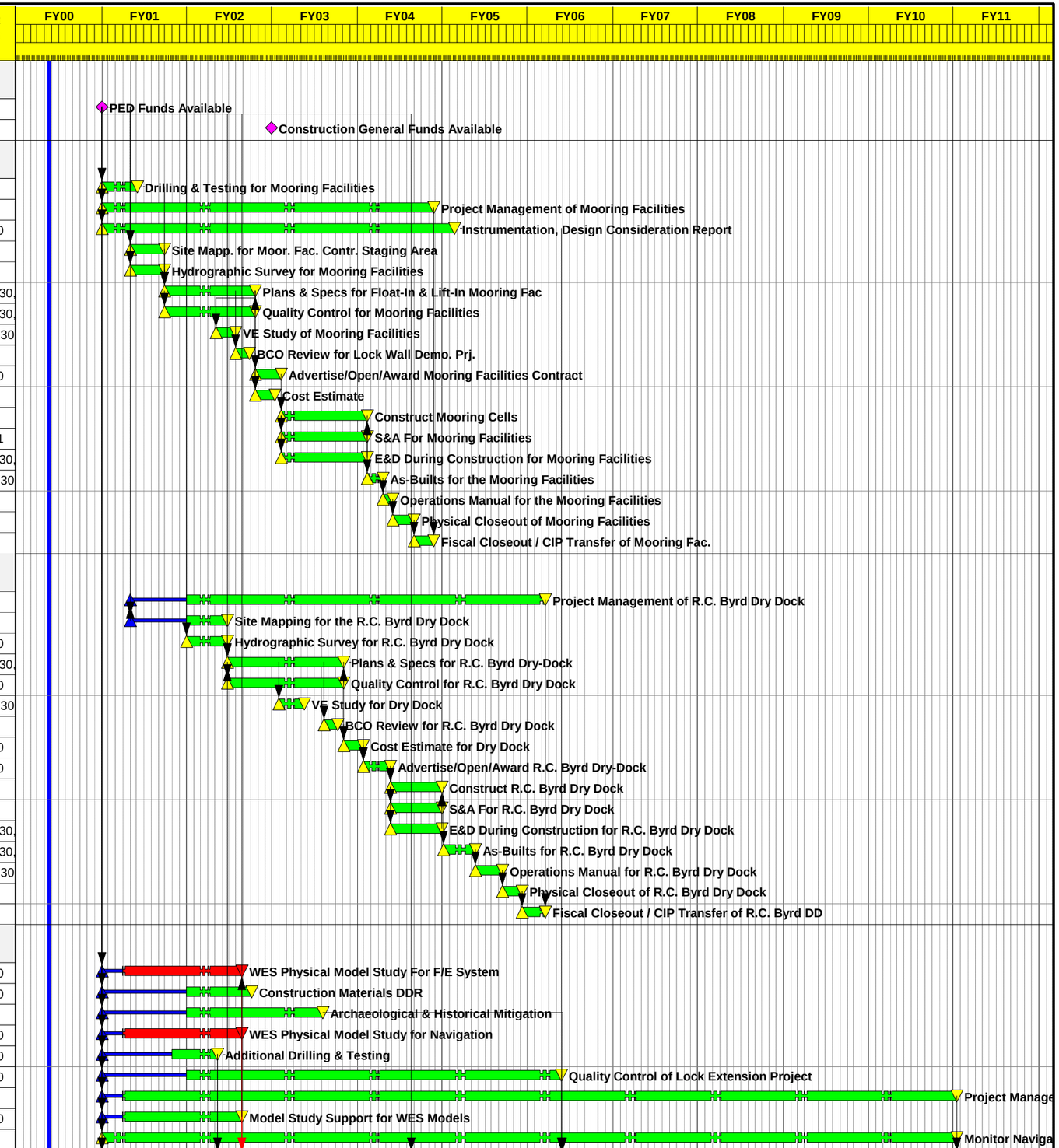
Earlier versions of these construction schedules were discussed with the following contractors who reviewed them and provided feedback:

Al Johnson Construction Co. (for gate bay & concrete production rates)
DBM Contractors, Inc. (for drilled shafts and construction methods)
Malcolm Drilling Co., Inc. (for drilled shafts and rock excavation)
American Divers (for underwater work)
Fletcher General Construction (for complete schedule)
Manson Construction & Engineering Company (for complete schedule)

All of the above contractors reviewed their areas of expertise and agreed that the construction schedules presented were feasible. They commented that one continuous closure of the 600' lock was much more desirable than a 12-hour closed/12 hour open schedule. A 12 hour closed/12 hour open scheme would greatly lengthen the total construction time required because most construction steps would become critical path items (in order to reopen the lock), and continual mobilization and demobilization would waste a lot of otherwise productive hours. Because of this feedback, a longer continuous closure was generally chosen over a short-term open/short-term closed schedule. An exception to this was made when a 12-hour closed/12 hour open schedule would not require multiple mobilizations and fit well with a particular construction step.

24.3 DESIGN SCHEDULE FOR ALL PLANS

Activity ID	Activity Description	Orig Dur	Rem Dur	Early Start	Early Finish	Suspend Date	Resume Date	Budgeted Cost ($1,000s)	Cost Acct
Funding Milestones									
DES035	PED Funds Available	0	0	02OCT00*				0.00	
DES045	Construction General Funds Available	0	0	01OCT02*				0.00	
PHASE I - Lock Wall Demo. Prj. (Mooring Cells)									
DES300	Drilling & Testing for Mooring Facilities	90	90	02OCT00	02MAR01			48.18	30
DES460	Project Management of Mooring Facilities	939*	939*	02OCT00	26AUG04			84.00	30
DES620	Instrumentation, Design Consideration Report	1,000	1,000	02OCT00	19NOV04			271.40	30, 30
DES500	Site Mapp. for Moor. Fac. Contr. Staging Area	105	105	01FEB01*	27JUN01			5.00	30
DES510	Hydrographic Survey for Mooring Facilities	105	105	01FEB01*	27JUN01			15.00	30
DES160	Plans & Specs for Float-In & Lift-In Mooring Fac	260	260	28JUN01	23JUL02			386.26	30, 30, 30,
DES350	Quality Control for Mooring Facilities	260*	260*	28JUN01	23JUL02			20.32	30, 30, 30,
DES340	VE Study of Mooring Facilities	60	60	06FEB02	30APR02			14.58	30, 30, 30
DES730	BCO Review for Lock Wall Demo. Prj.	40	40	01MAY02	25JUN02			0.00	
AOA100	Advertise/Open/Award Mooring Facilities Contract	80	80	24JUL02	12NOV02			13.00	30, 30
DES380	Cost Estimate	60	60	24JUL02	15OCT02			23.56	30
CON140	Construct Mooring Cells	240	240	13NOV02	11NOV03			2,374.00	05
CON145	S&A For Mooring Facilities	240*	240*	13NOV02	11NOV03			166.35	31, 31
DES320	E&D During Construction for Mooring Facilities	240*	240*	13NOV02	11NOV03			75.11	30, 30, 30,
DES570	As-Builts for the Mooring Facilities	30	30	12NOV03	21JAN04			16.08	30, 30, 30
DES580	Operations Manual for the Mooring Facilities	30	30	22JAN04	03MAR04			10.00	30
DES630	Physical Closeout of Mooring Facilities	63	63	04MAR04	31MAY04			0.00	
DES640	Fiscal Closeout / CIP Transfer of Mooring Fac.	63	63	01JUN04	26AUG04			0.00	
PHASE II - R.C. Byrd Dry Dock									
DES470	Project Management of R.C. Byrd Dry Dock	1,183*	1,011*	01FEB01A	16DEC05			63.00	30
DES520	Site Mapping for the R.C. Byrd Dry Dock	105	105	01FEB01A	21MAR02	01FEB01	01OCT01	5.00	30
DES530	Hydrographic Survey for R.C. Byrd Dry Dock	105	105	01OCT01*	21MAR02			5.00	30, 30
DES170	Plans & Specs for R.C. Byrd Dry-Dock	340	340	22MAR02	07AUG03			1,111.38	30, 30, 30,
DES410	Quality Control for R.C. Byrd Dry Dock	340*	340*	22MAR02	07AUG03			11.11	30, 30
DES400	VE Study for Dry Dock	60	60	01NOV02	20FEB03			36.08	30, 30, 30
DES740	BCO Review for R.C. Byrd Dry Dock	40	40	16MAY03	10JUL03			0.00	
DES390	Cost Estimate for Dry Dock	60	60	08AUG03	30OCT03			24.46	30, 30
AOA110	Advertise/Open/Award R.C. Byrd Dry-Dock	60	60	31OCT03	20FEB04			13.00	30, 30
CON150	Construct R.C. Byrd Dry Dock	160	160	23FEB04*	01OCT04			7,500.00	05
CON230	S&A For R.C. Byrd Dry Dock	160*	160*	23FEB04	01OCT04			507.00	31
DES220	E&D During Construction for R.C. Byrd Dry Dock	160*	160*	23FEB04	01OCT04			164.59	30, 30, 30,
DES240	As-Builts for R.C. Byrd Dry Dock	80	80	04OCT04	21FEB05			73.50	30, 30, 30,
DES590	Operations Manual for R.C. Byrd Dry Dock	80	80	22FEB05	13JUN05			23.52	30, 30, 30
DES650	Physical Closeout of R.C. Byrd Dry Dock	63	63	14JUN05	08SEP05			0.00	
DES660	Fiscal Closeout / CIP Transfer of R.C. Byrd DD	63	63	09SEP05	16DEC05			0.00	
PHASE III - Lock Extension									
DES100	WES Physical Model Study For F/E System	340	340	02OCT00A	23MAY02	02OCT00	02JAN01	760.00	30, 30
DES130	Construction Materials DDR	180	180	02OCT00A	04JUL02	02OCT00	01OCT01	116.28	30, 30
DES140	Archaeological & Historical Mitigation	380	380	02OCT00A	08MAY03	02OCT00	01OCT01	100.00	30
DES200	WES Physical Model Study for Navigation	340	340	02OCT00A	23MAY02	02OCT00	02JAN01	760.00	30, 30
DES210	Additional Drilling & Testing	120	120	02OCT00A	11FEB02	02OCT00	01AUG01	372.00	30, 30
DES420	Quality Control of Lock Extension Project	1,290*	1,050*	02OCT00A	24FEB06			34.65	30, 30
DES480	Project Management of Lock Extension	2,416*	2,366*	02OCT00A	12OCT10			1,134.00	30
DES90	Model Study Support for WES Models	390*	340*	02OCT00A	23MAY02			85.00	30, 30
DES720	Monitor Navigation Data Base	2,416*	2,416*	02OCT00	12OCT10			400.00	30



Start Date	01JAN99
Finish Date	05APR11
Data Date	20FEB00
Run Date	02MAY00 09:09

Early Bar
Progress Bar
Critical Activity

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Greenup Active Design Schedule
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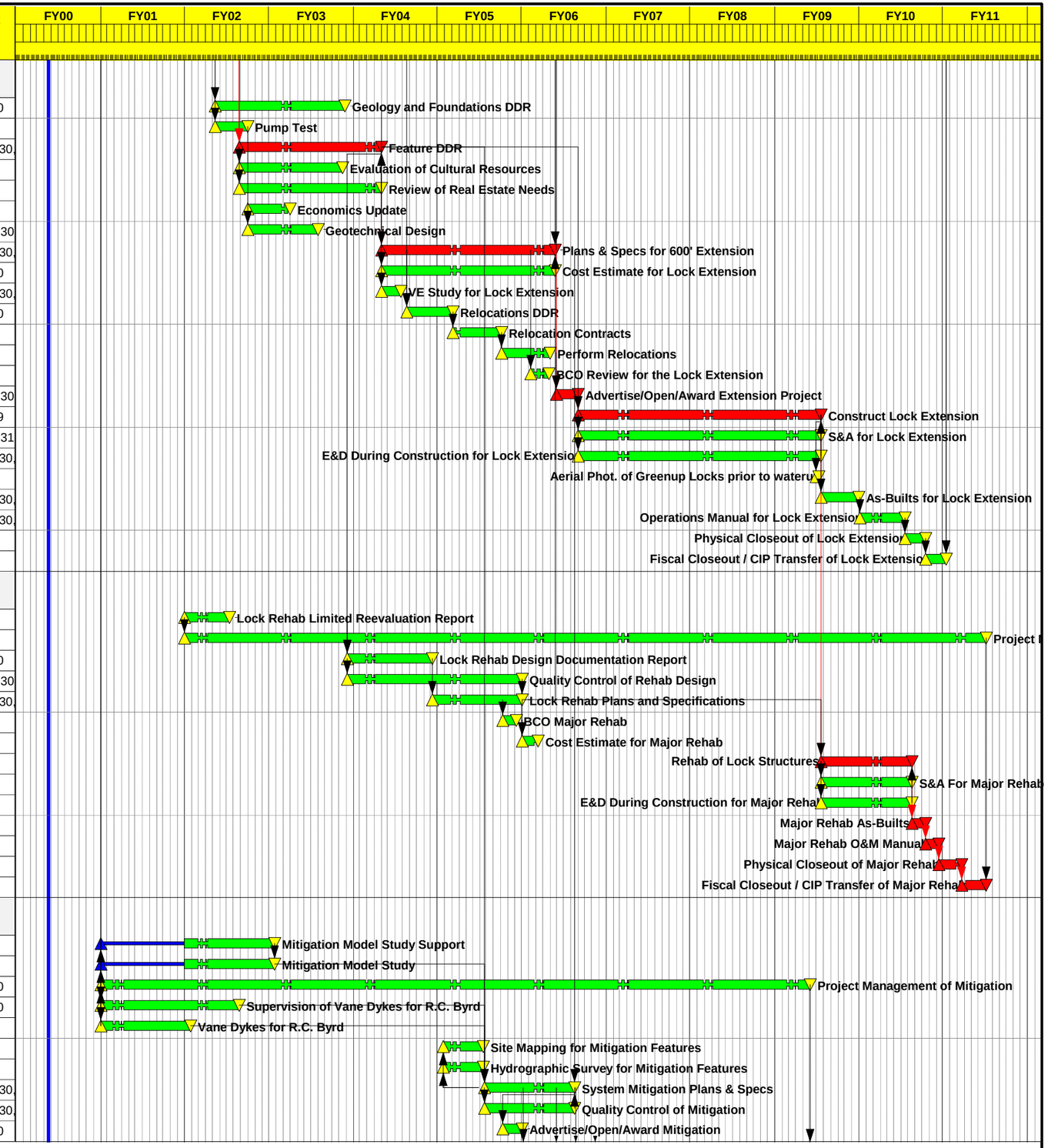
Activity ID	Activity Description	Orig Dur	Rem Dur	Early Start	Early Finish	Suspend Date	Resume Date	Budgeted Cost ($1,000s)	Cost Acct
PHASE III - Lock Extension									
DES120	Geology and Foundations DDR	380	380	12FEB02	25AUG03			69.20	30, 30
DES270	Pump Test	100	100	12FEB02	01JUL02			44.00	30
DES110	Feature DDR	400	400	24MAY02	30JAN04			4,632.86	30, 30, 30,
DES150	Evaluation of Cultural Resources	300	300	24MAY02	14AUG03			50.00	30
DES330	Review of Real Estate Needs	400*	400*	24MAY02	30JAN04			50.00	30
DES710	Economics Update	116	116	01JUL02*	01JAN03			100.00	30
DES230	Geotechnical Design	200	200	02JUL02	05MAY03			67.40	30, 30, 30
DES180	Plans & Specs for 600' Extension	500	500	02FEB04	24FEB06			5,139.36	30, 30, 30,
DES360	Cost Estimate for Lock Extension	500*	500*	02FEB04	24FEB06			93.01	30, 30
DES370	VE Study for Lock Extension	60	60	02FEB04	23APR04			470.43	30, 30, 30,
REL010	Relocations DDR	135	135	24MAY04	08DEC04			44.62	30, 30
REL025	Relocation Contracts	135	135	09DEC04	04JUL05			40.00	30
REL020	Perform Relocations	135	135	05JUL05	03FEB06			600.00	02
DES750	BCO Review for the Lock Extension	40	40	08NOV05	27JAN06			0.00	
AOA120	Advertise/Open/Award Extension Project	70	70	27FEB06	02JUN06			61.00	30, 30, 30
CON160	Construct Lock Extension	690	690	05JUN06	17APR09			125,663.00	05, 19
CON270	S&A for Lock Extension	690*	690*	05JUN06	17APR09			8,560.70	31, 31, 31
DES250	E&D During Construction for Lock Extension	690*	690*	05JUN06	17APR09			1,007.36	30, 30, 30,
DES540	Aerial Phot. of Greenup Locks prior to waterup	10	10	30MAR09	10APR09			0.00	
DES260	As-Builts for Lock Extension	120	120	20APR09	02OCT09			221.00	30, 30, 30,
DES310	Operations Manual for Lock Extension	120	120	05OCT09	19APR10			377.95	30, 30, 30,
DES670	Physical Closeout of Lock Extension	63	63	20APR10	15JUL10			0.00	
DES680	Fiscal Closeout / CIP Transfer of Lock Extension	63	63	16JUL10	12OCT10			0.00	
Phase III - Major Rehabilitation 2008-2009									
CON290	Lock Rehab Limited Reevaluation Report	120	120	01OCT01*	11APR02			4.40	30
CON310	Project Management of Rehab	2,280*	2,280*	01OCT01	05APR11			0.00	
CON250	Lock Rehab Design Documentation Report	240	240	08SEP03	06SEP04			17.38	30, 30
CON280	Quality Control of Rehab Design	500*	500*	08SEP03	04OCT05			23.11	30, 30, 30
CON260	Lock Rehab Plans and Specifications	260	260	07SEP04	04OCT05			594.38	30, 30, 30,
CON360	BCO Major Rehab	40	40	13JUL05	06SEP05			0.00	
CON370	Cost Estimate for Major Rehab	40	40	05OCT05	09DEC05			0.00	
CON240	Rehab of Lock Structures	260	260	20APR09	17MAY10			27,271.00	05
CON380	S&A For Major Rehab	260*	260*	20APR09	17MAY10			466.00	31
CON390	E&D During Construction for Major Rehab	260*	260*	20APR09	17MAY10			0.00	
CON340	Major Rehab As-Builts	42	42	18MAY10	14JUL10			0.00	
CON350	Major Rehab O&M Manual	42	42	15JUL10	10SEP10			0.00	
CON320	Physical Closeout of Major Rehab	63	63	13SEP10	20DEC10			0.00	
CON330	Fiscal Closeout / CIP Transfer of Major Rehab	63	63	21DEC10	05APR11			0.00	
PHASE IV - Project Mitigation									
DES290	Mitigation Model Study Support	500*	260*	02OCT00A	24OCT02			30.00	30
DES770	Mitigation Model Study	260	260	02OCT00A	24OCT02	02OCT00	01OCT01	100.00	30
DES490	Project Management of Mitigation	2,016*	2,016*	02OCT00	02MAR09			16.00	30, 30
DES600	Supervision of Vane Dykes for R.C. Byrd	390	390	02OCT00	23MAY02			10.00	30, 30
DES610	Vane Dykes for R.C. Byrd	260	260	02OCT00	26OCT01			35.00	30
DES550	Site Mapping for Mitigation Features	105	105	25OCT04	18APR05			0.00	
DES560	Hydrographic Survey for Mitigation Features	105	105	25OCT04	18APR05			0.00	30
DES190	System Mitigation Plans & Specs	260	260	26APR05	19MAY06			197.94	30, 30, 30,
DES450	Quality Control of Mitigation	260*	260*	26APR05	19MAY06			20.63	30, 30, 30,
AOA130	Advertise/Open/Award Mitigation	60	60	12JUL05	03OCT05*			33.00	30, 30



Start Date	01JAN99	Early Bar
Finish Date	05APR11	Progress Bar
Data Date	20FEB00	Critical Activity
Run Date	02MAY00 09:09	

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Greenup Active Design Schedule
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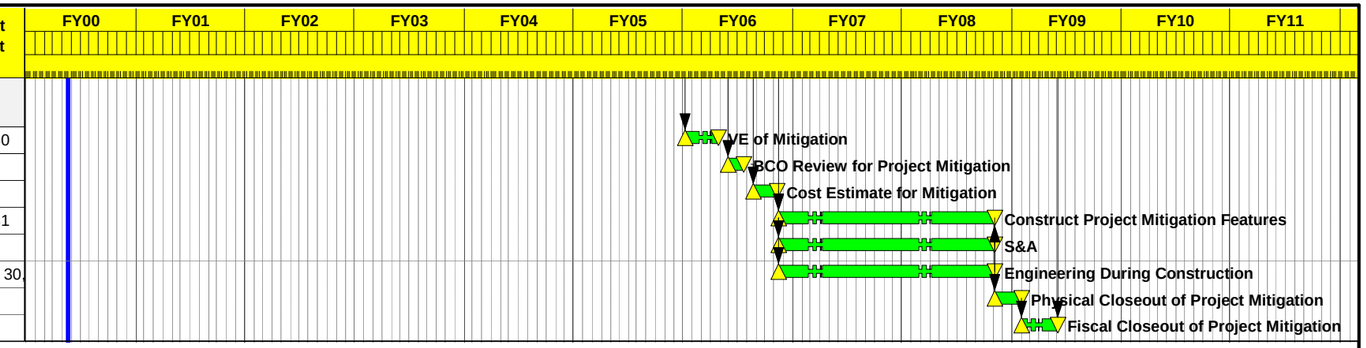
PHASE IV - Project Mitigation

Activity ID	Activity Description	Orig Dur	Rem Dur	Early Start	Early Finish	Suspend Date	Resume Date	Budgeted Cost ($1,000s)	Cost Acct
DES440	VE of Mitigation	60	60	11OCT05	27JAN06			16.08	30, 30
DES760	BCO Review for Project Mitigation	40	40	27FEB06	21APR06			0.00	
DES430	Cost Estimate for Mitigation	60	60	22MAY06	11AUG06			25.87	30
CON170	Construct Project Mitigation Features	480	480	14AUG06	07AUG08			5,638.08	06, 31
CON300	S&A	480*	480*	14AUG06	07AUG08			243.00	31
DES280	Engineering During Construction	480*	480*	14AUG06	07AUG08			34.36	30, 30, 30,
DES690	Physical Closeout of Project Mitigation	63	63	08AUG08	04NOV08			0.00	
DES700	Fiscal Closeout of Project Mitigation	63	63	05NOV08	02MAR09			0.00	



Start Date	01JAN99
Finish Date	05APR11
Data Date	20FEB00
Run Date	02MAY00 09:09

Early Bar
Progress Bar
Critical Activity

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Greenup Active Design Schedule
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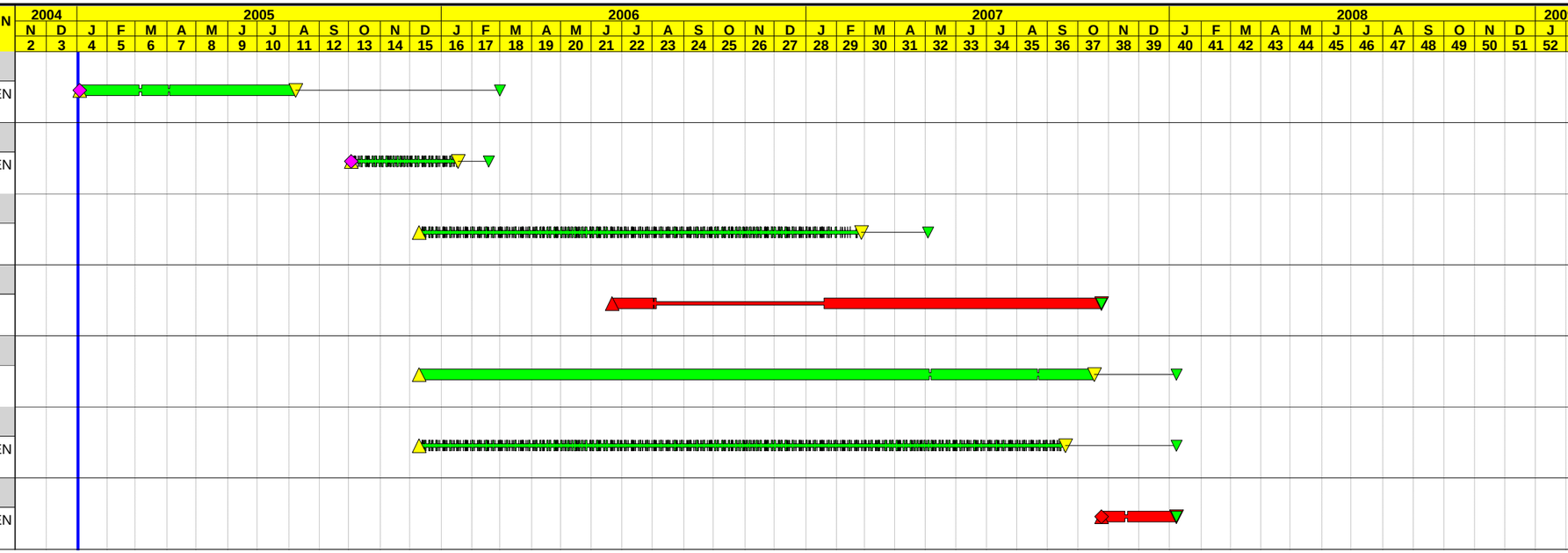
24.4 CONDENSED PLAN 1 - AUXILIARY LOCK EXTENSION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
+ R.C. Byrd Dry Dock							
		5,214	03JAN05 08:00	08AUG05 13:59	RCBDD		OPEN
+ Greenup Mobilization							
		685	03OCT05 08:00	17JAN06 08:59	MOB	STRT	OPEN
+ Land Wall Extension							
		2,848	09DEC05 12:00	26FEB07 15:59	LWEXT		
+ Miter Gate Monoliths Etc							
		11,760	21JUN06 10:00	24OCT07 09:59	MITER		
+ Floating Approach Walls							
		16,252	09DEC05 12:00	17OCT07 15:59	FW		
+ Project Mitigation							
		4,160	09DEC05 12:00	18SEP07 13:59	MITAGA		OPEN
+ Demob							
		1,804	24OCT07 10:00	07JAN08 13:59	DEMOB		OPEN



Project Start	01OCT04 00:00
Project Finish	07JAN08 13:59
Data Date	03JAN05 00:00
Run Date	07OCT99 14:00

Early Bar
Float Bar
Progress Bar
Critical Activity

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PLN1

Sheet 1 of 1

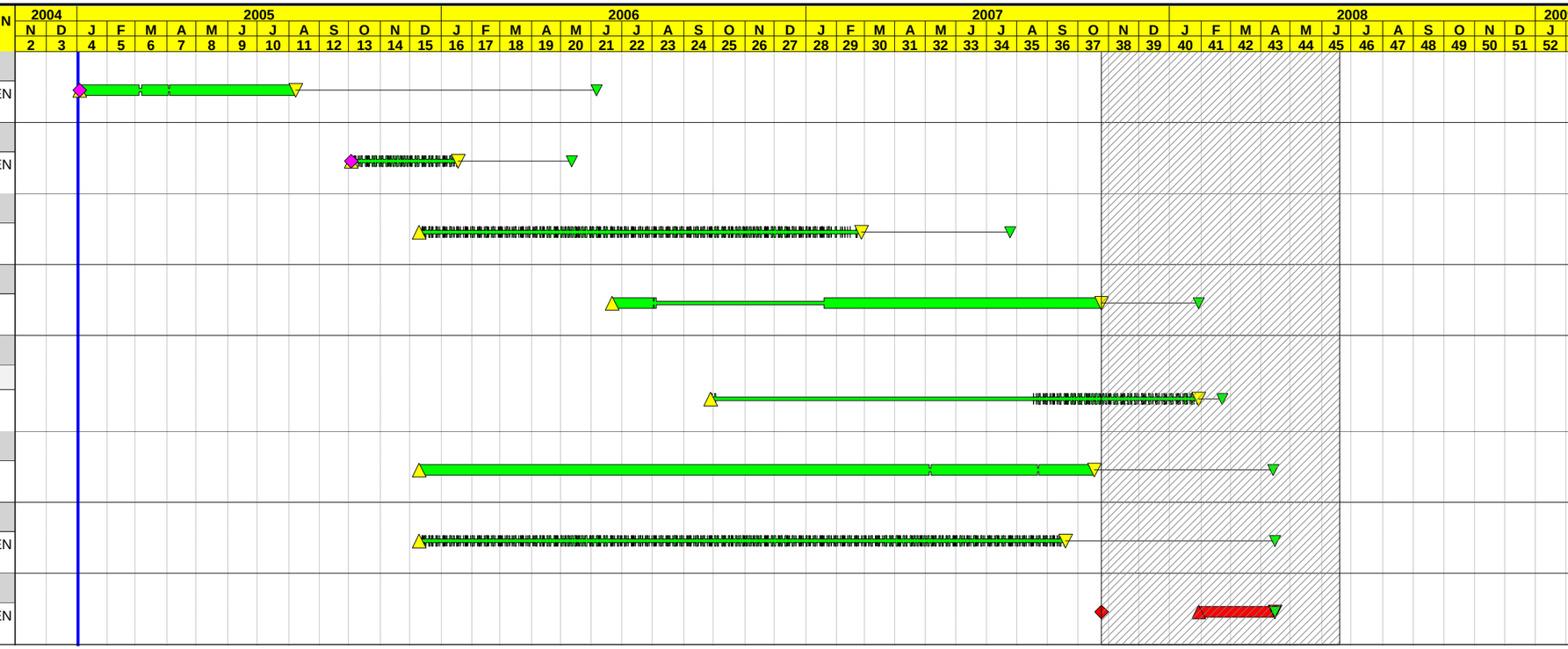
USACE

Plan 1 - Auxiliary Extension

Condensed

24.5 CONDENSED PLAN 2 - AUXILIARY EXTENSION WITH MODIFICATIONS SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
+ R.C. Byrd Dry Dock							
		5,214	03JAN05 08:00	08AUG05 13:59	RCBDD		OPEN
+ Greenup Mobilization							
		685	03OCT05 08:00	17JAN06 08:59	MOB	STRT	OPEN
+ Land Wall Extension							
		2,848	09DEC05 12:00	26FEB07 15:59	LWEXT		
+ Miter Gate Monoliths Etc							
		11,760	21JUN06 10:00	24OCT07 09:59	MITER		
Auxiliary Filling and Emptying System							
+ EMTY							
		3,144	27SEP06 12:00	29JAN08 14:59	AUXFE	EMTY	
+ Floating Approach Walls							
		16,252	09DEC05 12:00	17OCT07 15:59	FW		
+ Project Mitigation							
		4,160	09DEC05 12:00	18SEP07 13:59	MITAGA		OPEN
+ Demob							
		4,152	24OCT07 10:00	14APR08 09:59	DEMOB		OPEN



Project Start	01OCT04 00:00
Project Finish	14APR08 09:59
Data Date	03JAN05 00:00
Run Date	07OCT99 13:00

Early Bar
Float Bar
Progress Bar
Critical Activity

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PLN2

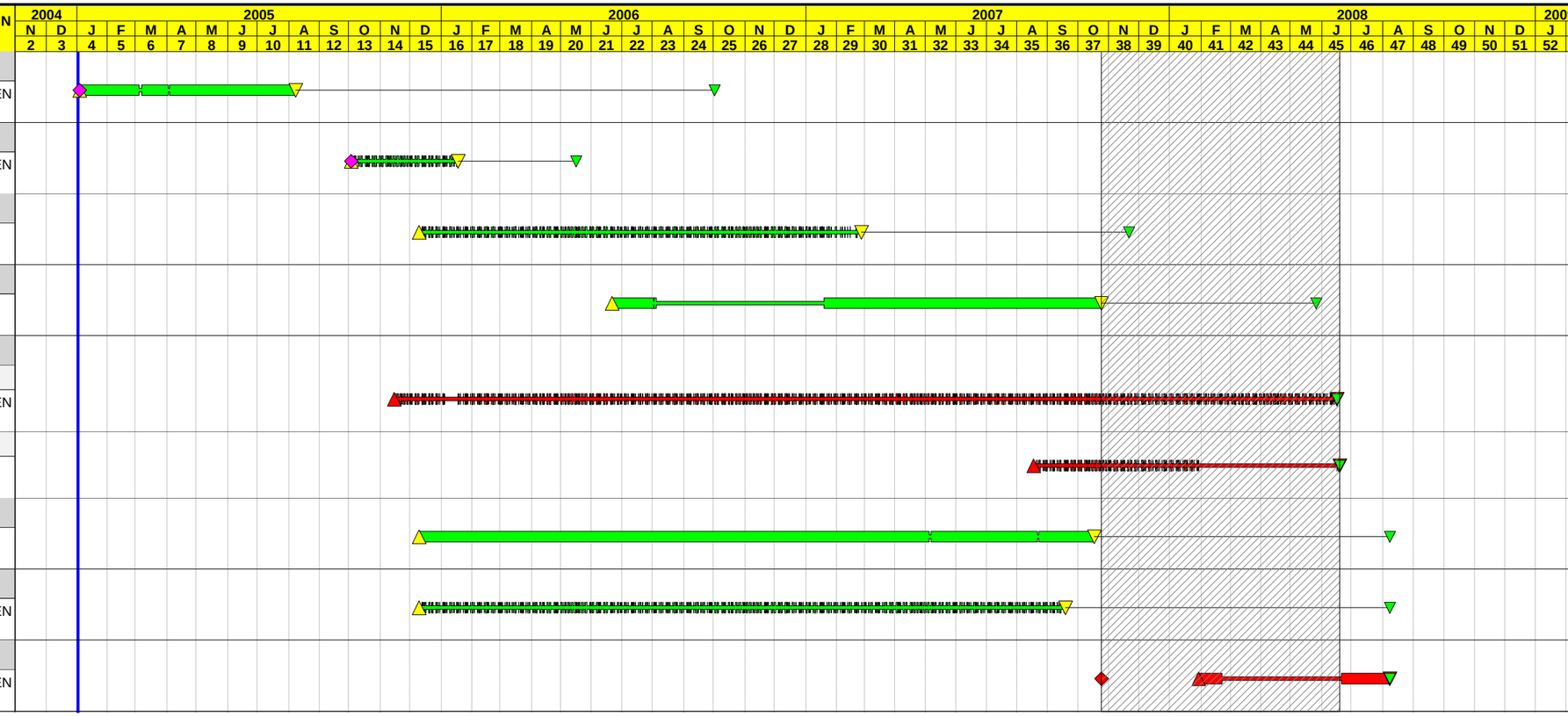
USACE

Plan 2 - Aux. Ext. w/Modification

Condensed

24.6 CONDENSED PLAN 3 - AUXILIARY EXTENSION WITH CULVERT SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
+ R.C. Byrd Dry Dock							
		5,214	03JAN05 08:00	08AUG05 13:59	RCBDD		OPEN
+ Greenup Mobilization							
		685	03OCT05 08:00	17JAN06 08:59	MOB	STRT	OPEN
+ Land Wall Extension							
		2,848	09DEC05 12:00	26FEB07 15:59	LWEXT		
+ Miter Gate Monoliths Etc							
		11,760	21JUN06 10:00	24OCT07 09:59	MITER		
Auxiliary Filling and Emptying System							
+ FILL							
		6,064	15NOV05 14:00	16JUN08 11:59	AUXFE	FILL	OPEN
+ EMTY							
		1,976	17AUG07 12:00	19JUN08 16:59	AUXFE	EMTY	
+ Floating Approach Walls							
		16,252	09DEC05 12:00	17OCT07 15:59	FW		
+ Project Mitigation							
		4,160	09DEC05 12:00	18SEP07 13:59	MITAGA		OPEN
+ Demob							
		6,940	24OCT07 10:00	08AUG08 13:59	DEMOB		OPEN



Project Start	01OCT04 00:00
Project Finish	08AUG08 13:59
Data Date	03JAN05 00:00
Run Date	07OCT99 13:00

Early Bar
Float Bar
Progress Bar
Critical Activity

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PLN3

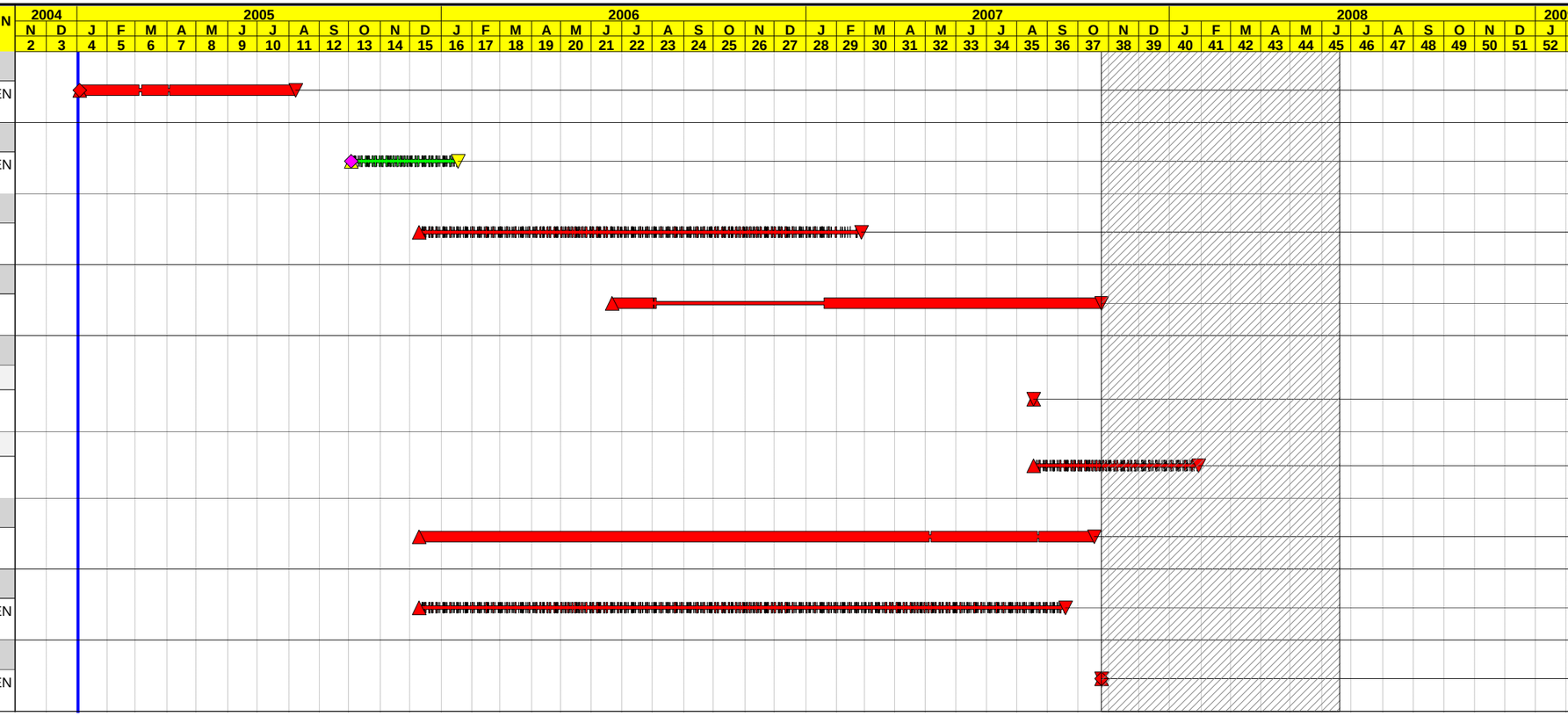
USACE

Plan 3 - Aux. Extension w/Culvert

Condensed Schedule

24.7 CONDENSED PLAN 4 - AUXILIARY EXTENSION – PHASED CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
+ R.C. Byrd Dry Dock							
		5,214	03JAN05 08:00	08AUG05 13:59	RCBDD		OPEN
+ Greenup Mobilization							
		685	03OCT05 08:00	17JAN06 08:59	MOB	STRT	OPEN
+ Land Wall Extension							
		2,848	09DEC05 12:00	26FEB07 15:59	LWEXT		
+ Miter Gate Monoliths Etc							
		11,760	21JUN06 10:00	24OCT07 09:59	MITER		
Auxiliary Filling and Emptying System							
+ FILL							
		0	17AUG07 12:00	20FEB12 12:59	AUXFE	EMTY	
+ EMTY							
		1,056	17AUG07 12:00	29JAN08 14:59	AUXFE	EMTY	
+ Floating Approach Walls							
		16,252	09DEC05 12:00	17OCT07 15:59	FW		
+ Project Mitigation							
		4,160	09DEC05 12:00	18SEP07 13:59	MITAGA		OPEN
+ Demob							
		0	24OCT07 10:00	20FEB12 14:59	DEMOB		OPEN



Project Start	01OCT04 00:00
Project Finish	20FEB12 14:59
Data Date	03JAN05 00:00
Run Date	07OCT99 13:00

Early Bar
Float Bar
Progress Bar
Critical Activity

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PLN4

Sheet 1 of 1

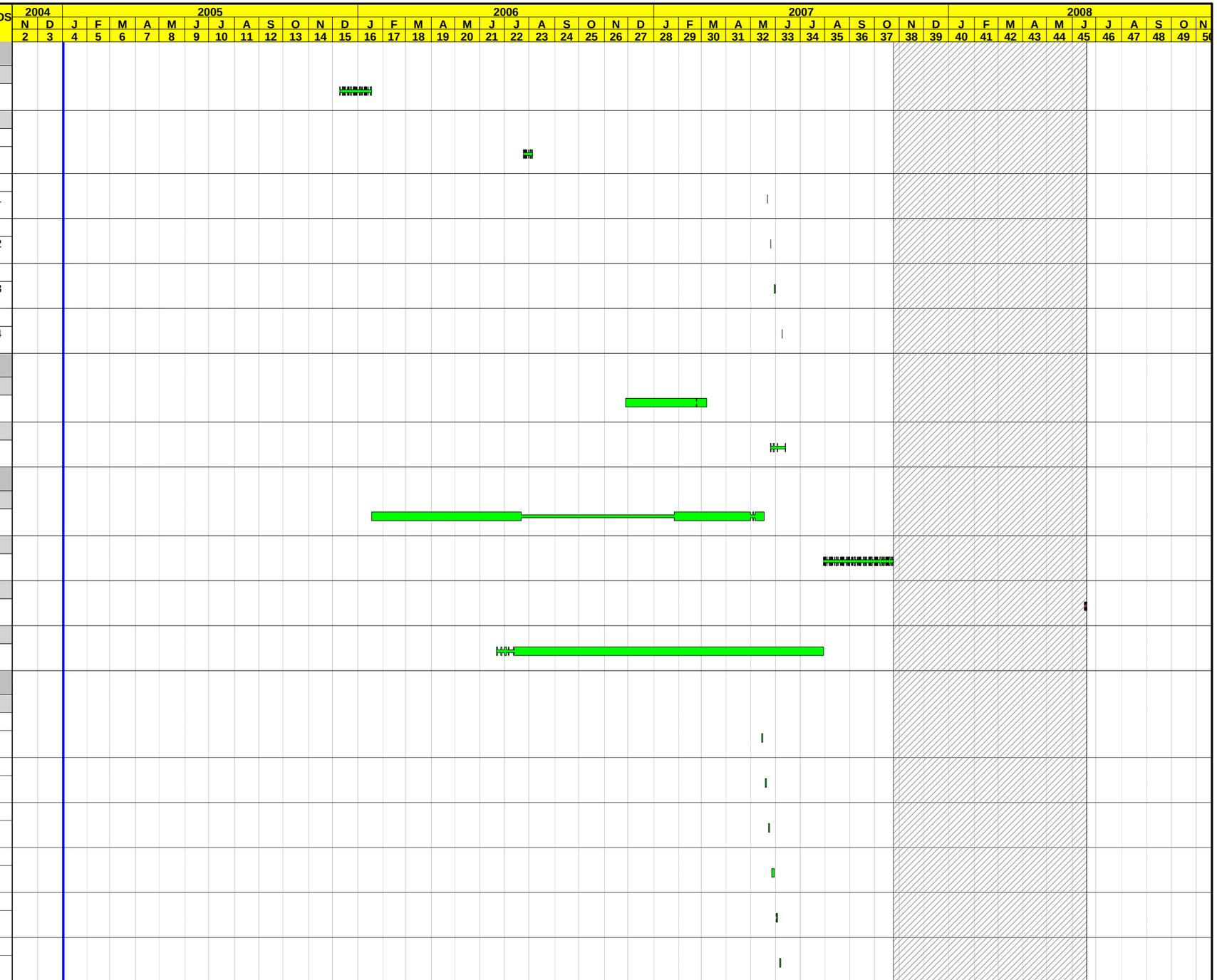
USACE

Plan 4 - Aux. Extension Phased

Condensed

24.8 CONSTRUCTION IMPACTS TO CHAMBERS (PLAN-3)

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN	AUX	CLOS #
Main Chamber - 12 Hours Closed / 12 Hours Open									
+ Aux Chamber - 12 Hours Closed / 12 Hours Open									
		240	09DEC05 12:00	17JAN06 08:59	LWEXT	STRT	12H	12H	
Aux Chamber Closed, but maybe 12on/12off									
+ 0									
		80	24JUL06 15:00	04AUG06 13:59	MITER	STRT	12H	C12	0
+ T1									
		11	22MAY07 04:00	22MAY07 14:59	MITER	A	12H	C12	T1
+ T2									
		11	26MAY07 00:00	26MAY07 10:59	MITER	B	12H	C12	T2
+ T3									
		10	30MAY07 18:00	31MAY07 03:59	MITER	C	12H	C12	T3
+ T4									
		10	09JUN07 02:00	09JUN07 11:59	MITER	D	12H	C12	T4
Main Chamber Open Pass Slowd Helper Boats Needed									
+ Aux Chamber - 12 Hours Closed / 12 Hours Open									
		2,408	27NOV06 08:00	07MAR07 15:59	FW	UM	COPS	12H	
+ Aux Chamber Closed, but maybe 12on/12off									
		437	25MAY07 15:00	12JUN07 19:59	MITER		COPS	C12	
Main Chamber Open - No affect to traffic									
+ Aux Chamber - 12 Hours Closed / 12 Hours Open									
		11,647	17JAN06 09:00	17MAY07 15:59			OPEN	12H	
+ Full Closure of Aux Chamber									
		552	30JUL07 16:00	24OCT07 09:59	MITER	FINL	OPEN	FCL	
+ Aux Chamb Open Passage slowd Helper Boats needed									
		32	16JUN08 12:00	19JUN08 16:59	AUXFE	EMTY	OPEN	COPS	
+ Aux Chamber Closed, but maybe 12on/12off									
		9,702	21JUN06 10:00	30JUL07 15:59			OPEN	C12	
Simultaneous Full Closure									
Simultaneous Full Closure									
+ A									
		25	14MAY07 19:00	15MAY07 19:59	MITER	A	SFC	SFC	A
+ B									
		41	18MAY07 23:00	20MAY07 15:59	MITER		SFC	SFC	B
+ C									
		39	23MAY07 05:00	24MAY07 19:59	MITER		SFC	SFC	C
+ D									
		39	28MAY07 00:00	29MAY07 14:59	MITER		SFC	SFC	D
+ E									
		41	01JUN07 19:00	03JUN07 11:59	MITER	E	SFC	SFC	E
+ F									
		22	06JUN07 16:00	07JUN07 13:59	MITER		SFC	SFC	F



Project Start	01OCT04 00:00	Early Bar	
Project Finish	08AUG08 13:59	Progress Bar	
Data Date	03JAN05 00:00	Critical Activity	
Run Date	07OCT99 16:00		

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PLN3

Sheet 1 of 1

USACE

Plan 3 - Aux. Extension w/Culvert

Construction Impacts To Chambers

24.9 DETAILED CONSTRUCTION SCHEDULE (PLAN 3-AUXILIARY EXTENSION W/CULVERTS)

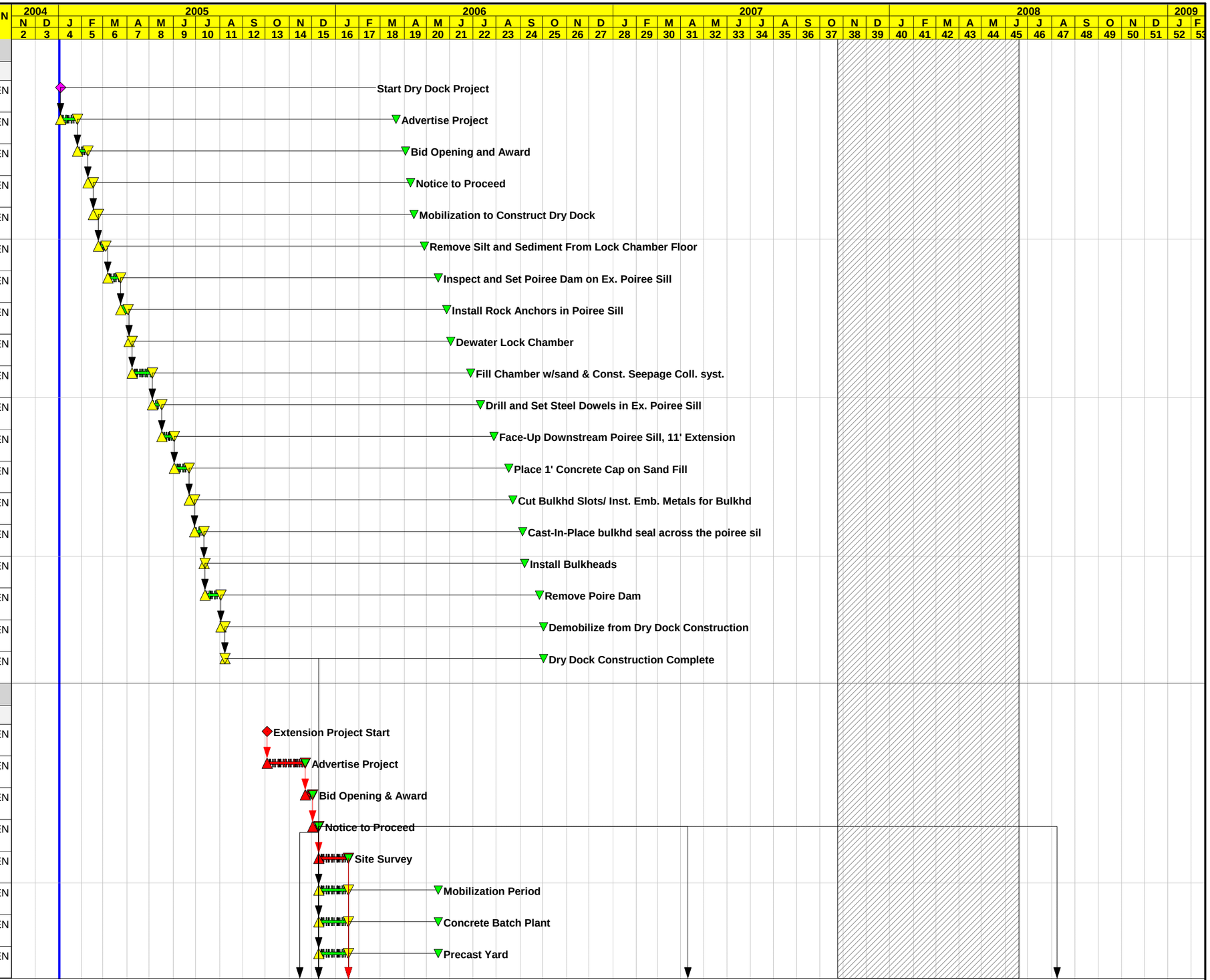
R.C. Byrd Dry Dock

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
DD10	Start Dry Dock Project	0	03JAN05 08:00*		RCBDD		OPEN
DD20	Advertise Project	160	03JAN05 08:00	26JAN05 14:59	RCBDD		OPEN
DD30	Bid Opening and Award	80	26JAN05 15:00	08FEB05 13:59	RCBDD		OPEN
DD40	Notice to Proceed	45	08FEB05 14:00	15FEB05 13:59	RCBDD		OPEN
DD50	Mobilization to Construct Dry Dock	40	15FEB05 14:00	22FEB05 08:59	RCBDD		OPEN
DD60	Remove Silt and Sediment From Lock Chamber Floor	80	22FEB05 09:00	04MAR05 16:59	RCBDD		OPEN
DD70	Inspect and Set Poiree Dam on Ex. Poiree Sill	120	07MAR05 08:00	24MAR05 10:59	RCBDD		OPEN
DD190	Install Rock Anchors in Poiree Sill	240	24MAR05 11:00	03APR05 10:59	RCBDD		OPEN
DD80	Dewater Lock Chamber	40	04APR05 08:00	08APR05 11:59	RCBDD		OPEN
DD90	Fill Chamber w/sand & Const. Seepage Coll. syst.	160	08APR05 12:00	04MAY05 09:59	RCBDD		OPEN
DD100	Drill and Set Steel Dowels in Ex. Poiree Sill	80	04MAY05 10:00	17MAY05 08:59	RCBDD		OPEN
DD110	Face-Up Downstream Poiree Sill, 11' Extension	120	17MAY05 09:00	03JUN05 11:59	RCBDD		OPEN
DD120	Place 1' Concrete Cap on Sand Fill	120	03JUN05 12:00	22JUN05 14:59	RCBDD		OPEN
DD130	Cut Bulkhd Slots/ Inst. Emb. Metals for Bulkhd	40	22JUN05 15:00	29JUN05 09:59	RCBDD		OPEN
DD140	Cast-In-Place bulkhd seal across the poiree sil	80	29JUN05 10:00	12JUL05 08:59	RCBDD		OPEN
DD150	Install Bulkheads	16	12JUL05 09:00	13JUL05 15:59	RCBDD		OPEN
DD160	Remove Poire Dam	120	13JUL05 16:00	02AUG05 09:59	RCBDD		OPEN
DD170	Demobilize from Dry Dock Construction	40	02AUG05 10:00	08AUG05 13:59	RCBDD		OPEN
DD180	Dry Dock Construction Complete	0	08AUG05 14:00	08AUG05 13:59	RCBDD		OPEN

Greenup Mobilization

STRT

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT10	Extension Project Start	0	03OCT05 08:00*		MOB	STRT	OPEN
EXT20	Advertise Project	320	03OCT05 08:00	21NOV05 12:59	MOB	STRT	OPEN
EXT30	Bid Opening & Award	80	21NOV05 13:00	02DEC05 11:59	MOB	STRT	OPEN
EXT40	Notice to Proceed	45	02DEC05 12:00	09DEC05 11:59	MOB	STRT	OPEN
EXT700	Site Survey	240	09DEC05 12:00	17JAN06 08:59	MOB	STRT	OPEN
EXT660	Mobilization Period	240	09DEC05 12:00	17JAN06 08:59	MOB	STRT	OPEN
EXT680	Concrete Batch Plant	240	09DEC05 12:00	17JAN06 08:59	MOB	STRT	OPEN
EXT690	Precast Yard	240	09DEC05 12:00	17JAN06 08:59	MOB	STRT	OPEN



Project Start	01OCT04 00:00
Project Finish	08AUG08 13:59
Data Date	03JAN05 00:00
Run Date	07OCT99 12:00

Early Bar
Float Bar
Progress Bar
Critical Activity

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PLN3

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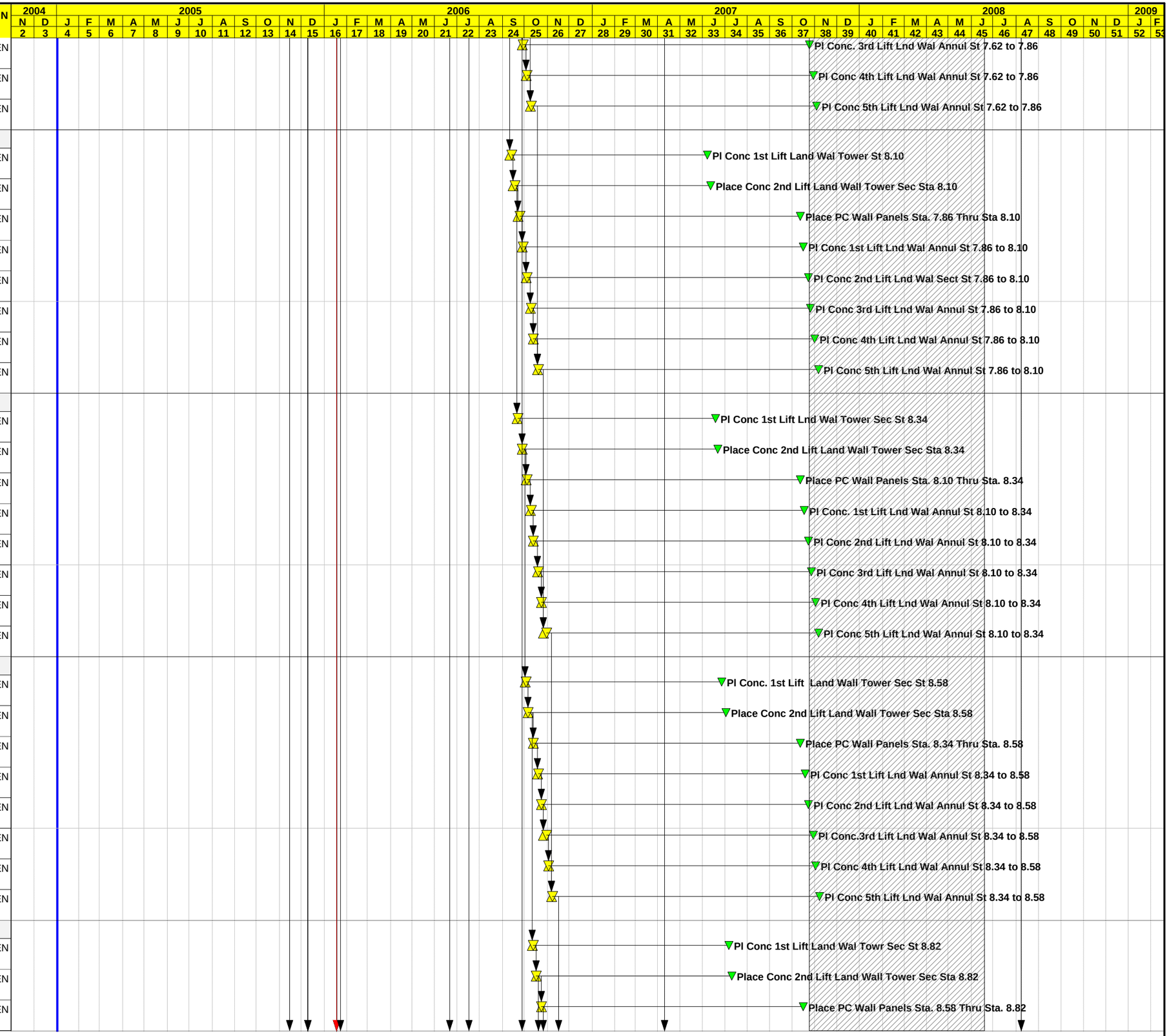
Plan 3 - Aux. Extension w/Culvert

Detailed Schedule

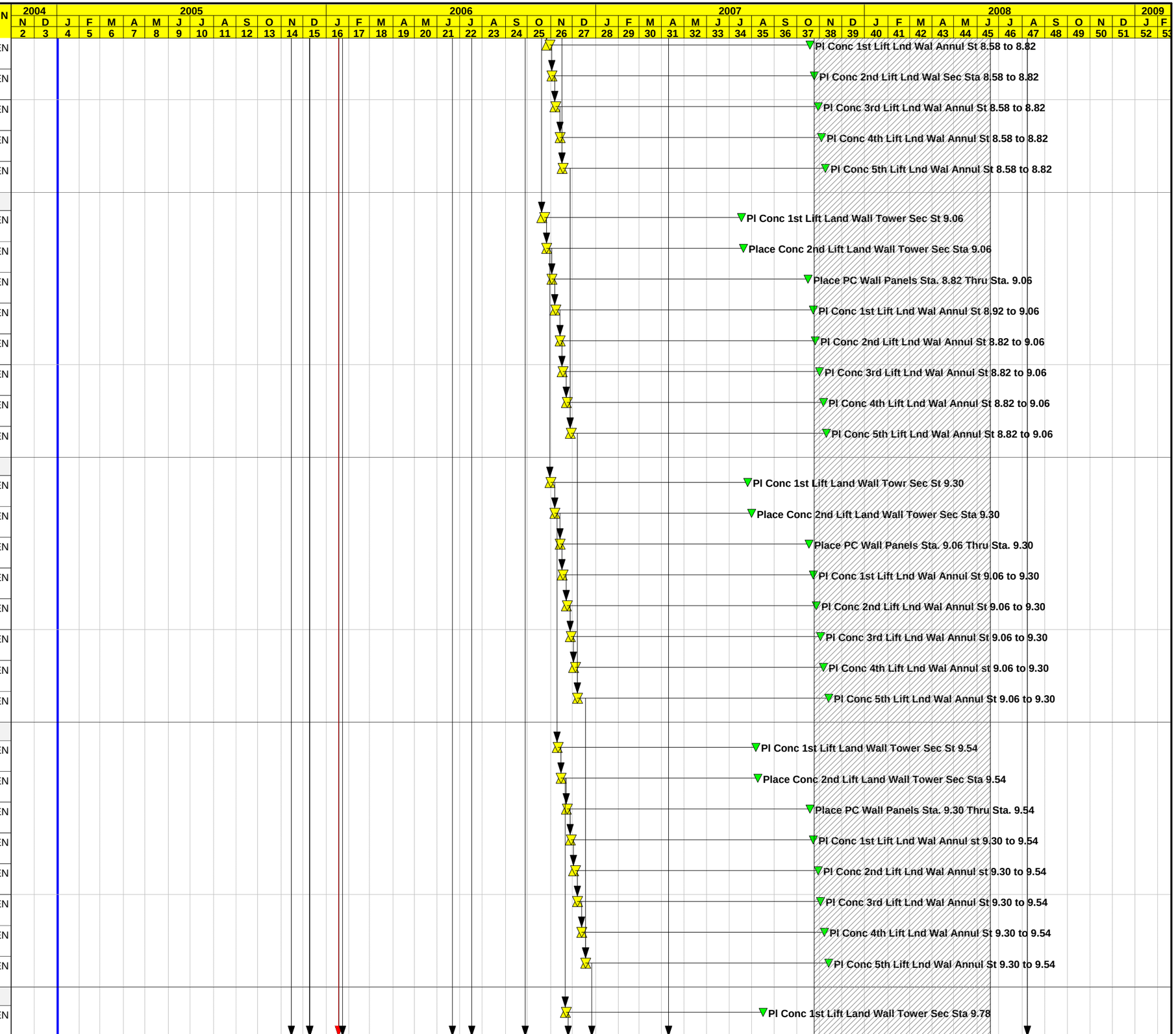
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT670	Field Office	112	09DEC05 12:00	27DEC05 15:59	MOB	STRT	OPEN
Land Wall Extension							
STRT							
EXT710	Demolition	240	09DEC05 12:00	17JAN06 08:59	LWEXT	STRT	12H
EXT720	Dredging Overburden	40	17JAN06 09:00	23JAN06 12:59	LWEXT	STRT	OPEN
EXT730	Land Wall & Lateral Rock Excavation	960	23JAN06 13:00	21JUN06 09:59	LWEXT	STRT	OPEN
615							
EXT1070	Place Conc 1st Lift Land Wall Tower Sec Sta 6.15	12	21JUN06 10:00	22JUN06 12:59	LWEXT	615	OPEN
EXT1100	Place Conc 2nd Lift Land Wall Tower Sec Sta 6.15	4	27JUN06 10:00	27JUN06 13:59	LWEXT	615	OPEN
642							
EXT1080	Pl Conc 1st Lift Land Wall Tower Sec Sta 6.42.5	12	30JUN06 11:00	03JUL06 13:59	LWEXT	642	OPEN
EXT1110	Place Conc. 2nd Lift Land Wall Tower Sec 6.42	4	06JUL06 11:00	06JUL06 14:59	LWEXT	642	OPEN
EXT1090	Place PC Wall Panels Sta. 6.00 Thru Sta 6.42.5	24	13JUL06 10:00	17JUL06 15:59	LWEXT	642	OPEN
EXT1120	Pl Conc 1st Lift Land Wal Annl St 6.00 to 6.42.5	8	17JUL06 16:00	18JUL06 14:59	LWEXT	642	OPEN
EXT1160	Pl Conc. 2nd Lift Lnd Wal Anul St 6.00 to 6.42.5	8	21JUL06 12:00	24JUL06 10:59	LWEXT	642	OPEN
EXT1220	Pl Conc 3rd Lift Lnd Wal Annul St 6.00 to 6.42.5	8	27JUL06 08:00	27JUL06 15:59	LWEXT	642	OPEN
EXT1290	Pl Conc 4th Lift Lnd Wal Annul St 6.00 to 6.42.5	8	01AUG06 13:00	02AUG06 11:59	LWEXT	642	OPEN
EXT1370	Pl Conc 5th Lift Lnd Wal Annul St 6.00 to 6.42.5	8	07AUG06 09:00	07AUG06 16:59	LWEXT	642	OPEN
666							
EXT1130	Place Conc 1st Lift Land Wall Tower Sec St 6+66	12	11JUL06 12:00	12JUL06 14:59	LWEXT	666	OPEN
EXT1131	Place Conc 2nd Lift Land Wall Tower Sec Sta 6.66	4	17JUL06 12:00	17JUL06 15:59	LWEXT	666	OPEN
EXT1132	Place PC Wall Panels Sta. 6.66	24	24JUL06 11:00	26JUL06 16:59	LWEXT	666	OPEN
EXT1133	Pl Conc 1st Lift Lnd Wal Annl St 6.42.5 to 6.66	8	31JUL06 14:00	01AUG06 12:59	LWEXT	666	OPEN
EXT1170	Pl Conc 2nd Lift Lnd Wal Annl St 6.42.5 to 6.66	8	04AUG06 10:00	07AUG06 08:59	LWEXT	666	OPEN
EXT1230	Pl Conc 3rd Lift Lnd Wal Annul St 6.42.5 to 6.66	8	09AUG06 15:00	10AUG06 13:59	LWEXT	666	OPEN
EXT1300	Pl Conc 4th Lift Lnd Wal Annul St 6.42.5 to 6.66	8	15AUG06 11:00	16AUG06 09:59	LWEXT	666	OPEN
EXT1380	Pl Conc 5th Lift Lnd Wal Annul St 6.42.5 to 6.66	8	18AUG06 16:00	21AUG06 14:59	LWEXT	666	OPEN
690							
EXT1150	Place Conc. 1st Lift Land Wall Tower Se St 6.90	12	20JUL06 13:00	21JUL06 15:59	LWEXT	690	OPEN
EXT1240	Pl Conc 2nd Lift Lnd Wal Towr Sec. St 6.90	4	26JUL06 13:00	26JUL06 16:59	LWEXT	690	OPEN
EXT1140	Place PC Wall Panels Sta. Sta 6.66 thru Sta 6.90	8	02AUG06 12:00	03AUG06 10:59	LWEXT	690	OPEN
EXT1190	Place Conc 1st Lift Lnd Wal Anl Sta 6.66 to 6.90	8	08AUG06 08:00	08AUG06 15:59	LWEXT	690	OPEN
EXT1250	Pl Conc.2nd Lift Land Wall Annul St 6.66 to 6.90	8	11AUG06 13:00	14AUG06 11:59	LWEXT	690	OPEN
EXT1310	Pl Conc 3rd Lift Lnd Wal Annul St 6.66 to 6.90	8	17AUG06 09:00	17AUG06 16:59	LWEXT	690	OPEN
EXT1390	Pl Conc 4th Lift Lnd Wal Annul St 6.66 to 6.90	8	22AUG06 14:00	23AUG06 12:59	LWEXT	690	OPEN

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT1460	Pl Conc 5th Lift Lnd Wal Annul St 6.66 to 6.90	8	28AUG06 10:00	29AUG06 08:59	LWEXT	690	OPEN
714							
EXT1180	Place Conc 1st Lift Land Wall Tower Se Sta 7.14	12	31JUL06 14:00	01AUG06 16:59	LWEXT	714	OPEN
EXT1181	Place Conc 2nd Lift Land Wall Tower Sec Sta 7.14	4	04AUG06 14:00	07AUG06 08:59	LWEXT	714	OPEN
EXT1200	Place PC Wall Panels Sta. 6.90 Thru Sta 7.14	8	11AUG06 13:00	14AUG06 11:59	LWEXT	714	OPEN
EXT1210	Pl Conc.1st Lift Land Wall Annul St 6.90 to 7.14	8	17AUG06 09:00	17AUG06 16:59	LWEXT	714	OPEN
EXT1211	Pl Conc.2ndLift Land Wall Annul St 6.90 to 7.14	8	22AUG06 14:00	23AUG06 12:59	LWEXT	714	OPEN
EXT1320	Pl Conc 3rd Lift Lnd Wal Annul St 6.90 to 7.14	8	28AUG06 10:00	29AUG06 08:59	LWEXT	714	OPEN
EXT1400	Pl Conc 4th Lift Lnd Wal Annul St 6.90 to 7.14	8	31AUG06 15:00	01SEP06 13:59	LWEXT	714	OPEN
EXT1470	Pl Conc 5th Lift Lnd Wal Annul St 6.90 to 7.14	8	06SEP06 11:00	07SEP06 09:59	LWEXT	714	OPEN
738							
EXT1260	Place Conc. 1st Lift Land Wall Tower Sec St 7.38	12	09AUG06 15:00	11AUG06 08:59	LWEXT	738	OPEN
EXT1261	Place Conc 2nd Lift Land Wall Tower Sec Sta 7.38	4	15AUG06 15:00	16AUG06 09:59	LWEXT	738	OPEN
EXT1270	Place PC Wall Panels Sta. 7.14 Thru Sta 7.38	8	22AUG06 14:00	23AUG06 12:59	LWEXT	738	OPEN
EXT1280	Pl Conc 1st Lift Land Wal Annul St 7.14 to 7.38	8	28AUG06 10:00	29AUG06 08:59	LWEXT	738	OPEN
EXT1330	Pl Conc 2nd Lift Lnd Wal Annul St 7.14 to 7.38	8	31AUG06 15:00	01SEP06 13:59	LWEXT	738	OPEN
EXT1410	Pl Con 3rd Lift Lnd Wal Annul St 7.14 to 7.38	8	06SEP06 11:00	07SEP06 09:59	LWEXT	738	OPEN
EXT1480	Pl Conc 4th Lift Lnd Wal Annul St 7.14 to 7.38	8	11SEP06 16:00	12SEP06 14:59	LWEXT	738	OPEN
EXT1540	Pl Conc 5th Lift Lnd Wal Annul St 7.14 to 7.38	8	15SEP06 12:00	18SEP06 10:59	LWEXT	738	OPEN
762							
EXT1340	Pl Conc 1st Lift Lnd Wal Tower St 7.62	12	18AUG06 16:00	22AUG06 09:59	LWEXT	762	OPEN
EXT1341	Place Conc 2nd Lift Land Wall Tower Sec Sta 7.62	4	28AUG06 14:00	29AUG06 08:59	LWEXT	762	OPEN
EXT1350	Place PC Wall Panels Sta. 7.38 Thru Sta 7.62	8	31AUG06 15:00	01SEP06 13:59	LWEXT	762	OPEN
EXT1360	Ple Conc 1st Lift Lnd Wal Annul St 7.38 to 7.62	8	06SEP06 11:00	07SEP06 09:59	LWEXT	762	OPEN
EXT1420	Pl Conc 2nd Lift Lnd Wal Annul St 7.38 to 7.62	8	11SEP06 16:00	12SEP06 14:59	LWEXT	762	OPEN
EXT1490	Pl Conc.3rd Lift Land Wal Annul St 7.38 to 7.62	8	15SEP06 12:00	18SEP06 10:59	LWEXT	762	OPEN
EXT1550	Pl Conc. 4th Lift Lnd Wal Annul St 7.38 to 7.62	8	21SEP06 08:00	21SEP06 15:59	LWEXT	762	OPEN
EXT1610	Pl Conc. 5th Lift Lnd Wal Annul St 7.38 to 7.62	8	26SEP06 13:00	27SEP06 11:59	LWEXT	762	OPEN
786							
EXT1430	Pl Conc 1st Lift Land Wall Tower St 7.86	12	31AUG06 15:00	04SEP06 08:59	LWEXT	786	OPEN
EXT1431	Place Conc 2nd Lift Land Wall Tower Sec Sta 7.86	4	06SEP06 15:00	07SEP06 09:59	LWEXT	786	OPEN
EXT1440	Place PC Wall Panels Sta. 7.62 Thru Sta 7.86	8	13SEP06 14:00	14SEP06 12:59	LWEXT	786	OPEN
EXT1450	Pl Conc 1st Lift Lnd Wal Annul St 7.62 to 7.86	8	19SEP06 10:00	20SEP06 08:59	LWEXT	786	OPEN
EXT1500	Pl Conc 2nd Lift Lnd Wal Annul St 7.62 to 7.86	8	22SEP06 15:00	25SEP06 13:59	LWEXT	786	OPEN

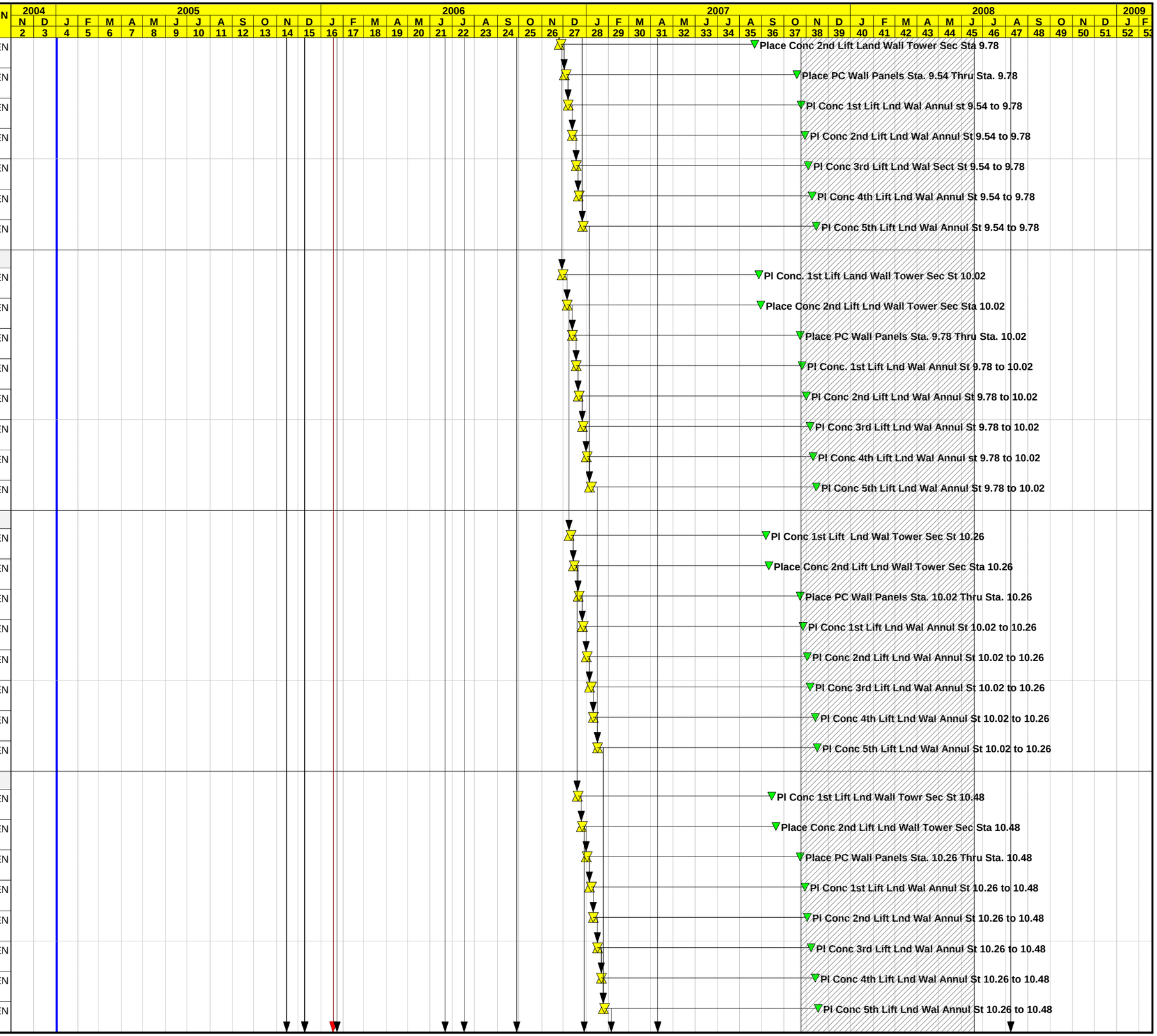
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT1560	Pl Conc. 3rd Lift Lnd Wal Annul St 7.62 to 7.86	8	28SEP06 11:00	29SEP06 09:59	LWEXT	786	OPEN
EXT1620	Pl Conc 4th Lift Lnd Wal Annul St 7.62 to 7.86	8	03OCT06 16:00	04OCT06 14:59	LWEXT	786	OPEN
EXT1680	Pl Conc 5th Lift Lnd Wal Annul St 7.62 to 7.86	8	09OCT06 12:00	10OCT06 10:59	LWEXT	786	OPEN
810							
EXT1510	Pl Conc 1st Lift Land Wal Tower St 8.10	12	11SEP06 16:00	13SEP06 09:59	LWEXT	810	OPEN
EXT1511	Place Conc 2nd Lift Land Wall Tower Sec Sta 8.10	4	15SEP06 16:00	18SEP06 10:59	LWEXT	810	OPEN
EXT1520	Place PC Wall Panels Sta. 7.86 Thru Sta 8.10	8	22SEP06 15:00	25SEP06 13:59	LWEXT	810	OPEN
EXT1530	Pl Conc 1st Lift Lnd Wal Annul St 7.86 to 8.10	8	28SEP06 11:00	29SEP06 09:59	LWEXT	810	OPEN
EXT1570	Pl Conc 2nd Lift Lnd Wal Sect St 7.86 to 8.10	8	03OCT06 16:00	04OCT06 14:59	LWEXT	810	OPEN
EXT1630	Pl Conc 3rd Lift Lnd Wal Annul St 7.86 to 8.10	8	09OCT06 12:00	10OCT06 10:59	LWEXT	810	OPEN
EXT1690	Pl Conc 4th Lift Lnd Wal Annul St 7.86 to 8.10	8	13OCT06 08:00	13OCT06 15:59	LWEXT	810	OPEN
EXT1750	Pl Conc 5th Lift Lnd Wal Annul St 7.86 to 8.10	8	18OCT06 13:00	19OCT06 11:59	LWEXT	810	OPEN
834							
EXT1580	Pl Conc 1st Lift Lnd Wal Tower Sec St 8.34	12	21SEP06 08:00	22SEP06 10:59	LWEXT	834	OPEN
EXT1581	Place Conc 2nd Lift Land Wall Tower Sec Sta 8.34	4	27SEP06 08:00	27SEP06 11:59	LWEXT	834	OPEN
EXT1590	Place PC Wall Panels Sta. 8.10 Thru Sta. 8.34	8	03OCT06 16:00	04OCT06 14:59	LWEXT	834	OPEN
EXT1600	Pl Conc. 1st Lift Lnd Wal Annul St 8.10 to 8.34	8	09OCT06 12:00	10OCT06 10:59	LWEXT	834	OPEN
EXT1640	Pl Conc 2nd Lift Lnd Wal Annul St 8.10 to 8.34	8	13OCT06 08:00	13OCT06 15:59	LWEXT	834	OPEN
EXT1700	Pl Conc 3rd Lift Lnd Wal Annul St 8.10 to 8.34	8	18OCT06 13:00	19OCT06 11:59	LWEXT	834	OPEN
EXT1760	Pl Conc 4th Lift Lnd Wal Annul St 8.10 to 8.34	8	24OCT06 09:00	24OCT06 16:59	LWEXT	834	OPEN
EXT1820	Pl Conc 5th Lift Lnd Wal Annul St 8.10 to 8.34	8	27OCT06 14:00	30OCT06 12:59	LWEXT	834	OPEN
858							
EXT1650	Pl Conc. 1st Lift Land Wall Tower Sec St 8.58	12	02OCT06 09:00	03OCT06 11:59	LWEXT	858	OPEN
EXT1651	Place Conc 2nd Lift Land Wall Tower Sec Sta 8.58	4	06OCT06 09:00	06OCT06 12:59	LWEXT	858	OPEN
EXT1660	Place PC Wall Panels Sta. 8.34 Thru Sta. 8.58	8	13OCT06 08:00	13OCT06 15:59	LWEXT	858	OPEN
EXT1670	Pl Conc 1st Lift Lnd Wal Annul St 8.34 to 8.58	8	18OCT06 13:00	19OCT06 11:59	LWEXT	858	OPEN
EXT1710	Pl Conc 2nd Lift Lnd Wal Annul St 8.34 to 8.58	8	24OCT06 09:00	24OCT06 16:59	LWEXT	858	OPEN
EXT1770	Pl Conc.3rd Lift Lnd Wal Annul St 8.34 to 8.58	8	27OCT06 14:00	30OCT06 12:59	LWEXT	858	OPEN
EXT1830	Pl Conc 4th Lift Lnd Wal Annul St 8.34 to 8.58	8	02NOV06 10:00	03NOV06 08:59	LWEXT	858	OPEN
EXT1890	Pl Conc 5th Lift Lnd Wal Annul St 8.34 to 8.58	8	07NOV06 15:00	08NOV06 13:59	LWEXT	858	OPEN
882							
EXT1720	Pl Conc 1st Lift Land Wal Towr Sec St 8.82	12	11OCT06 10:00	12OCT06 12:59	LWEXT	882	OPEN
EXT1721	Place Conc 2nd Lift Land Wall Tower Sec Sta 8.82	4	17OCT06 10:00	17OCT06 13:59	LWEXT	882	OPEN
EXT1730	Place PC Wall Panels Sta. 8.58 Thru Sta. 8.82	8	24OCT06 09:00	24OCT06 16:59	LWEXT	882	OPEN



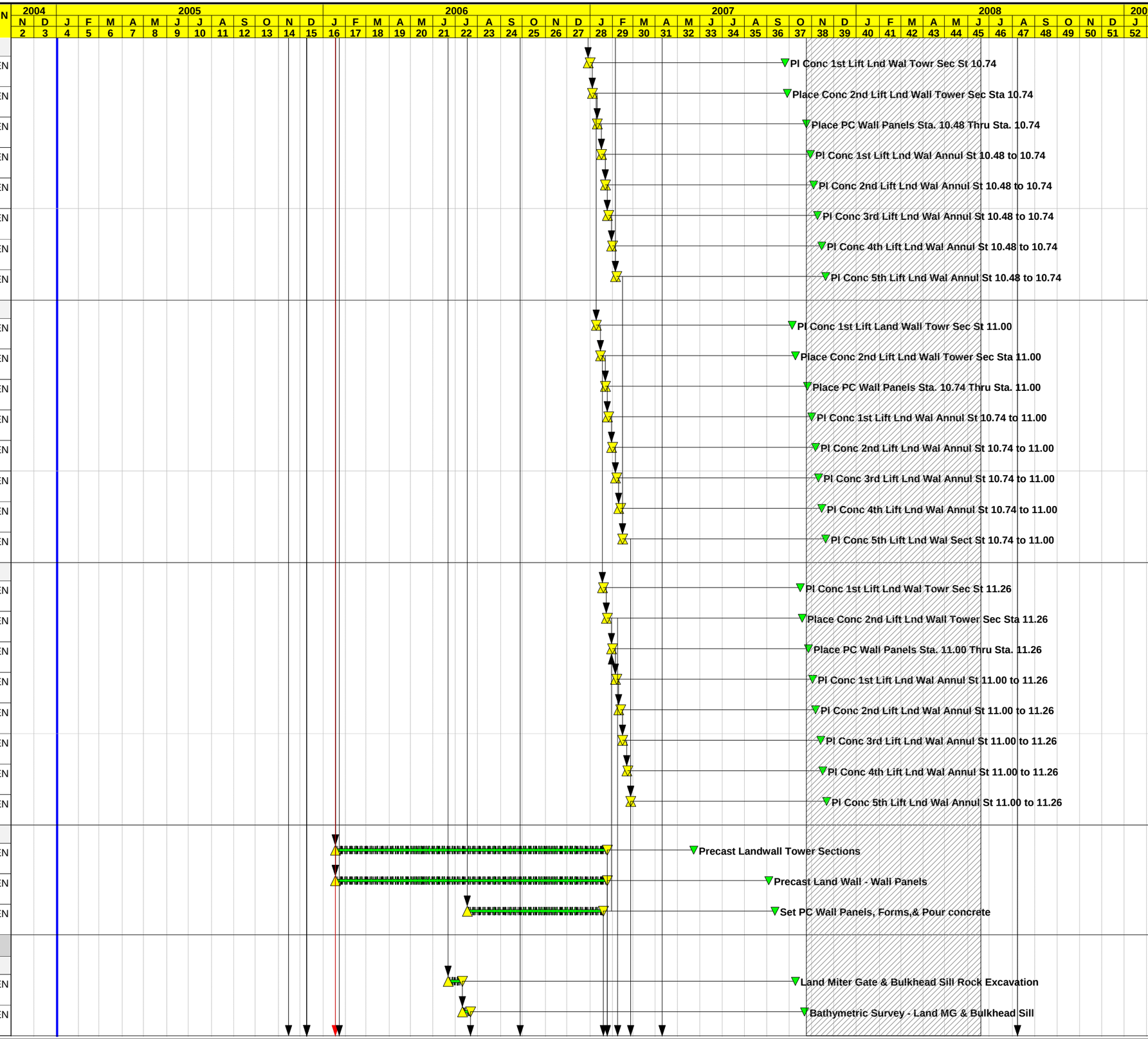
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT1740	Pl Conc 1st Lift Lnd Wal Annul St 8.58 to 8.82	8	27OCT06 14:00	30OCT06 12:59	LWEXT	882	OPEN
EXT1780	Pl Conc 2nd Lift Lnd Wal Sec Sta 8.58 to 8.82	8	02NOV06 10:00	03NOV06 08:59	LWEXT	882	OPEN
EXT1840	Pl Conc 3rd Lift Lnd Wal Annul St 8.58 to 8.82	8	07NOV06 15:00	08NOV06 13:59	LWEXT	882	OPEN
EXT1900	Pl Conc 4th Lift Lnd Wal Annul St 8.58 to 8.82	8	13NOV06 11:00	14NOV06 09:59	LWEXT	882	OPEN
EXT1960	Pl Conc 5th Lift Lnd Wal Annul St 8.58 to 8.82	8	16NOV06 16:00	17NOV06 14:59	LWEXT	882	OPEN
906							
EXT1790	Pl Conc 1st Lift Land Wall Tower Sec St 9.06	12	20OCT06 11:00	23OCT06 13:59	LWEXT	906	OPEN
EXT1791	Place Conc 2nd Lift Land Wall Tower Sec Sta 9.06	4	26OCT06 11:00	26OCT06 14:59	LWEXT	906	OPEN
EXT1800	Place PC Wall Panels Sta. 8.82 Thru Sta. 9.06	8	02NOV06 10:00	03NOV06 08:59	LWEXT	906	OPEN
EXT1810	Pl Conc 1st Lift Lnd Wal Annul St 8.92 to 9.06	8	07NOV06 15:00	08NOV06 13:59	LWEXT	906	OPEN
EXT1850	Pl Conc 2nd Lift Lnd Wal Annul St 8.82 to 9.06	8	13NOV06 11:00	14NOV06 09:59	LWEXT	906	OPEN
EXT1910	Pl Conc 3rd Lift Lnd Wal Annul St 8.82 to 9.06	8	16NOV06 16:00	17NOV06 14:59	LWEXT	906	OPEN
EXT1970	Pl Conc 4th Lift Lnd Wal Annul St 8.82 to 9.06	8	22NOV06 12:00	23NOV06 10:59	LWEXT	906	OPEN
EXT2030	Pl Conc 5th Lift Lnd Wal Annul St 8.82 to 9.06	8	28NOV06 08:00	28NOV06 15:59	LWEXT	906	OPEN
930							
EXT1860	Pl Conc 1st Lift Land Wall Towr Sec St 9.30	12	31OCT06 12:00	01NOV06 14:59	LWEXT	930	OPEN
EXT1861	Place Conc 2nd Lift Land Wall Tower Sec Sta 9.30	4	06NOV06 12:00	06NOV06 15:59	LWEXT	930	OPEN
EXT1870	Place PC Wall Panels Sta. 9.06 Thru Sta. 9.30	8	13NOV06 11:00	14NOV06 09:59	LWEXT	930	OPEN
EXT1880	Pl Conc 1st Lift Lnd Wal Annul St 9.06 to 9.30	8	16NOV06 16:00	17NOV06 14:59	LWEXT	930	OPEN
EXT1920	Pl Conc 2nd Lift Lnd Wal Annul St 9.06 to 9.30	8	22NOV06 12:00	23NOV06 10:59	LWEXT	930	OPEN
EXT1980	Pl Conc 3rd Lift Lnd Wal Annul St 9.06 to 9.30	8	28NOV06 08:00	28NOV06 15:59	LWEXT	930	OPEN
EXT2040	Pl Conc 4th Lift Lnd Wal Annul st 9.06 to 9.30	8	01DEC06 13:00	04DEC06 11:59	LWEXT	930	OPEN
EXT2100	Pl Conc 5th Lift Lnd Wal Annul St 9.06 to 9.30	8	07DEC06 09:00	07DEC06 16:59	LWEXT	930	OPEN
954							
EXT1930	Pl Conc 1st Lift Land Wall Tower Sec St 9.54	12	09NOV06 13:00	10NOV06 15:59	LWEXT	954	OPEN
EXT1931	Place Conc 2nd Lift Land Wall Tower Sec Sta 9.54	4	15NOV06 13:00	15NOV06 16:59	LWEXT	954	OPEN
EXT1940	Place PC Wall Panels Sta. 9.30 Thru Sta. 9.54	8	22NOV06 12:00	23NOV06 10:59	LWEXT	954	OPEN
EXT1950	Pl Conc 1st Lift Lnd Wal Annul st 9.30 to 9.54	8	28NOV06 08:00	28NOV06 15:59	LWEXT	954	OPEN
EXT1990	Pl Conc 2nd Lift Lnd Wal Annul st 9.30 to 9.54	8	01DEC06 13:00	04DEC06 11:59	LWEXT	954	OPEN
EXT2050	Pl Conc 3rd Lift Lnd Wal Annul St 9.30 to 9.54	8	07DEC06 09:00	07DEC06 16:59	LWEXT	954	OPEN
EXT2110	Pl Conc 4th Lift Lnd Wal Annul St 9.30 to 9.54	8	12DEC06 14:00	13DEC06 12:59	LWEXT	954	OPEN
EXT2170	Pl Conc 5th Lift Lnd Wal Annul St 9.30 to 9.54	8	18DEC06 10:00	19DEC06 08:59	LWEXT	954	OPEN
978							
EXT2000	Pl Conc 1st Lift Land Wall Tower Sec Sta 9.78	12	20NOV06 14:00	21NOV06 16:59	LWEXT	978	OPEN



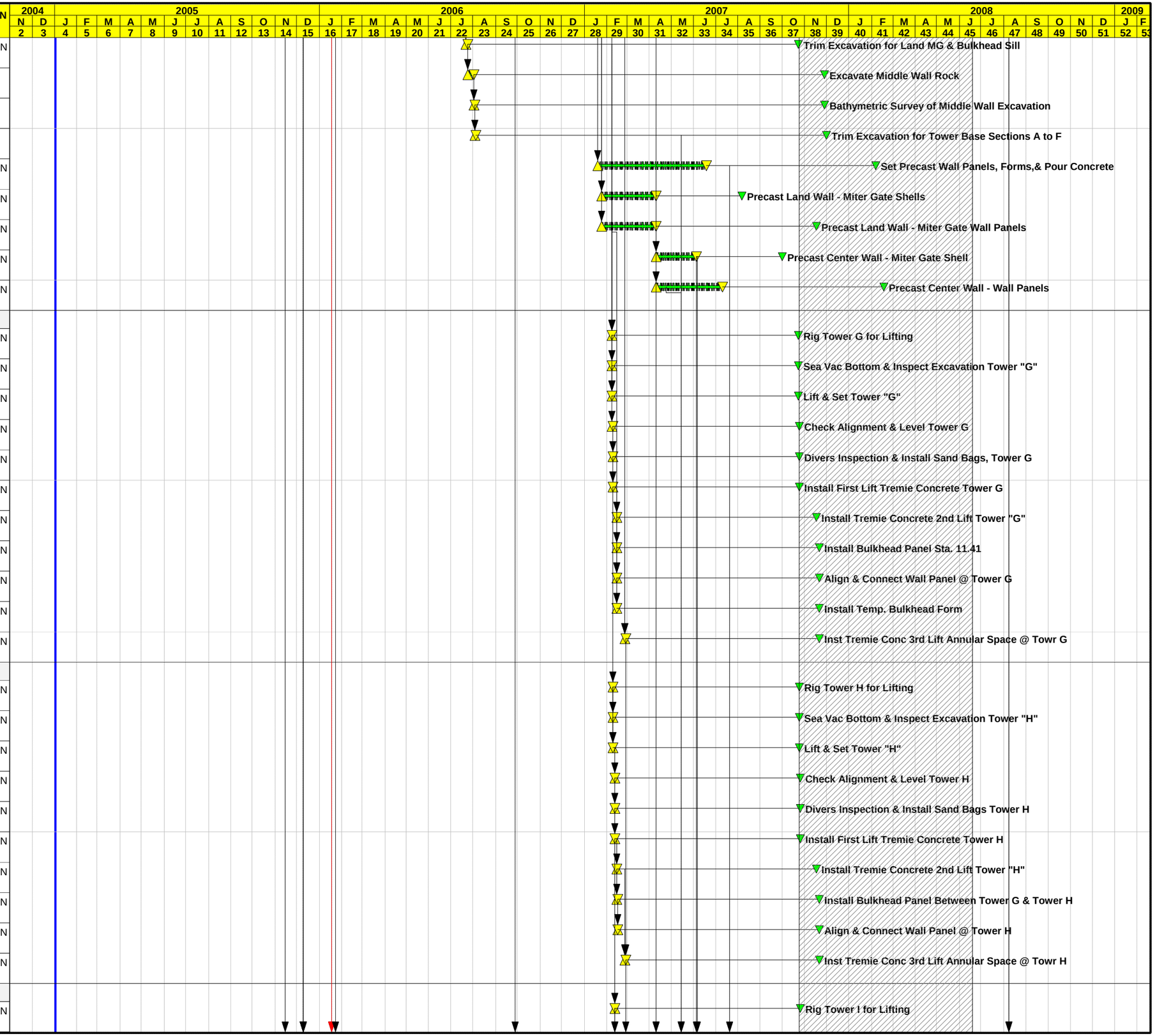
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT2001	Place Conc 2nd Lift Land Wall Tower Sec Sta 9.78	4	24NOV06 14:00	27NOV06 08:59	LWEXT	978	OPEN
EXT2010	Place PC Wall Panels Sta. 9.54 Thru Sta. 9.78	8	01DEC06 13:00	04DEC06 11:59	LWEXT	978	OPEN
EXT2020	Pl Conc 1st Lift Lnd Wal Annul st 9.54 to 9.78	8	07DEC06 09:00	07DEC06 16:59	LWEXT	978	OPEN
EXT2060	Pl Conc 2nd Lift Lnd Wal Annul St 9.54 to 9.78	8	12DEC06 14:00	13DEC06 12:59	LWEXT	978	OPEN
EXT2120	Pl Conc 3rd Lift Lnd Wal Sect St 9.54 to 9.78	8	18DEC06 10:00	19DEC06 08:59	LWEXT	978	OPEN
EXT2180	Pl Conc 4th Lift Lnd Wal Annul St 9.54 to 9.78	8	21DEC06 15:00	22DEC06 13:59	LWEXT	978	OPEN
EXT2240	Pl Conc 5th Lift Lnd Wal Annul St 9.54 to 9.78	8	27DEC06 11:00	28DEC06 09:59	LWEXT	978	OPEN
1002							
EXT2070	Pl Conc. 1st Lift Land Wall Tower Sec St 10.02	12	29NOV06 15:00	01DEC06 08:59	LWEXT	1002	OPEN
EXT2071	Place Conc 2nd Lift Lnd Wall Tower Sec Sta 10.02	4	05DEC06 15:00	06DEC06 09:59	LWEXT	1002	OPEN
EXT2080	Place PC Wall Panels Sta. 9.78 Thru Sta. 10.02	8	12DEC06 14:00	13DEC06 12:59	LWEXT	1002	OPEN
EXT2090	Pl Conc. 1st Lift Lnd Wal Annul St 9.78 to 10.02	8	18DEC06 10:00	19DEC06 08:59	LWEXT	1002	OPEN
EXT2130	Pl Conc 2nd Lift Lnd Wal Annul St 9.78 to 10.02	8	21DEC06 15:00	22DEC06 13:59	LWEXT	1002	OPEN
EXT2190	Pl Conc 3rd Lift Lnd Wal Annul St 9.78 to 10.02	8	27DEC06 11:00	28DEC06 09:59	LWEXT	1002	OPEN
EXT2250	Pl Conc 4th Lift Lnd Wal Annul st 9.78 to 10.02	8	01JAN07 16:00	02JAN07 14:59	LWEXT	1002	OPEN
EXT2310	Pl Conc 5th Lift Lnd Wal Annul St 9.78 to 10.02	8	05JAN07 12:00	08JAN07 10:59	LWEXT	1002	OPEN
1026							
EXT2140	Pl Conc 1st Lift Lnd Wal Tower Sec St 10.26	12	08DEC06 16:00	12DEC06 09:59	LWEXT	1026	OPEN
EXT2141	Place Conc 2nd Lift Lnd Wall Tower Sec Sta 10.26	4	14DEC06 16:00	15DEC06 10:59	LWEXT	1026	OPEN
EXT2150	Place PC Wall Panels Sta. 10.02 Thru Sta. 10.26	8	21DEC06 15:00	22DEC06 13:59	LWEXT	1026	OPEN
EXT2160	Pl Conc 1st Lift Lnd Wal Annul St 10.02 to 10.26	8	27DEC06 11:00	28DEC06 09:59	LWEXT	1026	OPEN
EXT2200	Pl Conc 2nd Lift Lnd Wal Annul St 10.02 to 10.26	8	01JAN07 16:00	02JAN07 14:59	LWEXT	1026	OPEN
EXT2260	Pl Conc 3rd Lift Lnd Wal Annul St 10.02 to 10.26	8	05JAN07 12:00	08JAN07 10:59	LWEXT	1026	OPEN
EXT2320	Pl Conc 4th Lift Lnd Wal Annul St 10.02 to 10.26	8	11JAN07 08:00	11JAN07 15:59	LWEXT	1026	OPEN
EXT2380	Pl Conc 5th Lift Lnd Wal Annul St 10.02 to 10.26	8	16JAN07 13:00	17JAN07 11:59	LWEXT	1026	OPEN
1048							
EXT2210	Pl Conc 1st Lift Lnd Wall Towr Sec St 10.48	12	20DEC06 08:00	21DEC06 10:59	LWEXT	1048	OPEN
EXT2211	Place Conc 2nd Lift Lnd Wall Tower Sec Sta 10.48	4	26DEC06 08:00	26DEC06 11:59	LWEXT	1048	OPEN
EXT2220	Place PC Wall Panels Sta. 10.26 Thru Sta. 10.48	8	01JAN07 16:00	02JAN07 14:59	LWEXT	1048	OPEN
EXT2230	Pl Conc 1st Lift Lnd Wal Annul St 10.26 to 10.48	8	05JAN07 12:00	08JAN07 10:59	LWEXT	1048	OPEN
EXT2270	Pl Conc 2nd Lift Lnd Wal Annul St 10.26 to 10.48	8	11JAN07 08:00	11JAN07 15:59	LWEXT	1048	OPEN
EXT2330	Pl Conc 3rd Lift Lnd Wal Annul St 10.26 to 10.48	8	16JAN07 13:00	17JAN07 11:59	LWEXT	1048	OPEN
EXT2390	Pl Conc 4th Lift Lnd Wal Annul St 10.26 to 10.48	8	22JAN07 09:00	22JAN07 16:59	LWEXT	1048	OPEN
EXT2450	Pl Conc 5th Lift Lnd Wal Annul St 10.26 to 10.48	8	25JAN07 14:00	26JAN07 12:59	LWEXT	1048	OPEN



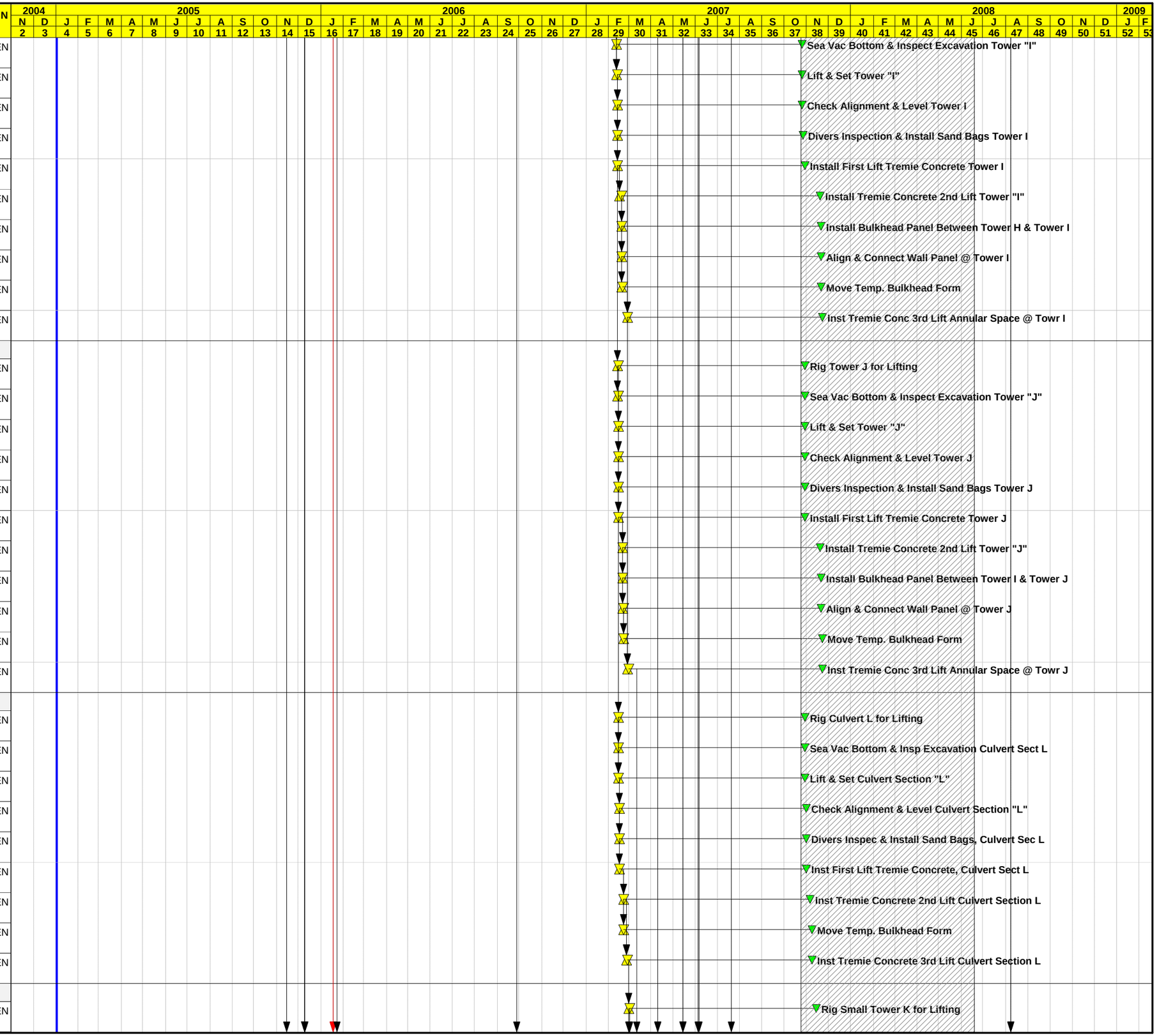
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
1074							
EXT2280	Pl Conc 1st Lift Lnd Wal Towr Sec St 10.74	12	29DEC06 09:00	01JAN07 11:59	LWEXT	1074	OPEN
EXT2281	Place Conc 2nd Lift Lnd Wall Tower Sec Sta 10.74	4	04JAN07 09:00	04JAN07 12:59	LWEXT	1074	OPEN
EXT2290	Place PC Wall Panels Sta. 10.48 Thru Sta. 10.74	8	11JAN07 08:00	11JAN07 15:59	LWEXT	1074	OPEN
EXT2300	Pl Conc 1st Lift Lnd Wal Annul St 10.48 to 10.74	8	16JAN07 13:00	17JAN07 11:59	LWEXT	1074	OPEN
EXT2340	Pl Conc 2nd Lift Lnd Wal Annul St 10.48 to 10.74	8	22JAN07 09:00	22JAN07 16:59	LWEXT	1074	OPEN
EXT2400	Pl Conc 3rd Lift Lnd Wal Annul St 10.48 to 10.74	8	25JAN07 14:00	26JAN07 12:59	LWEXT	1074	OPEN
EXT2460	Pl Conc 4th Lift Lnd Wal Annul St 10.48 to 10.74	8	31JAN07 10:00	01FEB07 08:59	LWEXT	1074	OPEN
EXT2490	Pl Conc 5th Lift Lnd Wal Annul St 10.48 to 10.74	8	05FEB07 15:00	06FEB07 13:59	LWEXT	1074	OPEN
1100							
EXT2350	Pl Conc 1st Lift Land Wall Towr Sec St 11.00	12	09JAN07 10:00	10JAN07 12:59	LWEXT	1100	OPEN
EXT2351	Place Conc 2nd Lift Lnd Wall Tower Sec Sta 11.00	4	15JAN07 10:00	15JAN07 13:59	LWEXT	1100	OPEN
EXT2360	Place PC Wall Panels Sta. 10.74 Thru Sta. 11.00	8	22JAN07 09:00	22JAN07 16:59	LWEXT	1100	OPEN
EXT2370	Pl Conc 1st Lift Lnd Wal Annul St 10.74 to 11.00	8	25JAN07 14:00	26JAN07 12:59	LWEXT	1100	OPEN
EXT2410	Pl Conc 2nd Lift Lnd Wal Annul St 10.74 to 11.00	8	31JAN07 10:00	01FEB07 08:59	LWEXT	1100	OPEN
EXT2470	Pl Conc 3rd Lift Lnd Wal Annul St 10.74 to 11.00	8	05FEB07 15:00	06FEB07 13:59	LWEXT	1100	OPEN
EXT2500	Pl Conc 4th Lift Lnd Wal Annul St 10.74 to 11.00	8	09FEB07 11:00	12FEB07 09:59	LWEXT	1100	OPEN
EXT2520	Pl Conc 5th Lift Lnd Wal Sect St 10.74 to 11.00	8	14FEB07 16:00	15FEB07 14:59	LWEXT	1100	OPEN
1126							
EXT2420	Pl Conc 1st Lift Lnd Wal Towr Sec St 11.26	12	18JAN07 11:00	19JAN07 13:59	LWEXT	1126	OPEN
EXT2421	Place Conc 2nd Lift Lnd Wall Tower Sec Sta 11.26	4	24JAN07 11:00	24JAN07 14:59	LWEXT	1126	OPEN
EXT2430	Place PC Wall Panels Sta. 11.00 Thru Sta. 11.26	8	31JAN07 10:00	01FEB07 08:59	LWEXT	1126	OPEN
EXT2440	Pl Conc 1st Lift Lnd Wal Annul St 11.00 to 11.26	8	05FEB07 15:00	06FEB07 13:59	LWEXT	1126	OPEN
EXT2480	Pl Conc 2nd Lift Lnd Wal Annul St 11.00 to 11.26	8	09FEB07 11:00	12FEB07 09:59	LWEXT	1126	OPEN
EXT2510	Pl Conc 3rd Lift Lnd Wal Annul St 11.00 to 11.26	8	14FEB07 16:00	15FEB07 14:59	LWEXT	1126	OPEN
EXT2530	Pl Conc 4th Lift Lnd Wal Annul St 11.00 to 11.26	8	20FEB07 12:00	21FEB07 10:59	LWEXT	1126	OPEN
EXT2540	Pl Conc 5th Lift Lnd Wal Annul St 11.00 to 11.26	8	26FEB07 08:00	26FEB07 15:59	LWEXT	1126	OPEN
FINL							
EXT990	Precast Landwall Tower Sections	2,400	17JAN06 09:00	24JAN07 14:59	LWEXT	FINL	OPEN
EXT1000	Precast Land Wall - Wall Panels	2,400	17JAN06 09:00	24JAN07 14:59	LWEXT	FINL	OPEN
EXT2550	Set PC Wall Panels, Forms,& Pour concrete	1,200	17JUL06 16:00	19JAN07 09:59	LWEXT	FINL	OPEN
Miter Gate Monoliths Etc							
STRT							
EXT740	Land Miter Gate & Bulkhead Sill Rock Excavation	120	21JUN06 10:00	10JUL06 12:59	MITER	STRT	OPEN
EXT750	Bathymetric Survey - Land MG & Bulkhead Sill	80	10JUL06 13:00	21JUL06 11:59	MITER	STRT	OPEN



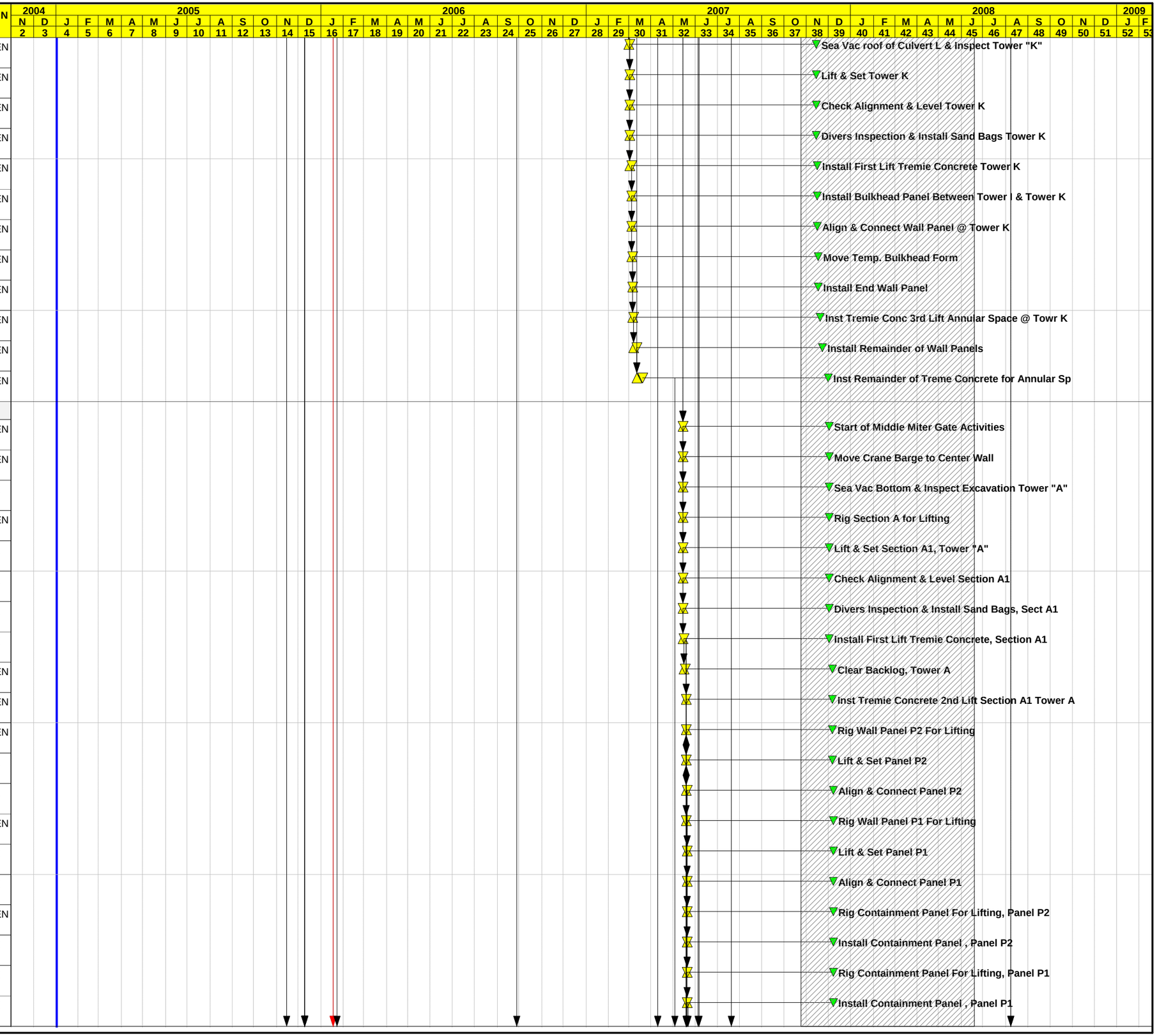
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT2560	Trim Excavation for Land MG & Bulkhead Sill	12	21JUL06 12:00	24JUL06 14:59	MITER	STRT	OPEN
EXT3220	Excavate Middle Wall Rock	56	24JUL06 15:00	01AUG06 16:59	MITER	STRT	12H
EXT3230	Bathymetric Survey of Middle Wall Excavation	6	02AUG06 08:00	02AUG06 13:59	MITER	STRT	12H
EXT3240	Trim Excavation for Tower Base Sections A to F	18	02AUG06 14:00	04AUG06 13:59	MITER	STRT	12H
EXT3210	Set Precast Wall Panels, Forms,& Pour Concrete	960	19JAN07 10:00	18JUN07 15:59	MITER	STRT	OPEN
EXT1010	Precast Land Wall - Miter Gate Shells	480	24JAN07 15:00	10APR07 08:59	MITER	STRT	OPEN
EXT1020	Precast Land Wall - Miter Gate Wall Panels	480	24JAN07 15:00	10APR07 08:59	MITER	STRT	OPEN
EXT1030	Precast Center Wall - Miter Gate Shell	360	10APR07 09:00	05JUN07 08:59	MITER	STRT	OPEN
EXT1040	Precast Center Wall - Wall Panels	600	10APR07 09:00	11JUL07 14:59	MITER	STRT	OPEN
G							
EXT2570	Rig Tower G for Lifting	2	08FEB07 12:00	08FEB07 13:59	MITER	G	OPEN
EXT2580	Sea Vac Bottom & Inspect Excavation Tower "G"	2	08FEB07 12:00	08FEB07 13:59	MITER	G	OPEN
EXT2590	Lift & Set Tower "G"	2	08FEB07 14:00	08FEB07 15:59	MITER	G	OPEN
EXT2600	Check Alignment & Level Tower G	2	08FEB07 16:00	09FEB07 08:59	MITER	G	OPEN
EXT2610	Divers Inspection & Install Sand Bags, Tower G	2	09FEB07 09:00	09FEB07 10:59	MITER	G	OPEN
EXT2620	Install First Lift Tremie Concrete Tower G	2	09FEB07 11:00	09FEB07 12:59	MITER	G	OPEN
EXT2920	Install Tremie Concrete 2nd Lift Tower "G"	4	14FEB07 10:00	14FEB07 13:59	MITER	G	OPEN
EXT2930	Install Bulkhead Panel Sta. 11.41	2	14FEB07 14:00	14FEB07 15:59	MITER	G	OPEN
EXT2940	Align & Connect Wall Panel @ Tower G	3	14FEB07 16:00	15FEB07 09:59	MITER	G	OPEN
EXT2950	Install Temp. Bulkhead Form	4	15FEB07 10:00	15FEB07 13:59	MITER	G	OPEN
EXT2960	Inst Tremie Conc 3rd Lift Annular Space @ Towr G	4	26FEB07 16:00	27FEB07 10:59	MITER	G	OPEN
H							
EXT2630	Rig Tower H for Lifting	2	09FEB07 13:00	09FEB07 14:59	MITER	H	OPEN
EXT2640	Sea Vac Bottom & Inspect Excavation Tower "H"	2	09FEB07 13:00	09FEB07 14:59	MITER	H	OPEN
EXT2650	Lift & Set Tower "H"	2	09FEB07 15:00	09FEB07 16:59	MITER	H	OPEN
EXT2660	Check Alignment & Level Tower H	2	12FEB07 08:00	12FEB07 09:59	MITER	H	OPEN
EXT2670	Divers Inspection & Install Sand Bags Tower H	2	12FEB07 10:00	12FEB07 11:59	MITER	H	OPEN
EXT2680	Install First Lift Tremie Concrete Tower H	2	12FEB07 12:00	12FEB07 13:59	MITER	H	OPEN
EXT2970	Install Tremie Concrete 2nd Lift Tower "H"	4	15FEB07 11:00	15FEB07 14:59	MITER	H	OPEN
EXT2980	Install Bulkhead Panel Between Tower G & Tower H	3	15FEB07 15:00	16FEB07 08:59	MITER	H	OPEN
EXT2990	Align & Connect Wall Panel @ Tower H	4	16FEB07 09:00	16FEB07 12:59	MITER	H	OPEN
EXT3020	Inst Tremie Conc 3rd Lift Annular Space @ Towr H	4	26FEB07 16:00	27FEB07 10:59	MITER	H	OPEN
I							
EXT2690	Rig Tower I for Lifting	2	12FEB07 14:00	12FEB07 15:59	MITER	I	OPEN



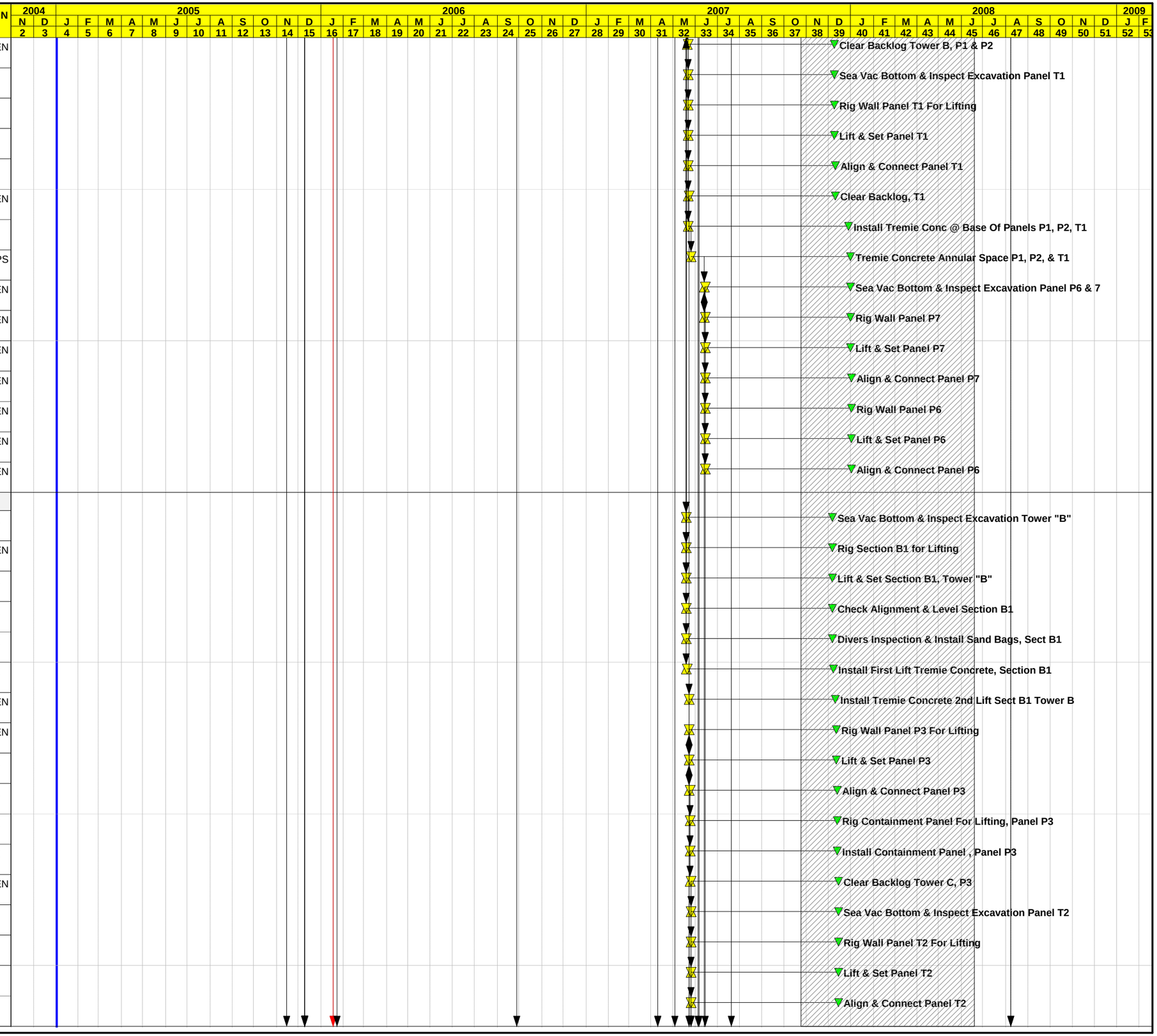
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT2700	Sea Vac Bottom & Inspect Excavation Tower "I"	2	12FEB07 14:00	12FEB07 15:59	MITER	I	OPEN
EXT2710	Lift & Set Tower "I"	2	12FEB07 16:00	13FEB07 08:59	MITER	I	OPEN
EXT2720	Check Alignment & Level Tower I	2	13FEB07 09:00	13FEB07 10:59	MITER	I	OPEN
EXT2730	Divers Inspection & Install Sand Bags Tower I	3	13FEB07 11:00	13FEB07 13:59	MITER	I	OPEN
EXT2740	Install First Lift Tremie Concrete Tower I	4	13FEB07 14:00	14FEB07 08:59	MITER	I	OPEN
EXT3030	Install Tremie Concrete 2nd Lift Tower "I"	4	16FEB07 15:00	19FEB07 09:59	MITER	I	OPEN
EXT3040	Install Bulkhead Panel Between Tower H & Tower I	2	19FEB07 10:00	19FEB07 11:59	MITER	I	OPEN
EXT3050	Align & Connect Wall Panel @ Tower I	3	19FEB07 12:00	19FEB07 14:59	MITER	I	OPEN
EXT3000	Move Temp. Bulkhead Form	4	19FEB07 15:00	20FEB07 09:59	MITER	I	OPEN
EXT3080	Inst Tremie Conc 3rd Lift Annular Space @ Towr I	4	27FEB07 11:00	27FEB07 14:59	MITER	I	OPEN
J							
EXT2750	Rig Tower J for Lifting	2	14FEB07 09:00	14FEB07 10:59	MITER	J	OPEN
EXT2760	Sea Vac Bottom & Inspect Excavation Tower "J"	2	14FEB07 09:00	14FEB07 10:59	MITER	J	OPEN
EXT2770	Lift & Set Tower "J"	2	14FEB07 11:00	14FEB07 12:59	MITER	J	OPEN
EXT2780	Check Alignment & Level Tower J	2	14FEB07 13:00	14FEB07 14:59	MITER	J	OPEN
EXT2790	Divers Inspection & Install Sand Bags Tower J	3	14FEB07 15:00	15FEB07 08:59	MITER	J	OPEN
EXT2800	Install First Lift Tremie Concrete Tower J	4	15FEB07 09:00	15FEB07 12:59	MITER	J	OPEN
EXT3090	Install Tremie Concrete 2nd Lift Tower "J"	4	20FEB07 10:00	20FEB07 13:59	MITER	J	OPEN
EXT3100	Install Bulkhead Panel Between Tower I & Tower J	2	20FEB07 14:00	20FEB07 15:59	MITER	J	OPEN
EXT3110	Align & Connect Wall Panel @ Tower J	3	20FEB07 16:00	21FEB07 09:59	MITER	J	OPEN
EXT3120	Move Temp. Bulkhead Form	4	21FEB07 10:00	21FEB07 13:59	MITER	J	OPEN
EXT3130	Inst Tremie Conc 3rd Lift Annular Space @ Towr J	4	27FEB07 15:00	28FEB07 09:59	MITER	J	OPEN
L							
EXT2809	Rig Culvert L for Lifting	2	15FEB07 13:00	15FEB07 14:59	MITER	L	OPEN
EXT2810	Sea Vac Bottom & Insp Excavation Culvert Sect L	2	15FEB07 13:00	15FEB07 14:59	MITER	L	OPEN
EXT2820	Lift & Set Culvert Section "L"	2	15FEB07 15:00	15FEB07 16:59	MITER	L	OPEN
EXT2830	Check Alignment & Level Culvert Section "L"	2	16FEB07 08:00	16FEB07 09:59	MITER	L	OPEN
EXT2840	Divers Inspec & Install Sand Bags, Culvert Sec L	3	16FEB07 10:00	16FEB07 12:59	MITER	L	OPEN
EXT2850	Inst First Lift Tremie Concrete, Culvert Sect L	4	16FEB07 13:00	16FEB07 16:59	MITER	L	OPEN
EXT3010	Inst Tremie Concrete 2nd Lift Culvert Section L	4	21FEB07 14:00	22FEB07 08:59	MITER	L	OPEN
EXT3060	Move Temp. Bulkhead Form	4	22FEB07 09:00	22FEB07 12:59	MITER	L	OPEN
EXT3070	Inst Tremie Concrete 3rd Lift Culvert Section L	4	26FEB07 15:00	27FEB07 09:59	MITER	L	OPEN
K							
EXT2860	Rig Small Tower K for Lifting	2	01MAR07 16:00	02MAR07 08:59	MITER	K	OPEN



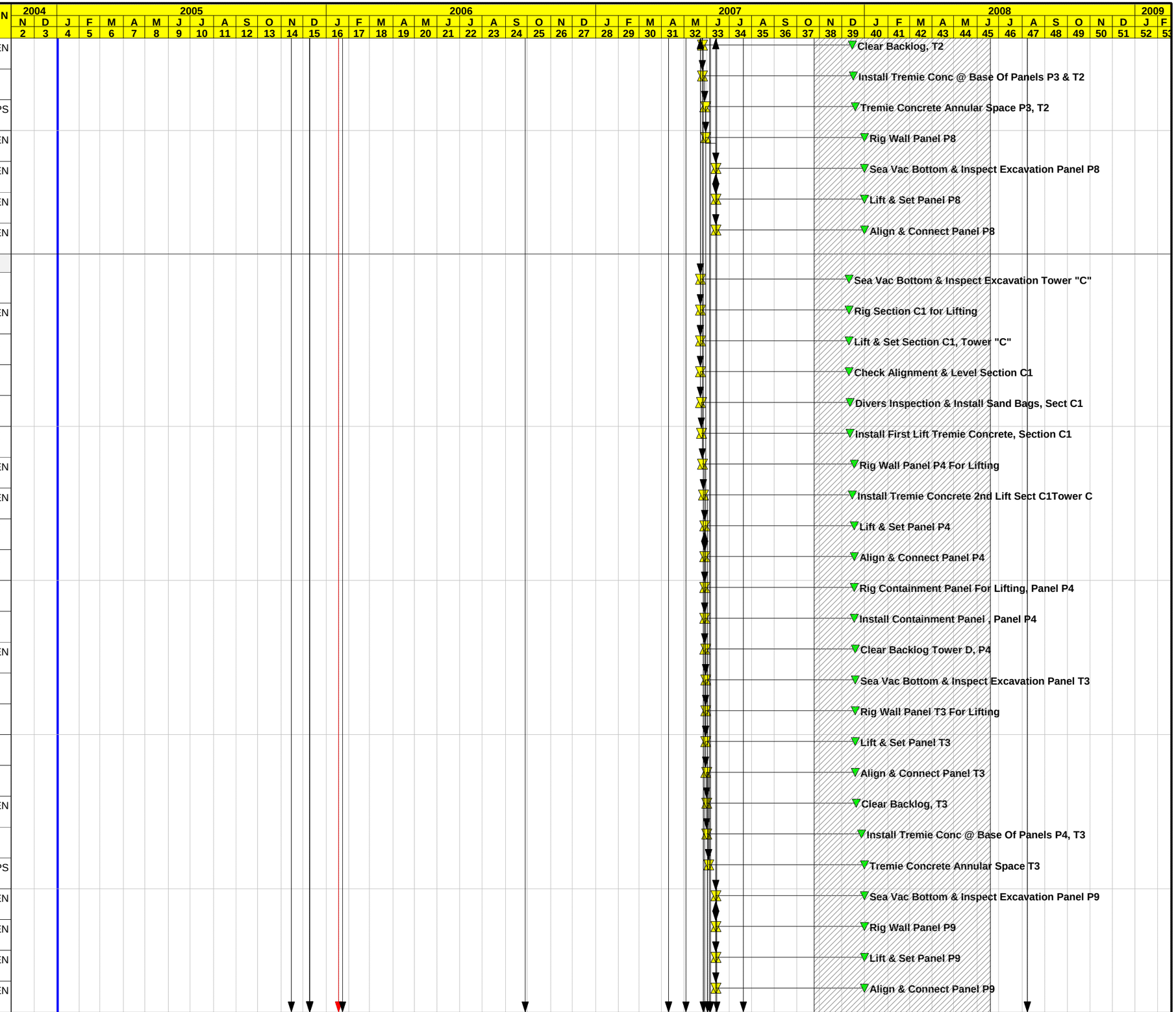
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT2870	Sea Vac roof of Culvert L & Inspect Tower "K"	2	01MAR07 16:00	02MAR07 08:59	MITER	K	OPEN
EXT2880	Lift & Set Tower K	2	02MAR07 09:00	02MAR07 10:59	MITER	K	OPEN
EXT2890	Check Alignment & Level Tower K	2	02MAR07 11:00	02MAR07 12:59	MITER	K	OPEN
EXT2900	Divers Inspection & Install Sand Bags Tower K	3	02MAR07 13:00	02MAR07 15:59	MITER	K	OPEN
EXT2910	Install First Lift Tremie Concrete Tower K	4	02MAR07 16:00	05MAR07 10:59	MITER	K	OPEN
EXT3140	Install Bulkhead Panel Between Tower I & Tower K	2	05MAR07 11:00	05MAR07 12:59	MITER	K	OPEN
EXT3150	Align & Connect Wall Panel @ Tower K	3	05MAR07 13:00	05MAR07 15:59	MITER	K	OPEN
EXT3160	Move Temp. Bulkhead Form	4	05MAR07 16:00	06MAR07 10:59	MITER	K	OPEN
EXT3170	Install End Wall Panel	4	06MAR07 11:00	06MAR07 14:59	MITER	K	OPEN
EXT3180	Inst Tremie Conc 3rd Lift Annular Space @ Towr K	4	06MAR07 15:00	07MAR07 09:59	MITER	K	OPEN
EXT3190	Install Remainder of Wall Panels	32	07MAR07 10:00	12MAR07 14:59	MITER	K	OPEN
EXT3200	Inst Remainder of Treme Concrete for Annular Sp	56	12MAR07 15:00	20MAR07 16:59	MITER	K	OPEN
A							
EXT3249	Start of Middle Miter Gate Activities	0	14MAY07 17:00	14MAY07 16:59	MITER	A	OPEN
EXT3250	Move Crane Barge to Center Wall	2	14MAY07 17:00	14MAY07 18:59	MITER	A	OPEN
EXT3270	Sea Vac Bottom & Inspect Excavation Tower "A"	5	14MAY07 19:00	14MAY07 23:59	MITER	A	SFC
EXT3260	Rig Section A for Lifting	2	14MAY07 19:00	14MAY07 20:59	MITER	A	OPEN
EXT3280	Lift & Set Section A1, Tower "A"	5	15MAY07 00:00	15MAY07 04:59	MITER	A	SFC
EXT3290	Check Alignment & Level Section A1	5	15MAY07 05:00	15MAY07 09:59	MITER	A	SFC
EXT3300	Divers Inspection & Install Sand Bags, Sect A1	5	15MAY07 10:00	15MAY07 14:59	MITER	A	SFC
EXT3310	Install First Lift Tremie Concrete, Section A1	5	15MAY07 15:00	15MAY07 19:59	MITER	A	SFC
EXT3320	Clear Backlog, Tower A	36	15MAY07 20:00	17MAY07 07:59	MITER	A	OPEN
EXT3400	Inst Tremie Concrete 2nd Lift Section A1 Tower A	3	18MAY07 20:00	18MAY07 22:59	MITER	A	OPEN
EXT3780	Rig Wall Panel P2 For Lifting	1	19MAY07 01:00	19MAY07 01:59	MITER	A	OPEN
EXT3790	Lift & Set Panel P2	3	19MAY07 10:00	19MAY07 12:59	MITER	A	SFC
EXT3800	Align & Connect Panel P2	9	19MAY07 13:00	19MAY07 21:59	MITER	A	SFC
EXT3720	Rig Wall Panel P1 For Lifting	1	19MAY07 13:00	19MAY07 13:59	MITER	A	OPEN
EXT3730	Lift & Set Panel P1	3	19MAY07 22:00	20MAY07 00:59	MITER	A	SFC
EXT3740	Align & Connect Panel P1	9	20MAY07 01:00	20MAY07 09:59	MITER	A	SFC
EXT3810	Rig Containment Panel For Lifting, Panel P2	3	20MAY07 01:00	20MAY07 03:59	MITER	A	OPEN
EXT3820	Install Containment Panel , Panel P2	3	20MAY07 04:00	20MAY07 06:59	MITER	A	SFC
EXT3750	Rig Containment Panel For Lifting, Panel P1	3	20MAY07 10:00	20MAY07 12:59	MITER	A	SFC
EXT3760	Install Containment Panel , Panel P1	3	20MAY07 13:00	20MAY07 15:59	MITER	A	SFC



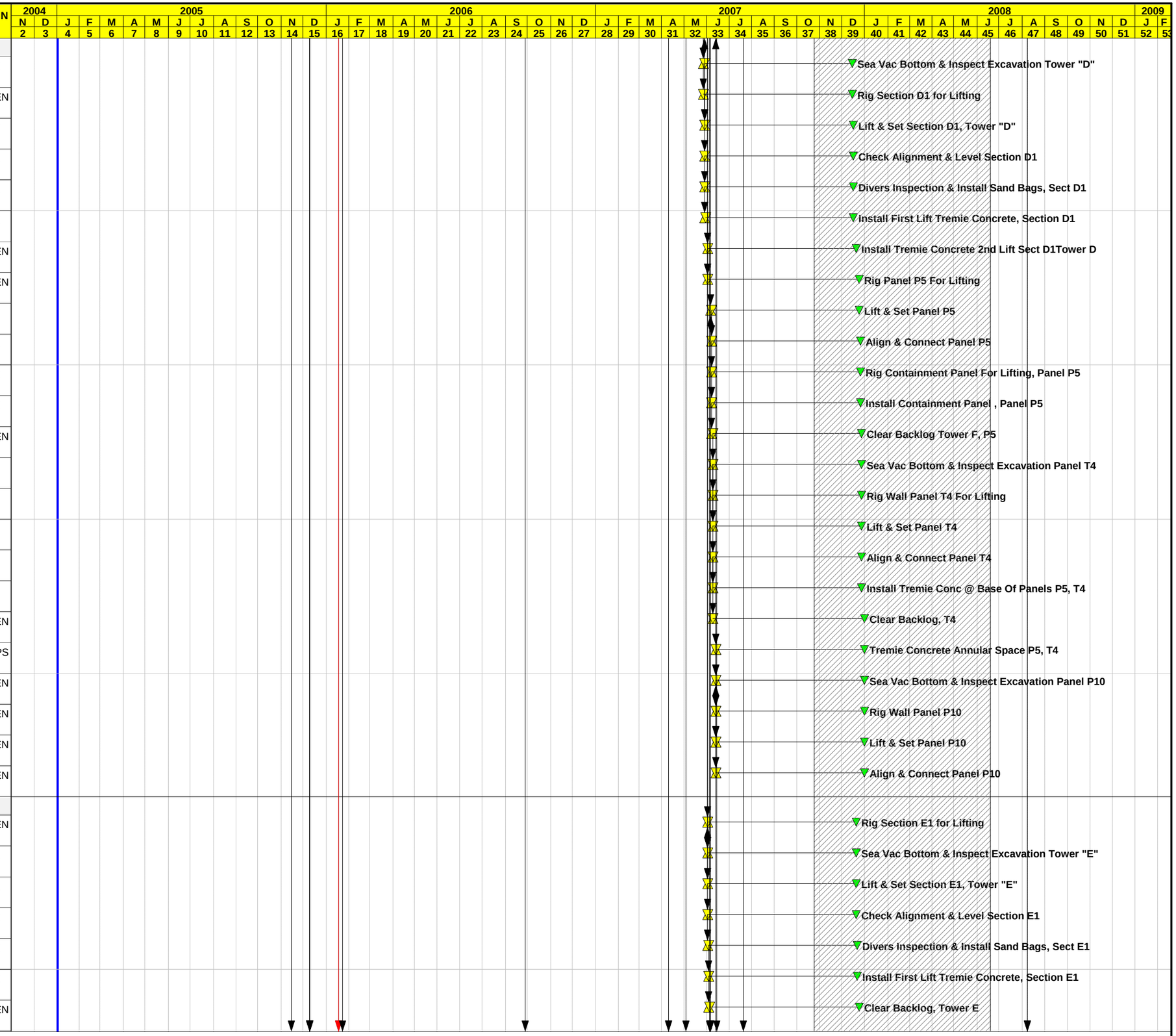
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT3770	Clear Backlog Tower B, P1 & P2	36	20MAY07 16:00	22MAY07 03:59	MITER	A	OPEN
EXT4030	Sea Vac Bottom & Inspect Excavation Panel T1	2	22MAY07 04:00	22MAY07 05:59	MITER	A	12H
EXT4040	Rig Wall Panel T1 For Lifting	1	22MAY07 06:00	22MAY07 06:59	MITER	A	12H
EXT4050	Lift & Set Panel T1	1	22MAY07 07:00	22MAY07 07:59	MITER	A	12H
EXT4060	Align & Connect Panel T1	3	22MAY07 08:00	22MAY07 10:59	MITER	A	12H
EXT4065	Clear Backlog, T1	6	22MAY07 11:00	22MAY07 16:59	MITER	A	OPEN
EXT4020	Install Tremie Conc @ Base Of Panels P1, P2, T1	4	22MAY07 11:00	22MAY07 14:59	MITER	A	12H
EXT4070	Tremie Concrete Annular Space P1, P2, & T1	8	25MAY07 15:00	25MAY07 22:59	MITER	A	COPS
EXT4220	Sea Vac Bottom & Inspect Excavation Panel P6 & 7	2	13JUN07 19:00	13JUN07 20:59	MITER	A	OPEN
EXT4230	Rig Wall Panel P7	2	13JUN07 19:00	13JUN07 20:59	MITER	A	OPEN
EXT4240	Lift & Set Panel P7	2	13JUN07 21:00	13JUN07 22:59	MITER	A	OPEN
EXT4250	Align & Connect Panel P7	3	13JUN07 23:00	14JUN07 01:59	MITER	A	OPEN
EXT4190	Rig Wall Panel P6	2	13JUN07 23:00	14JUN07 00:59	MITER	A	OPEN
EXT4200	Lift & Set Panel P6	2	14JUN07 02:00	14JUN07 03:59	MITER	A	OPEN
EXT4210	Align & Connect Panel P6	3	14JUN07 04:00	14JUN07 06:59	MITER	A	OPEN
B							
EXT3340	Sea Vac Bottom & Inspect Excavation Tower "B"	6	18MAY07 23:00	19MAY07 04:59	MITER	B	SFC
EXT3330	Rig Section B1 for Lifting	2	18MAY07 23:00	19MAY07 00:59	MITER	B	OPEN
EXT3350	Lift & Set Section B1, Tower "B"	5	19MAY07 05:00	19MAY07 09:59	MITER	B	SFC
EXT3360	Check Alignment & Level Section B1	5	19MAY07 10:00	19MAY07 14:59	MITER	B	SFC
EXT3370	Divers Inspection & Install Sand Bags, Sect B1	5	19MAY07 15:00	19MAY07 19:59	MITER	B	SFC
EXT3380	Install First Lift Tremie Concrete, Section B1	6	19MAY07 20:00	20MAY07 01:59	MITER	B	SFC
EXT3480	Install Tremie Concrete 2nd Lift Sect B1 Tower B	3	23MAY07 02:00	23MAY07 04:59	MITER	B	OPEN
EXT3840	Rig Wall Panel P3 For Lifting	1	23MAY07 17:00	23MAY07 17:59	MITER	B	OPEN
EXT3850	Lift & Set Panel P3	3	23MAY07 18:00	23MAY07 20:59	MITER	B	SFC
EXT3860	Align & Connect Panel P3	9	23MAY07 21:00	24MAY07 05:59	MITER	B	SFC
EXT3870	Rig Containment Panel For Lifting, Panel P3	3	24MAY07 06:00	24MAY07 08:59	MITER	B	SFC
EXT3880	Install Containment Panel , Panel P3	3	24MAY07 09:00	24MAY07 11:59	MITER	B	SFC
EXT3890	Clear Backlog Tower C, P3	36	24MAY07 12:00	25MAY07 23:59	MITER	B	OPEN
EXT4080	Sea Vac Bottom & Inspect Excavation Panel T2	2	26MAY07 00:00	26MAY07 01:59	MITER	B	12H
EXT4090	Rig Wall Panel T2 For Lifting	1	26MAY07 02:00	26MAY07 02:59	MITER	B	12H
EXT4100	Lift & Set Panel T2	1	26MAY07 03:00	26MAY07 03:59	MITER	B	12H
EXT4110	Align & Connect Panel T2	3	26MAY07 04:00	26MAY07 06:59	MITER	B	12H



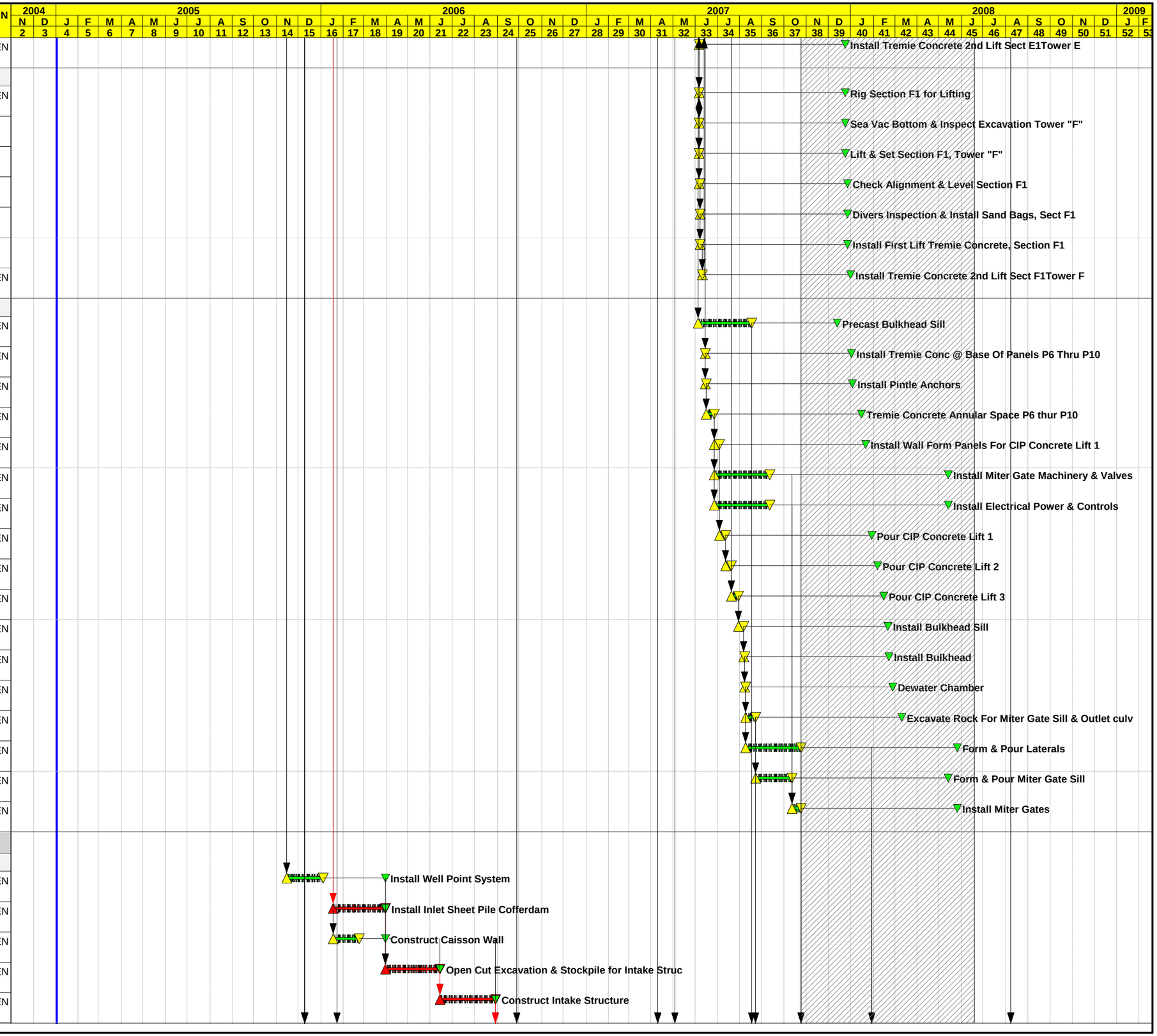
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT4115	Clear Backlog, T2	6	26MAY07 07:00	26MAY07 12:59	MITER	B	OPEN
EXT4125	Install Tremie Conc @ Base Of Panels P3 & T2	4	26MAY07 07:00	26MAY07 10:59	MITER	B	12H
EXT4120	Tremie Concrete Annular Space P3, T2	8	29MAY07 11:00	29MAY07 18:59	MITER	B	COPS
EXT4270	Rig Wall Panel P8	2	29MAY07 19:00	29MAY07 20:59	MITER	B	OPEN
EXT4260	Sea Vac Bottom & Inspect Excavation Panel P8	2	13JUN07 12:00	13JUN07 13:59	MITER	B	OPEN
EXT4280	Lift & Set Panel P8	2	13JUN07 14:00	13JUN07 15:59	MITER	B	OPEN
EXT4290	Align & Connect Panel P8	3	13JUN07 16:00	13JUN07 18:59	MITER	B	OPEN
C							
EXT3420	Sea Vac Bottom & Inspect Excavation Tower "C"	6	23MAY07 05:00	23MAY07 10:59	MITER	C	SFC
EXT3410	Rig Section C1 for Lifting	2	23MAY07 05:00	23MAY07 06:59	MITER	C	OPEN
EXT3430	Lift & Set Section C1, Tower "C"	6	23MAY07 11:00	23MAY07 16:59	MITER	C	SFC
EXT3440	Check Alignment & Level Section C1	6	23MAY07 17:00	23MAY07 22:59	MITER	C	SFC
EXT3450	Divers Inspection & Install Sand Bags, Sect C1	9	23MAY07 23:00	24MAY07 07:59	MITER	C	SFC
EXT3460	Install First Lift Tremie Concrete, Section C1	12	24MAY07 08:00	24MAY07 19:59	MITER	C	SFC
EXT3900	Rig Wall Panel P4 For Lifting	1	26MAY07 00:00	26MAY07 00:59	MITER	C	OPEN
EXT3560	Install Tremie Concrete 2nd Lift Sect C1Tower C	4	27MAY07 20:00	27MAY07 23:59	MITER	C	OPEN
EXT3910	Lift & Set Panel P4	3	28MAY07 12:00	28MAY07 14:59	MITER	C	SFC
EXT3920	Align & Connect Panel P4	9	28MAY07 15:00	28MAY07 23:59	MITER	C	SFC
EXT3930	Rig Containment Panel For Lifting, Panel P4	3	29MAY07 00:00	29MAY07 02:59	MITER	C	SFC
EXT3940	Install Containment Panel , Panel P4	3	29MAY07 03:00	29MAY07 05:59	MITER	C	SFC
EXT3950	Clear Backlog Tower D, P4	36	29MAY07 06:00	30MAY07 17:59	MITER	C	OPEN
EXT4130	Sea Vac Bottom & Inspect Excavation Panel T3	2	30MAY07 18:00	30MAY07 19:59	MITER	C	12H
EXT4140	Rig Wall Panel T3 For Lifting	1	30MAY07 18:00	30MAY07 18:59	MITER	C	12H
EXT4150	Lift & Set Panel T3	1	30MAY07 20:00	30MAY07 20:59	MITER	C	12H
EXT4160	Align & Connect Panel T3	3	30MAY07 21:00	30MAY07 23:59	MITER	C	12H
EXT4165	Clear Backlog, T3	6	31MAY07 00:00	31MAY07 05:59	MITER	C	OPEN
EXT4175	Install Tremie Conc @ Base Of Panels P4, T3	4	31MAY07 00:00	31MAY07 03:59	MITER	C	12H
EXT4170	Tremie Concrete Annular Space T3	8	03JUN07 04:00	03JUN07 11:59	MITER	C	COPS
EXT4300	Sea Vac Bottom & Inspect Excavation Panel P9	2	13JUN07 03:00	13JUN07 04:59	MITER	C	OPEN
EXT4310	Rig Wall Panel P9	2	13JUN07 05:00	13JUN07 06:59	MITER	C	OPEN
EXT4320	Lift & Set Panel P9	2	13JUN07 07:00	13JUN07 08:59	MITER	C	OPEN
EXT4330	Align & Connect Panel P9	3	13JUN07 09:00	13JUN07 11:59	MITER	C	OPEN



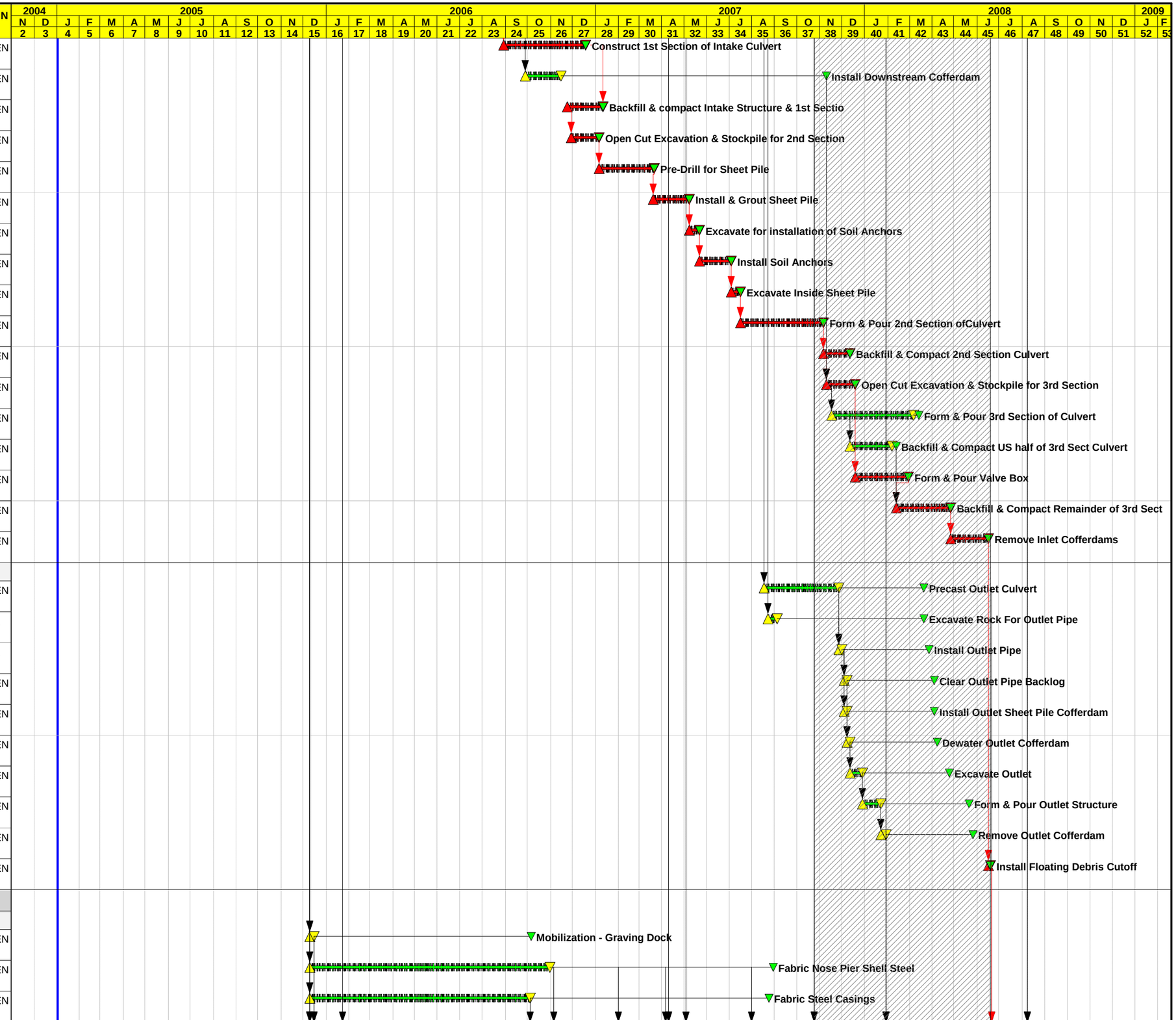
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
D							
EXT3500	Sea Vac Bottom & Inspect Excavation Tower "D"	6	28MAY07 00:00	28MAY07 05:59	MITER	D	SFC
EXT3490	Rig Section D1 for Lifting	2	28MAY07 00:00	28MAY07 01:59	MITER	D	OPEN
EXT3510	Lift & Set Section D1, Tower "D"	6	28MAY07 06:00	28MAY07 11:59	MITER	D	SFC
EXT3520	Check Alignment & Level Section D1	6	28MAY07 12:00	28MAY07 17:59	MITER	D	SFC
EXT3530	Divers Inspection & Install Sand Bags, Sect D1	9	28MAY07 18:00	29MAY07 02:59	MITER	D	SFC
EXT3540	Install First Lift Tremie Concrete, Section D1	12	29MAY07 03:00	29MAY07 14:59	MITER	D	SFC
EXT3640	Install Tremie Concrete 2nd Lift Sect D1Tower D	4	01JUN07 15:00	01JUN07 18:59	MITER	D	OPEN
EXT3960	Rig Panel P5 For Lifting	1	01JUN07 19:00	01JUN07 19:59	MITER	D	OPEN
EXT3970	Lift & Set Panel P5	3	06JUN07 20:00	06JUN07 22:59	MITER	D	SFC
EXT3980	Align & Connect Panel P5	9	06JUN07 23:00	07JUN07 07:59	MITER	D	SFC
EXT3990	Rig Containment Panel For Lifting, Panel P5	3	07JUN07 08:00	07JUN07 10:59	MITER	D	SFC
EXT4000	Install Containment Panel , Panel P5	3	07JUN07 11:00	07JUN07 13:59	MITER	D	SFC
EXT4010	Clear Backlog Tower F, P5	36	07JUN07 14:00	09JUN07 01:59	MITER	D	OPEN
EXT4011	Sea Vac Bottom & Inspect Excavation Panel T4	2	09JUN07 02:00	09JUN07 03:59	MITER	D	12H
EXT4012	Rig Wall Panel T4 For Lifting	1	09JUN07 02:00	09JUN07 02:59	MITER	D	12H
EXT4013	Lift & Set Panel T4	1	09JUN07 04:00	09JUN07 04:59	MITER	D	12H
EXT4014	Align & Connect Panel T4	3	09JUN07 05:00	09JUN07 07:59	MITER	D	12H
EXT4017	Install Tremie Conc @ Base Of Panels P5, T4	4	09JUN07 08:00	09JUN07 11:59	MITER	D	12H
EXT4015	Clear Backlog, T4	6	09JUN07 08:00	09JUN07 13:59	MITER	D	OPEN
EXT4016	Tremie Concrete Annular Space P5, T4	8	12JUN07 12:00	12JUN07 19:59	MITER	D	COPS
EXT4340	Sea Vac Bottom & Inspect Excavation Panel P10	2	12JUN07 20:00	12JUN07 21:59	MITER	D	OPEN
EXT4350	Rig Wall Panel P10	2	12JUN07 20:00	12JUN07 21:59	MITER	D	OPEN
EXT4360	Lift & Set Panel P10	2	12JUN07 22:00	12JUN07 23:59	MITER	D	OPEN
EXT4370	Align & Connect Panel P10	3	13JUN07 00:00	13JUN07 02:59	MITER	D	OPEN
E							
EXT3570	Rig Section E1 for Lifting	8	01JUN07 19:00	02JUN07 02:59	MITER	E	OPEN
EXT3580	Sea Vac Bottom & Inspect Excavation Tower "E"	6	01JUN07 19:00	02JUN07 00:59	MITER	E	SFC
EXT3590	Lift & Set Section E1, Tower "E"	6	02JUN07 03:00	02JUN07 08:59	MITER	E	SFC
EXT3600	Check Alignment & Level Section E1	6	02JUN07 09:00	02JUN07 14:59	MITER	E	SFC
EXT3610	Divers Inspection & Install Sand Bags, Sect E1	9	02JUN07 15:00	02JUN07 23:59	MITER	E	SFC
EXT3620	Install First Lift Tremie Concrete, Section E1	12	03JUN07 00:00	03JUN07 11:59	MITER	E	SFC
EXT3630	Clear Backlog, Tower E	36	03JUN07 12:00	04JUN07 23:59	MITER	E	OPEN



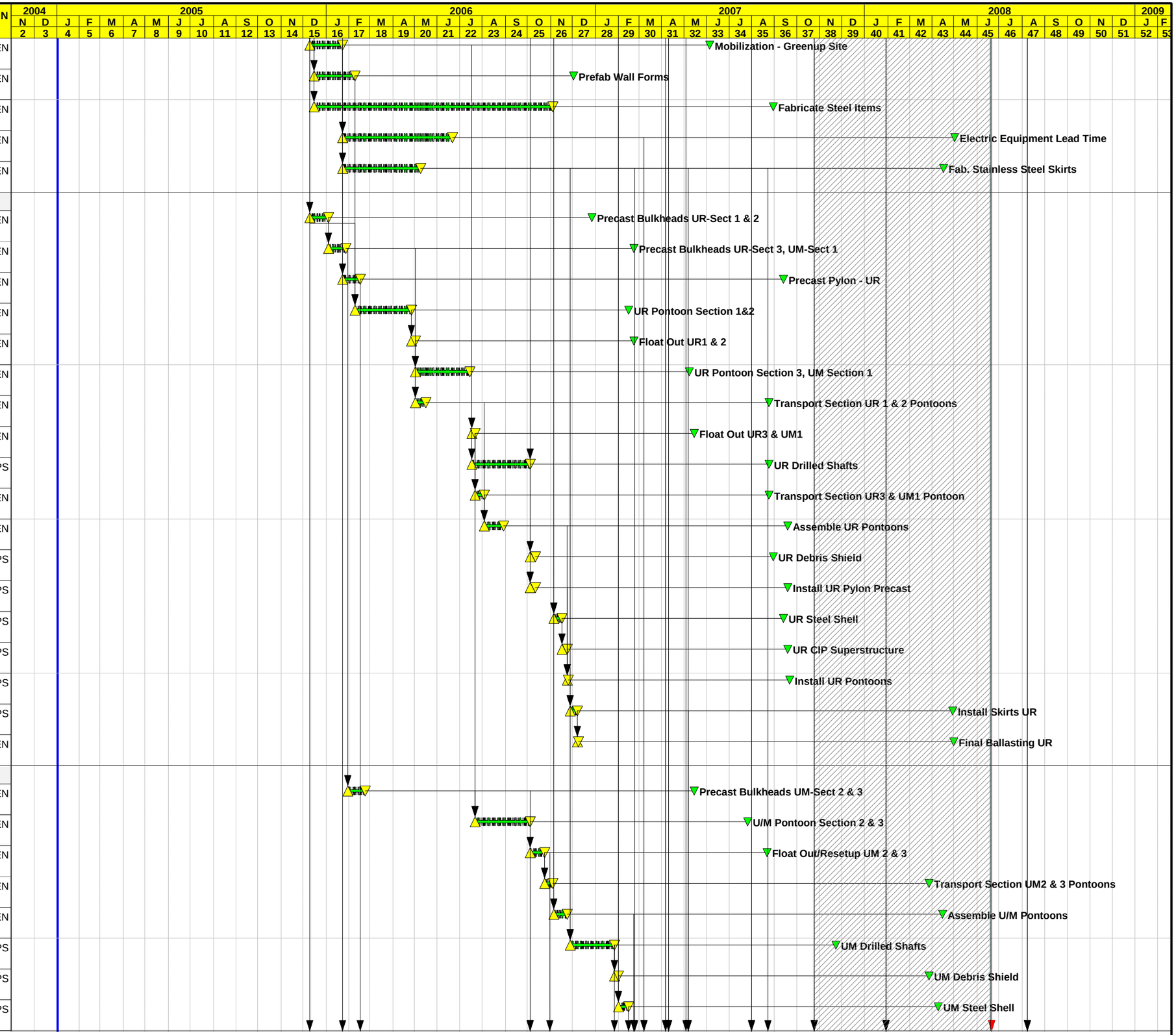
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT3650	Install Tremie Concrete 2nd Lift Sect E1Tower E	4	06JUN07 12:00	06JUN07 15:59	MITER	E	OPEN
F							
EXT3665	Rig Section F1 for Lifting	8	06JUN07 10:00	06JUN07 17:59	MITER	F	OPEN
EXT3660	Sea Vac Bottom & Inspect Excavation Tower "F"	2	06JUN07 16:00	06JUN07 17:59	MITER	F	SFC
EXT3670	Lift & Set Section F1, Tower "F"	2	06JUN07 18:00	06JUN07 19:59	MITER	F	SFC
EXT3680	Check Alignment & Level Section F1	2	06JUN07 20:00	06JUN07 21:59	MITER	F	SFC
EXT3690	Divers Inspection & Install Sand Bags, Sect F1	3	06JUN07 22:00	07JUN07 00:59	MITER	F	SFC
EXT3700	Install First Lift Tremie Concrete, Section F1	4	07JUN07 01:00	07JUN07 04:59	MITER	F	SFC
EXT3710	Install Tremie Concrete 2nd Lift Sect F1Tower F	4	10JUN07 05:00	10JUN07 08:59	MITER	F	OPEN
FINL							
EXT1050	Precast Bulkhead Sill	480	05JUN07 09:00	17AUG07 11:59	MITER	FINL	OPEN
EXT4380	Install Tremie Conc @ Base Of Panels P6 Thru P10	8	14JUN07 08:00	14JUN07 15:59	MITER	FINL	OPEN
EXT4390	Install Pintle Anchors	8	14JUN07 16:00	15JUN07 14:59	MITER	FINL	OPEN
EXT4400	Tremie Concrete Annular Space P6 thur P10	72	15JUN07 15:00	27JUN07 14:59	MITER	FINL	OPEN
EXT4410	Install Wall Form Panels For CIP Concrete Lift 1	40	27JUN07 15:00	04JUL07 09:59	MITER	FINL	OPEN
EXT4510	Install Miter Gate Machinery & Valves	480	27JUN07 15:00	11SEP07 08:59	MITER	FINL	OPEN
EXT4520	Install Electrical Power & Controls	480	27JUN07 15:00	11SEP07 08:59	MITER	FINL	OPEN
EXT4420	Pour CIP Concrete Lift 1	56	04JUL07 10:00	12JUL07 11:59	MITER	FINL	OPEN
EXT4430	Pour CIP Concrete Lift 2	56	12JUL07 12:00	20JUL07 13:59	MITER	FINL	OPEN
EXT4440	Pour CIP Concrete Lift 3	56	20JUL07 14:00	30JUL07 15:59	MITER	FINL	OPEN
EXT4450	Install Bulkhead Sill	40	30JUL07 16:00	06AUG07 10:59	MITER	FINL	OPEN
EXT4460	Install Bulkhead	8	06AUG07 11:00	07AUG07 09:59	MITER	FINL	OPEN
EXT4470	Dewater Chamber	24	07AUG07 10:00	09AUG07 15:59	MITER	FINL	OPEN
EXT4490	Excavate Rock For Miter Gate Sill & Outlet culv	80	09AUG07 16:00	22AUG07 14:59	MITER	FINL	OPEN
EXT4480	Form & Pour Laterals	480	09AUG07 16:00	24OCT07 09:59	MITER	FINL	OPEN
EXT4500	Form & Pour Miter Gate Sill	320	22AUG07 15:00	11OCT07 10:59	MITER	FINL	OPEN
EXT4530	Install Miter Gates	80	11OCT07 11:00	24OCT07 09:59	MITER	FINL	OPEN
Auxiliary Filling and Emptying System							
FILL							
EXT800	Install Well Point System	320	15NOV05 14:00	04JAN06 09:59	AUXFE	FILL	OPEN
EXT770	Install Inlet Sheet Pile Cofferdam	480	17JAN06 09:00	31MAR06 11:59	AUXFE	FILL	OPEN
EXT760	Construct Caisson Wall	240	17JAN06 09:00	22FEB06 14:59	AUXFE	FILL	OPEN
EXT780	Open Cut Excavation & Stockpile for Intake Struc	480	31MAR06 12:00	14JUN06 14:59	AUXFE	FILL	OPEN
EXT790	Construct Intake Structure	480	14JUN06 15:00	29AUG06 08:59	AUXFE	FILL	OPEN



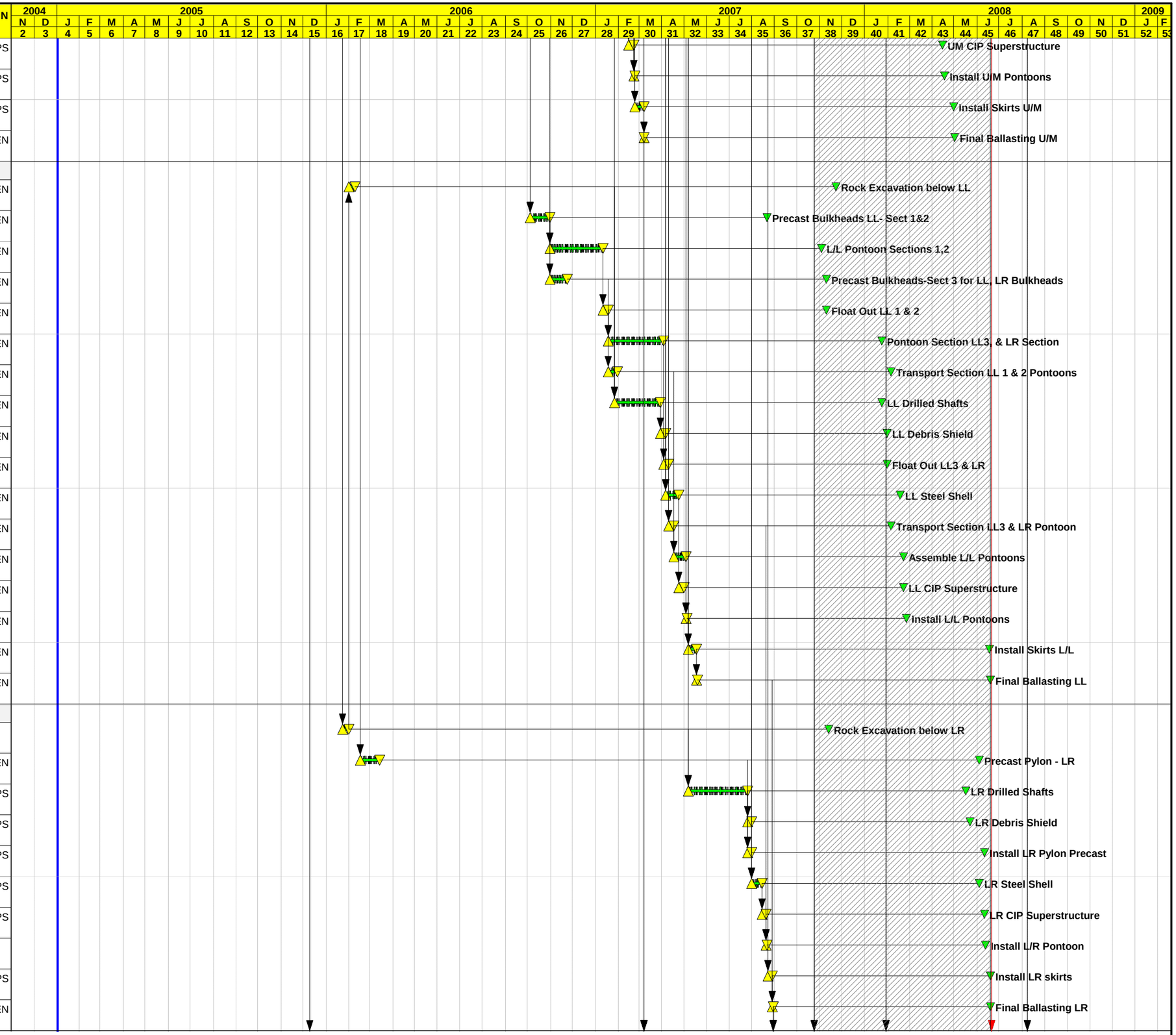
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
EXT810	Construct 1st Section of Intake Culvert	720	29AUG06 09:00	19DEC06 08:59	AUXFE	FILL	OPEN
EXT940	Install Downstream Cofferdam	320	27SEP06 12:00	15NOV06 16:59	AUXFE	FILL	OPEN
EXT820	Backfill & compact Intake Structure & 1st Sectio	320	23NOV06 11:00	11JAN07 15:59	AUXFE	FILL	OPEN
EXT830	Open Cut Excavation & Stockpile for 2nd Section	240	29NOV06 15:00	05JAN07 11:59	AUXFE	FILL	OPEN
EXT840	Pre-Drill for Sheet Pile	480	05JAN07 12:00	21MAR07 14:59	AUXFE	FILL	OPEN
EXT850	Install & Grout Sheet Pile	320	20MAR07 08:00	08MAY07 12:59	AUXFE	FILL	OPEN
EXT860	Excavate for installation of Soil Anchors	80	08MAY07 13:00	21MAY07 11:59	AUXFE	FILL	OPEN
EXT870	Install Soil Anchors	280	21MAY07 12:00	03JUL07 12:59	AUXFE	FILL	OPEN
EXT880	Excavate Inside Sheet Pile	80	03JUL07 13:00	16JUL07 11:59	AUXFE	FILL	OPEN
EXT890	Form & Pour 2nd Section ofCulvert	720	16JUL07 12:00	05NOV07 11:59	AUXFE	FILL	OPEN
EXT900	Backfill & Compact 2nd Section Culvert	240	05NOV07 12:00	12DEC07 08:59	AUXFE	FILL	OPEN
EXT910	Open Cut Excavation & Stockpile for 3rd Section	240	09NOV07 16:00	18DEC07 12:59	AUXFE	FILL	OPEN
EXT930	Form & Pour 3rd Section of Culvert	720	16NOV07 11:00	07MAR08 10:59	AUXFE	FILL	OPEN
EXT950	Backfill & Compact US half of 3rd Sect Culvert	360	12DEC07 09:00	06FEB08 08:59	AUXFE	FILL	OPEN
EXT920	Form & Pour Valve Box	480	18DEC07 13:00	29FEB08 15:59	AUXFE	FILL	OPEN
EXT960	Backfill & Compact Remainder of 3rd Sect	480	12FEB08 13:00	25APR08 15:59	AUXFE	FILL	OPEN
EXT970	Remove Inlet Cofferdams	320	25APR08 16:00	16JUN08 11:59	AUXFE	FILL	OPEN
EMTY							
EXT1060	Precast Outlet Culvert	640	17AUG07 12:00	26NOV07 12:59	AUXFE	EMTY	OPEN
EXT4540	Excavate Rock For Outlet Pipe	80	22AUG07 15:00	04SEP07 13:59	AUXFE	EMTY	FCL
EXT4550	Install Outlet Pipe	40	26NOV07 13:00	30NOV07 16:59	AUXFE	EMTY	FCL
EXT4560	Clear Outlet Pipe Backlog	40	03DEC07 08:00	07DEC07 11:59	AUXFE	EMTY	OPEN
EXT4570	Install Outlet Sheet Pile Cofferdam	40	03DEC07 08:00	07DEC07 11:59	AUXFE	EMTY	OPEN
EXT4580	Dewater Outlet Cofferdam	16	07DEC07 12:00	11DEC07 09:59	AUXFE	EMTY	OPEN
EXT4590	Excavate Outlet	120	11DEC07 10:00	28DEC07 12:59	AUXFE	EMTY	OPEN
EXT4600	Form & Pour Outlet Structure	160	28DEC07 13:00	23JAN08 10:59	AUXFE	EMTY	OPEN
EXT4610	Remove Outlet Cofferdam	40	23JAN08 11:00	29JAN08 14:59	AUXFE	EMTY	OPEN
EXT980	Install Floating Debris Cutoff	32	16JUN08 12:00	19JUN08 16:59	AUXFE	EMTY	OPEN
Floating Approach Walls							
STRT							
0005	Mobilization - Graving Dock	40	09DEC05 12:00	15DEC05 15:59	FW	STRT	OPEN
0022	Fabric Nose Pier Shell Steel	2,080	09DEC05 12:00	30OCT06 12:59	FW	STRT	OPEN
0021	Fabric Steel Casings	1,920	09DEC05 12:00	04OCT06 14:59	FW	STRT	OPEN



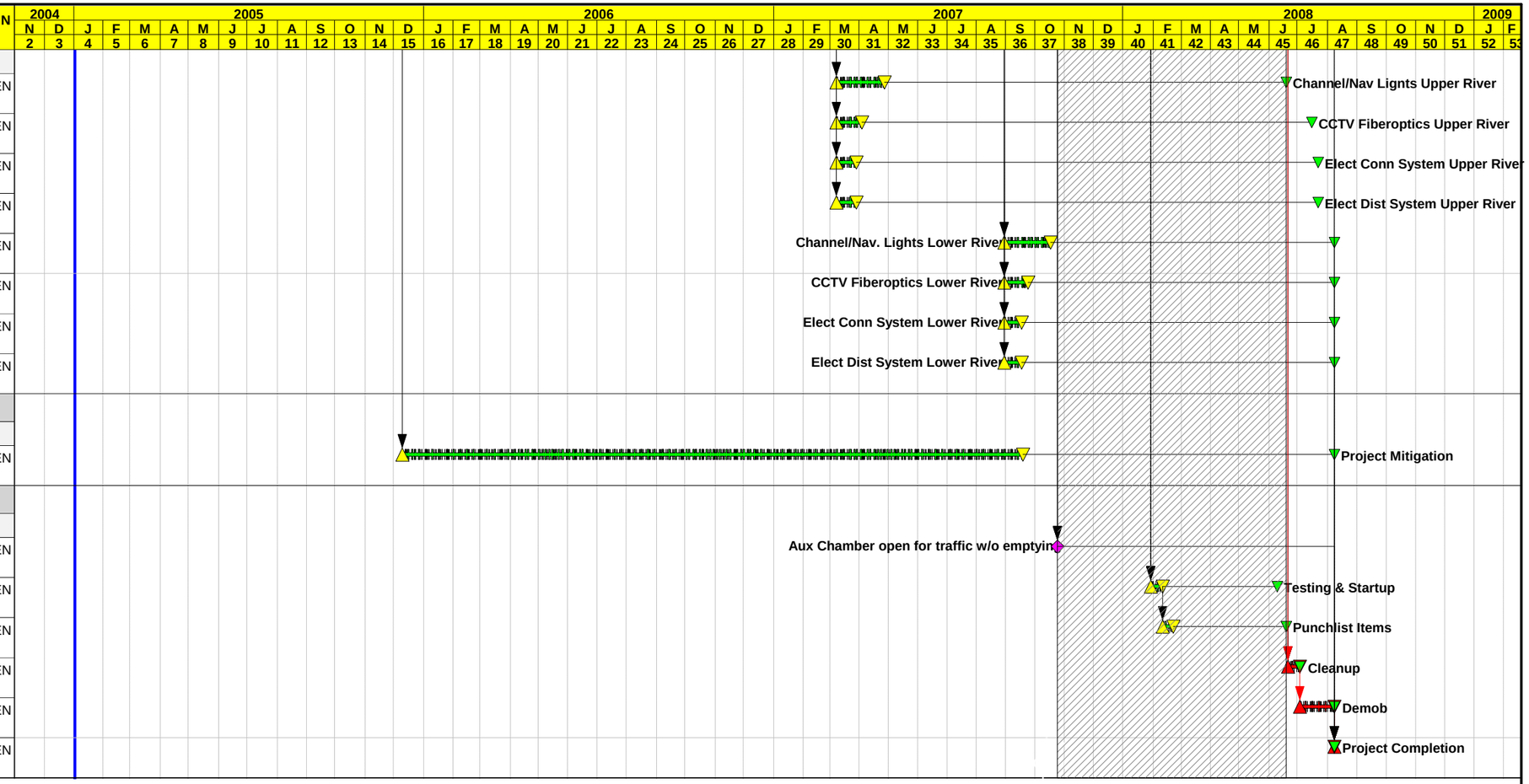
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
0023	Mobilization - Greenup Site	280	09DEC05 12:00	23JAN06 12:59	FW	STRT	OPEN
0007	Prefab Wall Forms	360	15DEC05 16:00	09FEB06 15:59	FW	STRT	OPEN
0009	Fabricate Steel Items	2,080	15DEC05 16:00	03NOV06 16:59	FW	STRT	OPEN
0053	Electric Equipment Lead Time	960	23JAN06 13:00	21JUN06 09:59	FW	STRT	OPEN
0049	Fab. Stainless Steel Skirts	680	23JAN06 13:00	09MAY06 08:59	FW	STRT	OPEN
UR							
0008	Precast Bulkheads UR-Sect 1 & 2	160	09DEC05 12:00	04JAN06 09:59	FW	UR	OPEN
0100	Precast Bulkheads UR-Sect 3, UM-Sect 1	160	04JAN06 10:00	27JAN06 16:59	FW	UR	OPEN
0036	Precast Pylon - UR	160	23JAN06 13:00	16FEB06 10:59	FW	UR	OPEN
0011	UR Pontoon Section 1&2	480	09FEB06 16:00	26APR06 09:59	FW	UR	OPEN
0107	Float Out UR1 & 2	40	26APR06 10:00	02MAY06 13:59	FW	UR	OPEN
0015	UR Pontoon Section 3, UM Section 1	480	02MAY06 14:00	14JUL06 16:59	FW	UR	OPEN
0038	Transport Section UR 1 & 2 Pontoons	80	02MAY06 14:00	15MAY06 12:59	FW	UR	OPEN
0108	Float Out UR3 & UM1	40	17JUL06 08:00	21JUL06 11:59	FW	UR	OPEN
0024	UR Drilled Shafts	520	17JUL06 08:00	04OCT06 14:59	FW	UR	COPS
0106	Transport Section UR3 & UM1 Pontoon	80	21JUL06 12:00	03AUG06 10:59	FW	UR	OPEN
0041	Assemble UR Pontoons	160	03AUG06 11:00	29AUG06 08:59	FW	UR	OPEN
0027	UR Debris Shield	40	04OCT06 15:00	11OCT06 09:59	FW	UR	COPS
0104	Install UR Pylon Precast	40	04OCT06 15:00	11OCT06 09:59	FW	UR	COPS
0028	UR Steel Shell	80	06NOV06 08:00	16NOV06 15:59	FW	UR	COPS
0029	UR CIP Superstructure	40	16NOV06 16:00	23NOV06 10:59	FW	UR	COPS
0044	Install UR Pontoons	40	23NOV06 11:00	25NOV06 02:59	FW	UR	COPS
0047	Install Skirts UR	80	27NOV06 08:00	07DEC06 15:59	FW	UR	COPS
0051	Final Ballasting UR	8	07DEC06 16:00	08DEC06 14:59	FW	UR	OPEN
UM							
0102	Precast Bulkheads UM-Sect 2 & 3	160	30JAN06 08:00	22FEB06 14:59	FW	UM	OPEN
0014	U/M Pontoon Section 2 & 3	480	21JUL06 12:00	04OCT06 14:59	FW	UM	OPEN
0017	Float Out/Resetup UM 2 & 3	120	04OCT06 15:00	24OCT06 08:59	FW	UM	OPEN
0037	Transport Section UM2 & 3 Pontoons	80	24OCT06 09:00	03NOV06 16:59	FW	UM	OPEN
0040	Assemble U/M Pontoons	120	06NOV06 08:00	23NOV06 10:59	FW	UM	OPEN
0025	UM Drilled Shafts	400	27NOV06 08:00	26JAN07 11:59	FW	UM	COPS
0030	UM Debris Shield	40	26JAN07 12:00	01FEB07 15:59	FW	UM	COPS
0031	UM Steel Shell	80	01FEB07 16:00	14FEB07 14:59	FW	UM	COPS



Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
0032	UM CIP Superstructure	40	14FEB07 15:00	21FEB07 09:59	FW	UM	COPS
0043	Install U/M Pontoons	40	21FEB07 10:00	23FEB07 01:59	FW	UM	COPS
0046	Install Skirts U/M	80	23FEB07 08:00	07MAR07 15:59	FW	UM	COPS
0050	Final Ballasting U/M	8	07MAR07 16:00	08MAR07 14:59	FW	UM	OPEN
LL							
0113	Rock Excavation below LL	60	01FEB06 10:00	09FEB06 15:59	FW	LL	OPEN
0013	Precast Bulkheads LL- Sect 1&2	160	04OCT06 15:00	30OCT06 12:59	FW	LL	OPEN
0016	L/L Pontoon Sections 1,2	480	30OCT06 13:00	11JAN07 15:59	FW	LL	OPEN
0018	Precast Bulkheads-Sect 3 for LL, LR Bulkheads	160	30OCT06 13:00	23NOV06 10:59	FW	LL	OPEN
0020	Float Out LL 1 & 2	40	11JAN07 16:00	18JAN07 10:59	FW	LL	OPEN
0019	Pontoon Section LL3, & LR Section	480	18JAN07 11:00	03APR07 13:59	FW	LL	OPEN
0039	Transport Section LL 1 & 2 Pontoons	80	18JAN07 11:00	31JAN07 09:59	FW	LL	OPEN
0026	LL Drilled Shafts	400	26JAN07 12:00	29MAR07 15:59	FW	LL	OPEN
0033	LL Debris Shield	40	29MAR07 16:00	05APR07 10:59	FW	LL	OPEN
0109	Float Out LL3 & LR	40	03APR07 14:00	10APR07 08:59	FW	LL	OPEN
0034	LL Steel Shell	120	05APR07 11:00	24APR07 13:59	FW	LL	OPEN
EXT4700	Transport Section LL3 & LR Pontoon	40	10APR07 09:00	16APR07 12:59	FW	LL	OPEN
0042	Assemble L/L Pontoons	120	16APR07 13:00	03MAY07 15:59	FW	LL	OPEN
0035	LL CIP Superstructure	40	24APR07 14:00	01MAY07 08:59	FW	LL	OPEN
0045	Install L/L Pontoons	40	03MAY07 16:00	05MAY07 07:59	FW	LL	OPEN
0048	Install Skirts L/L	80	07MAY07 08:00	17MAY07 15:59	FW	LL	OPEN
0052	Final Ballasting LL	8	17MAY07 16:00	18MAY07 14:59	FW	LL	OPEN
LR							
EXT4670	Rock Excavation below LR	60	23JAN06 13:00	01FEB06 09:59	FW	LR	12H
0103	Precast Pylon - LR	160	16FEB06 11:00	14MAR06 08:59	FW	LR	OPEN
0111	LR Drilled Shafts	520	07MAY07 08:00	25JUL07 14:59	FW	LR	COPS
0112	LR Debris Shield	40	25JUL07 15:00	01AUG07 09:59	FW	LR	COPS
EXT4740	Install LR Pylon Precast	40	25JUL07 15:00	01AUG07 09:59	FW	LR	COPS
EXT4730	LR Steel Shell	80	01AUG07 10:00	14AUG07 08:59	FW	LR	COPS
0110	LR CIP Superstructure	40	14AUG07 09:00	20AUG07 12:59	FW	LR	COPS
EXT4710	Install L/R Pontoon	40	20AUG07 13:00	22AUG07 04:59	FW	LR	12H
EXT4720	Install LR skirts	40	22AUG07 08:00	28AUG07 11:59	FW	LR	COPS
0105	Final Ballasting LR	8	28AUG07 12:00	29AUG07 10:59	FW	LR	OPEN



Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	COMP	COM2	MAIN
FINL							
0054	Channel/Nav Lignts Upper River	320	08MAR07 15:00	27APR07 10:59	FW	FINL	OPEN
0060	CCTV Fiberoptics Upper River	160	08MAR07 15:00	03APR07 12:59	FW	FINL	OPEN
0056	Elect Conn System Upper River	120	08MAR07 15:00	28MAR07 08:59	FW	FINL	OPEN
0058	Elect Dist System Upper River	120	08MAR07 15:00	28MAR07 08:59	FW	FINL	OPEN
0055	Channel/Nav. Lights Lower River	320	29AUG07 11:00	17OCT07 15:59	FW	FINL	OPEN
0061	CCTV Fiberoptics Lower River	160	29AUG07 11:00	24SEP07 08:59	FW	FINL	OPEN
0057	Elect Conn System Lower River	120	29AUG07 11:00	17SEP07 13:59	FW	FINL	OPEN
0059	Elect Dist System Lower River	120	29AUG07 11:00	17SEP07 13:59	FW	FINL	OPEN
Project Mitigation							
MIT10	Project Mitigation	4,160	09DEC05 12:00	18SEP07 13:59	MITAGA		OPEN
Demob							
EXT4800	Aux Chamber open for traffic w/o emptying	0	24OCT07 10:00		DEMOB		OPEN
EXT4620	Testing & Startup	80	29JAN08 15:00	11FEB08 13:59	DEMOB		OPEN
EXT4630	Punchlist Items	80	11FEB08 14:00	22FEB08 12:59	DEMOB		OPEN
EXT4640	Cleanup	80	20JUN08 08:00	02JUL08 15:59	DEMOB		OPEN
EXT4650	Demob	240	02JUL08 16:00	08AUG08 12:59	DEMOB		OPEN
EXT650	Project Completion	1	08AUG08 13:00	08AUG08 13:59	DEMOB		OPEN



SECTION 25 SPECIAL STUDIES

25.1 DRILLED CAISSON STUDY

The drilled caisson wall was initially proposed as a feasible alternative for the land wall monolith. The drilled caisson study was initiated based on preliminary assumptions of the rock strength parameters given to Black & Veatch and some brief discussions with the geotechnical engineers from the COE. As discussed in SECTION 7, revised and more precise rock strength parameters have been provided to Black & Veatch. These revised geotechnical parameters changed the analysis of the caisson land wall and temporarily removed it from the primary consideration at the land wall. The primary analysis to date has been conducted using LPILE Plus 3.0™ to consider several different caisson diameters and depths. The results and considerations for each evaluation of the drilled caisson are presented in the following subsections.

The drilled caisson method generally consists of drilling caissons to a design depth in the rock, lifting in pre-cast wall panels on either side of the caissons, and filling the annular space with tremie concrete. The drilled caisson structure is built to elevation 500 feet. Above this elevation, the structure is completed to elevation 537 feet using pre-cast panels and cast-in-place concrete.

The drilled caisson land wall has many cost- and construction time-saving advantages over the float-in or lift-in land wall methods for Plan 1, as discussed below:

1) Reduced rock excavation and disposal: Only 2 feet of excavation is required from the top of the rock to seal the bottom of the wall. The two foot of rock from elevation 470 to 468 foot is considered weathered rock. Weathered rock will be easier to remove and should not require blasting to fracture it. The rock inside the caissons is not classed as rock excavation. It is removed by the drilling process rather than rock excavation techniques. The volume of rock removed by drilling is approximately 850 CY. The cost for this removal is included in the cost of drilling the caissons. The rock will be ground to gravel size or smaller in the process of drilling. This gradation will be finer than most excavated rock material. The finer gradation may allow the rock removed in drilling to be used or disposed in areas not normally allocated for excavated rock;
2) Less material volume required for construction of the completed wall: The total width of the drilled caisson wall is approximately 12 feet. This means an approximate 50% reduction in concrete required for the wall. The volume of concrete required for 360 foot of gravity structure is approximately 23,900 cy and the volume required for the drilled caisson wall is 11,800 cy (including the embedded portions of the caissons). This large advantage in concrete is somewhat offset by the need for significant reinforcement in the caisson, however, reinforcing steel volumes will still be greatly reduced in comparison to the gravity structure; and
3) Minimal Auxiliary Gate Closure: Overall construction time is reduced by adopting the drilled caisson wall. The construction will take place from moderate sized barges (60’x 160’). Because of this the barges may be moved and the auxiliary lock may be opened each

weekend or, if the need is great, each night. This flexibility is important in reducing the impact of the construction on the operations of the locks at Greenup.

Due to the savings demonstrated in the above paragraph from the implementation of a drilled caisson land wall monolith at the Greenup Lock & Dam Extension site, a more detailed analysis of the loading on each caisson is recommended and discussed in Subsection 10.10.1.

25.1.1 Study Results and Considerations

Using the revised geotechnical parameters and P-Y curves specified by the COE, as discussed in Section 7.4, Black & Veatch completed the following evaluations of the drilled caisson using LPILE Plus.

The spacing of various diameter caissons varied based on the constructability of the caissons in proximity to each other and the additional land wall configuration details that needed to be included in the design. The evaluation of the axial, shear, and moment loads were applied at elevation 468 since the top two feet of rock, from elevation 470 to 468, was not considered to provide significant lateral resistance.

The Rock "layers" were evaluated and input in the following manner:

EL 468 to EL 465 Cross Bed Shear Zone, S_u of 390 psi

EL 465 to EL 428 Confined Siltstone/Sandstone, S_u of 3,823/4,500 psi

The P-Y curves for both of the above layers were provided by the COE and externally input into LPILE Plus. The curves are based on the recommended curve for strong rock as presented in the technical manual for LPILE Plus. Additional in-situ testing of the bedrock strength is still being performed.

The following table presents the different configurations that were evaluated upon receipt of these revised geotechnical parameters:

Table 40 Caisson Embedment/Deformation

Caisson Diameter, ft	Caisson Spacing, ft oc	Depth of Embedment, ft	Maximum Deformation, In
10	12	18	0.075
10	12	20	0.040*
12	16	20	0.065

* - The evaluation of this caisson considered the loads of a "fast fill" system with excavation to elevation 458 and used only the parameters for the confined siltstone/sandstone layers. This evaluation demonstrated that under the extreme loading condition for the drilled caisson land wall, the deformation is still at or slightly above the maximum allowable.

Based on the revised LPILE Plus analyses of deflection, maximum stress, and shear loads, the caisson appears to fail the maximum deflection criteria. The deflection criteria specified for the "cross bed shear zone" identifies the maximum deflection as less than or equal to 0.04 inches. As shown in the above table, the LPILE Plus analysis of the 10-foot diameter caisson at 12-foot spacing and the 12-foot diameter caisson at 16-foot spacing, the deflection criteria is exceeded by 0.035 and 0.024 inches, respectively. The 87 and 62 percent exceedence, respectively, of the maximum deflection criteria, at first review of the data, would seem to rule out the feasibility of the drilled caisson land wall. However, upon further review of the output

files for the LPILE Plus analyses, a more detailed analysis of the drilled caisson land wall should be considered that may be more representative of the actual forces acting on the overall completed land wall structure.

The summary of the LPILE Plus analyses for each of the above scenarios is presented in the calculations.

25.1.2 Future Study Considerations

Two significant sources need to be evaluated for their ability to reduce the stress in the individual caisson. A more detailed analysis is required to confirm the potential stress reduction methods:

- The potential for transfer of the load along the wall and the rock, not just within the individual caisson; and
- The load-bearing capacity of the wall around the caisson, as shown in Plate 2-40, that is not evaluated during the LPILE analysis.

25.2 TEMPERATURE PROFILES

25.2.1 Availability of Historic Temperature Data

The temperature profiles presented in this document are not site specific. They were developed for the Olmsted Locks and Dam Project. Presently, only sparse historic temperature data exist for the Greenup Project site.

It is important to recognize that the maximum relative temperature difference between the pool water and air would yield design-governing loads. In addition, the sign of the relative difference (i.e., water colder than the air versus air colder than the water) should be distinguished in the analysis.

The search for historic temperature data conducted during the study phase has yielded only very limited (statistically) usable data. It is recommended that the available data be collected and supplemented by additional data, which can be obtained by establishing a temperature measuring and documenting program as expanded below. Existing and supplemental data will be used during final design.

25.2.2 Temperature Data Collection Program

It is recommended that a data collection program be established to provide empirical data for use during the final design. The empirical data would allow correlation between data series representing water and air temperatures that were measured at the same time.

In addition, the data should be evaluated during the initial phase of data collection to decide whether water temperatures should be documented at different depths. If it is found that no significant temperature variation within the top 11 feet (This range equals the anticipated pontoon draft.) of the pool exist, the data collection may be simplified accordingly.

The measured air temperature will be indicative of, but not equal to, the temperature of the air-exposed part of the pontoon. The temperature of the pontoon will also depend on the direct sun and wind conditions. Therefore, these conditions should be documented and correlated to the empirical data.

It is anticipated that the temperature of the pool water does not vary significantly during the day and night; not so the air temperature. Therefore, the air temperature should be registered both during the day (preferably, early afternoon) and during the night hours (preferably before dawn) to capture the temperature extremes.

The following paragraphs are provided to indicate the techniques that can be used during the final design to identify, correlate, calibrate data, and determine design relevant load cases. This information may also be used in establishing the data collection program. In the next paragraphs, efforts related to the Olmsted Project are summarized.

25.2.3 Temperature Profiles Developed for the Olmsted Site

During the final design of the approach walls for the Olmsted Locks and Dam Project (near Olmsted, Illinois), two site-specific temperature profiles were developed: 'Summer Gradients,' and 'Winter Gradients.' Note that the term 'gradient' indicates the change of temperature from the pontoon's top to keel.

The project specific temperature range was minus 14 to plus 108 degrees Fahrenheit for the air and 37 to 87 degrees Fahrenheit for the river water. However, extreme temperature gradients rather than the maximum ambient temperatures were needed for pontoon design. Therefore, the temperature records measured during several seasons were scrutinized for the maximum relative difference between the temperature of the river water and the air temperature. The evaluation brought to light significant seasonal temperature variations. The findings were as follows:

- During the winter, the water was warmer than the air by 60 degrees Fahrenheit or less.
- During the summer, the air was warmer than the water by 40 degrees Fahrenheit or less.

These data series were processed to develop the design temperature gradients. For processing the data, the study of the temperature distribution of the (guide wall) pontoons at the John Day (Oregon) site was essential.

The varying temperature of the pontoon structure was surveyed at a multitude of locations of the pontoon and over an extended period of time capturing both summer and winter typical temperatures. The temperature profiles were developed from the obtained empirical data. The temperature profiles of the pontoon at John Day brought to light the relationship between the temperature of the water and air surrounding the pontoon and the temperature distribution over the pontoon cross section. The finding included that:

- The temperature gradient (over the pontoon height) is extremely non-uniform,
- The high-level temperature gradient would be located approximately within the top 2.5 feet of the pontoon.

Subsequently, the gradient profiles for the John Day pontoon were calibrated for the design of the Olmsted pontoons accounting for several parameters including:

- The difference in the geometry of pontoons.
- The difference in freeboard and draft.
- Water and air temperature at the Olmsted site.

The calibrated data for the winter and summer test series are shown on the following pages. Also included are the winter and summer temperature profiles that will govern pontoon design.

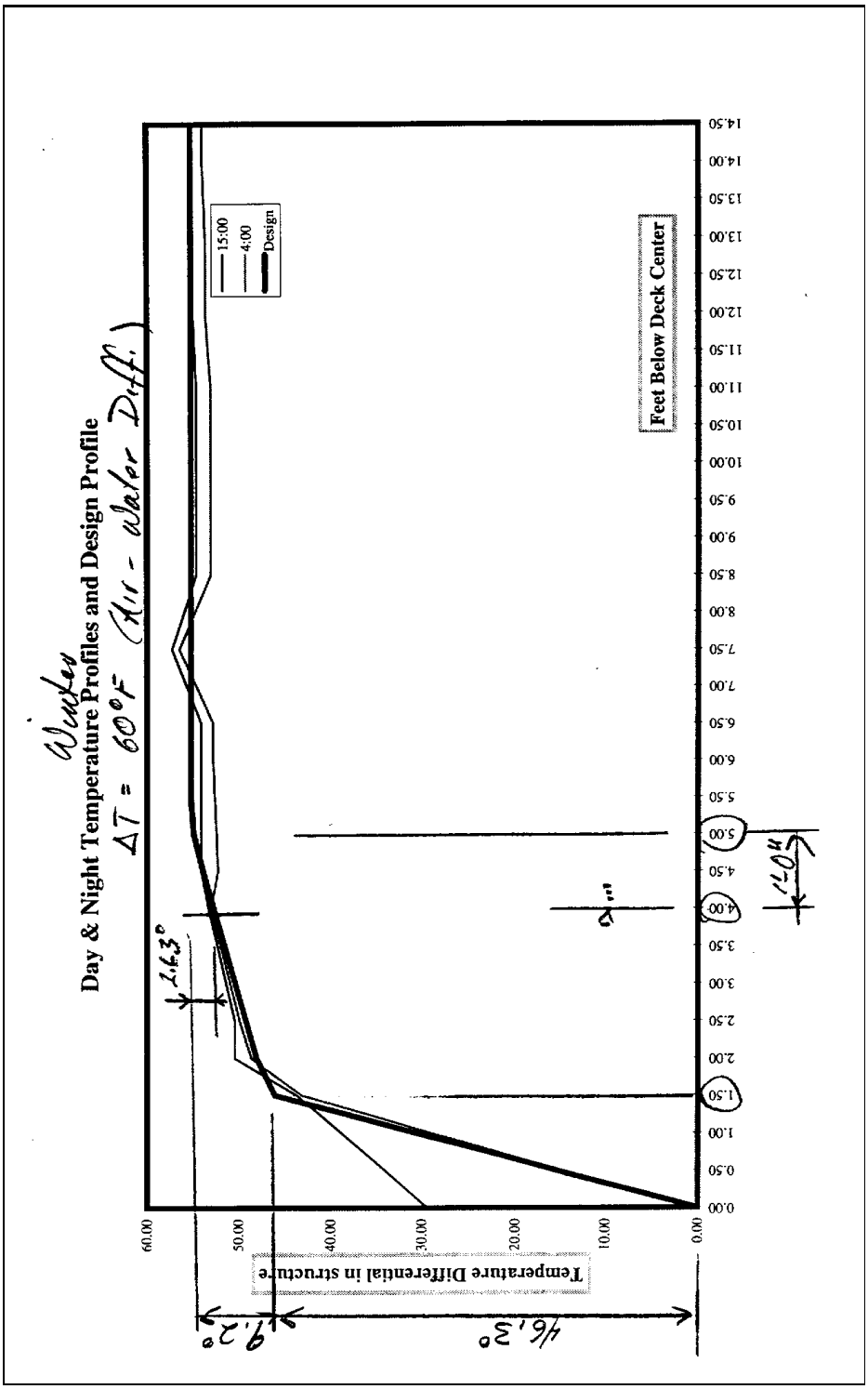


Figure 28. **Pontoon Winter Temperatures**

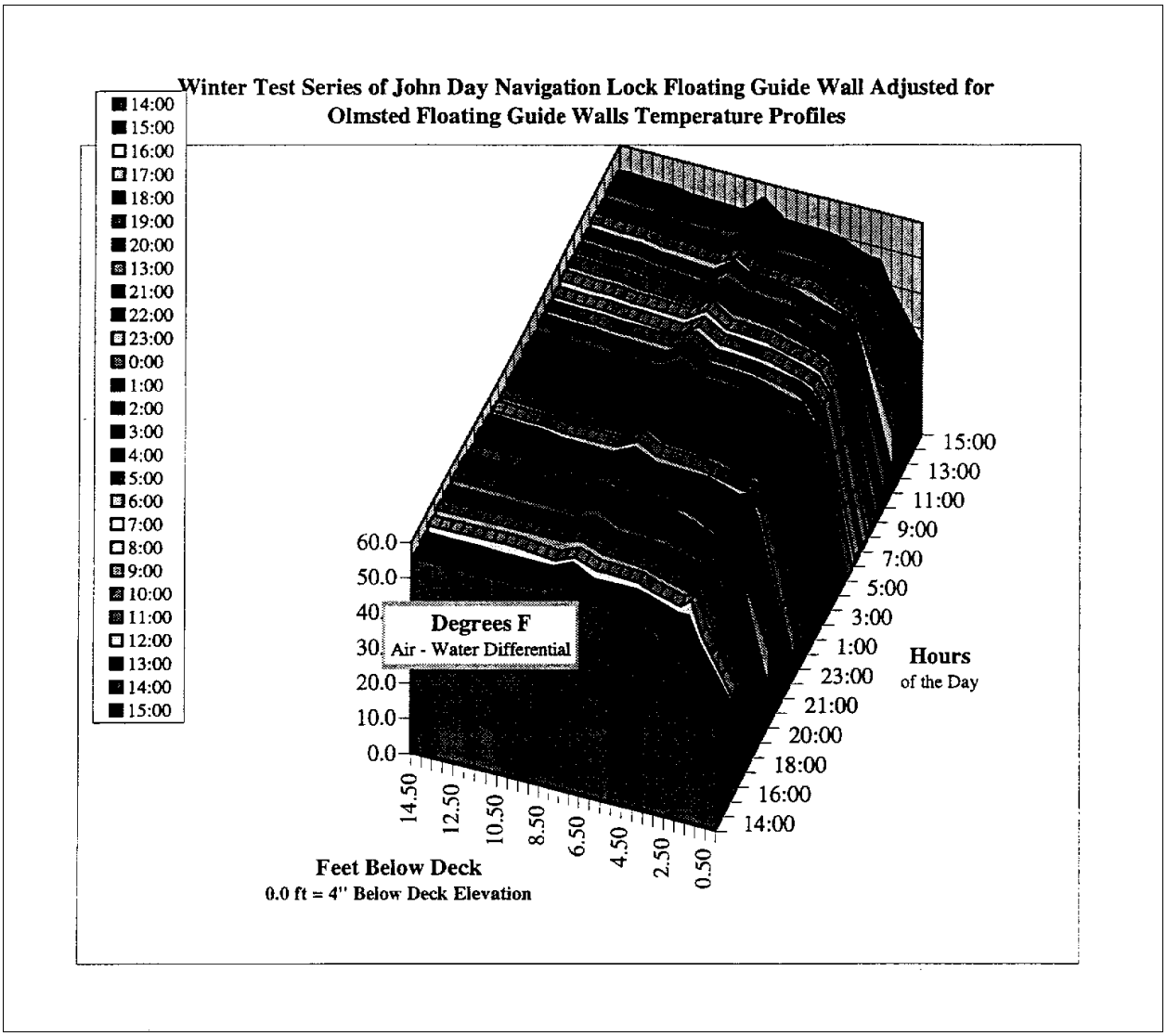


Figure 29. **Winter Temperature Variations with Time**

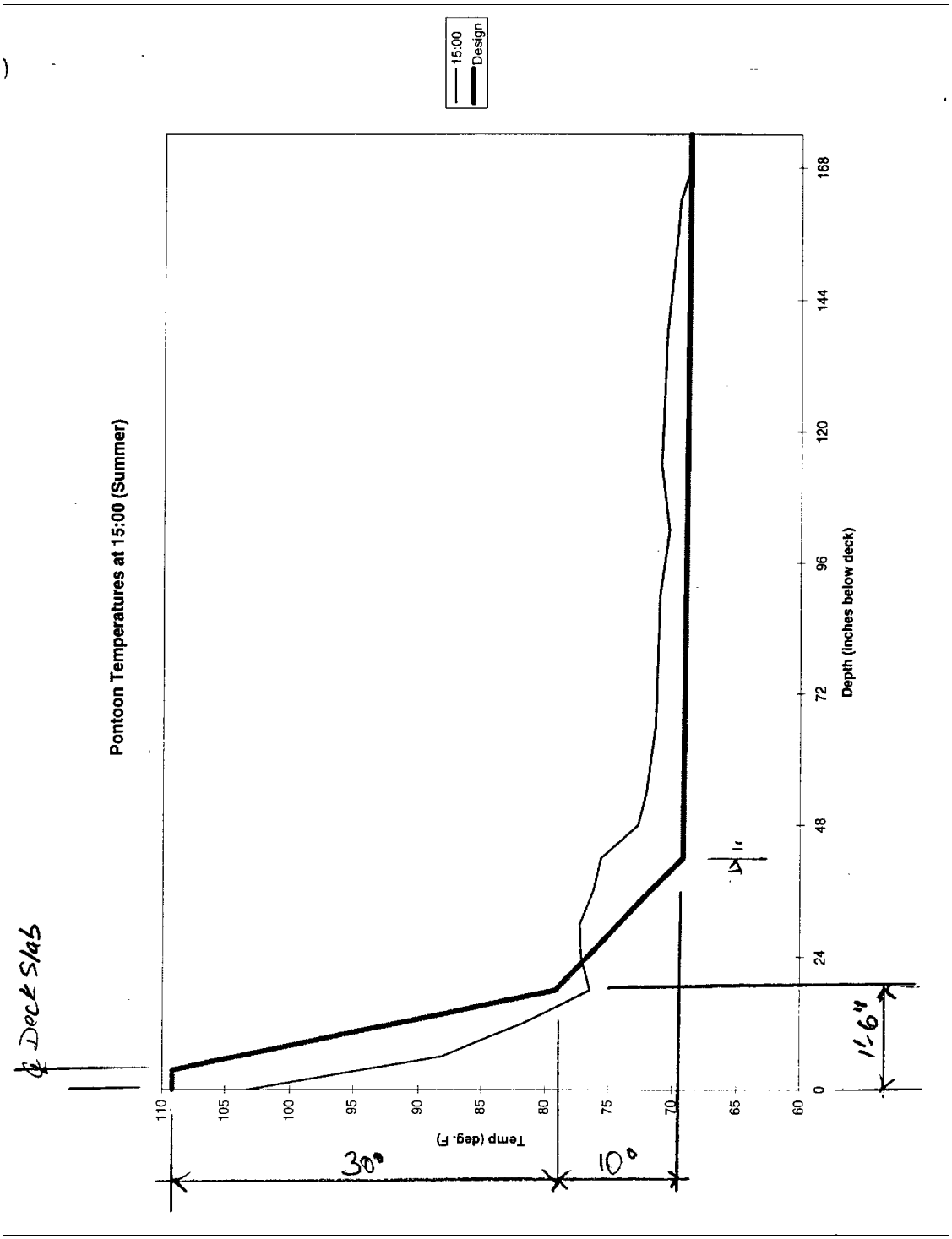
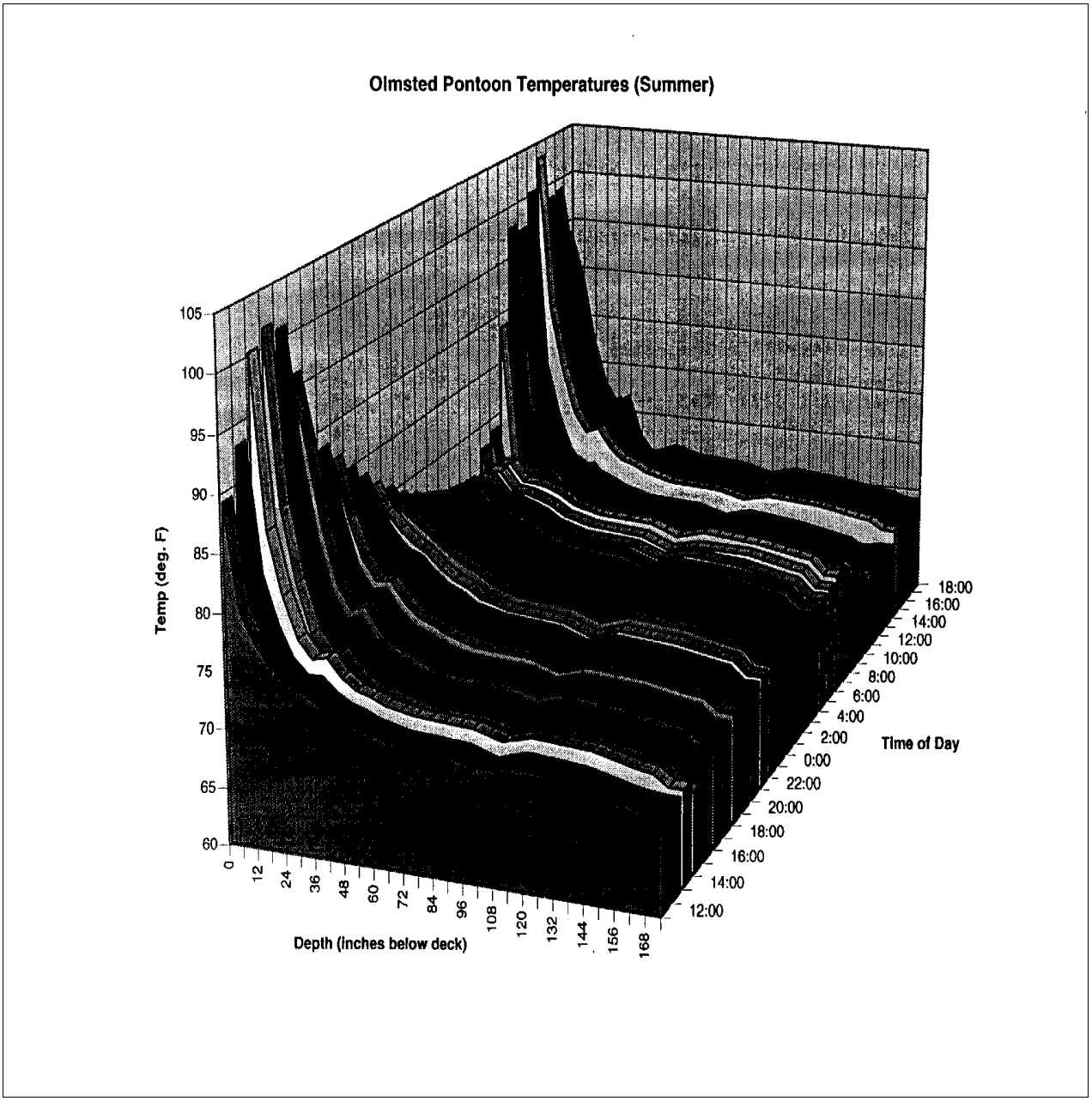


Figure 30. **Pontoon Summer Temperatures**

Figure 31. **Temperature Variation with Time – Summer**



25.3 GEOTECHNICAL AND SEISMOLOGICAL STUDIES

25.3.1 Geotechnical Studies

The preliminary geological information used in the study phase indicated that the top of the bedrock would vary only slightly about Elevation 470. In the analysis of the drilled shafts, it was assumed that the bedrock would render complete fixity and stability discarding any potential presence of loose granular or silty material. In addition, PY-curves (signifying the horizontal force-deflection relationship of the rock material in the immediate proximity of the drilled shaft) were assumed typical for the present rock material.

The Huntington District is preparing recommendations for borings and standard testing. It would be desirable to obtain detailed information on mechanical rock properties including PY-curves at all drilled shaft locations and at varying elevations. It is noteworthy that the design of the drilled shaft is sensitive to varying PY-curves within the top 25 feet (i.e., about 2.5 times the shaft diameter) of the rock embedment. PY-curves can be determined by using measured load-deflection behavior of the rock for the locations of interest.

Ideally, it would be desirable to obtain detailed test results from all drilled shaft locations for the final design of the drilled shaft foundations. If the findings of the ongoing geological testing should support the preliminary conclusions, and the rock properties are found to be consistent throughout the extent of the new installations, judgment should be exercised for limiting the number of tests. It is recommended, however, that detailed tests would be made at least at both upstream and downstream locations.

25.3.2 Seismological Studies

The project site is in seismic zone 1 per ER1110-2-1806. Based on this ER, the OBE and MDE (with coefficients of 5%, and 10% of g respectively) loads would not govern any component (nose piers, pylons, etc.) of the floating walls when compared with the design collision loads.

Unless further studies (Reference section 25.4, Collision Load Studies for details.) determine significantly lower design collision forces than assumed herein, the earthquake load will not become design governing load case for the floating alternatives.

The drilled shaft supported fixed alternative of the LLW has been designed based on the seismic load rather than the collision load. Further seismological investigations, however, would be recommended (if the fixed alternative should be recommended, and) if the hydraulic tests determine that significant sediment backfill would be likely.

25.4 COLLISION LOAD STUDIES

Impact (or collision) loads are integral components of the approach wall. The impact loads determine the channel sidewall thickness and thus the overall crosssection geometry, weight, and draft of the pontoon.

For the study phase analyses, the impact loads have been based on the comparison of the typical paths the barge traffic is taking when approaching the existing Greenup lock with the

barge approaches on other projects including the Olmsted Locks and Dam Project (presently under construction). These comparisons were then expanded to predict the typical path the barges would describe when approaching the extended Greenup locks. Varying paths were predicted to capture the design bandwidth of collision loads, which would commensurate with the variation of the landings ('soft', 'normal', and 'hard'). The parameters influencing the landing (approach angle, speed, etc.) were subjected to statistical evaluations.

It is recommended that additional studies be conducted for improving the collision load predictions before the commencement of the final design. Several approaches, either exclusive or in combination, are conceivable including the following:

1. Video monitoring of existing lock traffic. For this purpose, video cameras may be installed on the existing approach (or lock) walls aimed downstream and upstream. It is important that the (changing) position of the barge tow during the significant phases of the approach be quantifiable (relative to the wall's impact face and with respect to the time increment elapsed) for further analytical determination of the approach paths and approach velocities. The recorded process can be made quantifiable, e.g., by

- Overlaying a coordinate system on the approach scene. This can be accomplished by placing a translucent plane (which is divided by closed spaced gridlines) in the line of sight of the camera.
- Documenting the time-elapse in the frame-by-frame mode of recording.

Presently a collision-testing program is being conducted by the Corps using genuine river barges. In these test series rigid concrete walls are deliberately impacted with river barges that are instrumented to measure collision forces. In addition, the damage sustained is documented and correlated with the forces. The results of this program would be very valuable for assessing the project design collision forces. If final conclusions of the test program should not be available because the program would continue, preliminary conclusions may be possible.

2. Scale model testing of radio controlled model approach to the new lock configuration at the Waterways Experiment Station (WES) at Vicksburg, Mississippi. The test program would be devised resembling the test procedures developed for the Olmsted Locks and Dam Project, which included both controlled and uncontrolled approaches. Other parameter variations introduced included varying operators (three) and varying flow conditions (four).

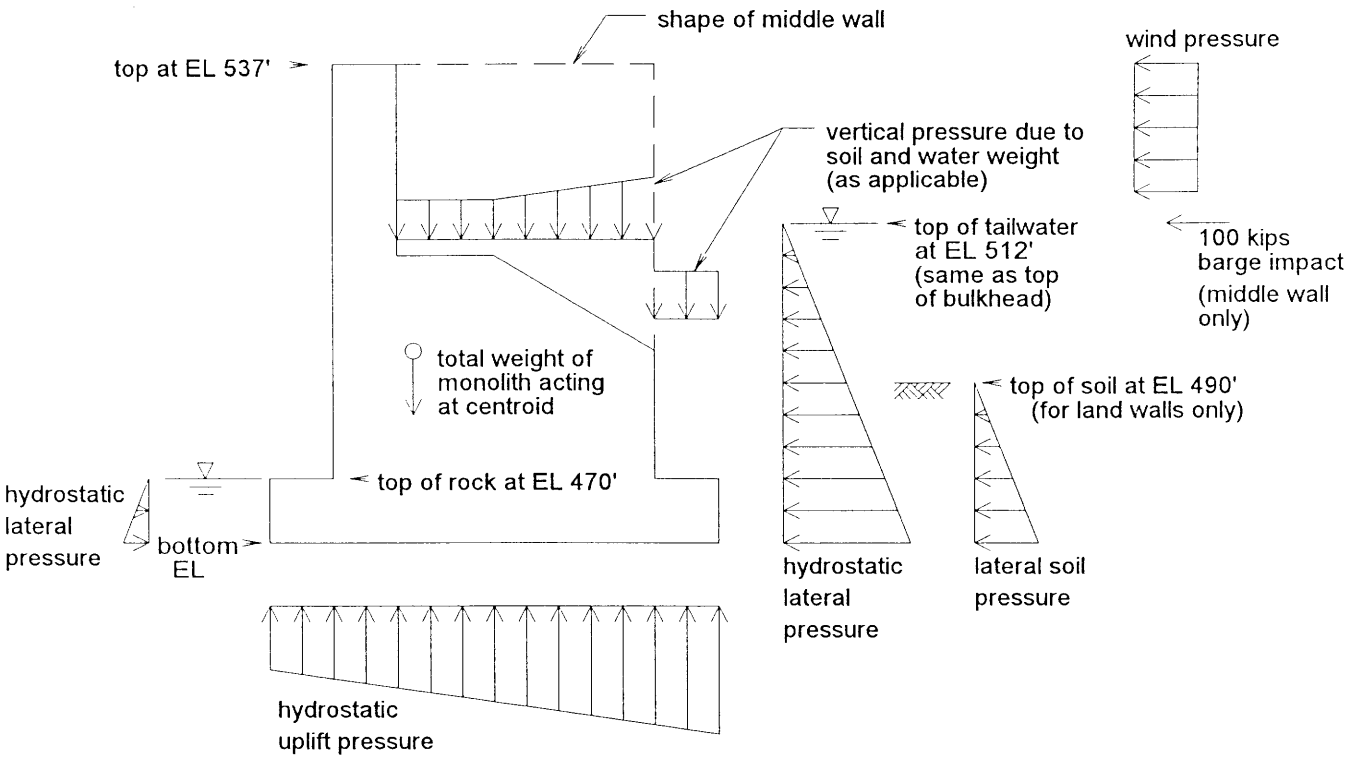
Ideally, it would be desirable to evaluate results from a variety of approaches. If not all of the above noted options can be pursued for limited time and resources, for instance, approach 1 and 2 appear most cost and time efficient.

SECTION 26 EXHIBITS

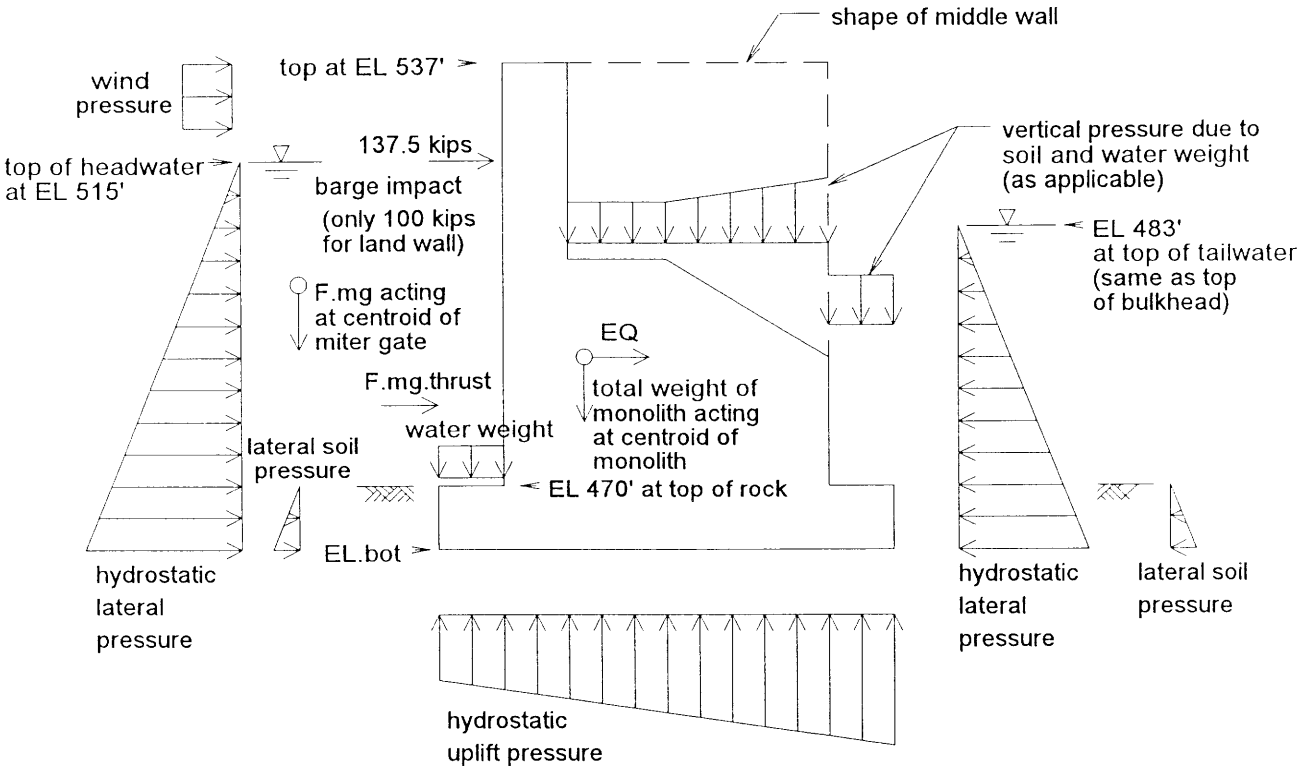
26.1 NOT USED

26.2 LOAD CONDITIONS

LOAD CASE 1 – UNUSUAL
LOAD CASE 2 - USUAL



LOAD CASE 1 - UNUSUAL



LOAD CASE 2 - USUAL

Notes:

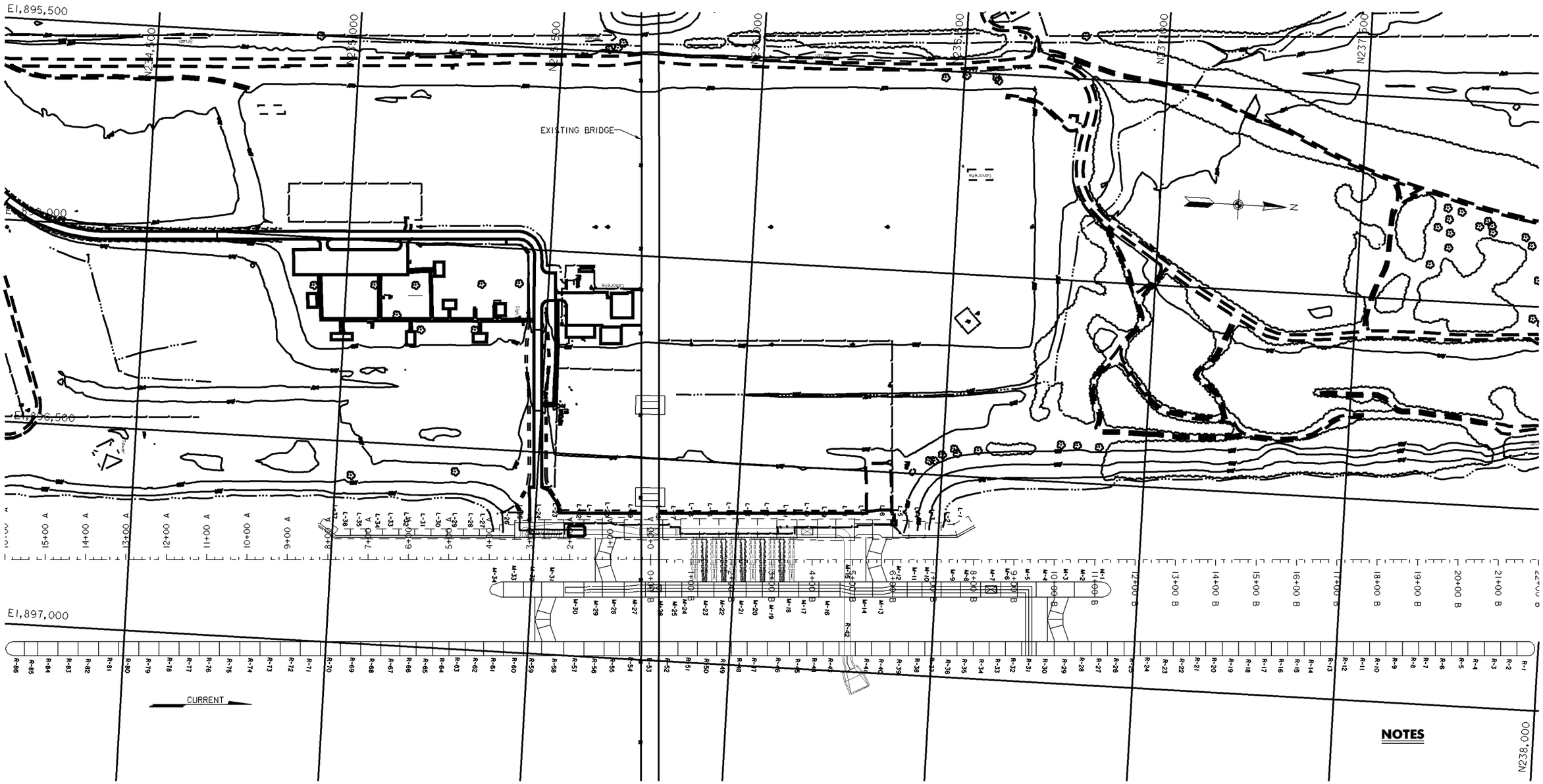
1. "EQ" = earthquake load = 0.15 x total weight, for Load Case 4 (Extreme) only
2. "M.mg" = moment due to miter gate weight plus debris, for gate walls only
2. "F.mg.thrust" = lateral thrust force from miter gate, for gate walls only

26.3 NOT USED

26.4 PLATES

26.4.1 600’ Lock Extension Alternatives

PLATE (1-1) EXISTING MAIN AND AUXILIARY LOCK LAYOUT
PLATE (1-2) NOT USED
PLATE (1-3) LOCK EXTENSION W/SUPPLEMENTAL FILL/EMPTY SYSTEM
OVERALL SITE PLAN – (AERIAL PHOTO OF SITE)
PLATE (1-4) PLAN 1 - AUXILIARY EXTENSION
PLATE (1-5) NOT USED
PLATE (1-6) PLAN 2 - AUXILIARY EXTENSION WITH MODIFICATIONS
PLATE (1-7) PLAN 3 - AUXILIARY EXTENSION WITH CULVERT
PLATE (1-8) PLAN 4 - AUXILIARY EXTENSION - PHASED CONSTRUCTION
PLATE (1-9) NOT USED
PLATE (1-10) NOT USED
PLATE (1-11) NOT USED
PLATE (1-12) PROJECT X- SECTIONS (0+00A – 2+00A)
PLATE (1-13) PROJECT X- SECTIONS (3+00A – 5+00A)
PLATE (1-14) PROJECT X- SECTIONS (6+00A – 8+00A)
PLATE (1-15) PROJECT X- SECTIONS (9+00A – 11+00A)
PLATE (1-16) PROJECT X- SECTIONS (12+00A – 14+00A)
PLATE (1-17) PROJECT X- SECTIONS (15+00A – 17+00A)
PLATE (1-18) PROJECT X- SECTIONS (18+00A – 20+00A)
PLATE (1-19) PROJECT X- SECTIONS (21+00A – 23+00A)
PLATE (1-20) PROJECT X- SECTIONS (24+00A – 26+00A)
PLATE (1-21) PROJECT X- SECTIONS (27+00A – 29+00A)
PLATE (1-22) PROJECT X- SECTIONS (0+00B – 2+00B)
PLATE (1-23) PROJECT X- SECTIONS (3+00B – 5+00B)
PLATE (1-24) PROJECT X- SECTIONS (6+00B – 8+00B)
PLATE (1-25) PROJECT X- SECTIONS (9+00B – 11+00B)
PLATE (1-26) PROJECT X- SECTIONS (12+00B – 14+00B)
PLATE (1-27) PROJECT X- SECTIONS (15+00B – 17+00B)
PLATE (1-28) PROJECT X- SECTIONS (18+00B – 20+00B)
PLATE (1-29) PROJECT X- SECTIONS (21+00B – 23+00B)
PLATE (1-30) PROJECT X- SECTIONS (24+00B – 26+00B)



NOTES

PLATE 1–1

PLAN

SCALE: 1" = 100'

100' 0 100'

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

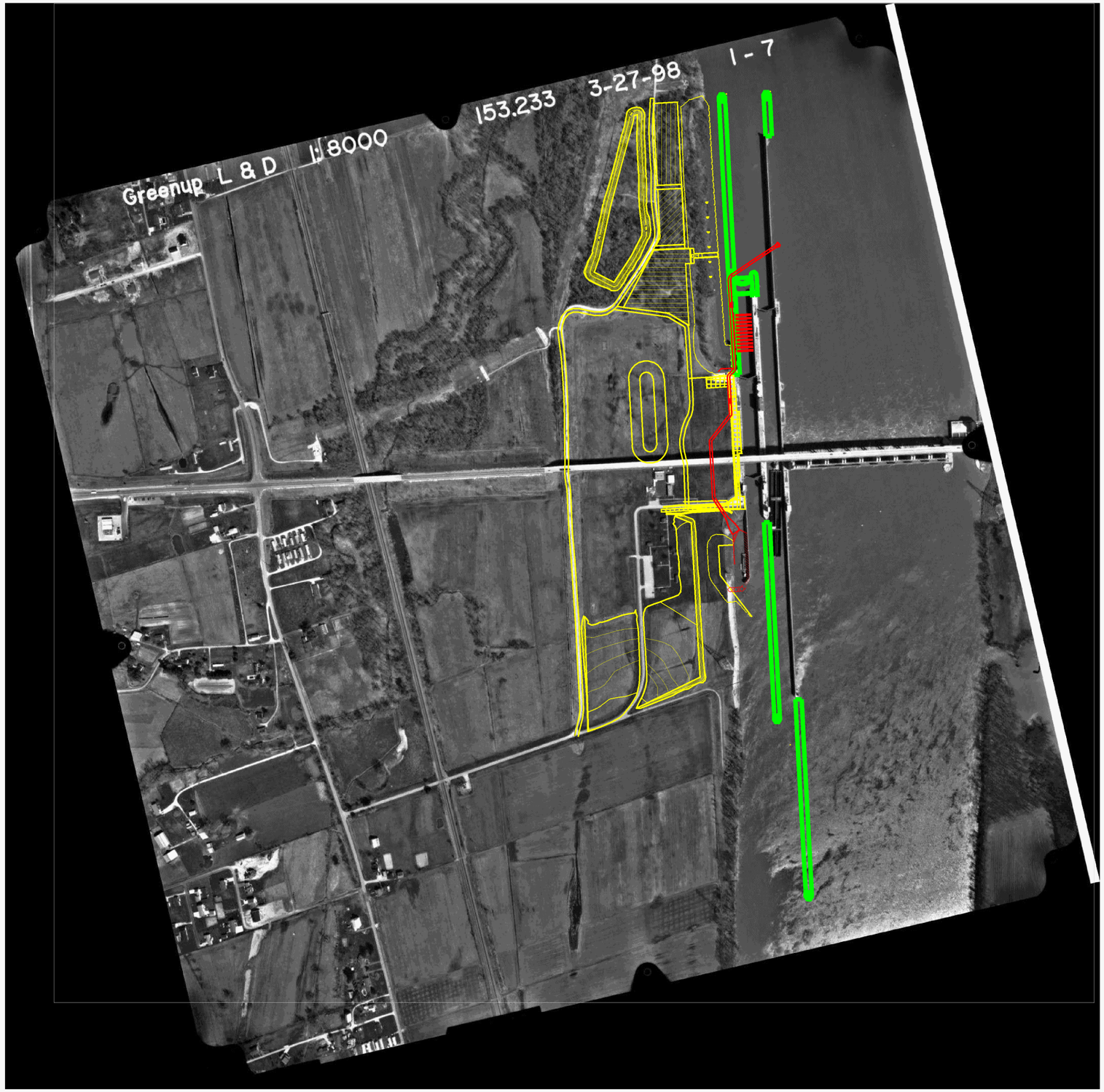
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

EXISTING MAIN AND AUXILIARY LOCK LAYOUT

Designed by:	D.L.C. W.L.W.	Scale: A5 SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: JUNE 1999	FILENAME: exlock.dgn PEN TABLE: b.pltb
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Codes:	Sheet 1 of 1
Reviewed by:			
Approved by:			



N

SITE PLAN

NOT TO SCALE

PLATE 1–3

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

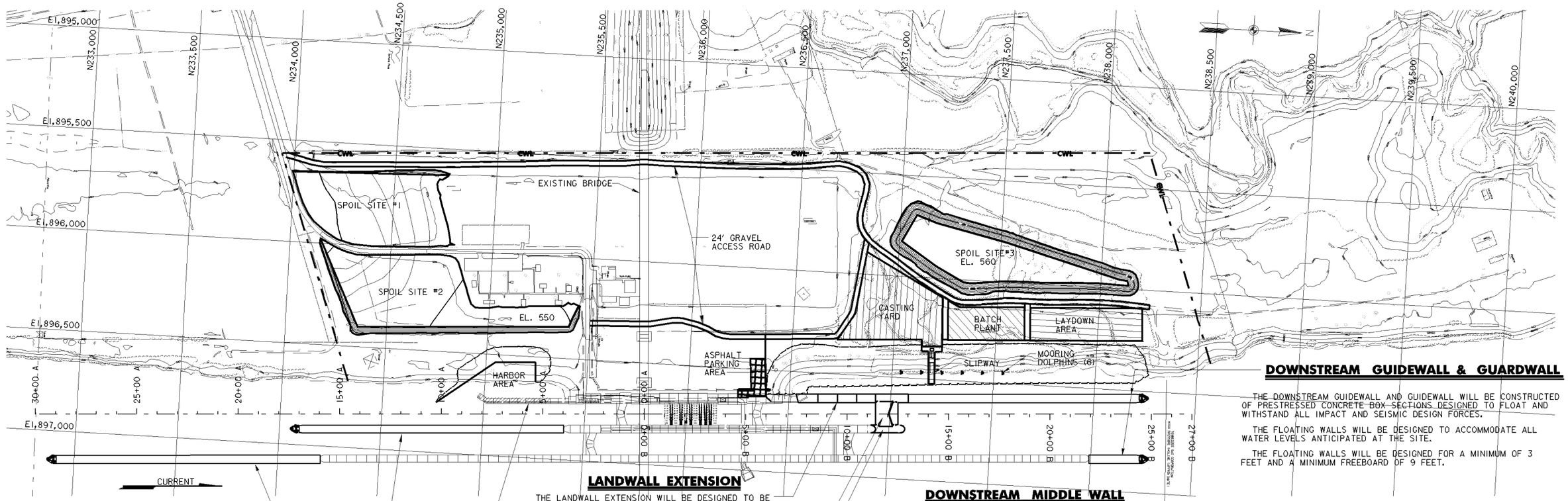
OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600' LOCK EXTENSION W/ SUPPLEMENTAL FILL/EMPTY SYSTEM

AERIAL PHOTO OF SITE

Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number: picture2.dgn
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	no pen table
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet 1 of 1
Reviewed by:			
Approved by:			



DOWNSTREAM GUIDEWALL & GUARDWALL

THE DOWNSTREAM GUIDEWALL AND GUIDEWALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

THE FLOATING WALLS WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

THE FLOATING WALLS WILL BE DESIGNED FOR A MINIMUM OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

LANDWALL EXTENSION

THE LANDWALL EXTENSION WILL BE DESIGNED TO BE CONSTRUCTED USING LIFT-IN TECHNIQUES.

DOWNSTREAM MIDDLE WALL

WALL EXTENSION WILL BE LIFT-IN CONCRETE STRUCTURES.

THE EXTENSION WILL CONNECT TO THE EXISTING DOWNSTREAM END OF THE MIDDLE WALL.

THE EXTENDED WALL WILL BE CAPABLE OF ACCOMODATING WALL ARMOR, LINEHOOKS AND CHECKPOSTS, FLOATING MOORING BITTS, EMBEDDED METALS AND A PIPE TRENCH.

UPSTREAM GUARD WALL

WALL IS AN EXTENSION TO THE UPPER RIVER WALL.

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL SHALL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

GATE BAY

THE ADDITIONAL DOWNSTREAM GATE BAY WILL CONSIST OF LIFT-IN CONCRETE STRUCTURES.

THE PINTLE FOR THE DOWNSTREAM MITER GATE WILL BE LOCATED AT STATION 12+20 B.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL BE CAPABLE OF ACCOMODATING THE EXISTING DOWNSTREAM MITER GATES AND OPERATING EQUIPMENT.

THE SIZE AND GEOMETRY OF THE MITER GATE RECESS AND MACHINERY RECESSES WILL BE THE SAME AS THE EXISTING RECESSES AND WILL BE CAPABLE OF ACCOMODATING A CONTROL STRUCTURE SIMILAR TO THE EXISTING.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL INCORPORATE A LOCK MAINTENANCE BULKHEAD RECESSES ON BOTH THE UPSTREAM AND DOWNSTREAM SIDE OF THE MITER GATES AND WILL BE CAPABLE OF ACCEPTING BULKHEADS TO PROVIDE FLOODING PROTECTION TO ELEVATION 512 WITH THE TOP OF THE BULKHEAD SILL BEING ELEVATION 470.

THE TOP OF THE MITER GATE SILL WILL BE AT ELEVATION 470 AND WILL BE AT ELEVATION 467 BETWEEN THE UPSTREAM LOCK BULKHEAD RECESS AND THE MITER LOCATION (SIMILAR TO THE EXISTING SILL).

THE SILL WILL INCORPORATE A DRY UTILITY CROSSOVER.

UPSTREAM GUIDE WALL

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL WILL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

WALL DEMOLITION

THE UPSTREAM AND DOWNSTREAM ENDS OF THE EXISTING LANDWALL WILL BE REMOVED:

1. MONOLITH L1 DOWNSTREAM
2. FROM STATION 4+64A TO STATION 8+23.3 A ON THE UPSTREAM END (MONOLITHS L-29 THROUGH L-37).

NOTES

PLAN

200′ 0 200′ 400′

SCALE IN FEET

PLATE 1–4

Revisions			
Symbol	Descriptions	Date	Approved

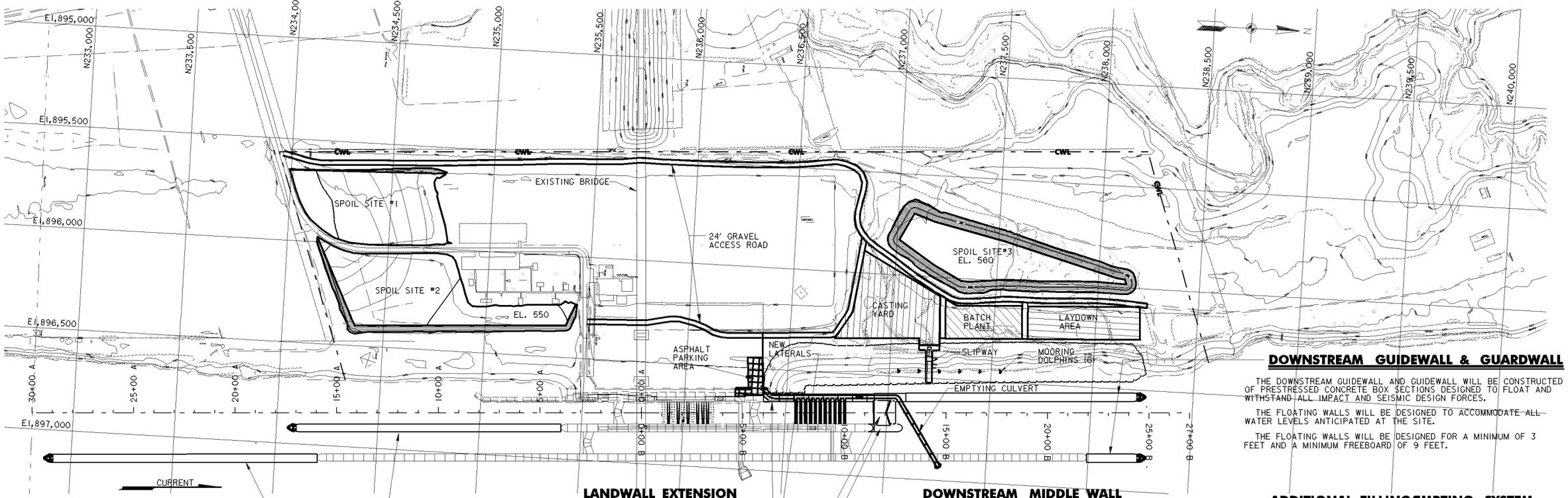
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM
PLAN 1
AUXILIARY EXTENSION
OVERALL SITE PLAN

Designed by:	D.L.C. W.L.W	Scale:	AS SHOWN
Drawn by:	G.L.C. G.S.A.	Date:	SEPT. 1999
Checked by:	D.L.C. WL.W. L.L.M.	Drawing Code:	
Reviewed by:		Sheet reference number:	
Approved by:		FILENAME: plan1.dgn PEN TABLE: b.ptb	
		Sheet 1 of 1	



UPSTREAM GUARD WALL

WALL IS AN EXTENSION TO THE UPPER RIVER WALL.

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL SHALL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

UPSTREAM GUIDE WALL

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL WILL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

LANDWALL EXTENSION

THE LANDWALL EXTENSION WILL BE DESIGNED TO BE CONSTRUCTED AS LIFT-IN CONCRETE STRUCTURES.

WALL DEMOLITION

THE DOWNSTREAM END OF THE EXISTING LANDWALL WILL BE REMOVED:

1. FROM STATION 6+00 B TO STATION 8+03.3 B ON THE DOWNSTREAM END (MONOLITHS L-1 THROUGH L-5).

DOWNSTREAM MIDDLE WALL

WALL EXTENSION WILL BE LIFT-IN CONCRETE STRUCTURES.

THE EXTENSION WILL CONNECT TO THE EXISTING DOWNSTREAM END OF THE MIDDLE WALL.

THE EXTENDED WALL WILL BE CAPABLE OF ACCOMODATING WALL ARMOR, LINEHOOKS AND CHECKPOSTS, FLOATING MOORING BITTS, EMBEDDED METALS AND A PIPE TRENCH.

GATE BAY

THE ADDITIONAL DOWNSTREAM GATE BAY WILL CONSIST OF LIFT-IN CONCRETE STRUCTURES.

THE PINTLE FOR THE DOWNSTREAM MITER GATE WILL BE LOCATED AT STATION 12+20 B.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL BE CAPABLE OF ACCOMODATING THE EXISTING DOWNSTREAM MITER GATES AND OPERATING EQUIPMENT.

THE SIZE AND GEOMETRY OF THE MITER GATE RECESS AND MACHINERY RECESSES WILL BE THE SAME AS THE EXISTING RECESSES AND WILL BE CAPABLE OF ACCOMODATING A CONTROL STRUCTURE SIMILAR TO THE EXISTING.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL INCORPORATE A LOCK MAINTENANCE BULKHEAD RECESSES ON BOTH THE UPSTREAM AND DOWNSTREAM SIDE OF THE MITER GATES AND WILL BE CAPABLE OF ACCEPTING BULKHEADS TO PROVIDE FLOODING PROTECTION TO ELEVATION 512 WITH THE TOP OF THE BULKHEAD SILL BEING ELEVATION 470.

THE TOP OF THE MITER GATE SILL WILL BE AT ELEVATION 470 AND WILL BE AT ELEVATION 467 BETWEEN THE UPSTREAM LOCK BULKHEAD RECESS AND THE MITER LOCATION (SIMILAR TO THE EXISTING SILL).

THE SILL WILL INCORPORATE A DRY UTILITY CROSSOVER.

DOWNSTREAM GUIDEWALL & GUARDWALL

THE DOWNSTREAM GUIDEWALL AND GUIDEWALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

THE FLOATING WALLS WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

THE FLOATING WALLS WILL BE DESIGNED FOR A MINIMUM OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

ADDITIONAL FILLING/EMPTING SYSTEM

THE ADDITIONAL FILLING AND EMPTYING SYSTEM WILL CONSIST OF:

1. CULVERT IN THE NEW MONOLITHS.
2. CONCRETE LATERALS IN THE LOCK CHAMBER.
3. EMPTYING CULVERT VALVE IN THE LAND WALL STRUCTUTRE.
4. CONCRETE OUTLET LOCATED RIVERWARD OF THE EXISTING RIVER WALL.

NOTES

PLAN

200' 0 200' 400'

SCALE IN FEET

PLATE 1-6

Revisions

Symbol	Descriptions	Date	Approved

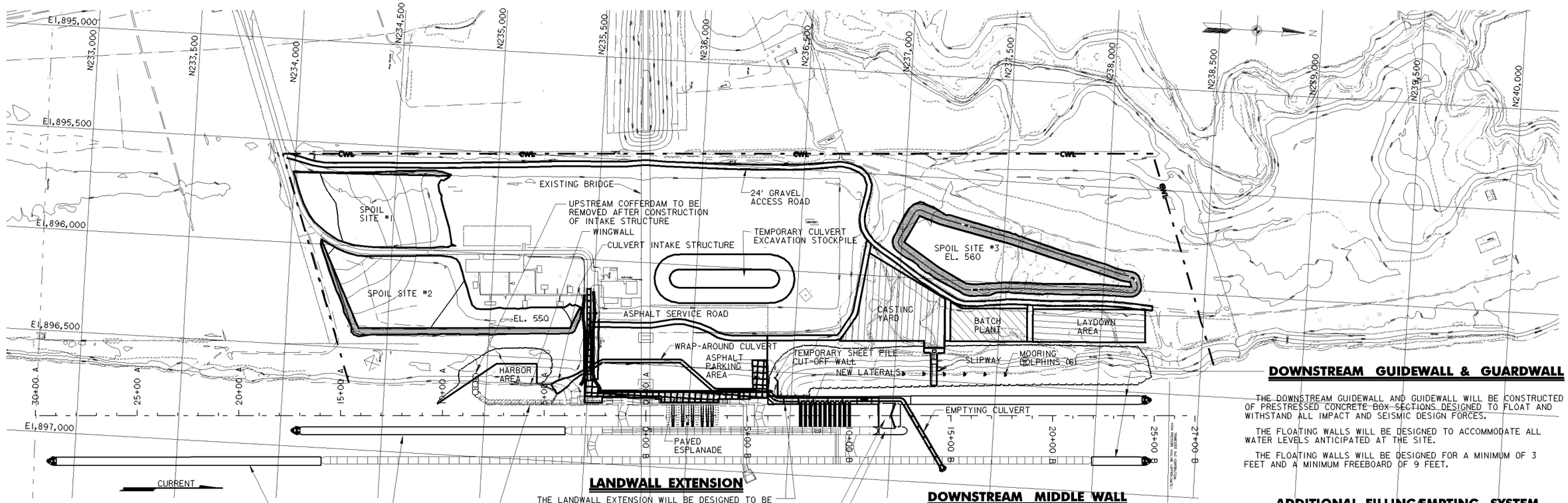
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM
PLAN 2
AUXILIARY EXTENSION WITH MODIFICATIONS
OVERALL SITE PLAN

Designed by:	D.L.C. W.L.W.		
Drawn by:	G.L.C. G.S.A.		
Checked by:	D.L.C. W.L.W. L.L.M.		
Reviewed by:		Scale: AS SHOWN	Sheet reference number:
Approved by:		Date: SEPT. 1999	FILENAME: plan2.dgn PIN TABLE: b.ptb
		Drawing Code:	Sheet 1 of 1



UPSTREAM GUARD WALL

WALL IS AN EXTENSION TO THE UPPER RIVER WALL.

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL SHALL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

UPSTREAM GUIDE WALL

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL WILL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

LANDWALL EXTENSION

THE LANDWALL EXTENSION WILL BE DESIGNED TO BE CONSTRUCTED AS LIFT-IN CONCRETE STRUCTURES.

WALL DEMOLITION

THE UPSTREAM AND DOWNSTREAM ENDS OF THE EXISTING LANDWALL WILL BE REMOVED:

1. FROM STATION 6+00 B TO STATION 8+03.3 B ON THE DOWNSTREAM END (MONOLITHS L-1 THROUGH L-5). (IF THE PRECAST OR FLOATIN MONLITHS ARE USED.)

2. FROM STATION 4+64A TO STATION 8+23.3 A ON THE UPSTREAM END (MONOLITHS L-29 THROUGH L-37).

DOWNSTREAM MIDDLE WALL

WALL EXTENSION WILL BE LIFT-IN CONCRETE STRUCTURES.

THE EXTENSION WILL CONNECT TO THE EXISTING DOWNSTREAM END OF THE MIDDLE WALL.

THE EXTENDED WALL WILL BE CAPABLE OF ACCOMODATING WALL ARMOR, LINEHOOKS AND CHECKPOSTS, FLOATING MOORING BITTS, EMBEDDED METALS AND A PIPE TRENCH.

GATE BAY

THE ADDITIONAL DOWNSTREAM GATE BAY WILL CONSIST OF LIFT-IN CONCRETE STRUCTURES.

THE PINTLE FOR THE DOWNSTREAM MITER GATE WILL BE LOCATED AT STATION 12+20 B.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL BE CAPABLE OF ACCOMODATING THE EXISTING DOWNSTREAM MITER GATES AND OPERATING EQUIPMENT.

THE SIZE AND GEOMETRY OF THE MITER GATE RECESS AND MACHINERY RECESSES WILL BE THE SAME AS THE EXISTING RECESSES AND WILL BE CAPABLE OF ACCOMODATING A CONTROL STRUCTURE SIMILAR TO THE EXISTING.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL INCORPORATE A LOCK MAINTENANCE BULKHEAD RECESSES ON BOTH THE UPSTREAM AND DOWNSTREAM SIDE OF THE MITER GATES AND WILL BE CAPABLE OF ACCEPTING BULKHEADS TO PROVIDE FLOODING PROTECTION TO ELEVATION 512 WITH THE TOP OF THE BULKHEAD SILL BEING ELEVATION 470.

THE TOP OF THE MITER GATE SILL WILL BE AT ELEVATION 470 AND WILL BE AT ELEVATION 467 BETWEEN THE UPSTREAM LOCK BULKHEAD RECESS AND THE MITER LOCATION (SIMILAR TO THE EXISTING SILL).

THE SILL WILL INCORPORATE A DRY UTILITY CROSSOVER.

DOWNSTREAM GUIDEWALL & GUARDWALL

THE DOWNSTREAM GUIDEWALL AND GUIDEWALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

THE FLOATING WALLS WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

THE FLOATING WALLS WILL BE DESIGNED FOR A MINIMUM OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

ADDITIONAL FILLING/EMPTING SYSTEM

THE ADDITIONAL FILLING AND EMPTYING SYSTEM WILL CONSIST OF:

1. CONCRETE INTAKE
2. WINGWALLS
3. REINFORCED CONCRETE CULVERT
4. FILLING VALVE STRUCTURE LOCATED IN THE ESPLANADE
5. FILLING CULVERT VALVE
6. CULVERT IN THE NEW MONOLITHS
7. CONCRETE LATERALS IN THE LOCK CHAMBER
8. EMPTYING CULVERT VALVE IN THE NEW LAND WALL STRUCTURE
9. CONCRETE OUTLET LOCATED RIVERWARD OF THE EXISTING RIVER WALL.

NOTES

PLAN

200′ 0 200′ 400′

SCALE IN FEET

PLATE 1–7

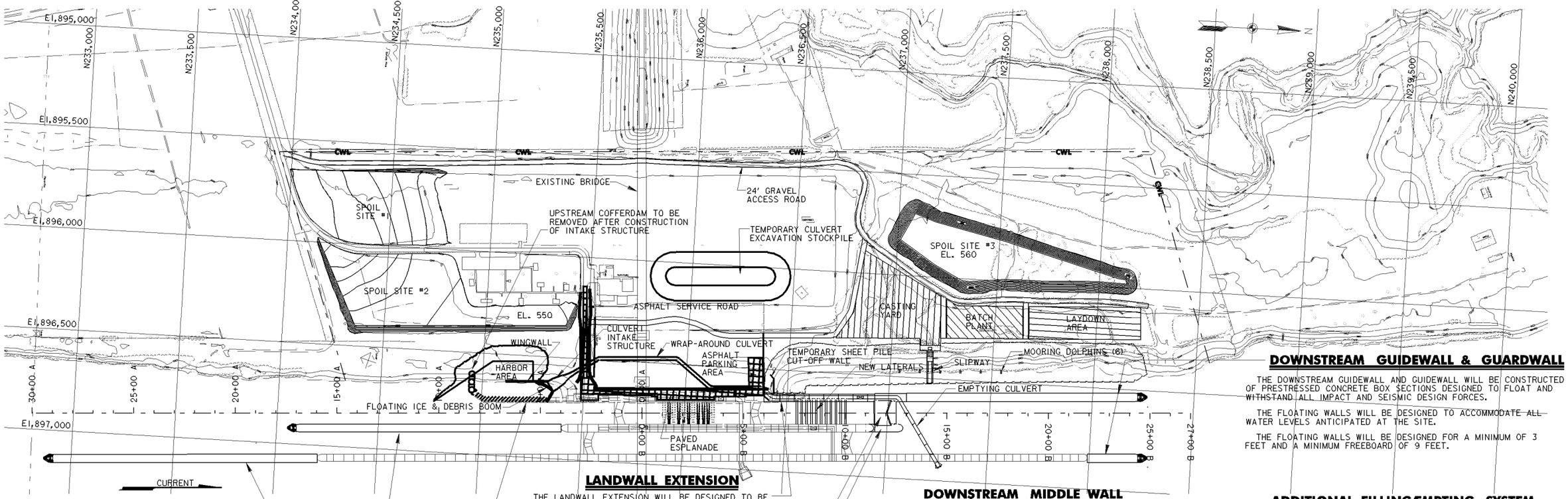
Revisions

Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
PLAN 3
AUXILIARY EXTENSION WITH CULVERT
OVERALL SITE PLAN

Designed by:	D.L.C. W.L.W	US Army Corps of Engineers	
Drawn by:	G.L.C. G.S.A.		
Checked by:	D.L.C. WL.W. L.L.M.		
Reviewed by:	Scale: AS SHOWN	Sheet reference number:	FILENAME: plan3.dgn PEN TABLE: b.ptb
Approved by:	Date: SEPT. 1999		
	Drawing Code:		Sheet 1 of 1



UPSTREAM GUARD WALL

WALL IS AN EXTENSION TO THE UPPER RIVER WALL.

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL SHALL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

UPSTREAM GUIDE WALL

WALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

WALL WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

FLOATING WALL WILL BE DESIGNED FOR A MINIMUM DRAFT OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

FLOW SKIRTS WILL BE DESIGNED TO PROVIDE FLOW RESTRICTION TO ELEVATION 500.0.

LANDWALL EXTENSION

THE LANDWALL EXTENSION WILL BE DESIGNED TO BE CONSTRUCTED AS LIFT-IN CONCRETE STRUCTURES.

WALL DEMOLITION

THE DOWNSTREAM (1ST CONSTRUCTION PHASE) AND THE UPSTREAM (2ND CONSTRUCTION PHASE) OF THE EXISTING LANDWALL WILL BE REMOVED:

1. DURING THE 1ST PHASE OF CONSTRUCTION FROM STATION 6+00 B TO STATION 8+03.3 B ON THE DOWNSTREAM END (MONOLITHS L-1 THROUGH L-5).

2. DURING THE 2ND PHASE OF CONSTRUCTION FROM STATION 4+64A TO STATION 8+23.3 A ON THE UPSTREAM END (MONOLITHS L-29 THROUGH L-37).

DOWNSTREAM MIDDLE WALL

WALL EXTENSION WILL BE LIFT-IN CONCRETE STRUCTURES.

THE EXTENSION WILL CONNECT TO THE EXISTING DOWNSTREAM END OF THE MIDDLE WALL.

THE EXTENDED WALL WILL BE CAPABLE OF ACCOMODATING WALL ARMOR, LINEHOOKS AND CHECKPOSTS, FLOATING MOORING BITTS, EMBEDDED METALS AND A PIPE TRENCH.

GATE BAY

THE ADDITIONAL DOWNSTREAM GATE BAY WILL CONSIST OF LIFT-IN CONCRETE STRUCTURES.

THE PINTLE FOR THE DOWNSTREAM MITER GATE WILL BE LOCATED AT STATION 12+20 B.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL BE CAPABLE OF ACCOMODATING THE EXISTING DOWNSTREAM MITER GATES AND OPERATING EQUIPMENT.

THE SIZE AND GEOMETRY OF THE MITER GATE RECESS AND MACHINERY RECESSES WILL BE THE SAME AS THE EXISTING RECESSES AND WILL BE CAPABLE OF ACCOMODATING A CONTROL STRUCTURE SIMILAR TO THE EXISTING.

THE ADDITIONAL DOWNSTREAM MITER GATE BAY WILL INCORPORATE A LOCK MAINTENANCE BULKHEAD RECESSES ON BOTH THE UPSTREAM AND DOWNSTREAM SIDE OF THE MITER GATES AND WILL BE CAPABLE OF ACCEPTING BULKHEADS TO PROVIDE FLOODING PROTECTION TO ELEVATION 512 WITH THE TOP OF THE BULKHEAD SILL BEING ELEVATION 470.

THE TOP OF THE MITER GATE SILL WILL BE AT ELEVATION 470 AND WILL BE AT ELEVATION 467 BETWEEN THE UPSTREAM LOCK BULKHEAD RECESS AND THE MITER LOCATION (SIMILAR TO THE EXISTING SILL).

THE SILL WILL INCORPORATE A DRY UTILITY CROSSOVER.

DOWNSTREAM GUIDEWALL & GUARDWALL

THE DOWNSTREAM GUIDEWALL AND GUIDEWALL WILL BE CONSTRUCTED OF PRESTRESSED CONCRETE BOX SECTIONS DESIGNED TO FLOAT AND WITHSTAND ALL IMPACT AND SEISMIC DESIGN FORCES.

THE FLOATING WALLS WILL BE DESIGNED TO ACCOMMODATE ALL WATER LEVELS ANTICIPATED AT THE SITE.

THE FLOATING WALLS WILL BE DESIGNED FOR A MINIMUM OF 3 FEET AND A MINIMUM FREEBOARD OF 9 FEET.

ADDITIONAL FILLING/EMPTING SYSTEM

THE ADDITIONAL FILLING AND EMPTYING SYSTEM WILL CONSIST OF:

1. CONCRETE INTAKE
2. WINGWALLS
3. REINFORCED CONCRETE CULVERT
4. FILLING VALVE STRUCTURE LOCATED IN THE ESPLANADE
5. FILLING CULVERT VALVE
6. CULVERT IN THE NEW MONOLITHS
7. CONCRETE LATERALS IN THE LOCK CHAMBER
8. EMPTYING CULVERT VALVE IN THE NEW LAND WALL STRUCTURE
9. CONCRETE OUTLET LOCATED RIVERWARD OF THE EXISTING RIVER WALL.

NOTES

PLAN

200′ 0 200′ 400′

SCALE IN FEET

PLATE 1–8

Revisions			
Symbol	Descriptions	Date	Approved

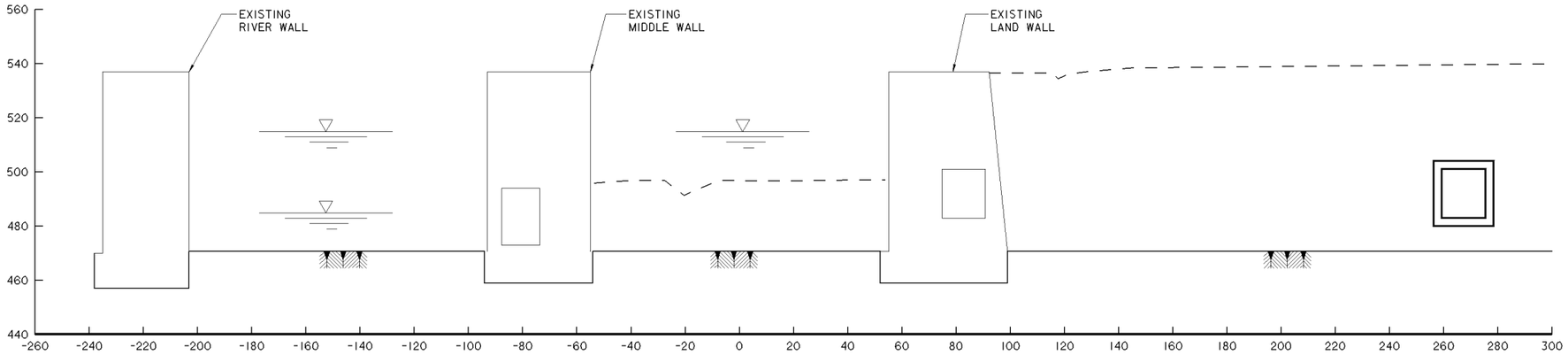
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM
PLAN 4
AUXILIARY EXTENSION–FUTURE PHASED
OVERALL SITE PLAN

Designed by:	D.I.C. W.L.W.		
Drawn by:	G.L.C. G.S.A.		
Checked by:	D.I.C. W.L.W. L.L.M.		
Reviewed by:		Scale: AS SHOWN	Sheet reference number:
Approved by:		Date: SEPT. 1999	FILENAME: plan4.dgn PIN TABLE: b.ptb
		Drawing Code:	Sheet 1 of 1



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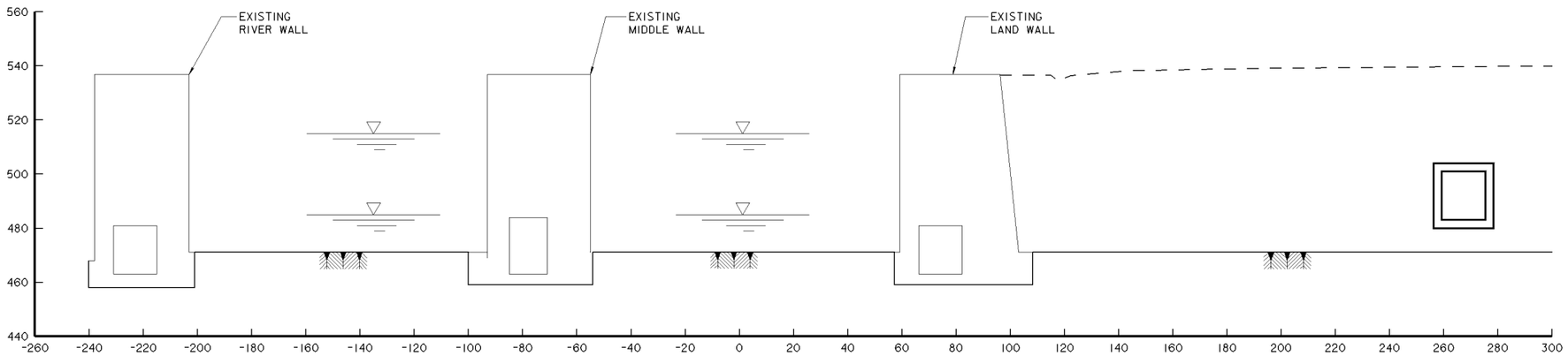
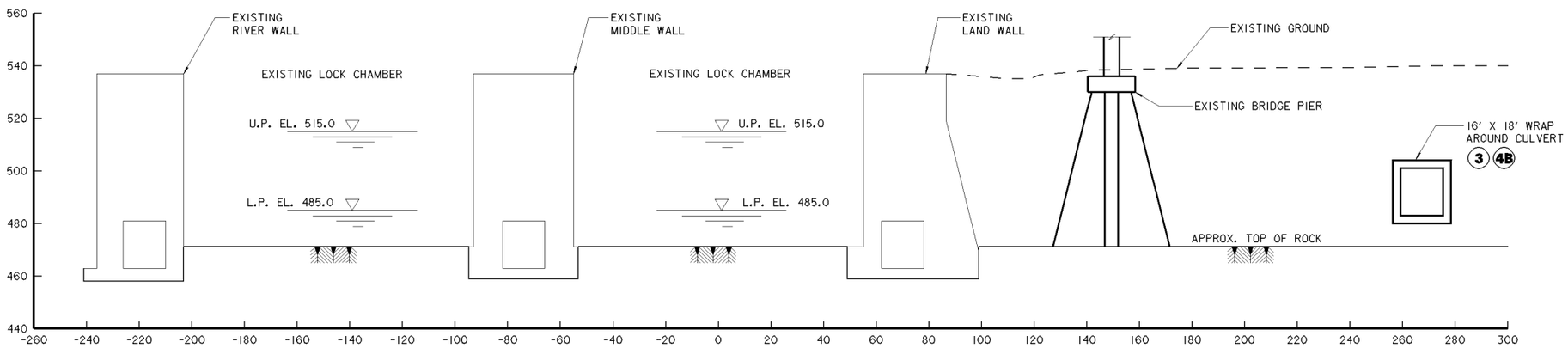


1+00 A



0+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–12

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

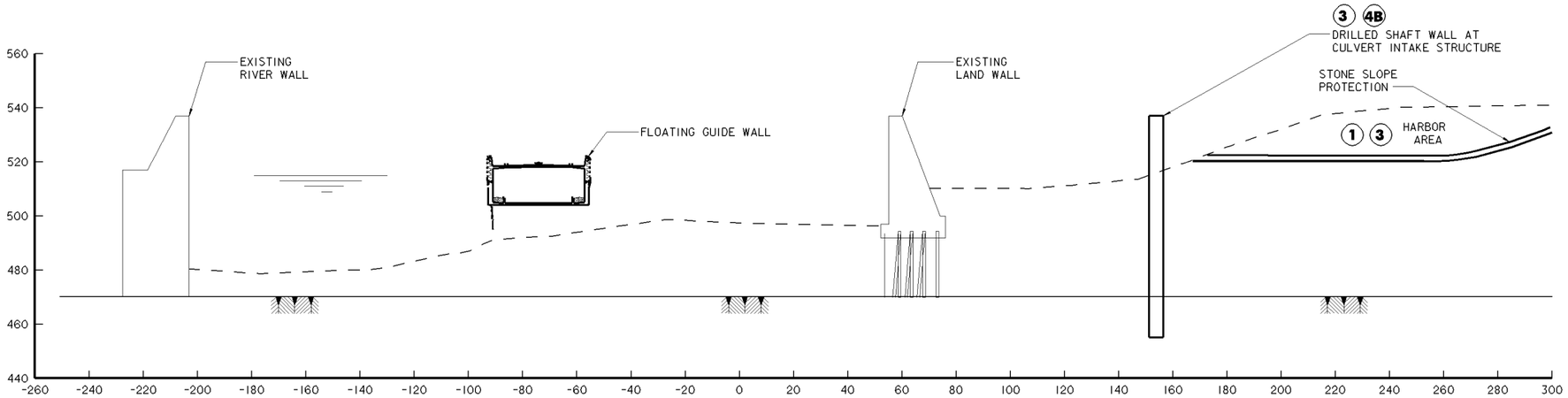
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION CROSS–SECTIONS STA. 0+00A TO STA. 2+00A

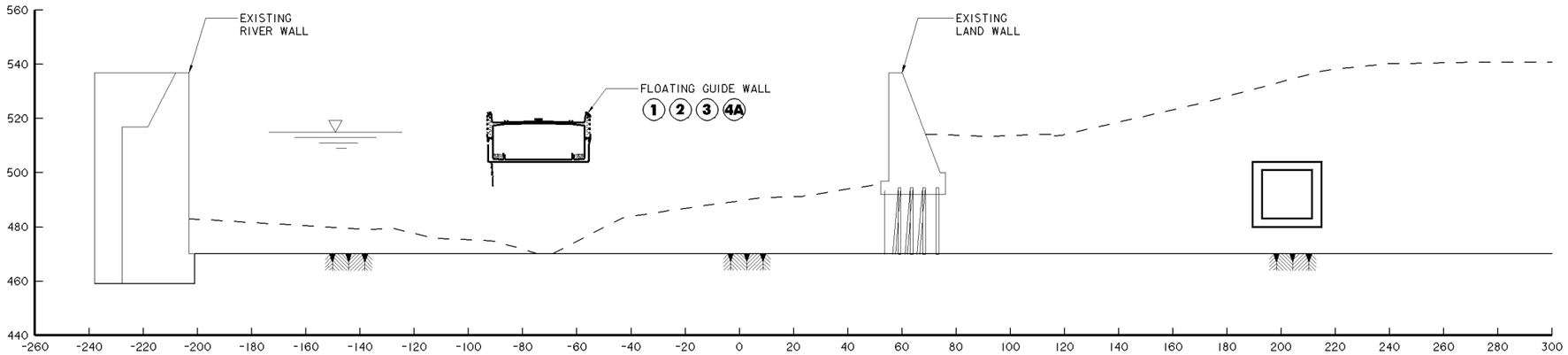
Designed by:	D.L.C. W.L.W.		
Drawn by:	G.L.C. G.S.A.		
Checked by:	D.L.C. W.L.W. L.L.M.		
Reviewed by:		Scale: AS SHOWN	Sheet reference number:
Approved by:		Date: SEPT. 1999	
		Drawing Code:	

FILENAME: 0faIxs0T.dgn
FGN TABLE: b.ptb

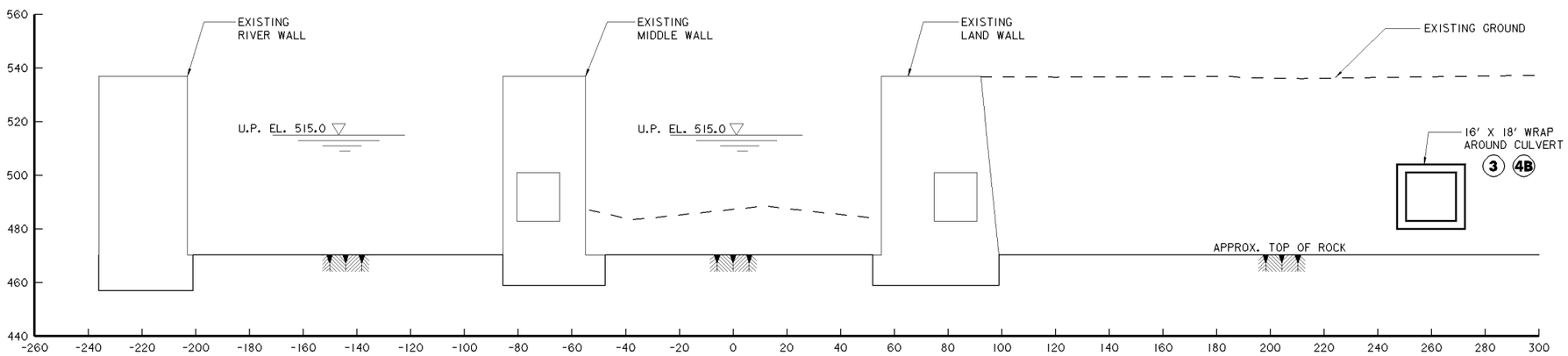
Sheet 1 of 19



5+00 A



4+00 A



3+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–13

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

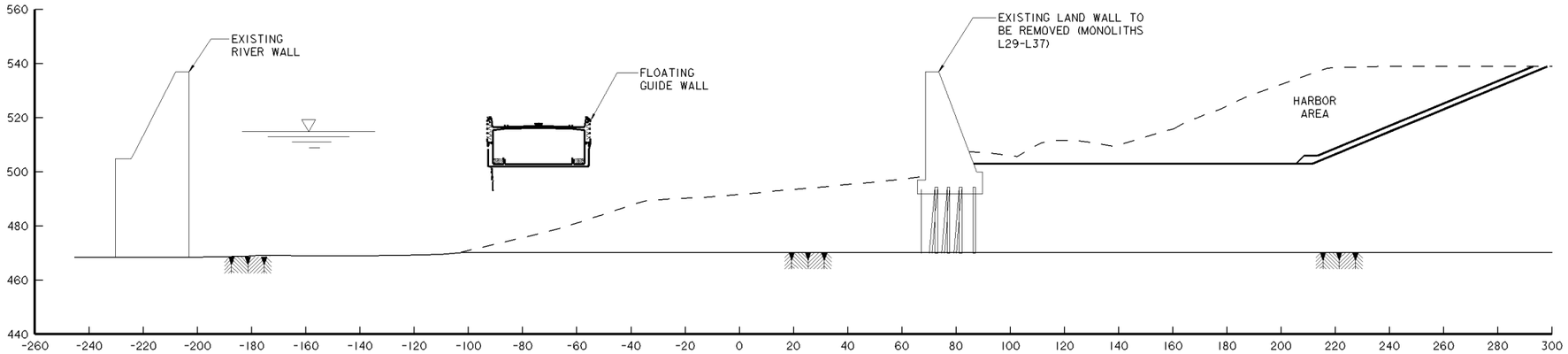
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

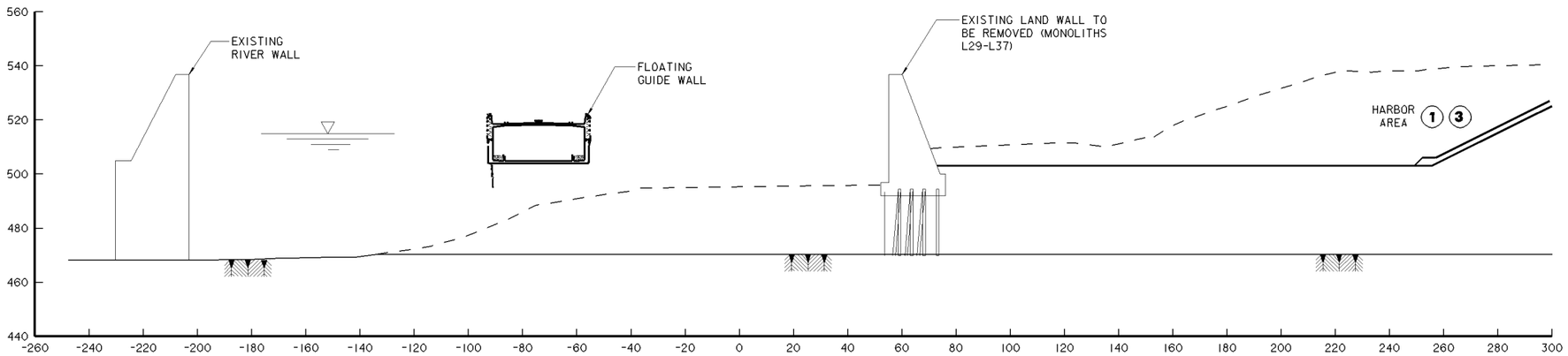
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS–SECTIONS
STA. 3+00A TO STA. 5+00A

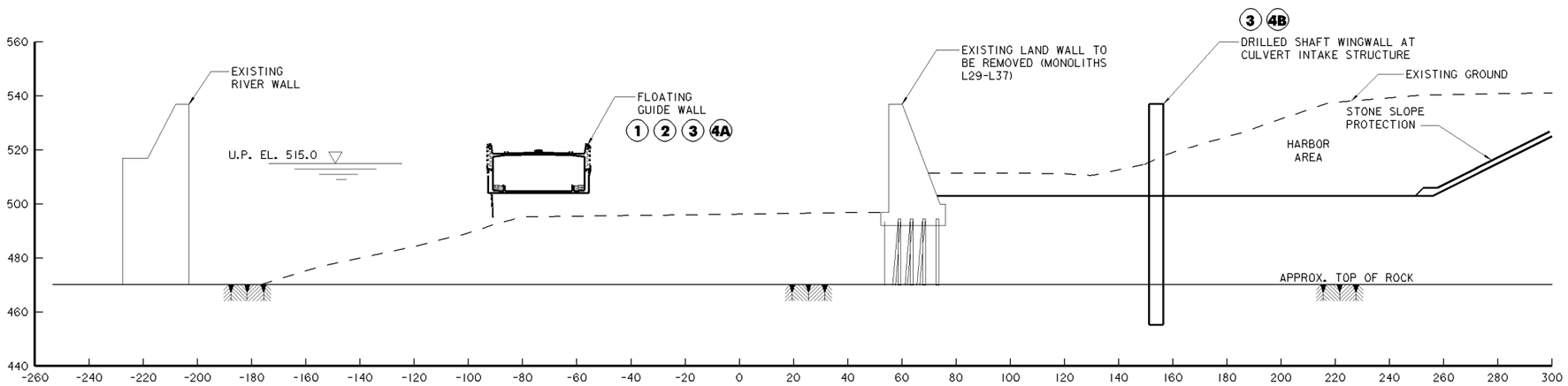
Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	FILENAME: 0falxs02.dgn PEN TABLE: b.ptb
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet 2 of 19
Reviewed by:			
Approved by:			



8+00 A



7+00 A



6+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–14

Revisions

Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

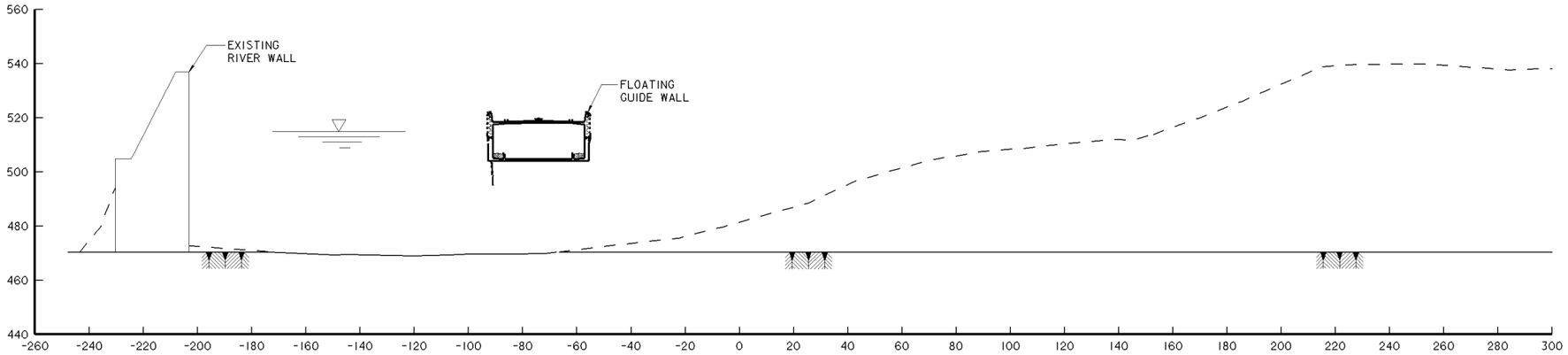
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

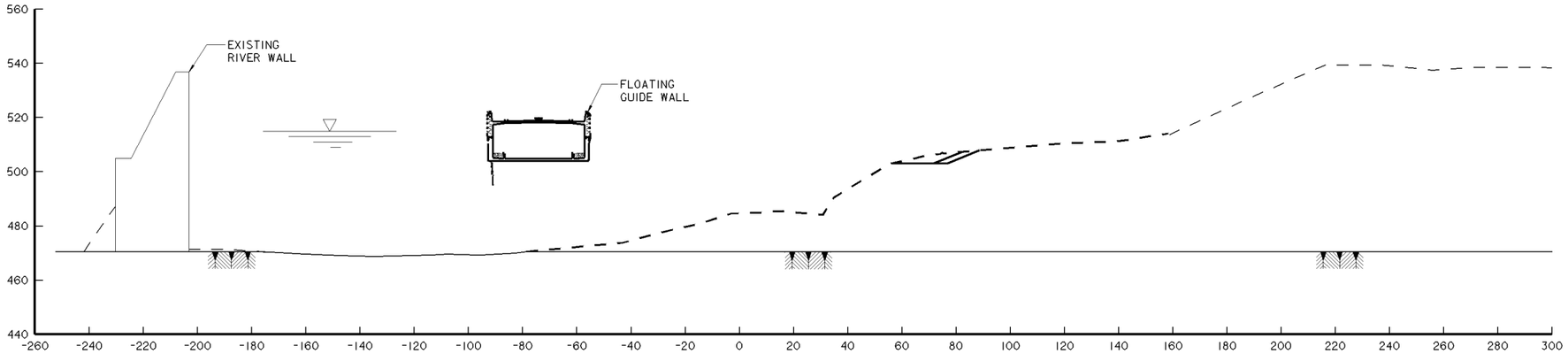
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION CROSS–SECTIONS STA. 6+00A TO STA. 8+00A

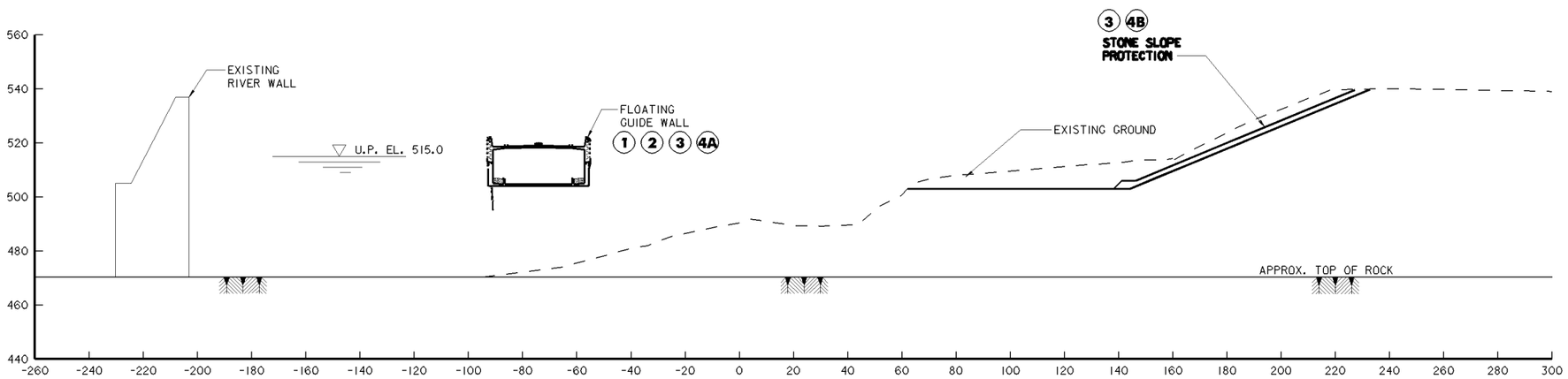
Designed by:	D.L.C. W.L.W.		
Drawn by:	G.L.C. G.S.A.		
Checked by:	D.L.C. W.L.W. L.L.M.		
Reviewed by:		Scale: AS SHOWN	Sheet reference number:
Approved by:		Date: SEPT. 1999	FILENAME: 0falxs03.dgn PSN TABLE: b.ptb
		Drawing Code:	Sheet 3 of 19



11+00 A



10+00 A



9+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-15

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

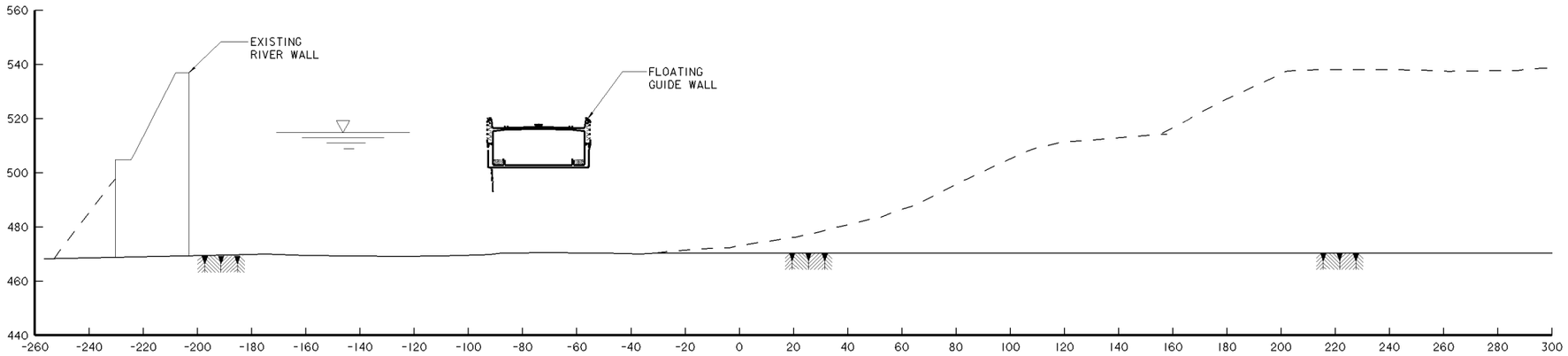
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

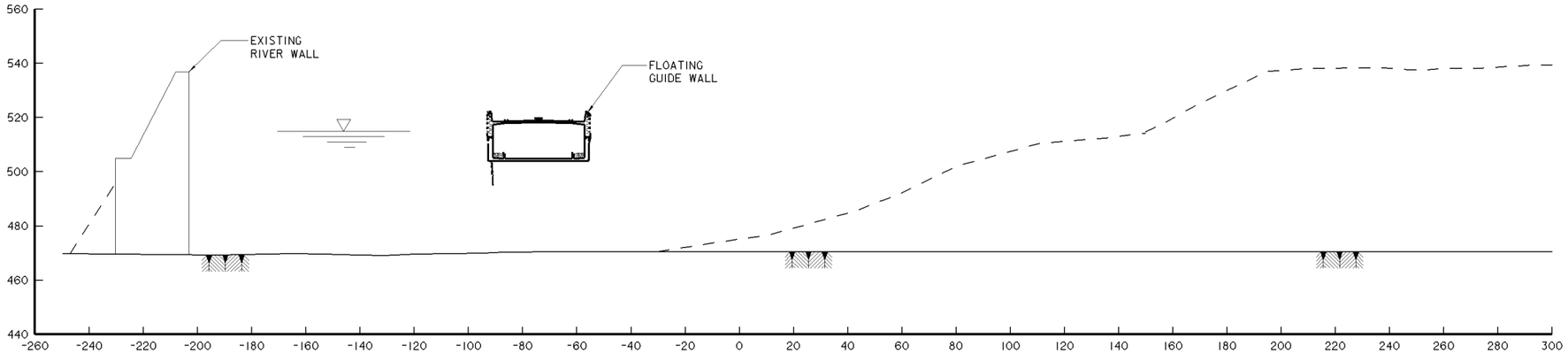
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 9+00A TO STA. 11+00A

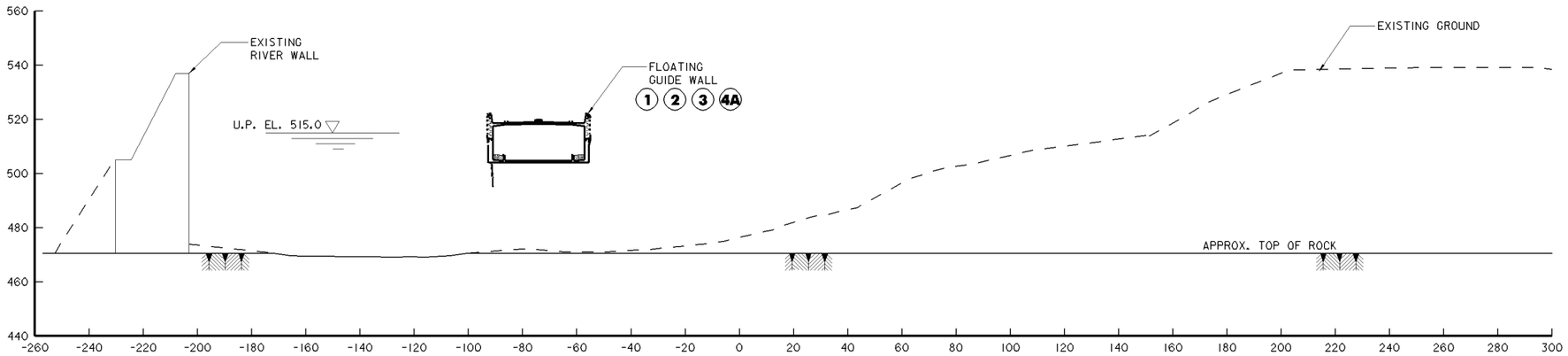
Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	FILENAME: 0falxs04.dgn PEN TABLE: b.ptb
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet 4 of 19
Reviewed by:			
Approved by:			



14+00 A



13+00 A



12+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

1 - PLAN 1
2 - PLAN 2
3 - PLAN 3
4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-16

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

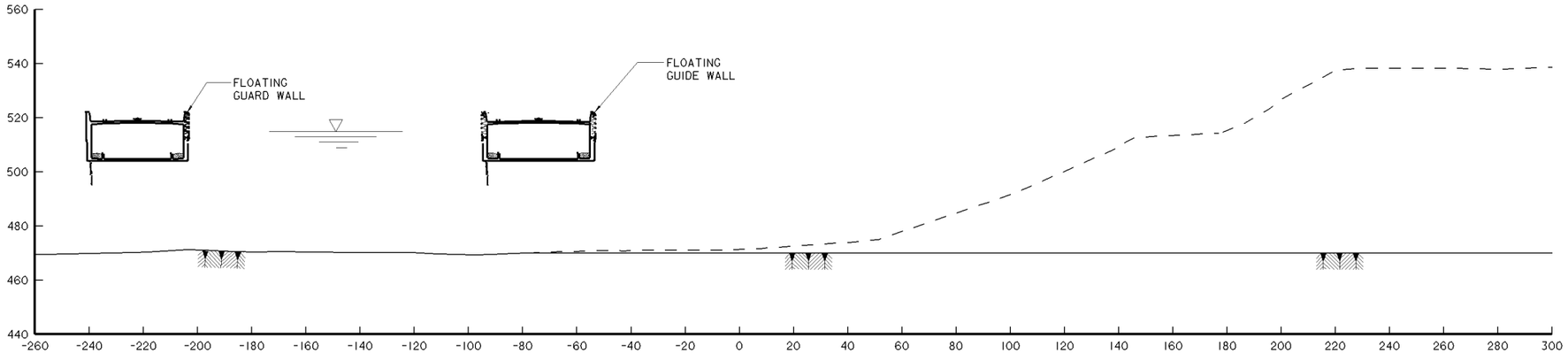
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

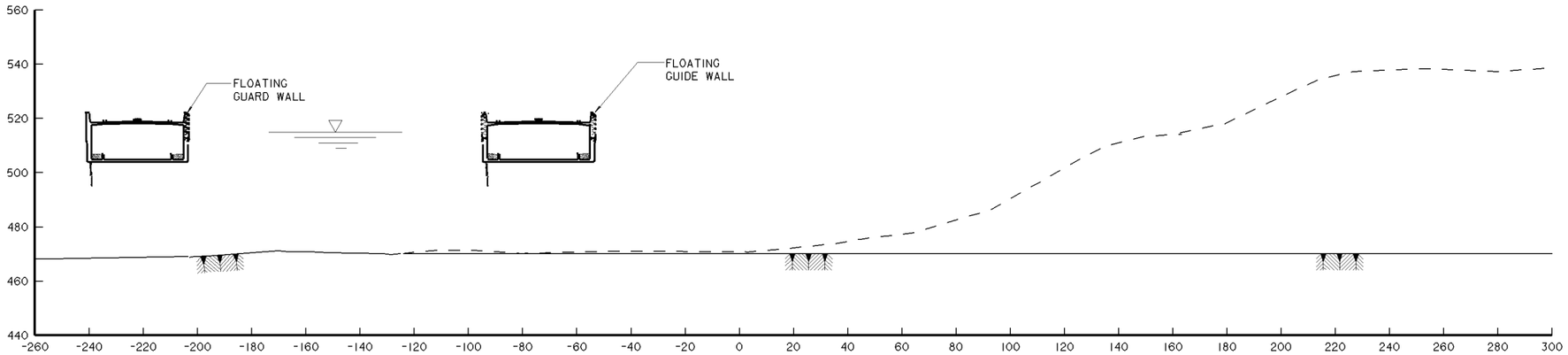
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 12+00A TO STA. 14+00A

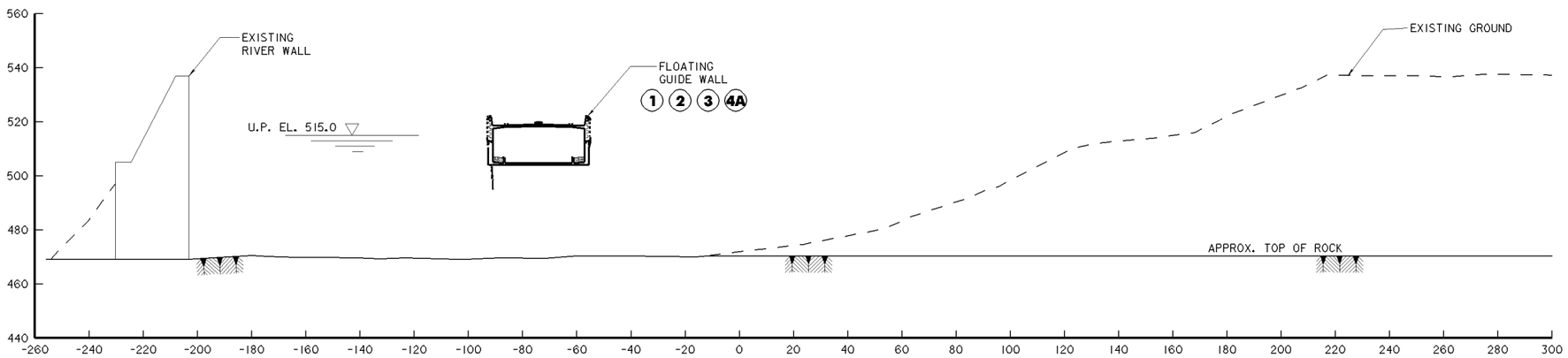
Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	FILENAME: 0faixs05.dgn PEN TABLE: b.ptb
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet 5 of 19
Reviewed by:			
Approved by:			



17+00 A



16+00 A



15+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-17

Revisions			
Symbol	Descriptions	Date	Approved

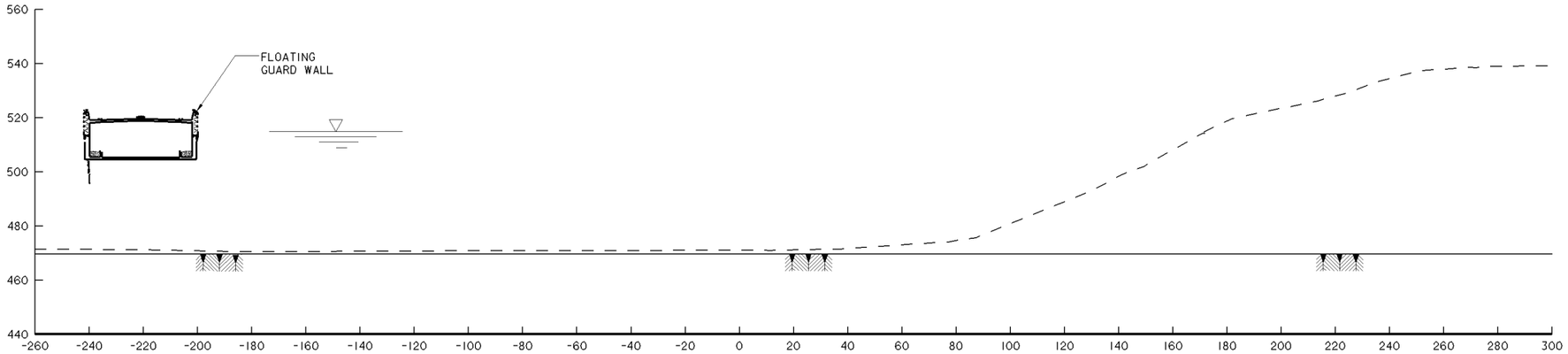
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

OHIO RIVER MAIN STEM STUDY

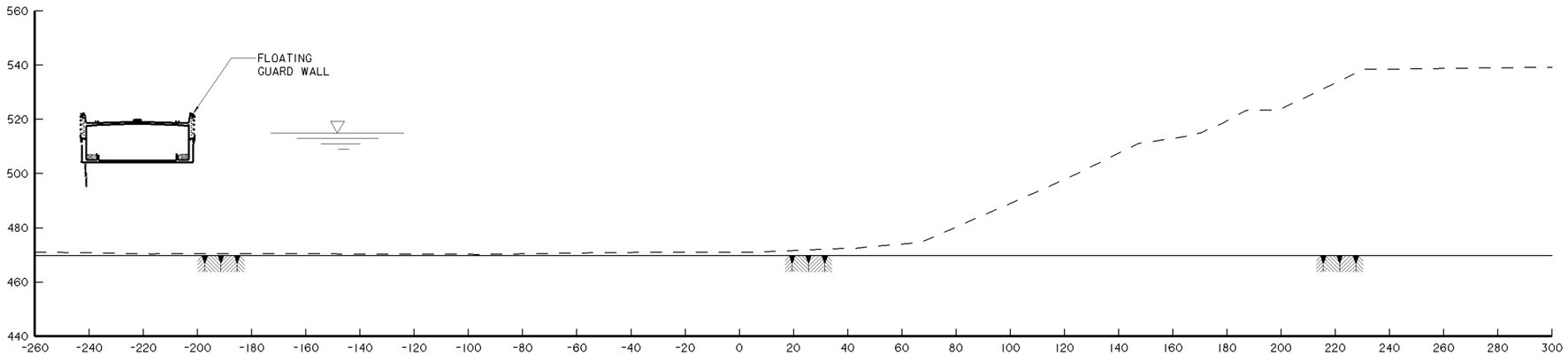
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 15+00A TO STA. 17+00A

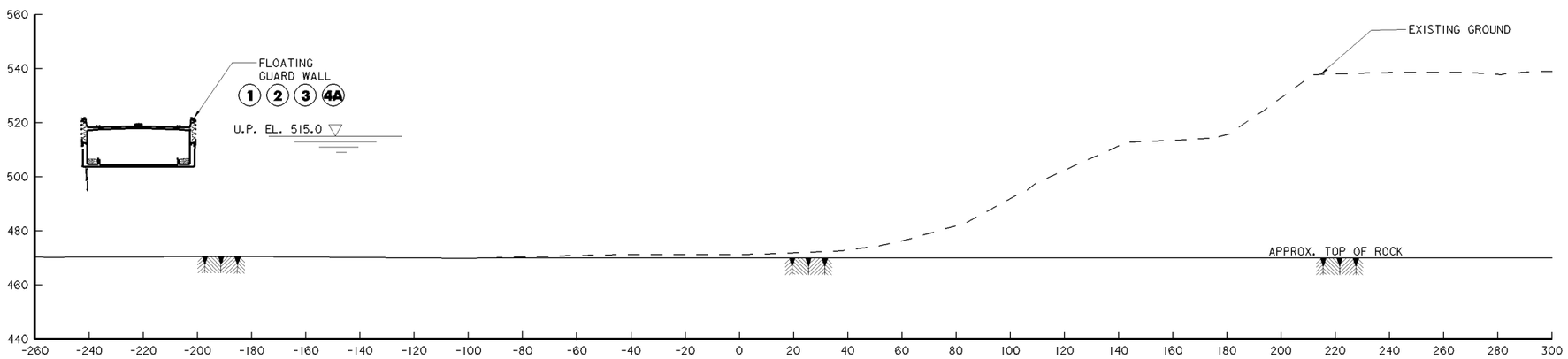
Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	FILENAME: 0falxs06.dgn
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	PEN TABLE: b.ptb
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet 6 of 19
Reviewed by:		Sheet reference numbers	
Approved by:			



20+00 A



19+00 A



18+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- (1) - PLAN 1
- (2) - PLAN 2
- (3) - PLAN 3
- (4A) - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- (4B) - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–18

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

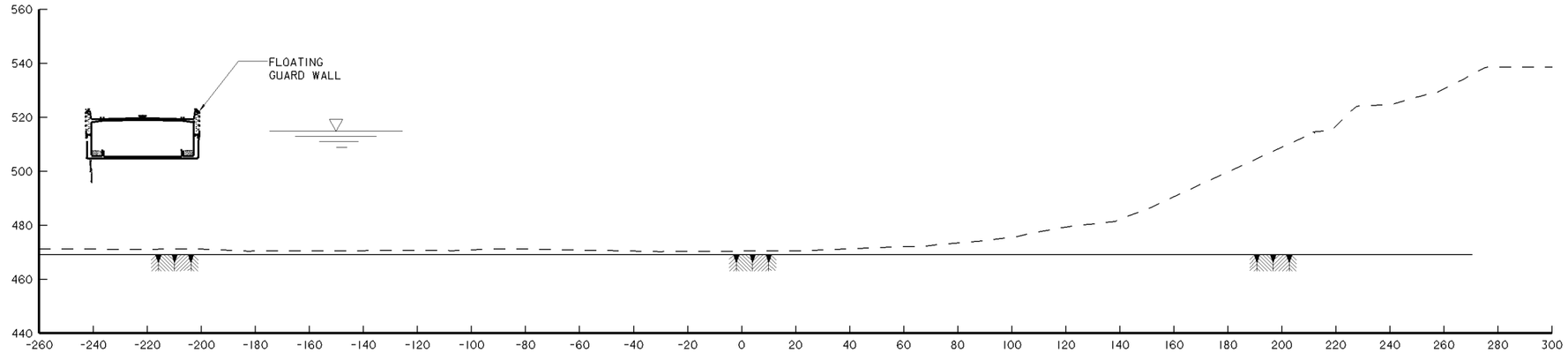
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

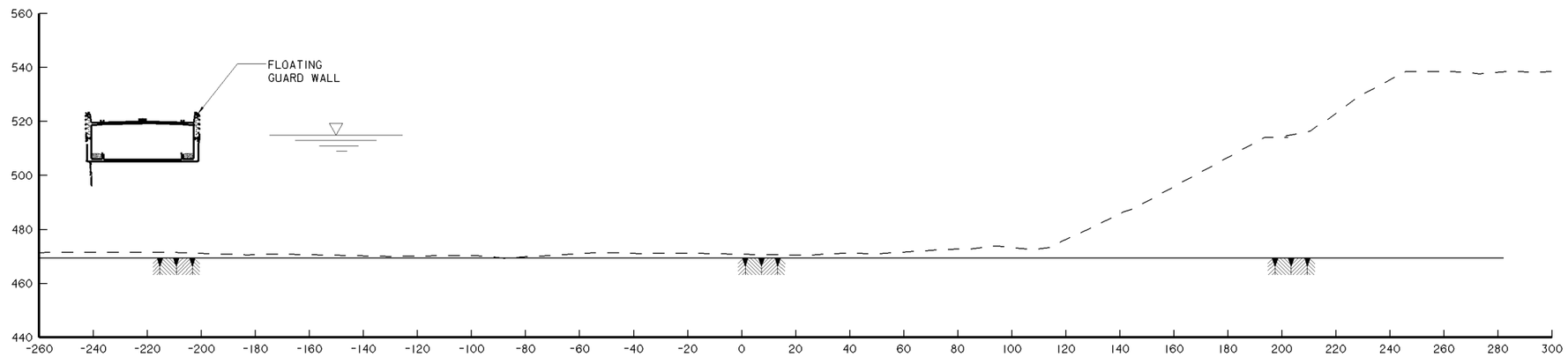
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 18+00A TO STA. 20+00A

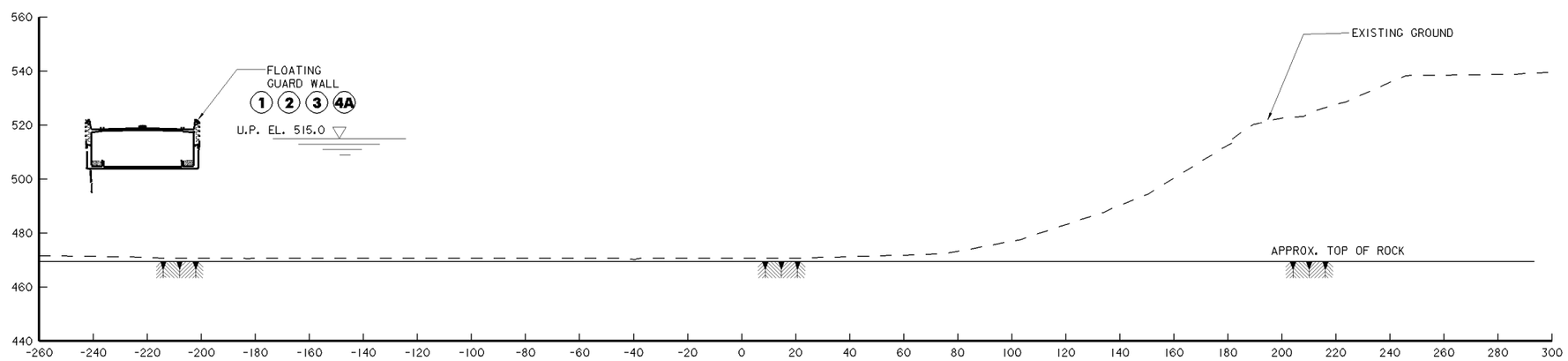
Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	PILENAME: 0fabxs07.dgn
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	PEN TABLE: b.ptb
Reviewed by:			Sheet 7 of 19
Approved by:			



23+00 A



22+00 A



21+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- (1) - PLAN 1
- (2) - PLAN 2
- (3) - PLAN 3
- (4A) - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- (4B) - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–19

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

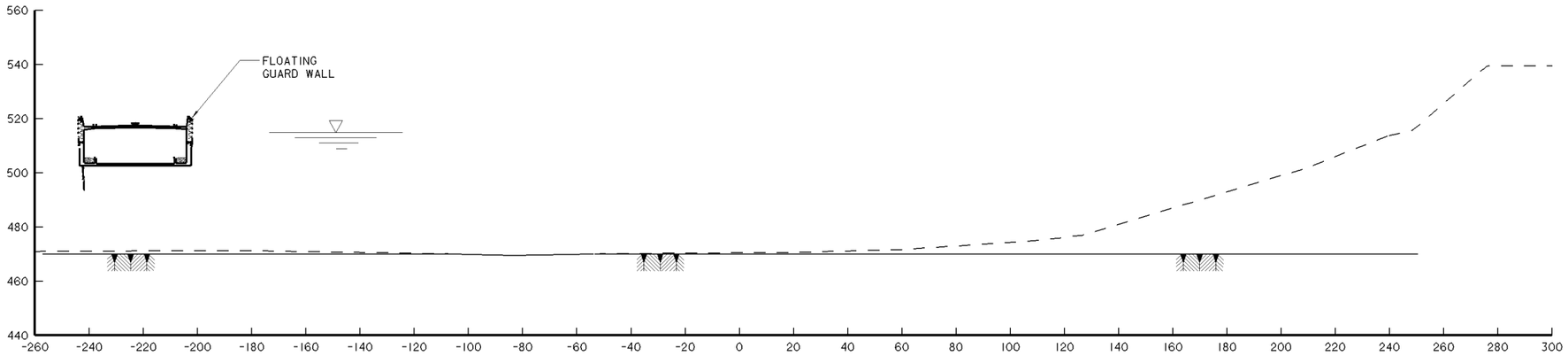
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

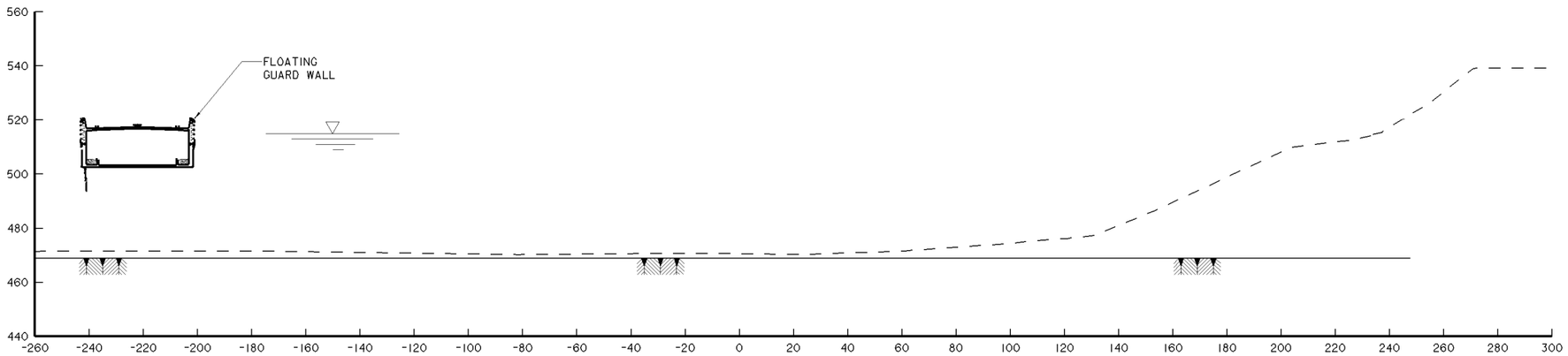
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS–SECTIONS
STA. 21+00A TO STA. 23+00A

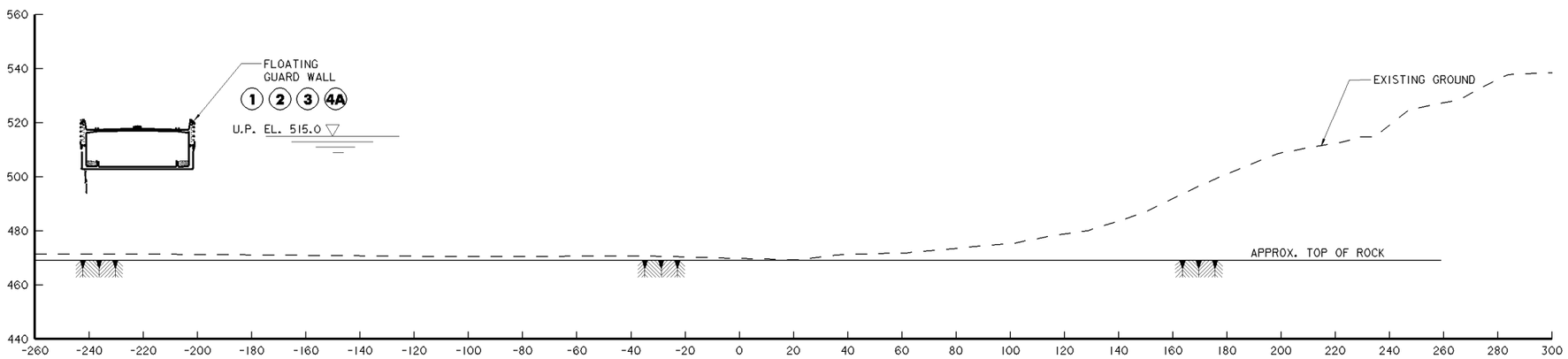
Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	FILENAME: 0falxs08.dgn
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	PEN TABLE: b.ptb
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet reference number:
Reviewed by:			Sheet 8 of 19
Approved by:			



26+00 A



25+00 A



24+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

1 - PLAN 1
2 - PLAN 2
3 - PLAN 3
4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–20

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

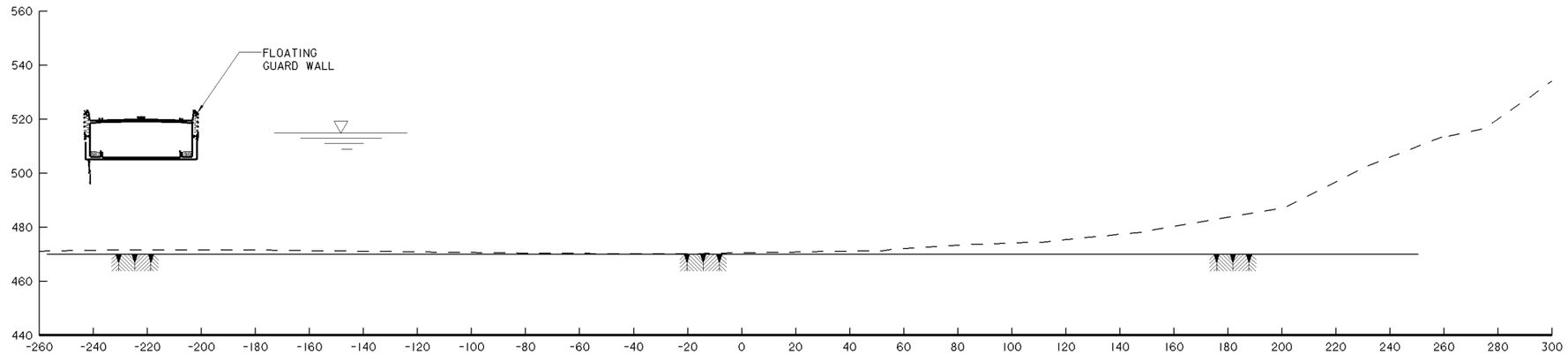
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

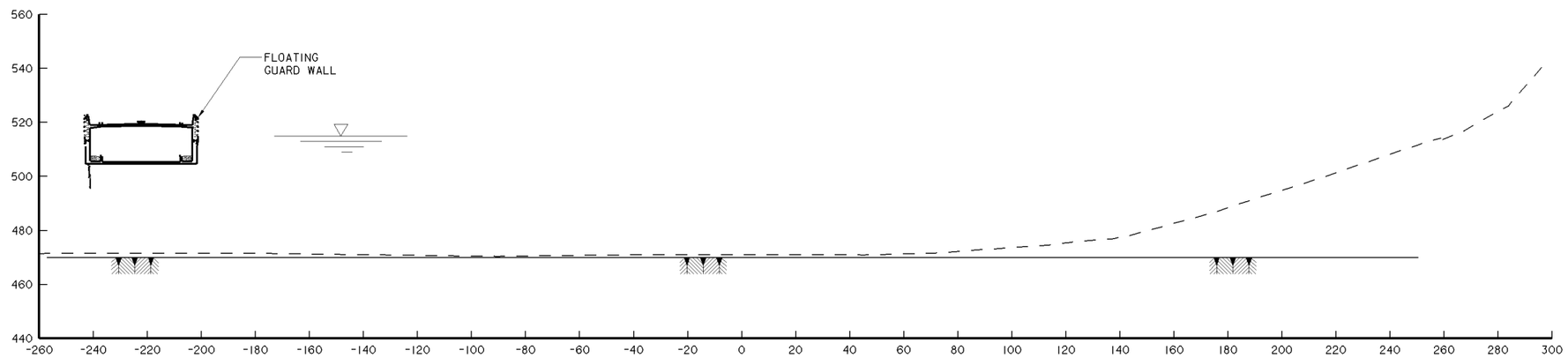
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS–SECTIONS
STA. 24+00A TO STA. 26+00A

Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	FILENAME: 0faixs09.dgn
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	PEN TABLE: b.ptb
Reviewed by:			Sheet 9 of 19
Approved by:			



29+00 A



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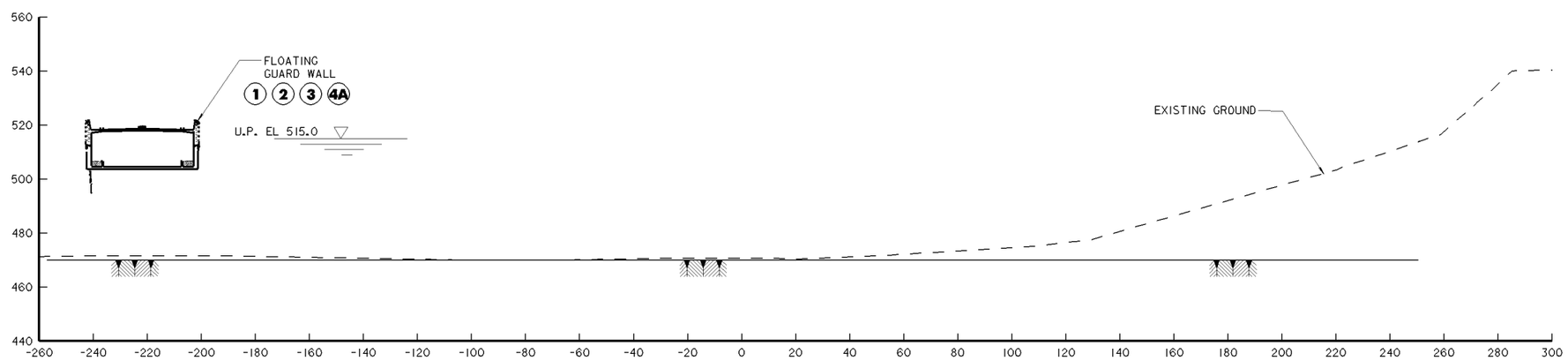


27+00 A

PLAN(S) TO WHICH NEW WORK APPLIES

- (1) - PLAN 1
- (2) - PLAN 2
- (3) - PLAN 3
- (4A) - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- (4B) - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–21

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

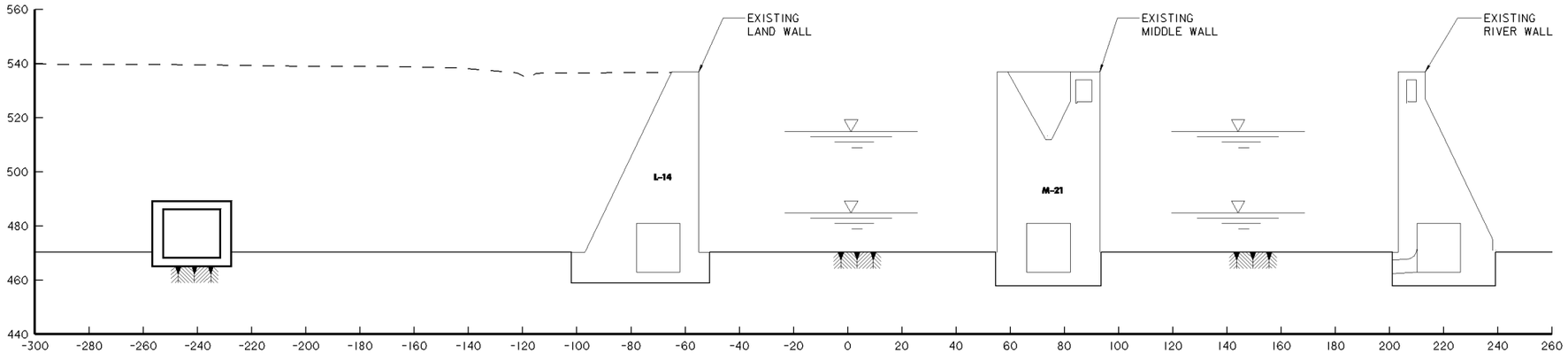
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

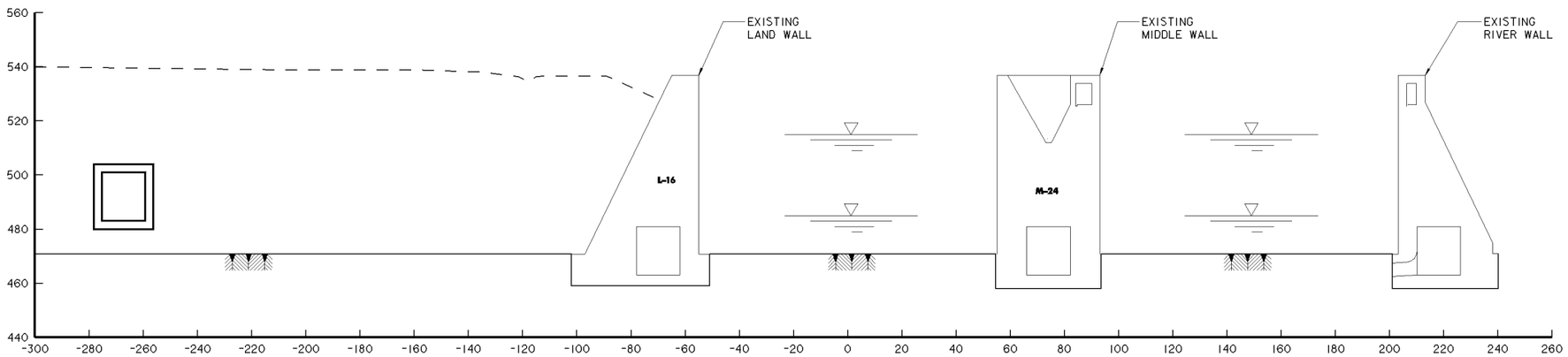
GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS–SECTIONS
STA. 27+00A TO STA. 29+00A

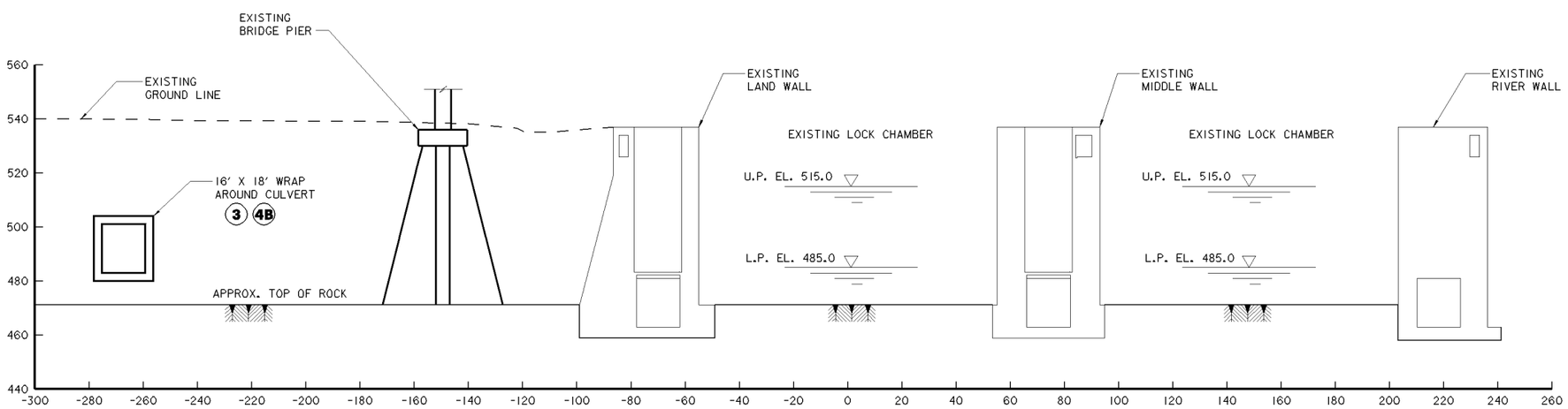
Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	FILENAME; PEN TABLE: 0falxs10.dgn
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	b.ptb
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet 10 of 19
Reviewed by:		Sheet reference number:	
Approved by:			



2+00 B



1+00 B



0+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-22

Revisions

Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 0+00B TO STA. 2+00B

Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	FILENAME: 0falxs11.dgn PEN TABLE: b.ptb
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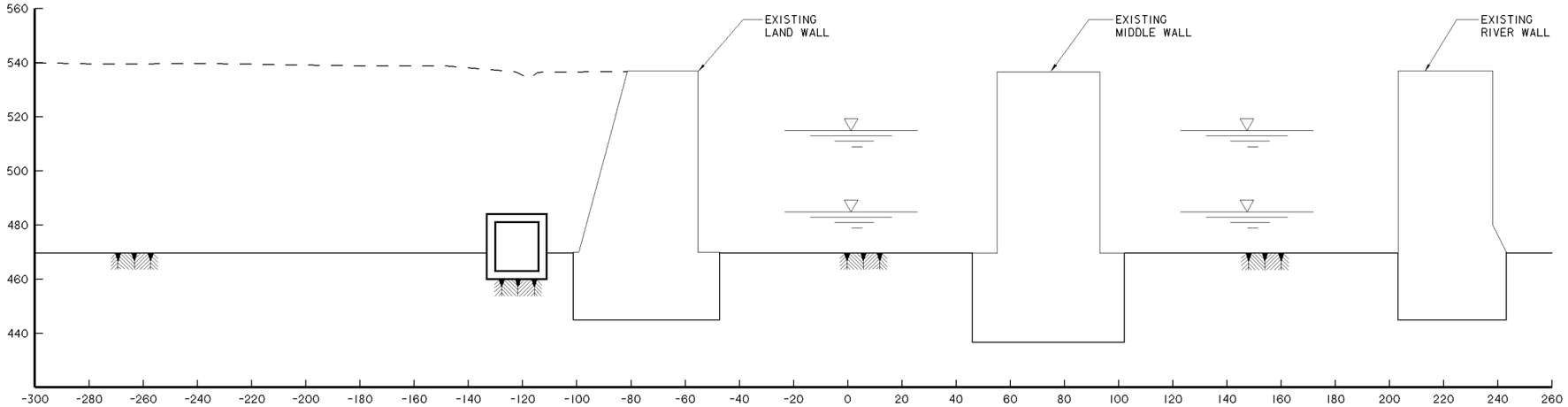
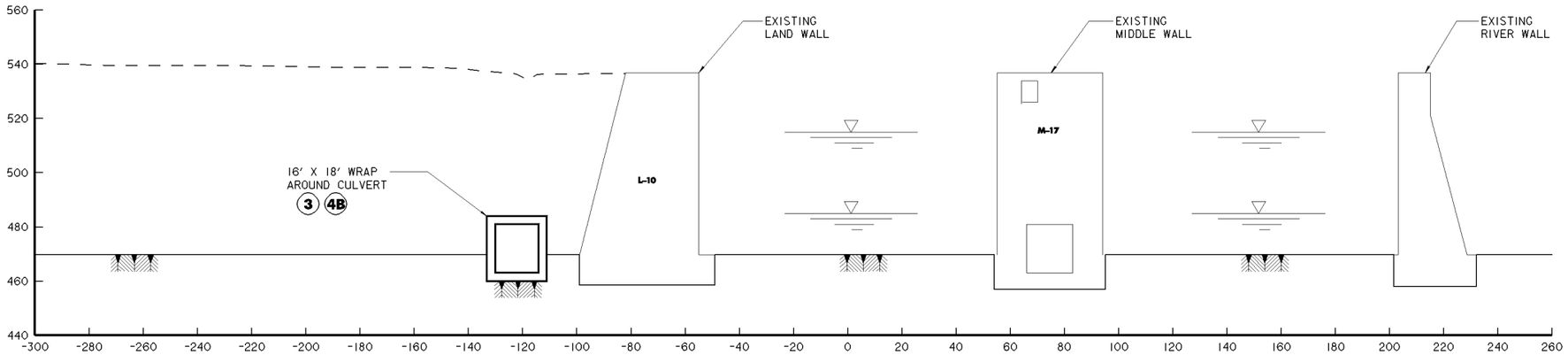
Reviewed by:			
Approved by:			



5+00 B



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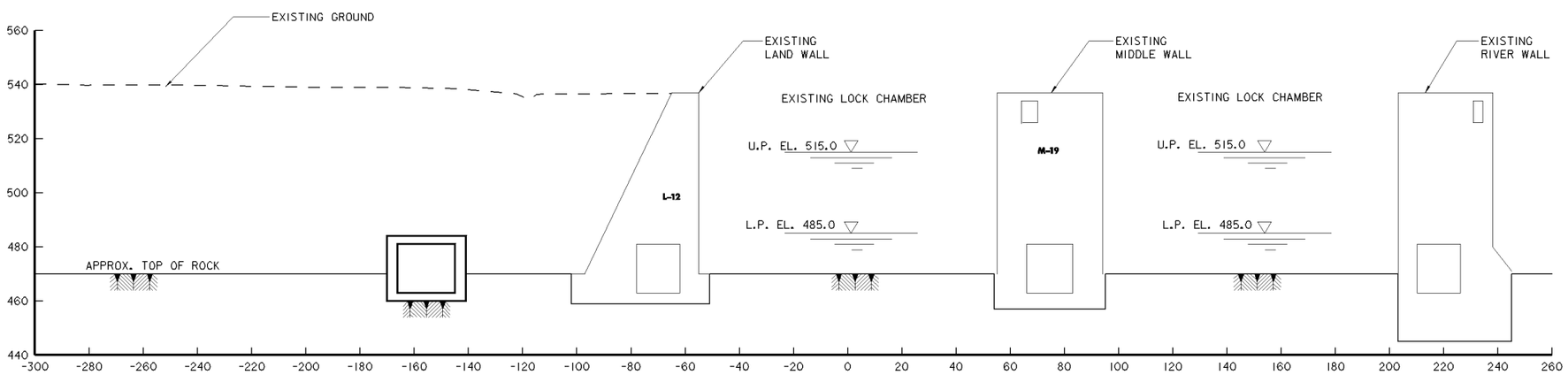


3+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-23

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

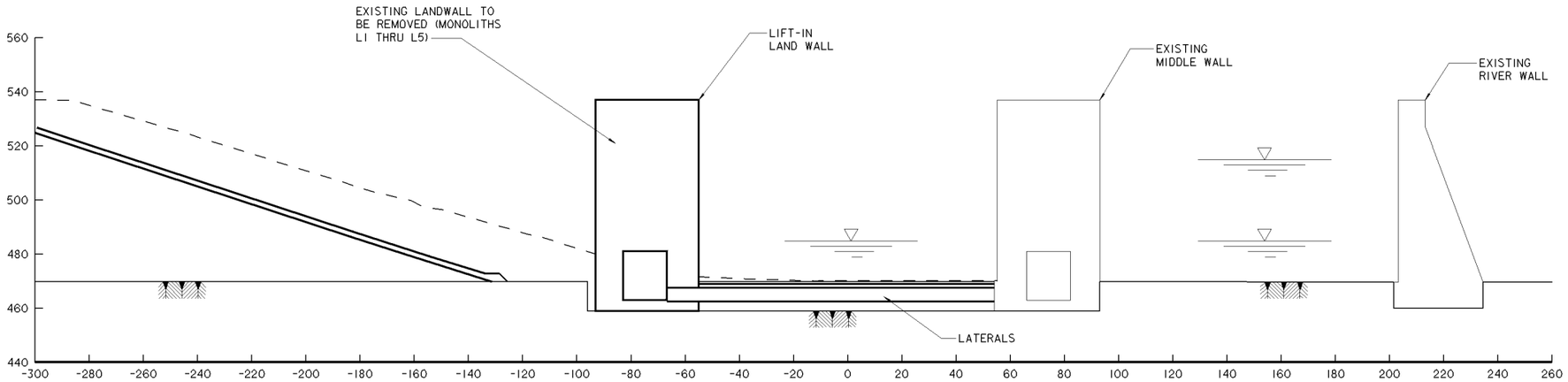
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 3+00B TO STA. 5+00B

Designed by:	D.L.C. W.L.W.	Scale: AS SHOWN	Sheet reference number:
Drawn by:	G.L.C. G.S.A.	Date: SEPT. 1999	FILENAME: 0faixs12.dgn
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	PEN TABLE: b.ptb
Reviewed by:			Sheet 12 of 19
Approved by:			



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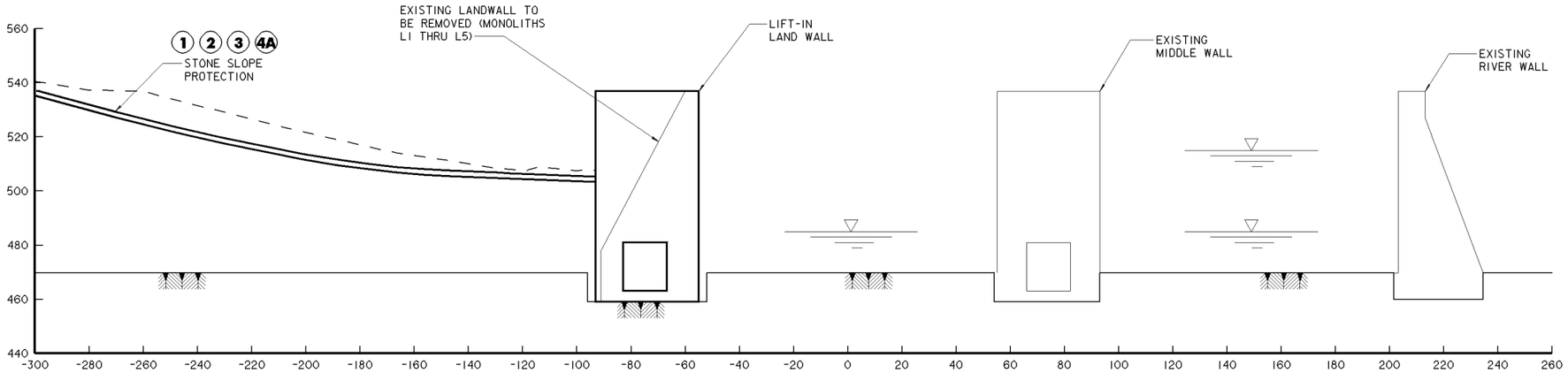
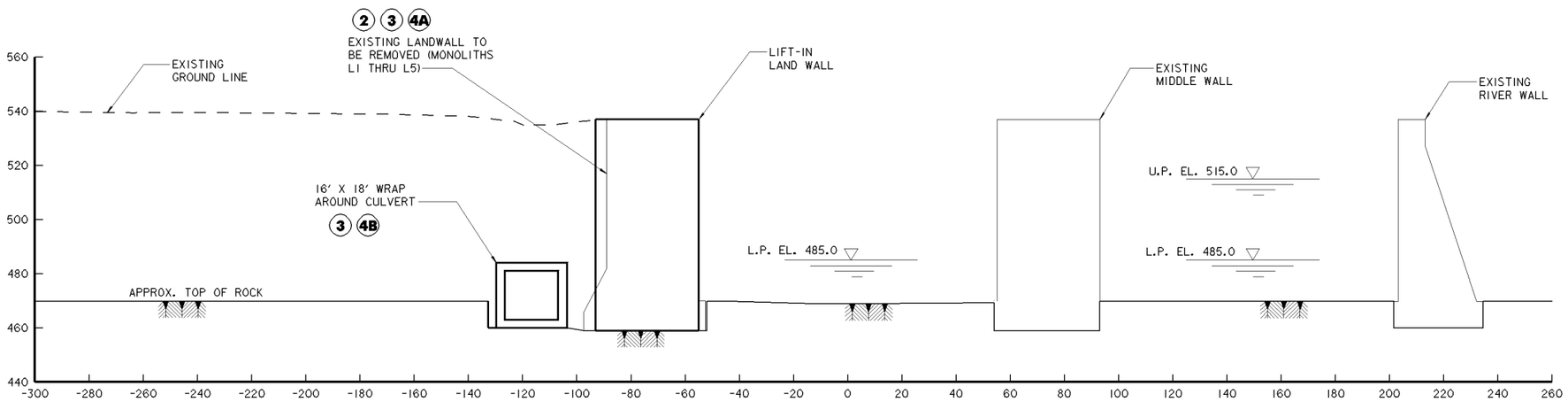


7+00 B



6+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1–24

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 6+00B TO STA. 8+00B

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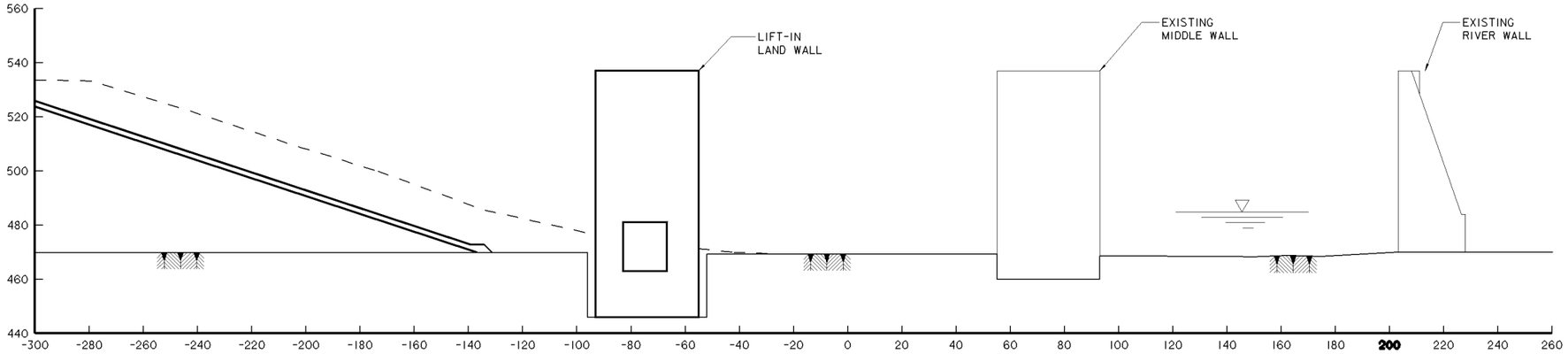
Approved by:				



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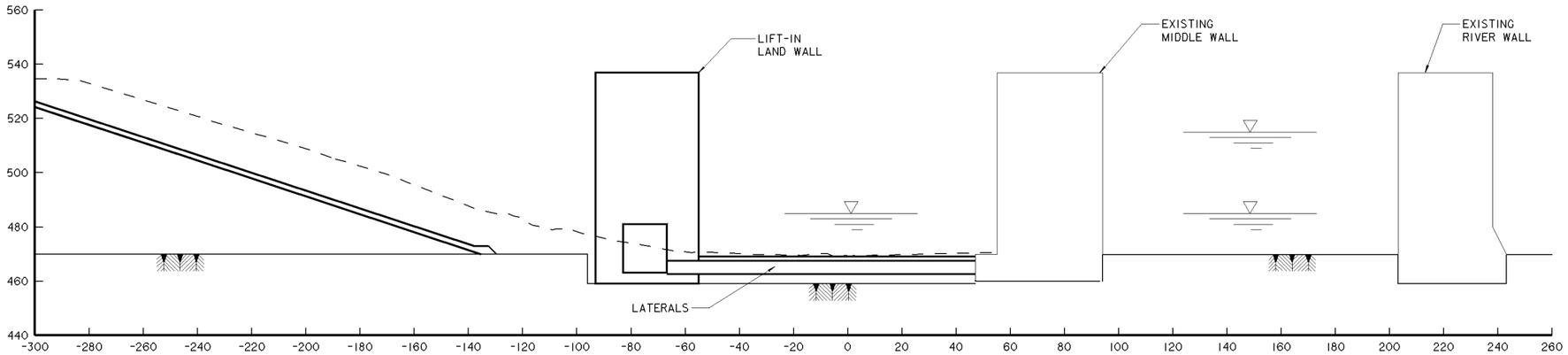

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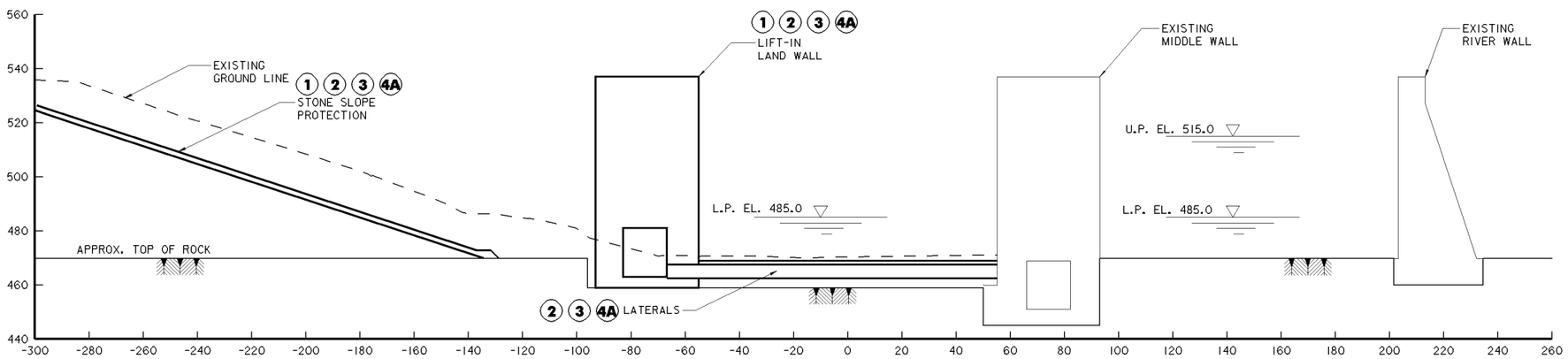

9+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-25

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 9+00B TO STA. 11+00B

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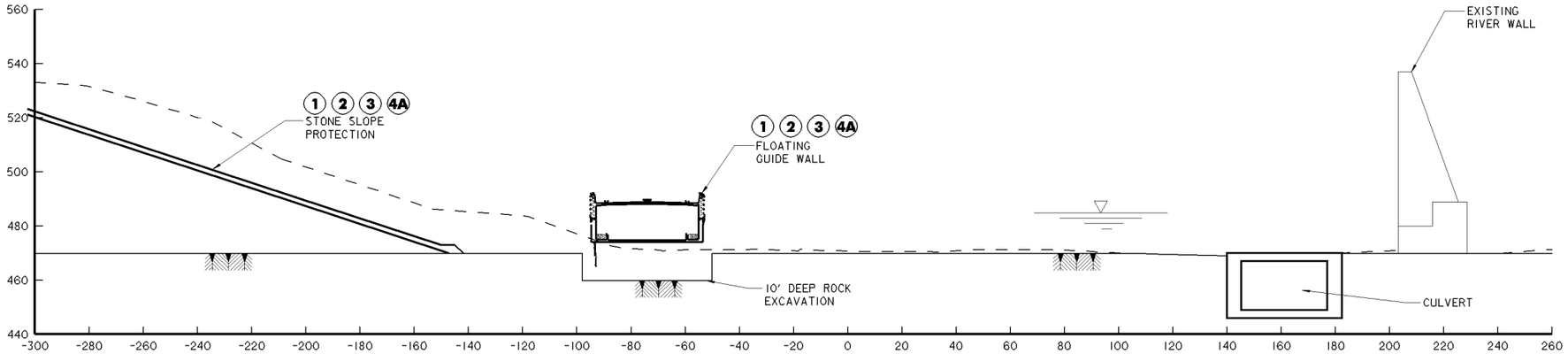

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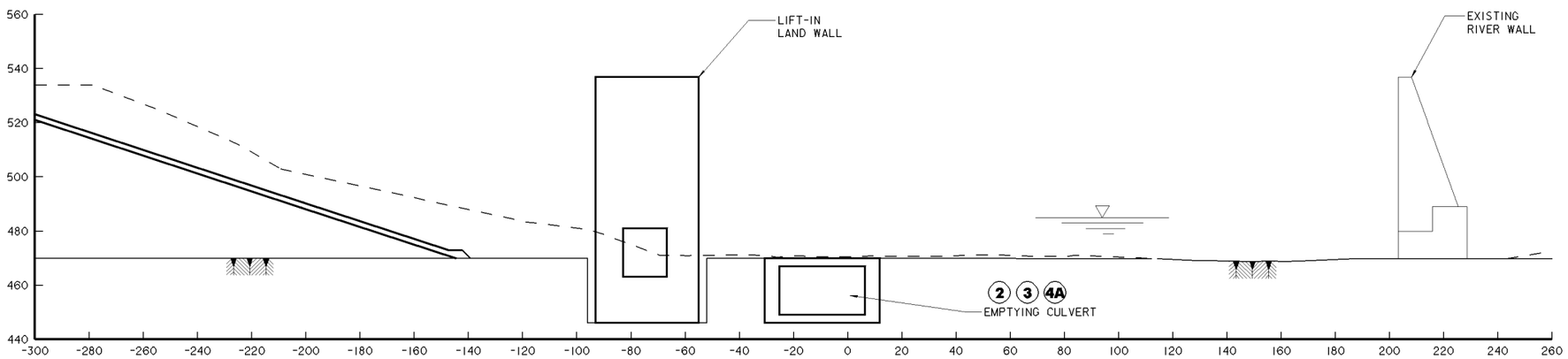

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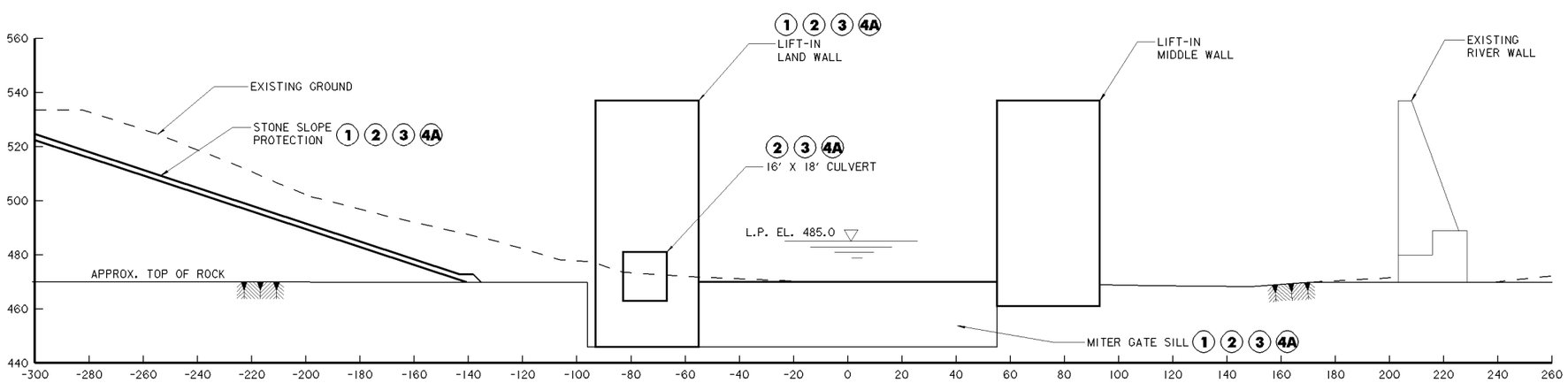

12+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

1 - PLAN 1
2 - PLAN 2
3 - PLAN 3
4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-26

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 12+00B TO STA. 14+00B

Designed by:	D.L.C. W.L.W.		
Drawn by:	G.L.C. G.S.A.		
Checked by:	D.L.C. W.L.W. L.L.M.		
Reviewed by:		Scale: AS SHOWN	Sheet reference number:
Approved by:		Date: SEPT. 1999	
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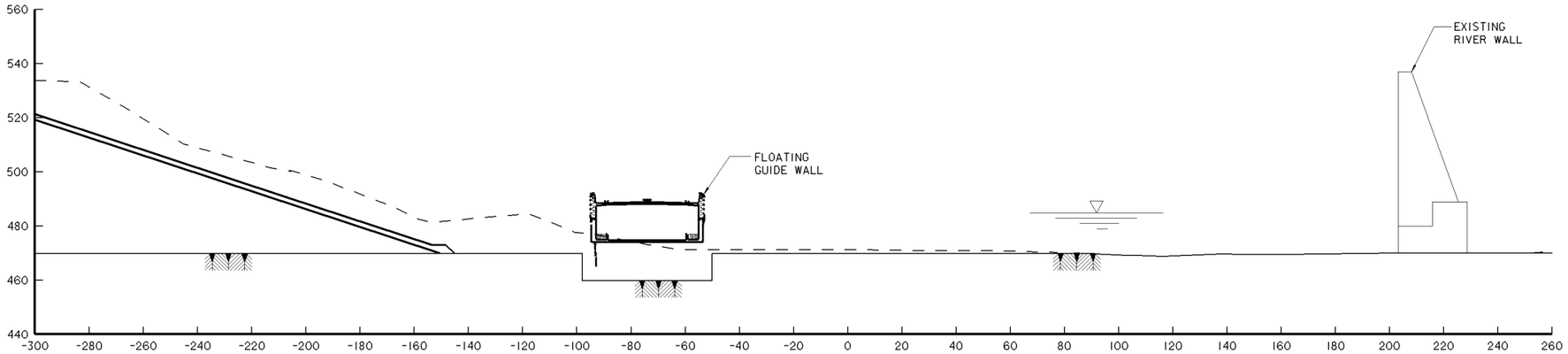

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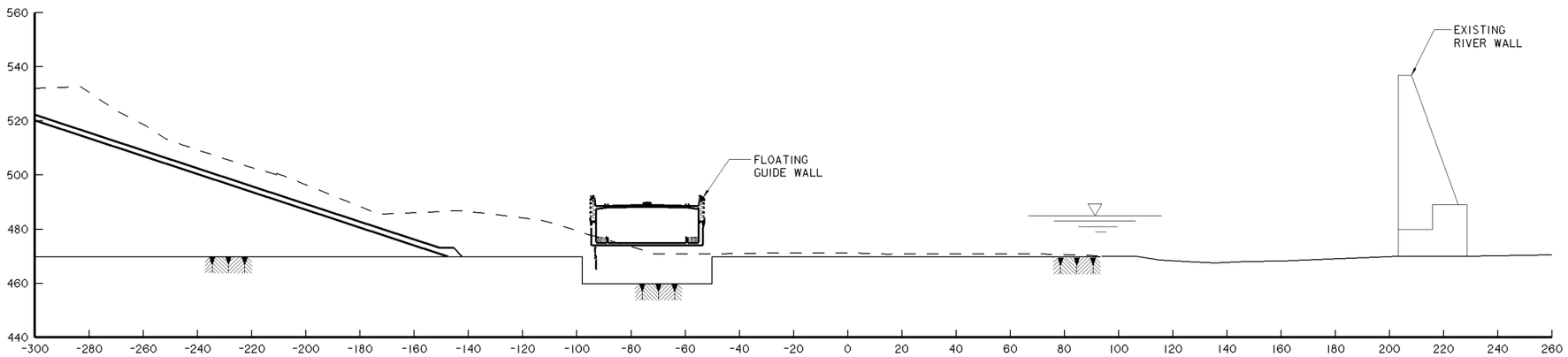

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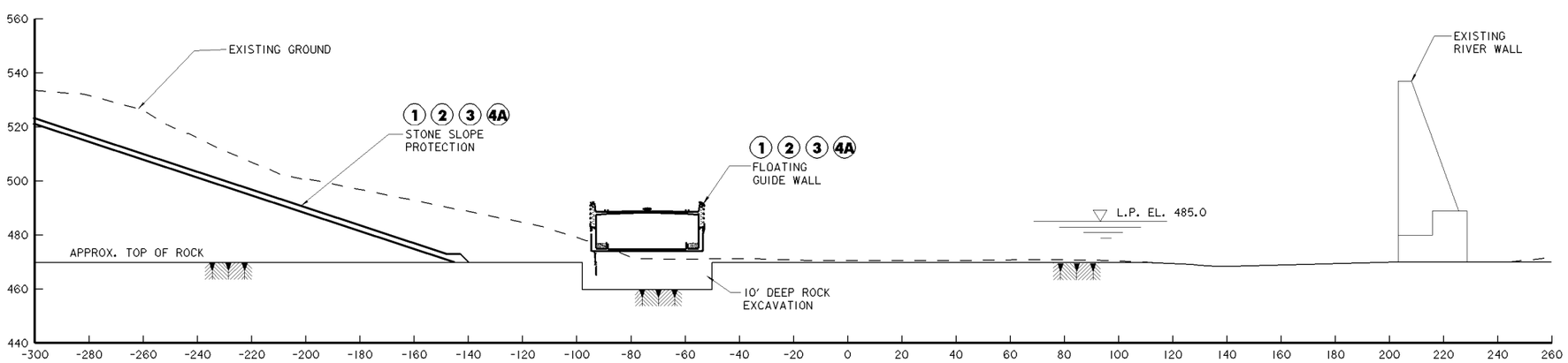

15+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

- 1 - PLAN 1
- 2 - PLAN 2
- 3 - PLAN 3
- 4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- 4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-27

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 15+00B TO STA. 17+00B

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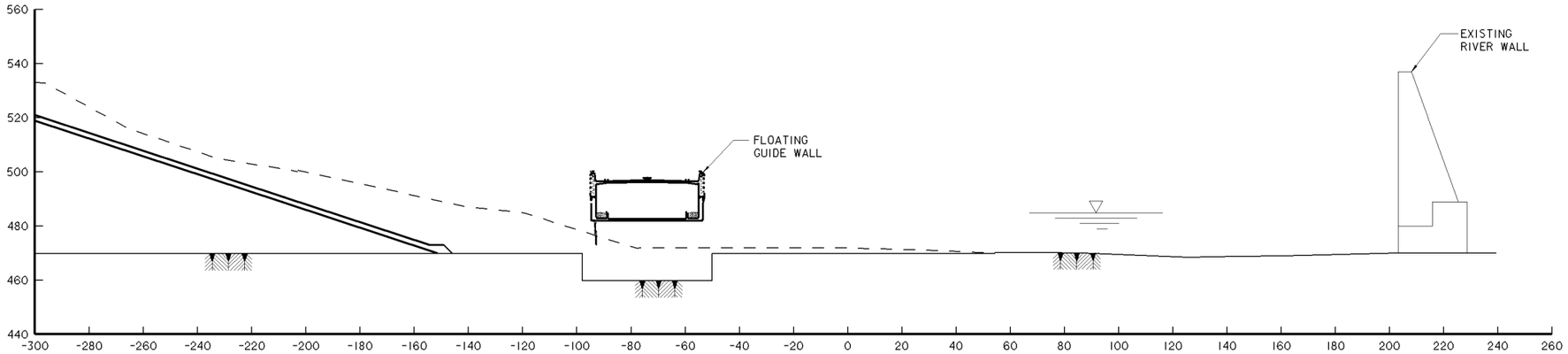

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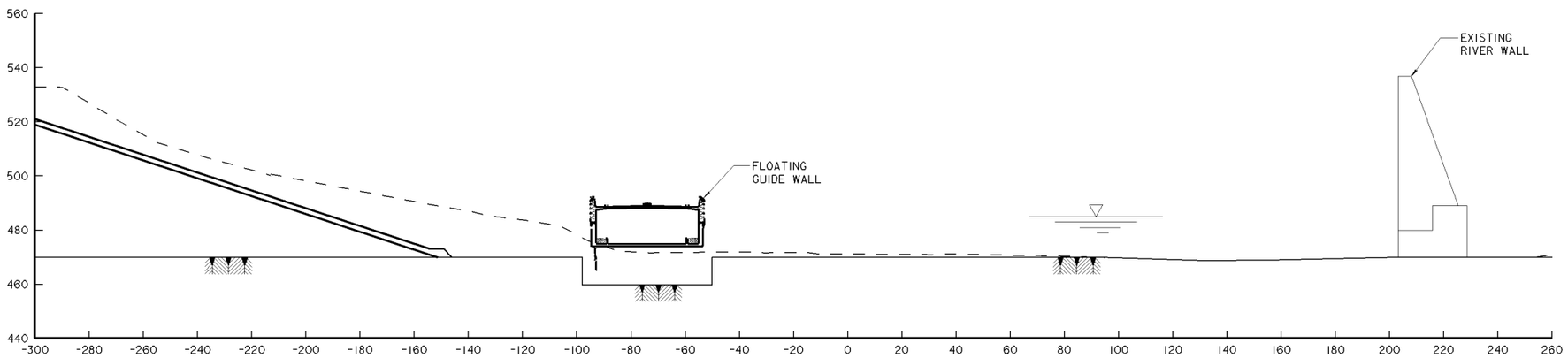

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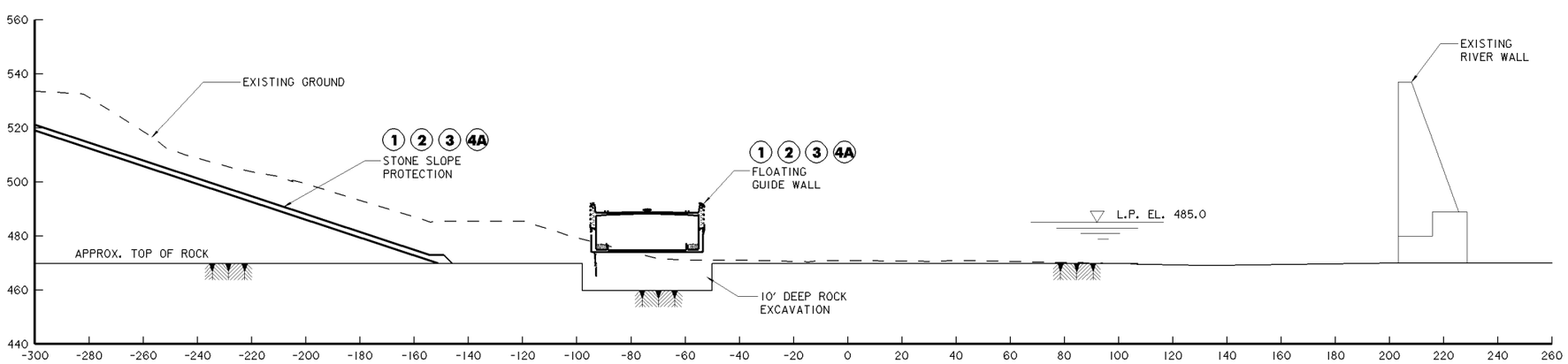

18+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

1 - PLAN 1
2 - PLAN 2
3 - PLAN 3
4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-28

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 18+00B TO STA. 20+00B

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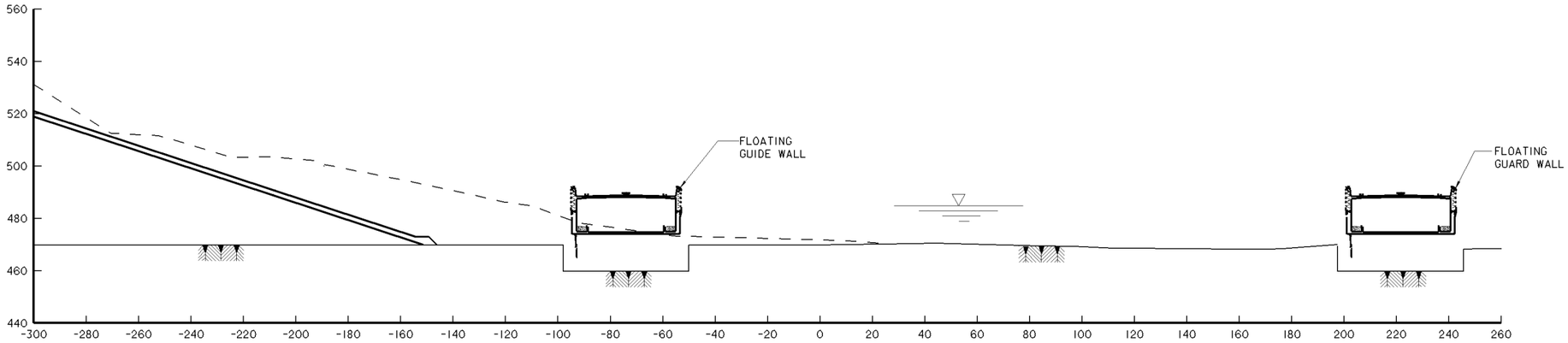
Approved by:			



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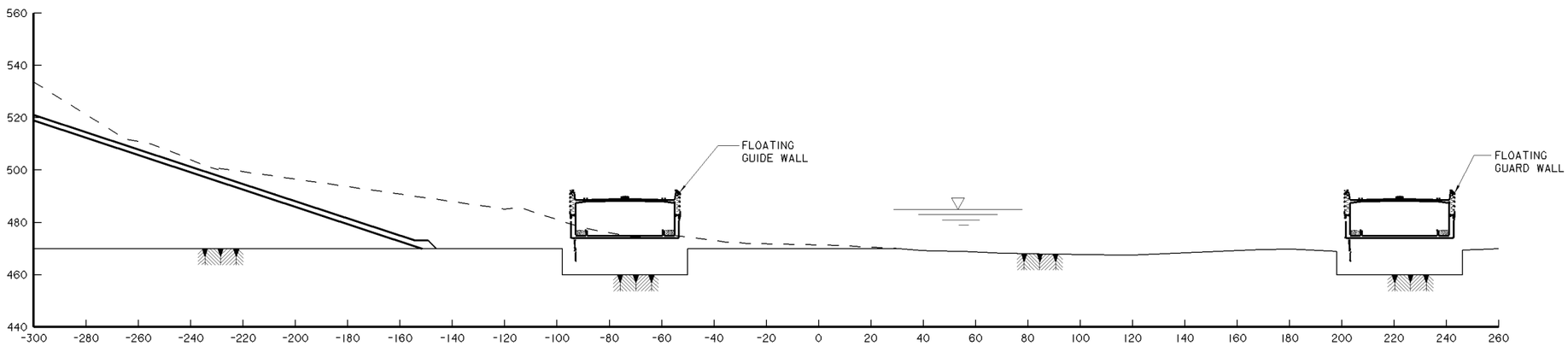

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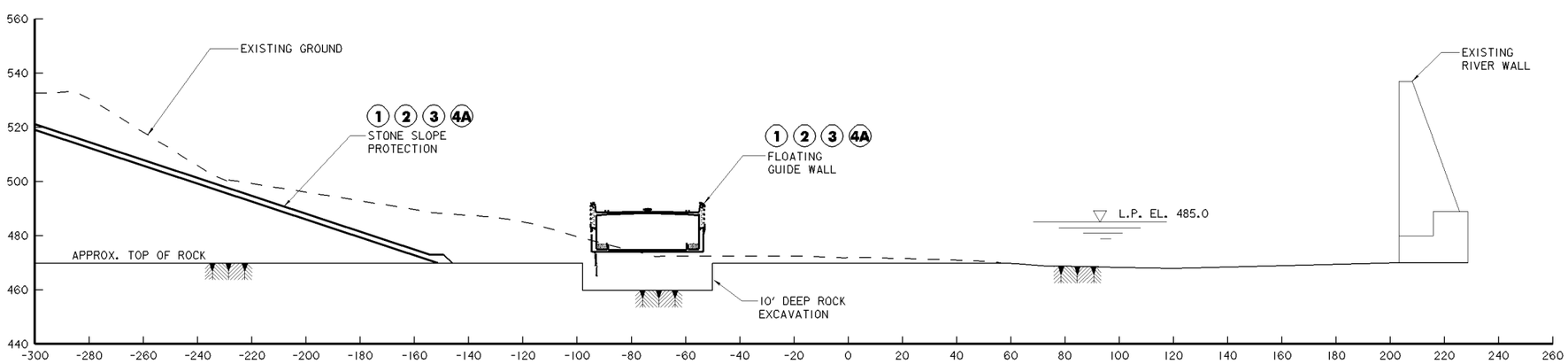

21+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

- (1) - PLAN 1
- (2) - PLAN 2
- (3) - PLAN 3
- (4A) - PLAN 4 (1ST PHASE OF CONSTRUCTION)
- (4B) - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-29

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 21+00B TO STA. 23+00B

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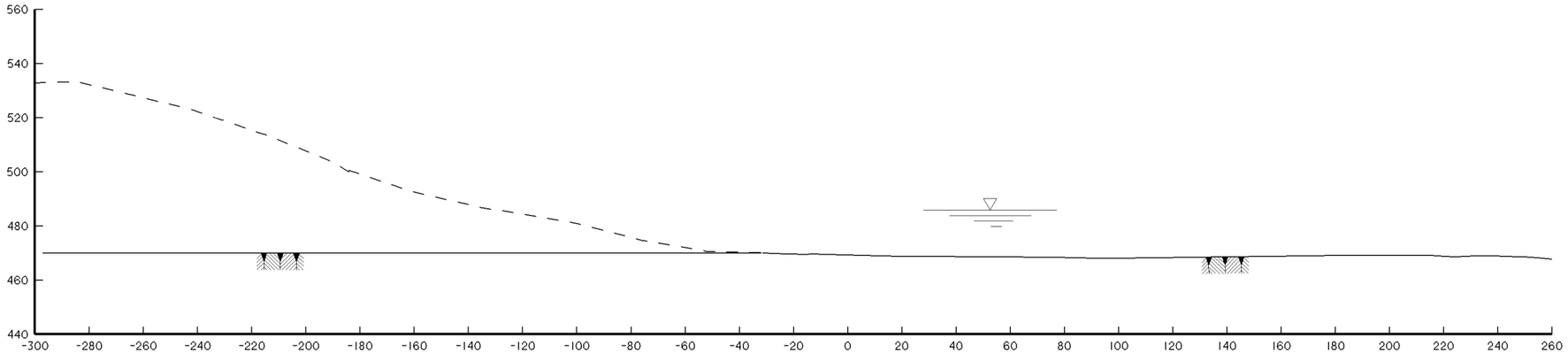
Reviewed by:			Sheet 18 of 19
Approved by:			



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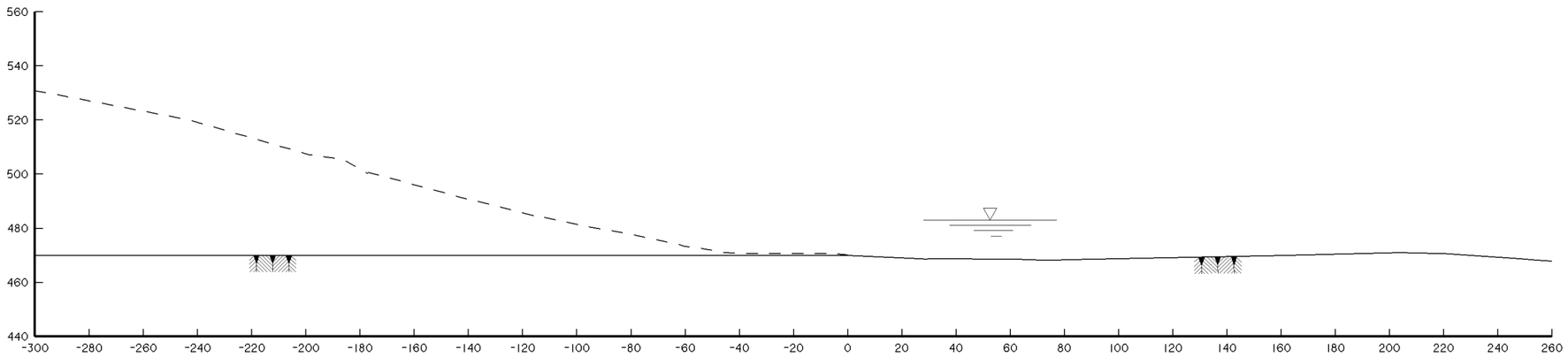

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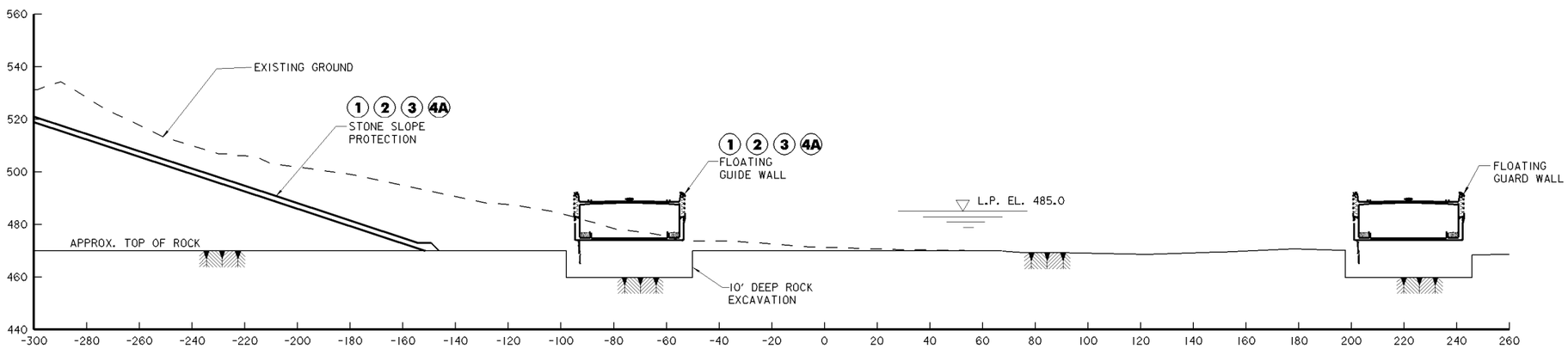

24+00 B

PLAN(S) TO WHICH NEW WORK APPLIES

1 - PLAN 1
2 - PLAN 2
3 - PLAN 3
4A - PLAN 4 (1ST PHASE OF CONSTRUCTION)
4B - PLAN 4 (2ND PHASE OF CONSTRUCTION)

PLATE 1-30

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY

GREENUP LOCKS & DAM

600 FOOT LOCK EXTENSION
CROSS-SECTIONS
STA. 24+00B TO STA. 26+00B

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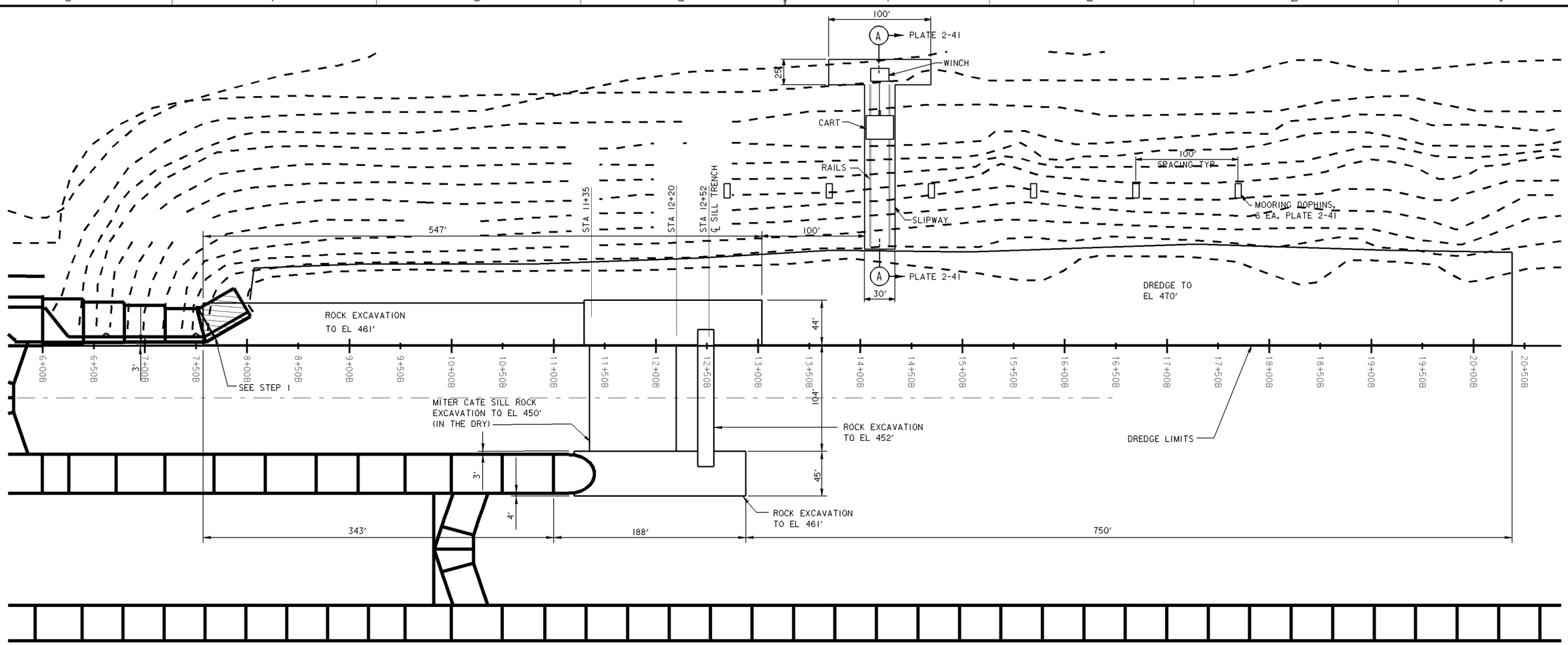
Checked by:	D.L.C. W.L.W. L.L.M.	Drawing Code:	Sheet 19 of 19
Reviewed by:			
Approved by:			

26.4.2 Lockwall Extension Plans and Construction Methods

PLATE (2-1) PLAN 1 DREDGE & EXCAVATION PLAN
PLATE (2-2) PLAN 1 AUXILIARY EXTENSION
PLATE (2-3) PLAN 1 LAND WALL PLAN WO/AUX F/E SYSTEM
PLATE (2-4) PLAN 1 LANDSIDE GATE MONOLITH WO/AUX F/E SYSTEM
PLATE (2-5) PLAN 1 MIDDLE WALL LIFT-IN PLAN
PLATE (2-6) PLAN 1 LAND WALL SECTION WO/AUX F/E SYSTEM
PLATE (2-7) PLAN 1 LANDSIDE GATE SECTION WO/AUX F/E SYSTEM
PLATE (2-8) BLOCK B,C & D PLANS
PLATE (2-9) BLOCK E & F PLANS AND ELEVATION
PLATE (2-10) PANEL DETAILS
PLATE (2-11) DREDGE & EXCAVATION PLAN EXT. W/CULVERT
PLATE (2-12) PLAN 2 AUX. EXTENSION MODIFIED
PLATE (2-13) PLAN 3 AUX. EXTENSION W/CULVERT
PLATE (2-14) PLAN 4 AUX. EXTENSION - PHASED CONSTRUCTION
PLATE (2-15) NOT USED
PLATE (2-16) PLANS 2,3 & 4 LAND WALL MONOLITH PLAN
PLATE (2-17) PLANS 2,3 & 4 LANDSIDE GATE MONOLITH W/AUX F/E SYSTEM
PLATE (2-18) PLANS 2,3 & 4 MIDDLE WALL LIFT-IN PLAN
PLATE (2-19) PLANS 2,3 & 4 LANDSIDE PLAN & ELEVATION W/AUX F/E SYSTEM
PLATE (2-20) PLANS 2,3 & 4 LANDSIDE PLAN & ELEVATION W/AUX F/E SYSTEM
PLATE (2-21) PLANS 2,3 & 4 LANDSIDE GATE PLAN & ELEVATION W/AUX F/E SYSTEM
PLATE (2-22) MIDDLE WALL PLAN & ELEVATIONS
PLATE (2-23) PLANS 2,3 & 4 LAND WALL MONOLITH PLAN W/AUX F/E SYSTEM
PLATE (2-24) PLANS 2,3 & 4 LAND WALL MONOLITH SECTIONS W/AUX F/E SYSTEM
PLATE (2-25) PLANS 2,3 & 4 LAND WALL MONOLITH SECTIONS W/AUX F/E SYSTEM
PLATE (2-26) PLANS 2,3 & 4 LAND WALL MONOLITH SECTIONS W/AUX F/E SYSTEM
PLATE (2-27) PLANS 2,3 & 4 LAND WALL MONOLITH SECTIONS W/AUX F/E SYSTEM
PLATE (2-28) PLANS 2,3 & 4 LAND WALL MONOLITH SECTIONS W/AUX F/E SYSTEM

PLATE (2-29) PLANS 2,3 & 4 LANDSIDE GATE SECTION W/AUX F/E SYSTEM
PLATE (2-30) LIFT-IN MITER GATE ELEVATION
PLATE (2-31) BULKHEAD SILL CONSTRUCTION SEQUENCE
PLATE (2-32) UTILITY TUNNEL PLAN & ELEVATION
PLATE (2-33) LAND WALL CONSTRUCTION
PLATE (2-34) MIDDLE WALL CONSTRUCTION
PLATE (2-35) LIFT-IN CONSTRUCTION SEQUENCE
PLATE (2-36) LIFT-IN CONSTRUCTION SEQUENCE
PLATE (2-37) LIFT-IN CONSTRUCTION SEQUENCE
PLATE (2-38) LIFT-IN STRUCTURE PLAN & SECTION
PLATE (2-39) DRILLED CAISSON OVERVIEW
PLATE (2-40) DRILLED CAISSON PLAN & SECTION
PLATE (2-41) FITOUT AREA PLAN AND ELEVATION



FLOW

OHIO RIVER

CONSTRUCTION SEQUENCE

STEP 1

1a. DEMOLISH MONOLITH L1 PRIOR TO DREDGING

STEP 2

2a. DREDGE FOUNDATION TRENCH.

2b. USE SHALLOW WATER ACOUSTIC BED SCANNER TO SURVEY TRENCH SURFACE.

2c. REFINE TRENCH GRADE IF NECESSARY.

STEP 3

3a. CONSTRUCT LAND WALL AND GATE MONOLITHS.

STEP 4

4a. INSTALL MAINTENCE BULKHEAD

4b. DEWATER TO EL 450

4c. EXCAVATE FOR MITER GATE SILL IN THE DRY

EXCAVATION PLAN

SCALE: 1" = 40'

40' 0 40'

PLATE 2-1

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

PLAN 1 – AUXILIARY EXTENSION DREDGE & EXCAVATION PLAN

Designed by: J.K.	Scale: AS SHOWN	Sheet reference number:	GLD_2-1.DGN
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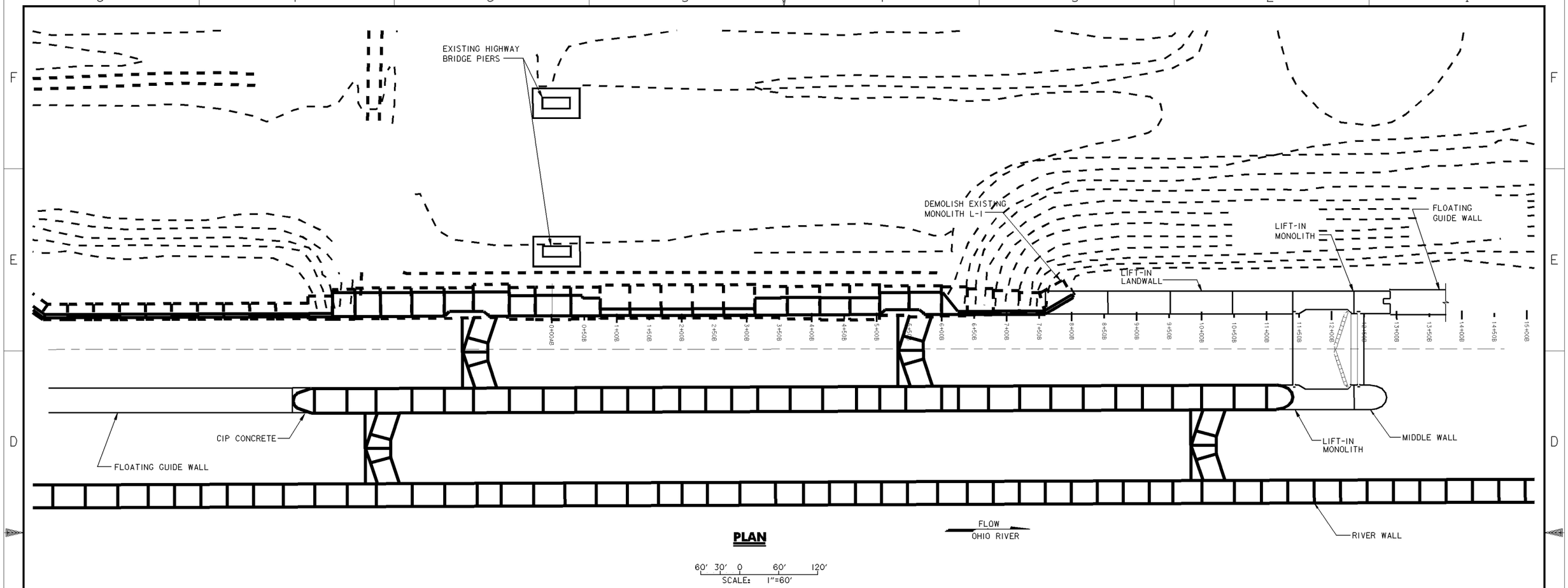

PLATE 2-2

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

PLAN 1
AUXILIARY EXTENSION

Designed by: P.P.	Scale: AS SHOWN	Sheet reference numbers	GLD_2-2.DGN
Drawn by: L.E.N.	Date: JUNE 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet X of X
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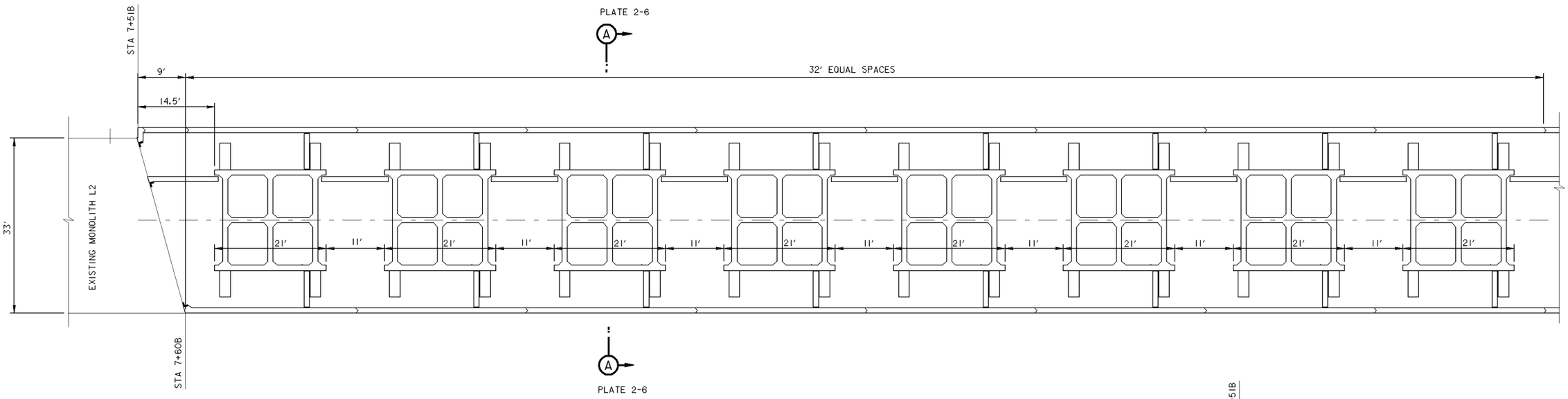

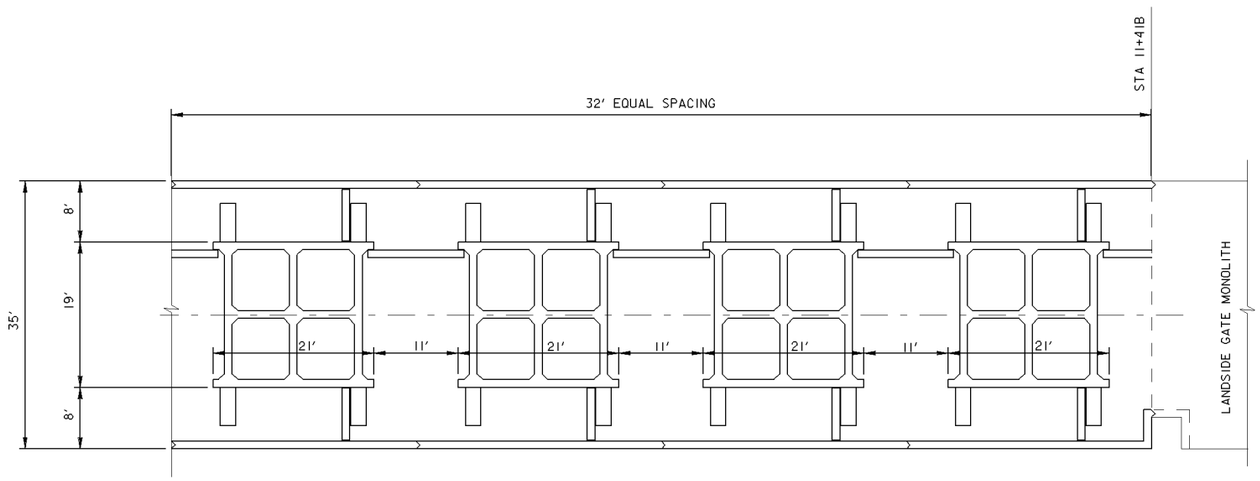

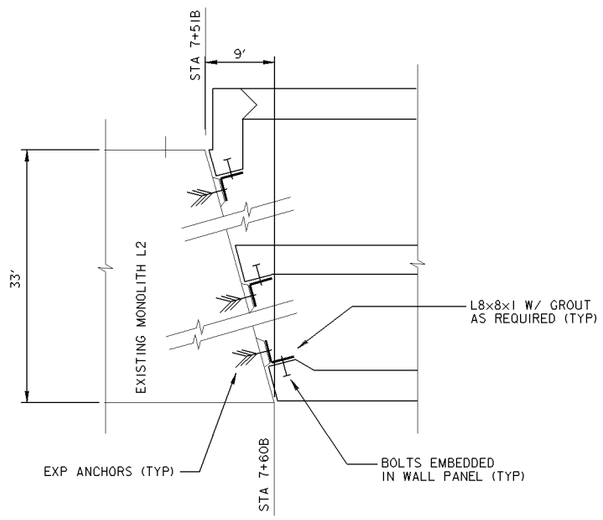

CONNECTION TO EXISTING MONOLITHS

NOT TO SCALE

LANDWALL MONOLITHS-PLAN 1

SCALE: 1"=8'

NOTE:

1. BLOCKS FOR LAND WALL WEIGH 181 TONS EACH

PLATE 2-3

Revisions			
Symbol	Descriptions	Date	Approved

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CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLAN 1
LANDWALL PLAN
WO/AUX F/E SYSTEM

Designed by: PP	Scale: AS SHOWN	Sheet reference number:	GLD_2-3.DGN
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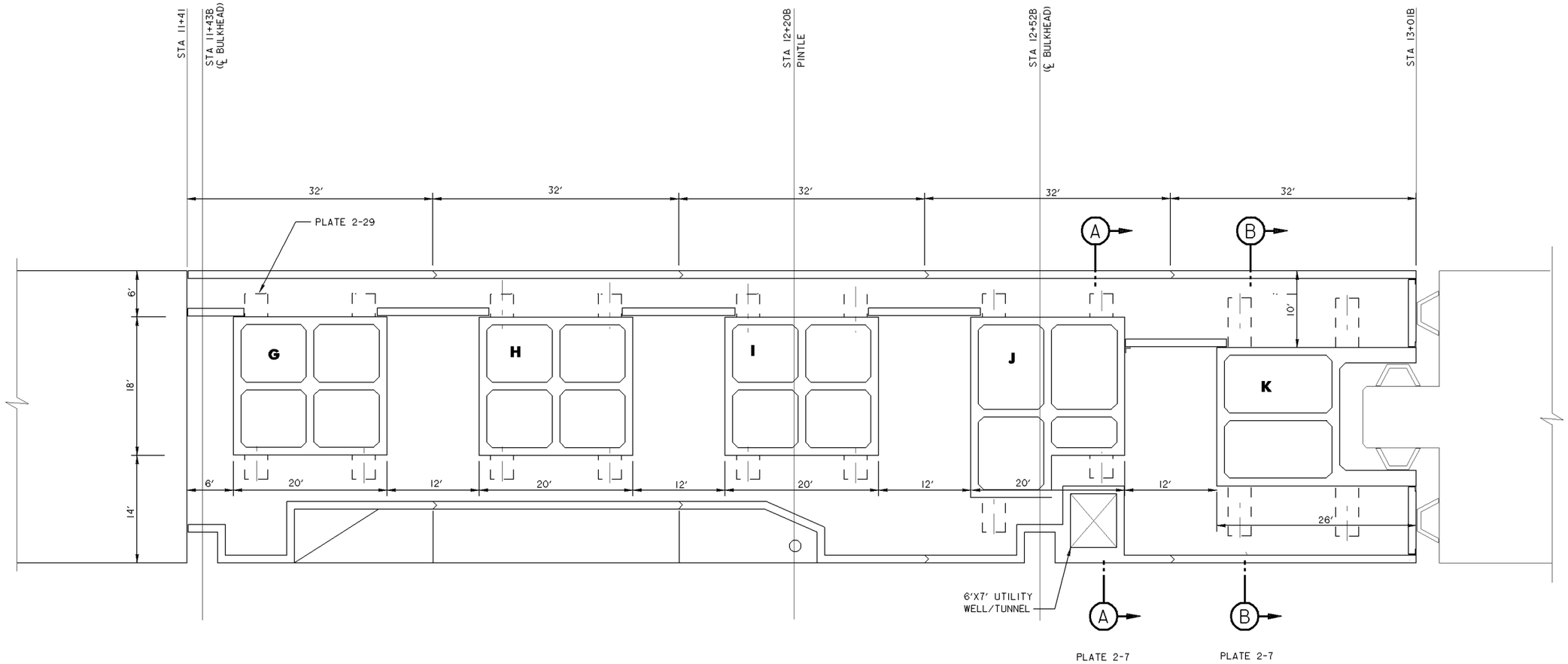

LANDSIDE GATE MONOLITH–PLAN 1

SCALE: 1″=6′

PLATE 2–4

Revisions			
Symbol	Descriptions	Date	Approved

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CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLAN 1
LANDSIDE GATE MONOLITH
WO/AUX F/E SYSTEM

Designed by: XX	Scale: AS SHOWN	Sheet reference number:	GLD_2-4.DGN
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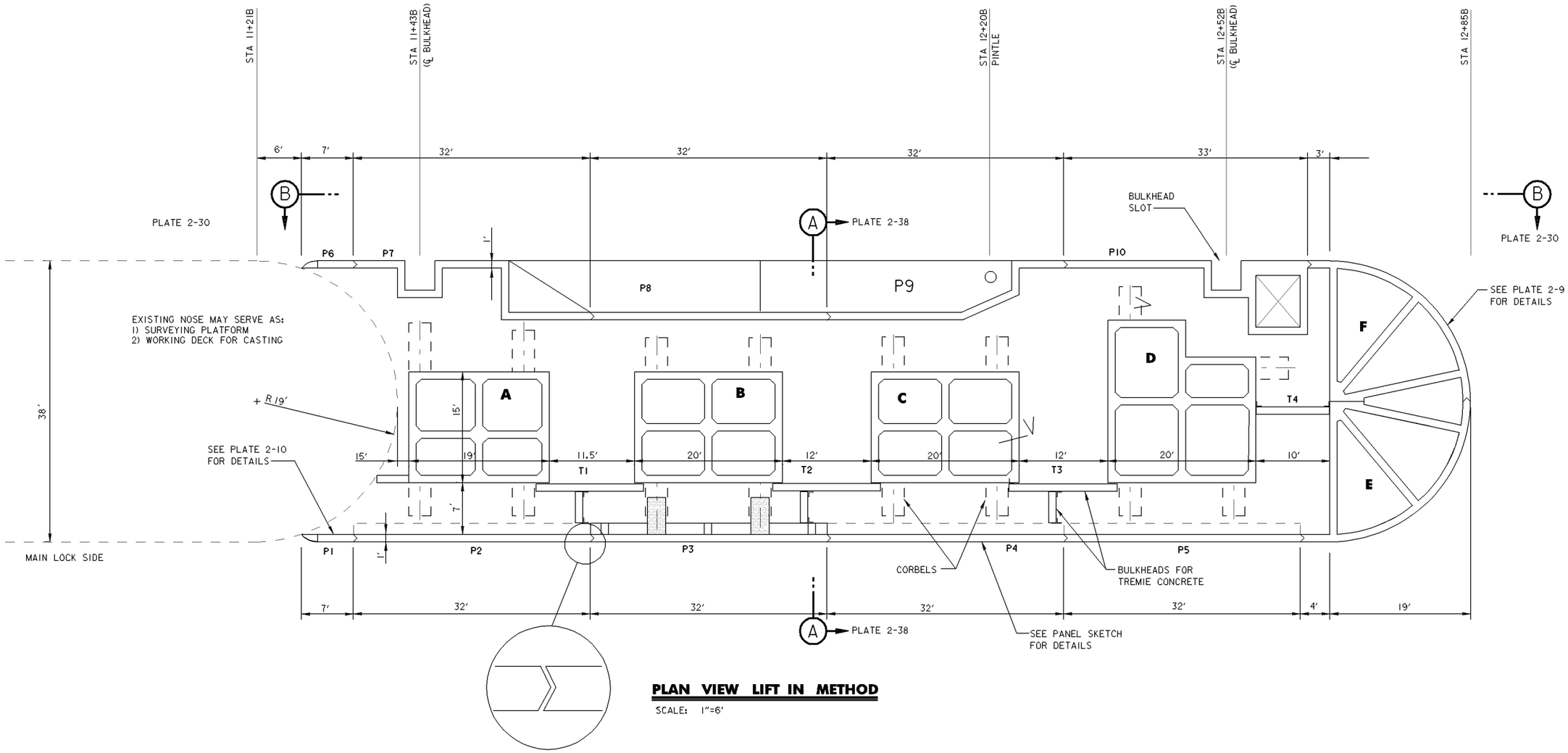

PLAN VIEW LIFT IN METHOD

SCALE: 1"=6′

PLATE 2–5

Revisions			
Symbol	Descriptions	Date	Approved

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CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLAN 1
MIDDLE WALL LIFT-IN PLAN

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Drawn by: L.T.	Date: JUNE 1999		b.ptb
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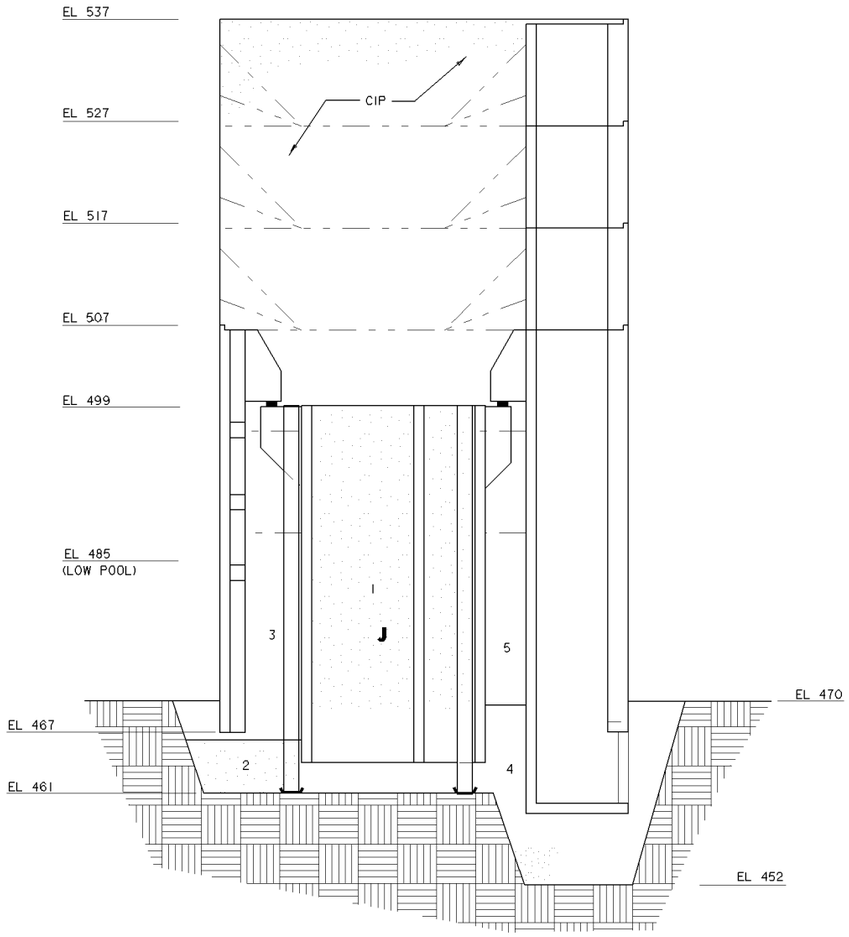
Approved by: XX			

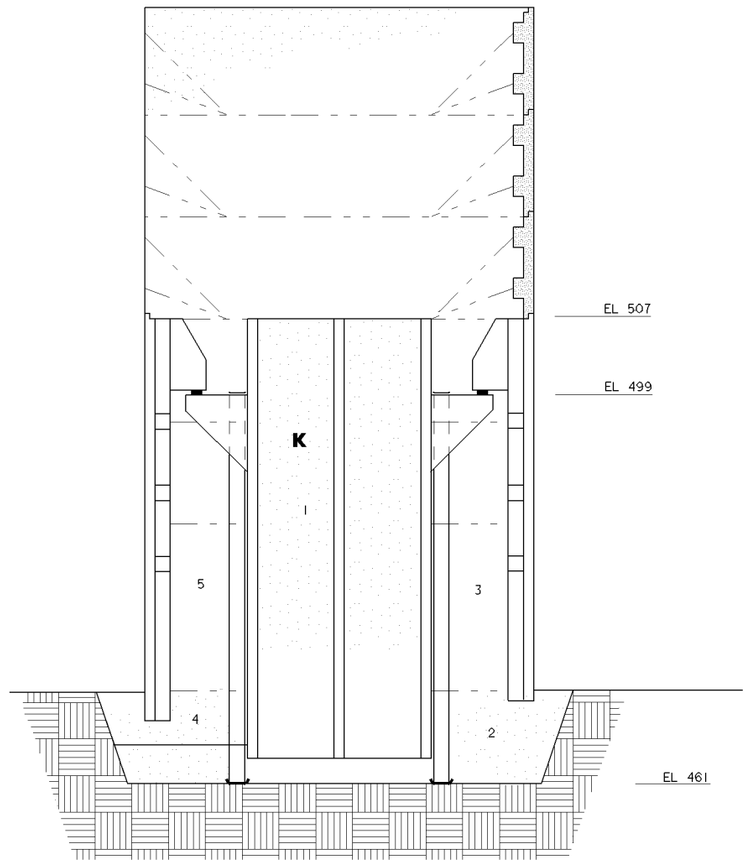


NOTES:

1. FIRST LIFT (2, 4) TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.

2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.

SECTION A–A (FROM PLATE 2–4)



NOTES:

1. FIRST LIFT (2, 4) TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.

2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.

SECTION B–B (FROM PLATE 2–4)

PLATE 2–7

Revisions			
Symbol	Descriptions	Date	Approved

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CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLAN 1
LANDSIDE GATE SECTION WO/AUX F/E SYSTEM

Designed by: G.Z.	Scale: NO TO SCALE	Sheet reference number:	GLD_2-7.DGN
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Checked by: XX	Drawing Code:		Sheet X of X
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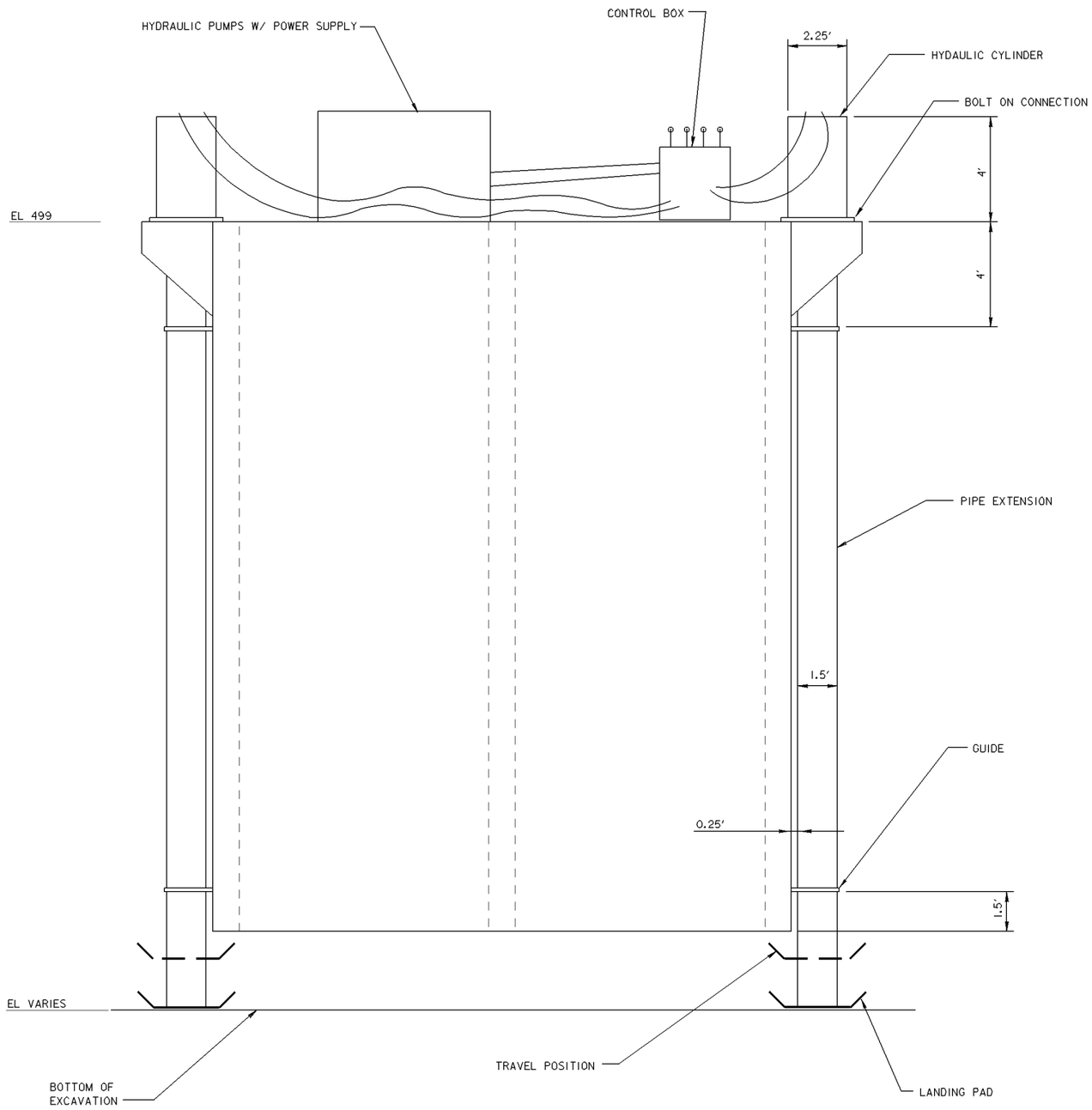
Approved by: XX			



TYPICAL BLOCK

TYPICAL HYDRAULIC CYLINDER ELEVATION

NOTE:
THIS IS A GENERALIZED HYDRAULIC SYSTEM CONFIGURATION. CYLINDERS POWER SUPPLY, PUMP, AND CONTROL BOX ARE REUSABLE.

PLATE 2–8

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
BLOCKS B,C&D PLANS

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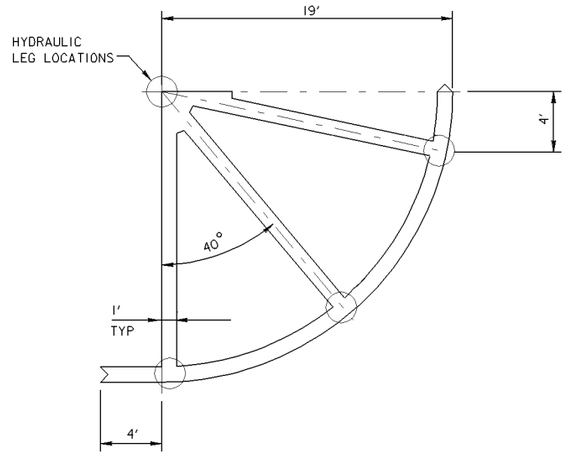
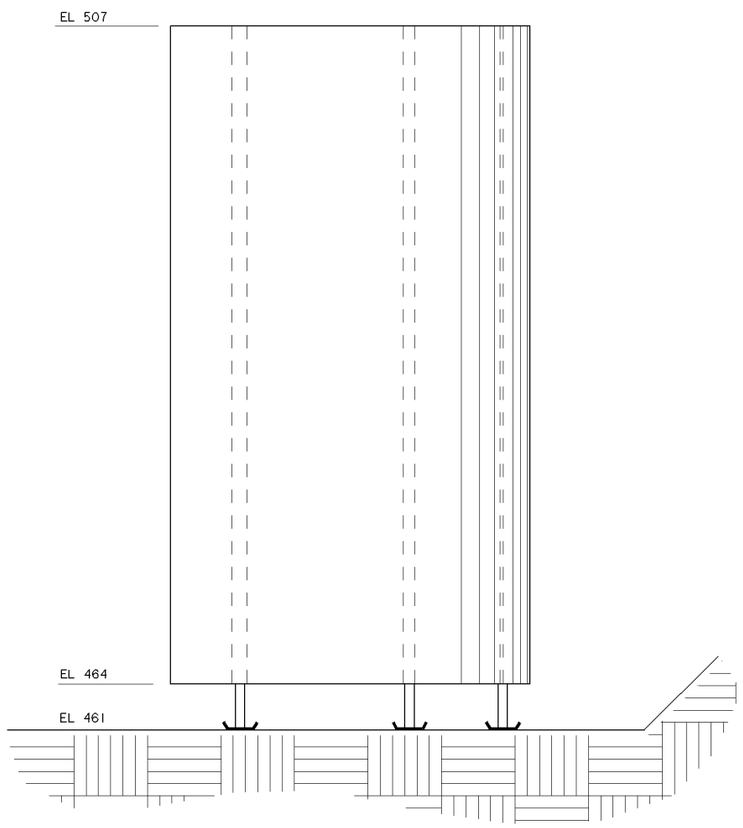
Approved by: XX			



PLAN



ELEVATION

BLOCK " E&F "

PLATE 2–9

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

BLOCKS E&F PLAN & ELEVATION

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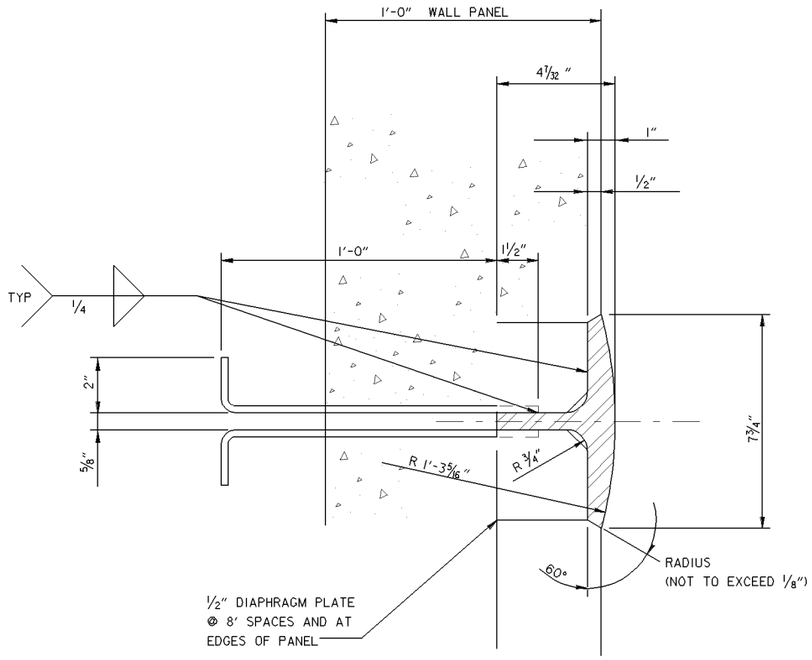
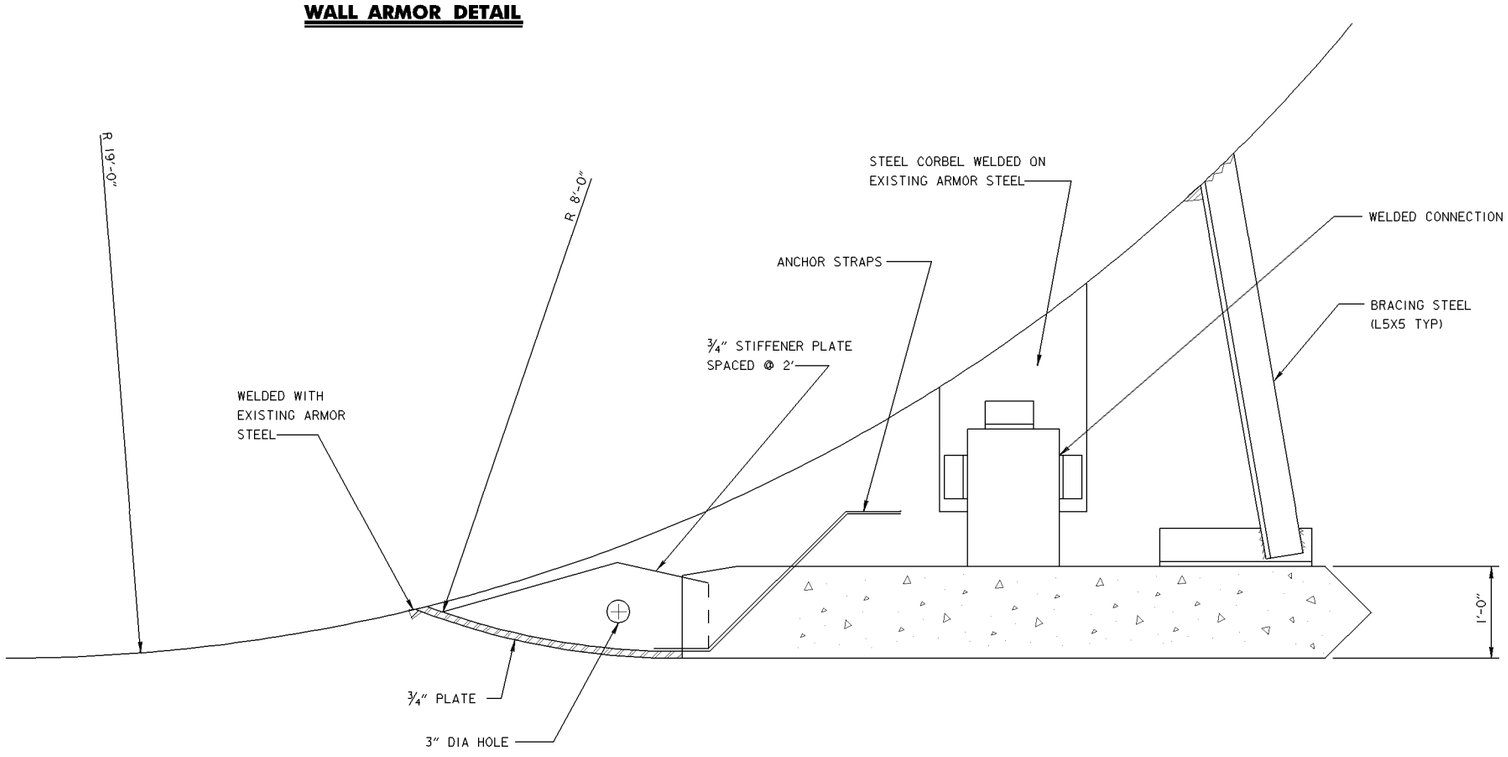


WALL ARMOR DETAIL



TRANSITION WALL PANEL (P1 & P6)

PLATE 2-10

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PANEL DETAILS

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Drawn by:	XX
Checked by:	XX
Reviewed by:	XX
Approved by:	XX
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Date:	JUNE 1999
Drawing Code:	
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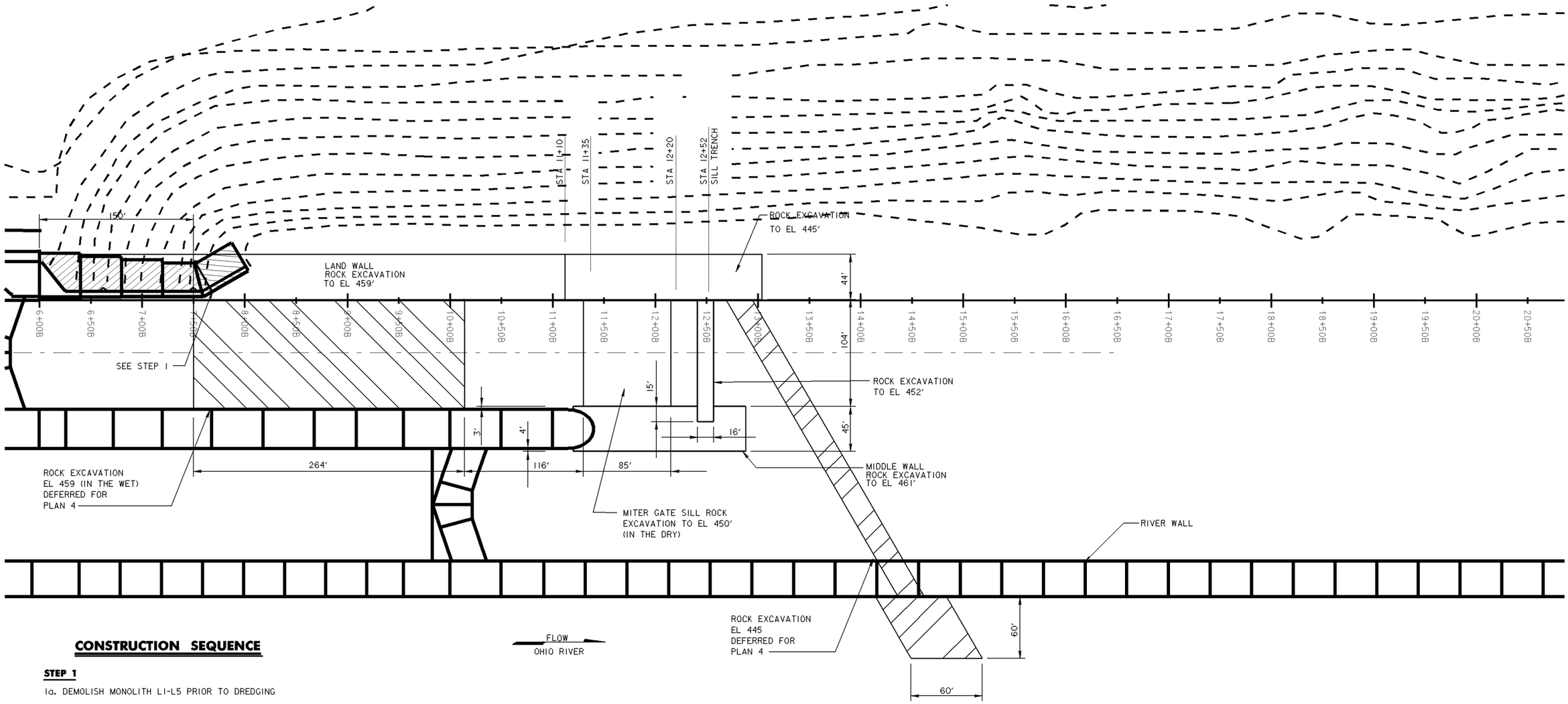
Sheet	of



CONSTRUCTION SEQUENCE

STEP 1

1a. DEMOLISH MONOLITH L1-L5 PRIOR TO DREDGING

STEP 2

2a. DREDGE FOUNDATION TRENCH.

2b. USE SHALLOW WATER ACOUSTIC BED SCANNER TO SURVEY TRENCH SURFACE.

2c. REFINE TRENCH GRADE IF NECESSARY.

STEP 3

3a. CONSTRUCT LAND WALL AND GATE MONOLITHS.

STEP 4

4a. INSTALL MAINTENANCE BULKHEAD

4b. DEWATER TO EL 450

4c. EXCAVATE FOR MITER GATE SILL IN THE DRY

EXCAVATION PLAN
ALTERNATES 2,3,4

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

PLATE 2-11

Revisions			
Symbol	Descriptions	Date	Approved

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U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2, 3 & 4
DREDGE & EXCAVATION PLAN
AUXILIARY EXTENSION W/CULVERT

Designed by: J.K.	Scale: AS SHOWN	Sheet reference number:	GLD_2-11.DGN
Drawn by: L.T.	Date: JUNE 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet X of X
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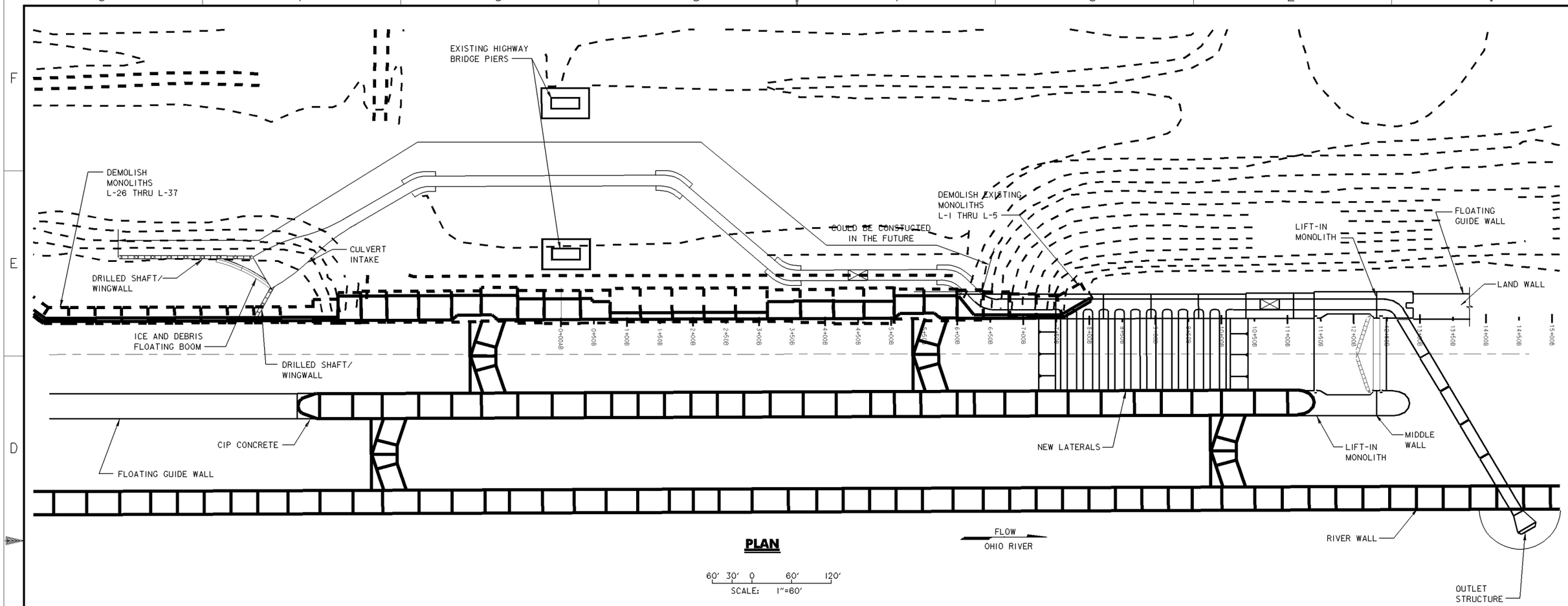

PLAN

60′ 30′ 0 60′ 120′
SCALE: 1″=60′

PLAN 2

PLATE 2–12

Revisions			
Symbol	Descriptions	Date	Approved

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U.S.ARMY ENGINEER DISTRICT
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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

PLAN 2
AUX. EXTENSION MODIFIED

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Drawn by: L.E.N.			
Checked by: XX			
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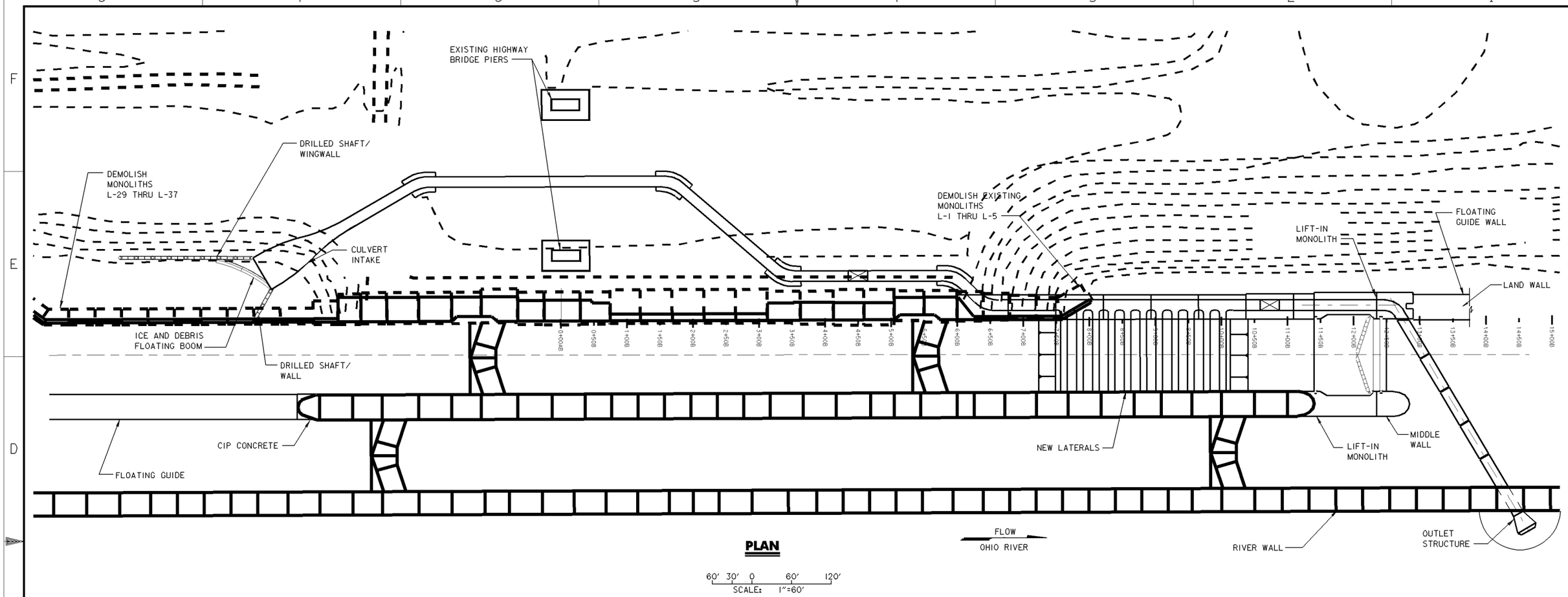

PLAN

60′ 30′ 0 60′ 120′
SCALE: 1″=60′

PLAN 3

PLATE 2–13

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLAN 3
AUX. EXTENSION W/CULVERT

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Drawn by: L.E.N.			
Checked by: XX			
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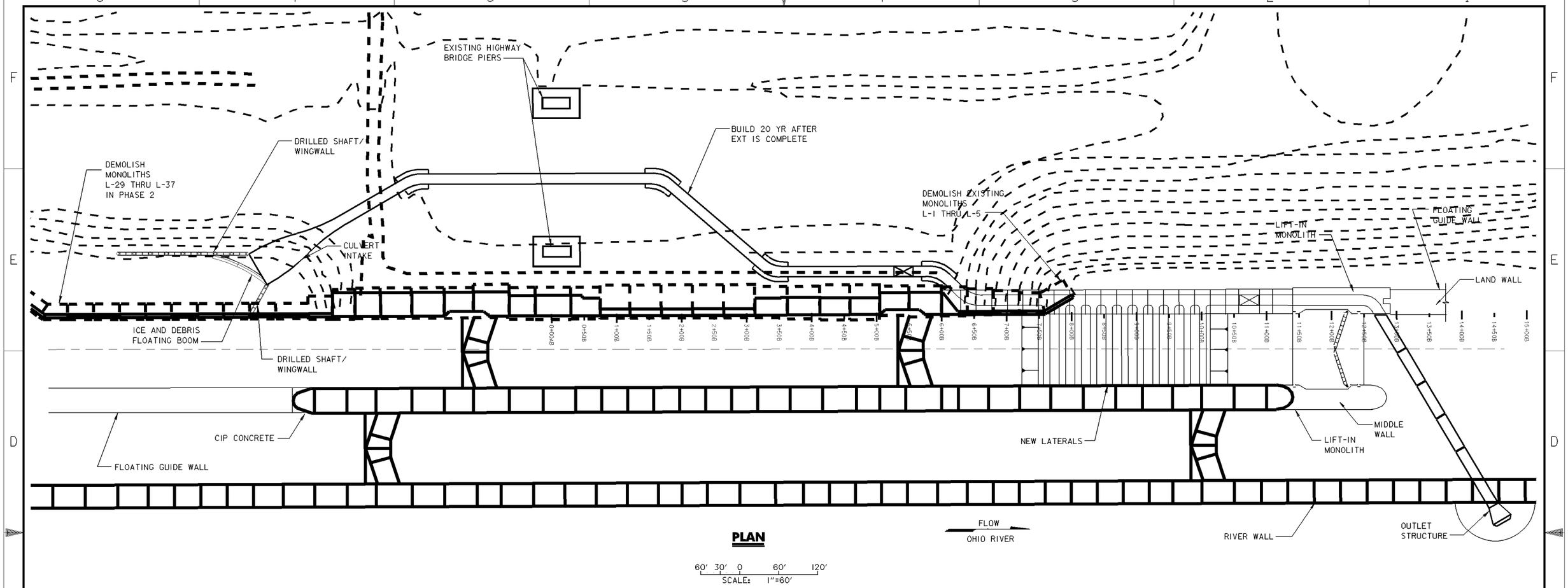

PLAN

PLAN 4

PLATE 2-14

Revisions			
Symbol	Descriptions	Date	Approved

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U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

PLAN 4

AUX. EXT. PHASED CONSTRUCTION

Designed by: P.P.	Scale: AS SHOWN	Sheet reference numbers	GLD_2-14.DGN
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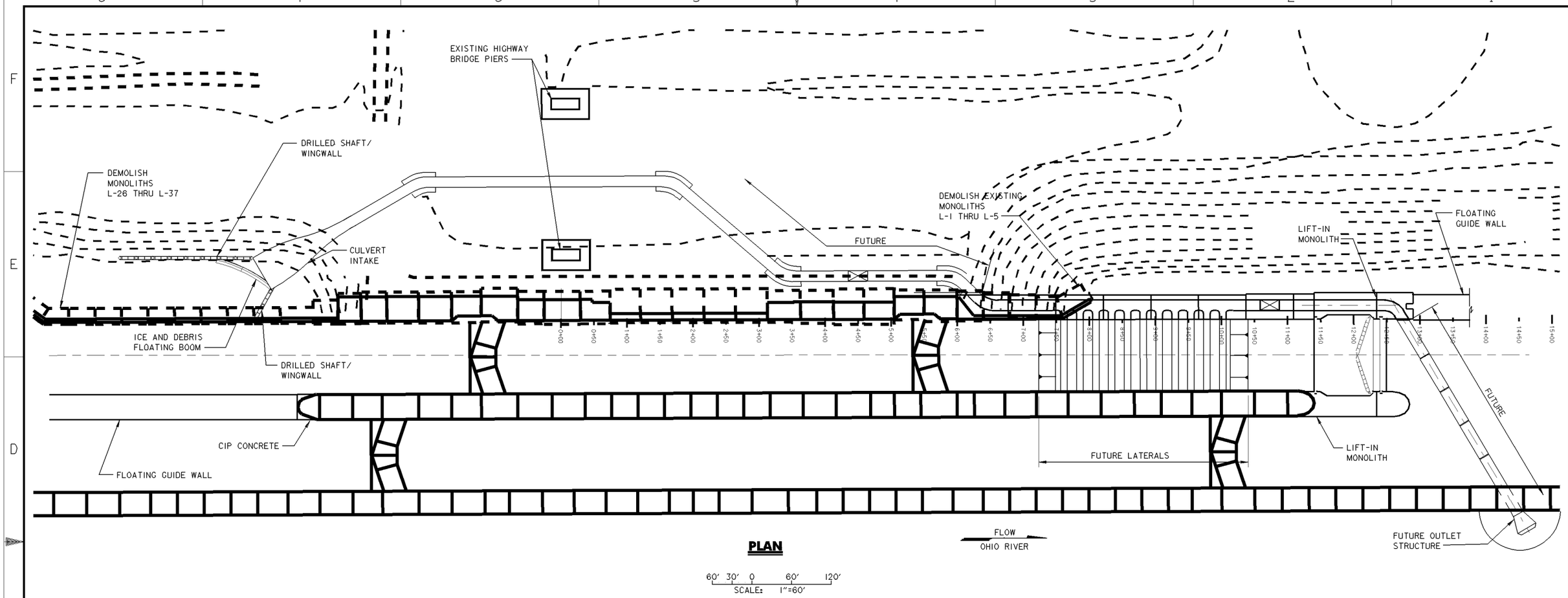

PLAN

PLAN 1B

PLATE 2-15

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

PLAN 1B

AUX. EXTENSION CAPABLE

Designed by: P.P.	Scale: AS SHOWN	Sheet reference numbers	GLD_2-15.DGN
Drawn by: L.E.N.	Date: JUNE 1999		b.ptb
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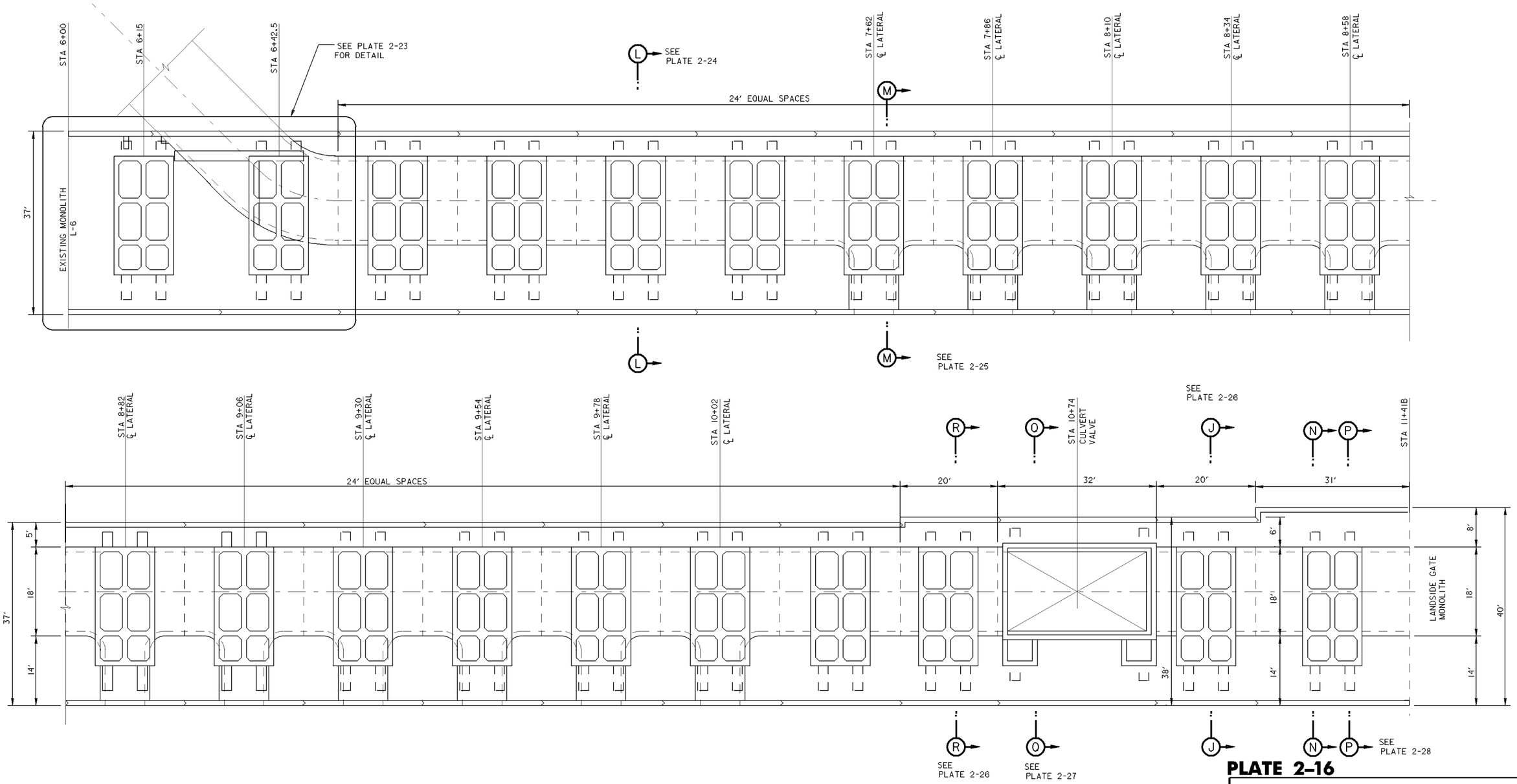

PLATE 2–16

LANDWALL MONOLITHS–PLANS 2,3,4

SCALE: 1"=8'

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2, 3 & 4
LANDWALL MONOLITH PLAN

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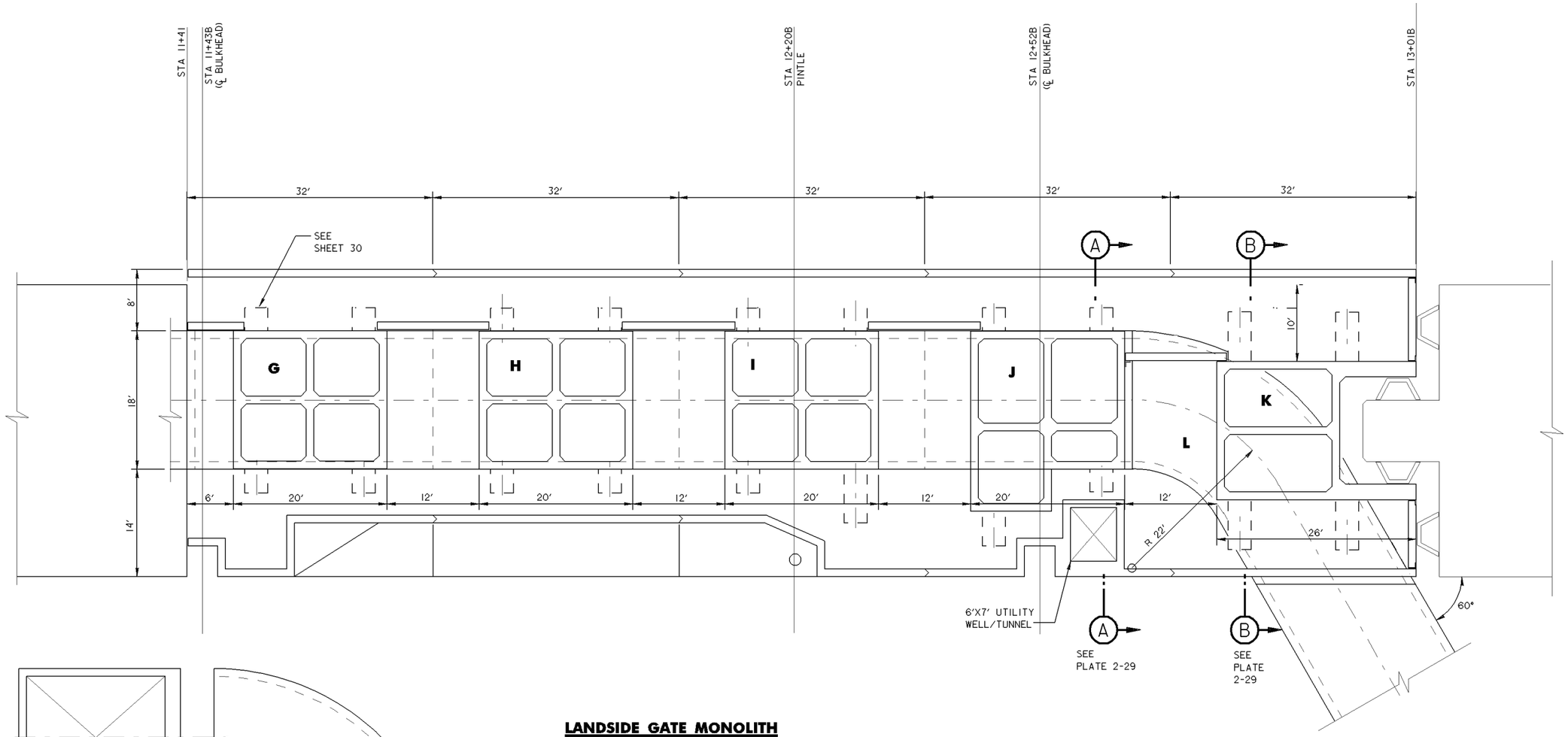
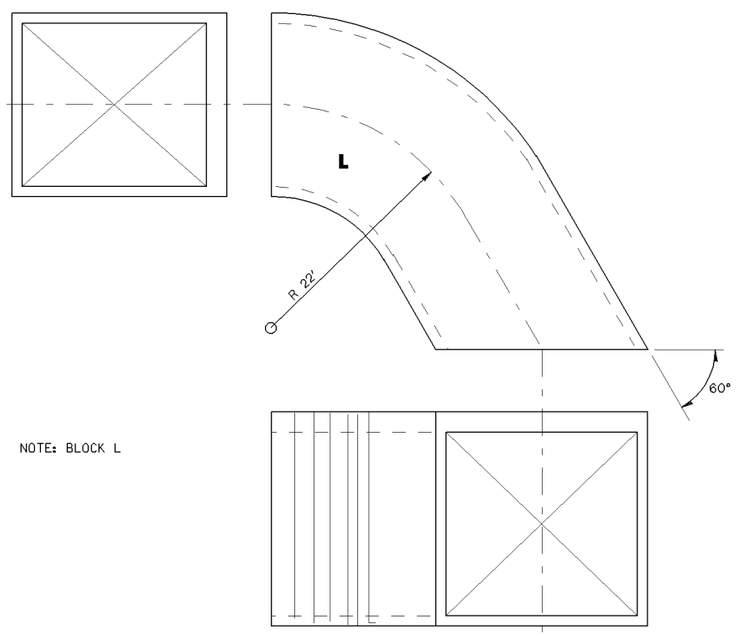


LANDSIDE GATE MONOLITH

SCALE: 1"=6'



NOTE: BLOCK L

CULVERT

PLATE 2-17

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3,&4
LANDSIDE GATE MONOLITH
W/AUX F/E SYSTEM

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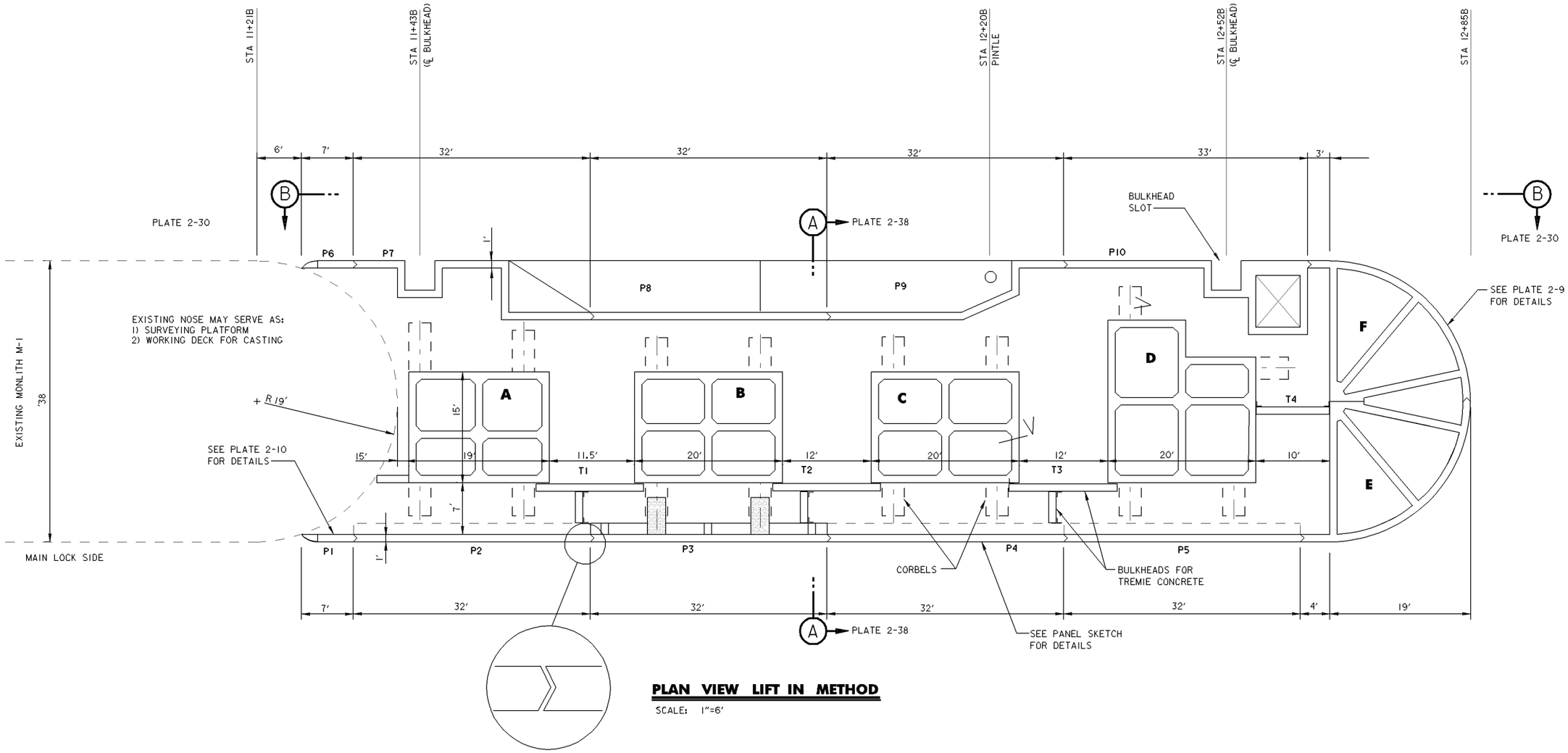

PLAN VIEW LIFT IN METHOD

SCALE: 1"=6′

PLATE 2–18

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3,&4
MIDDLE WALL LIFT-IN PLAN

Designed by:	XX
Drawn by:	L.T.
Checked by:	XX
Reviewed by:	XX
Approved by:	XX
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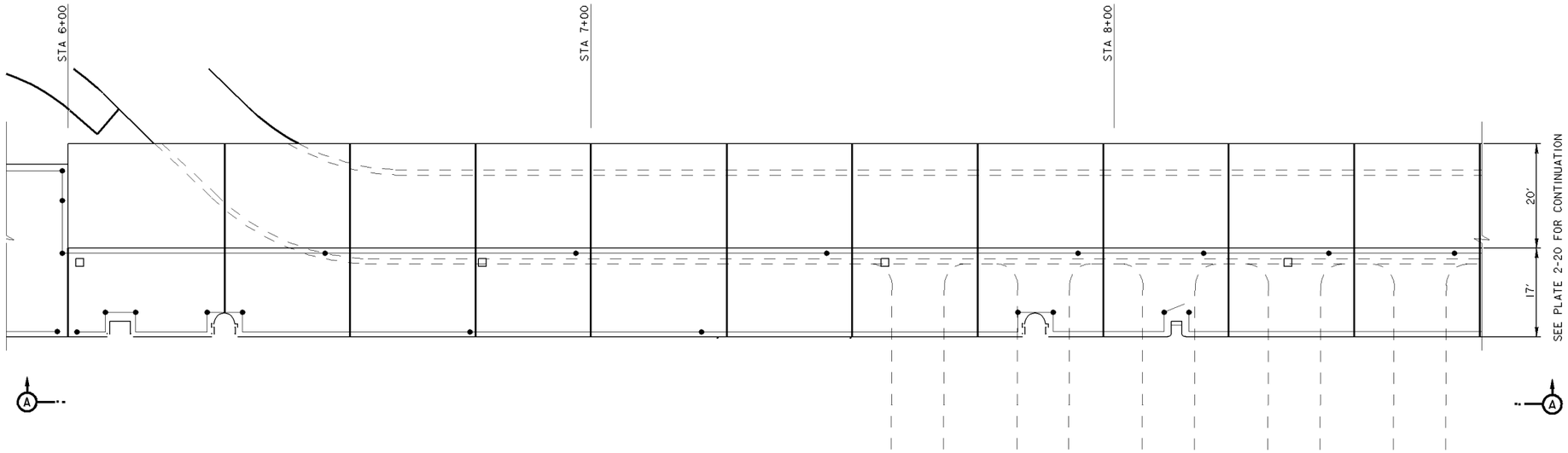
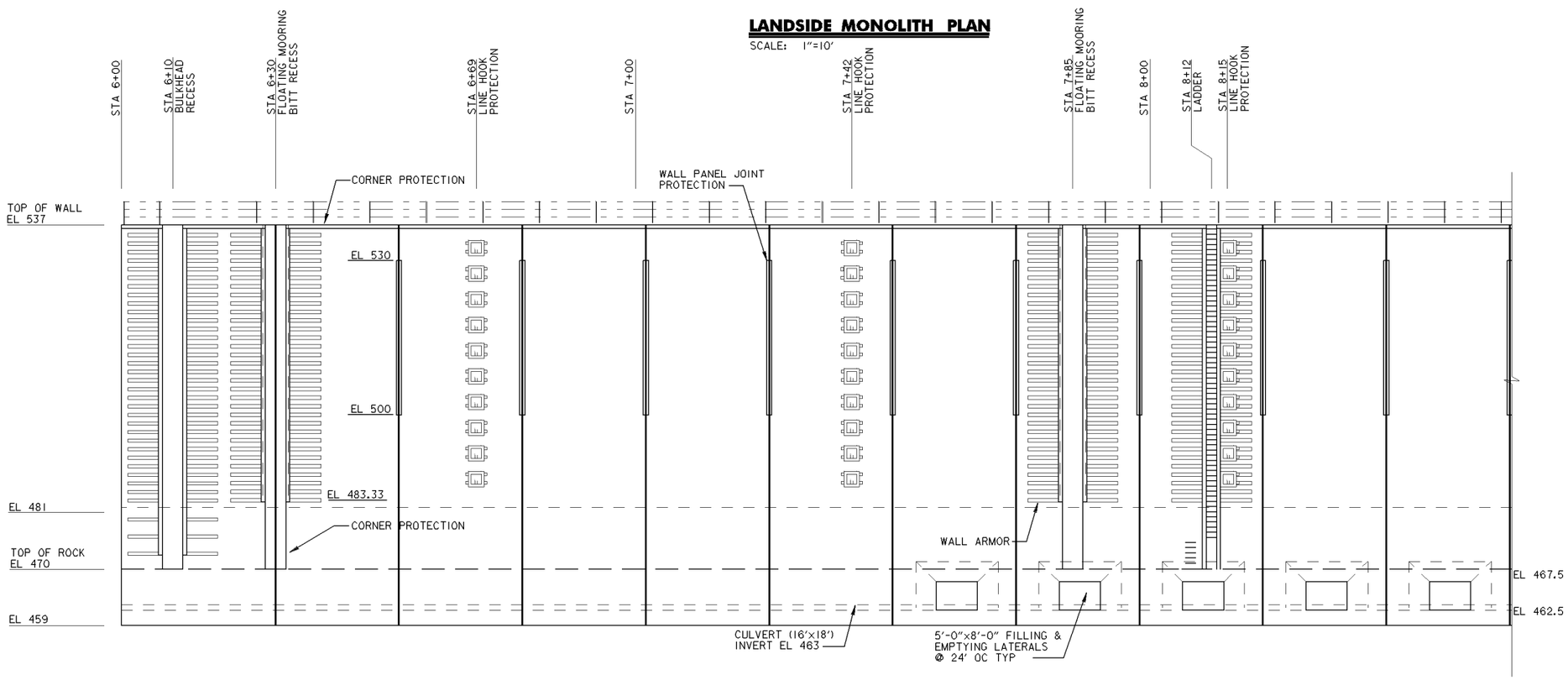


LANDSIDE MONOLITH PLAN

SCALE: 1"=10'



SECTION A–A

SCALE: 1"=10'

PLATE 2–19

Revisions			
Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDSIDE PLAN & ELEVATION
W/AUX. F/E SYSTEM

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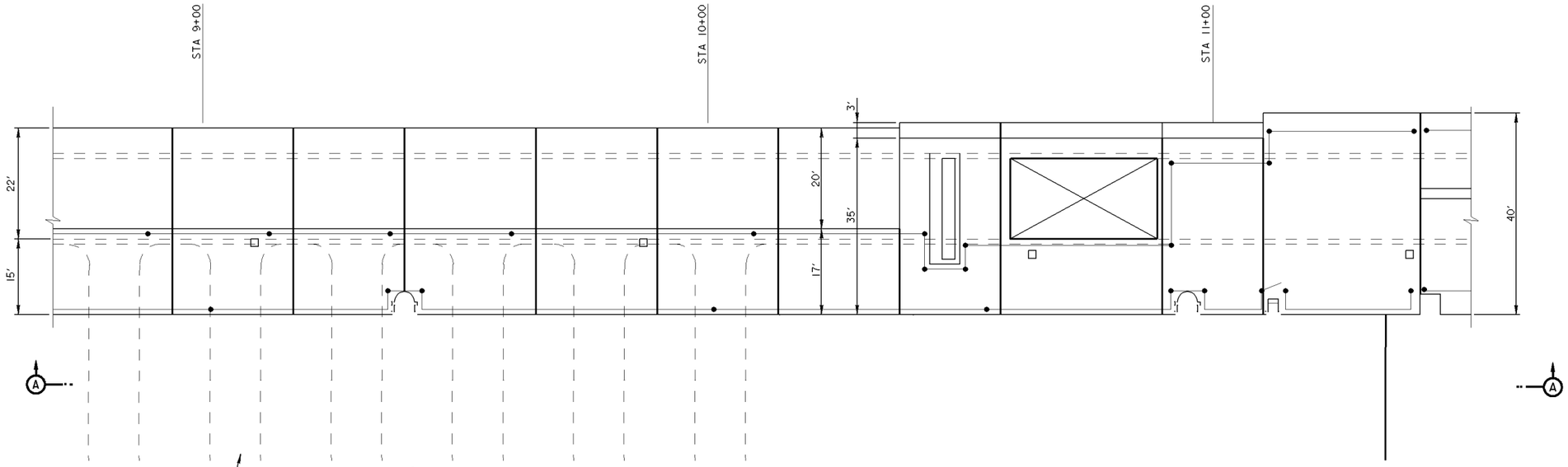
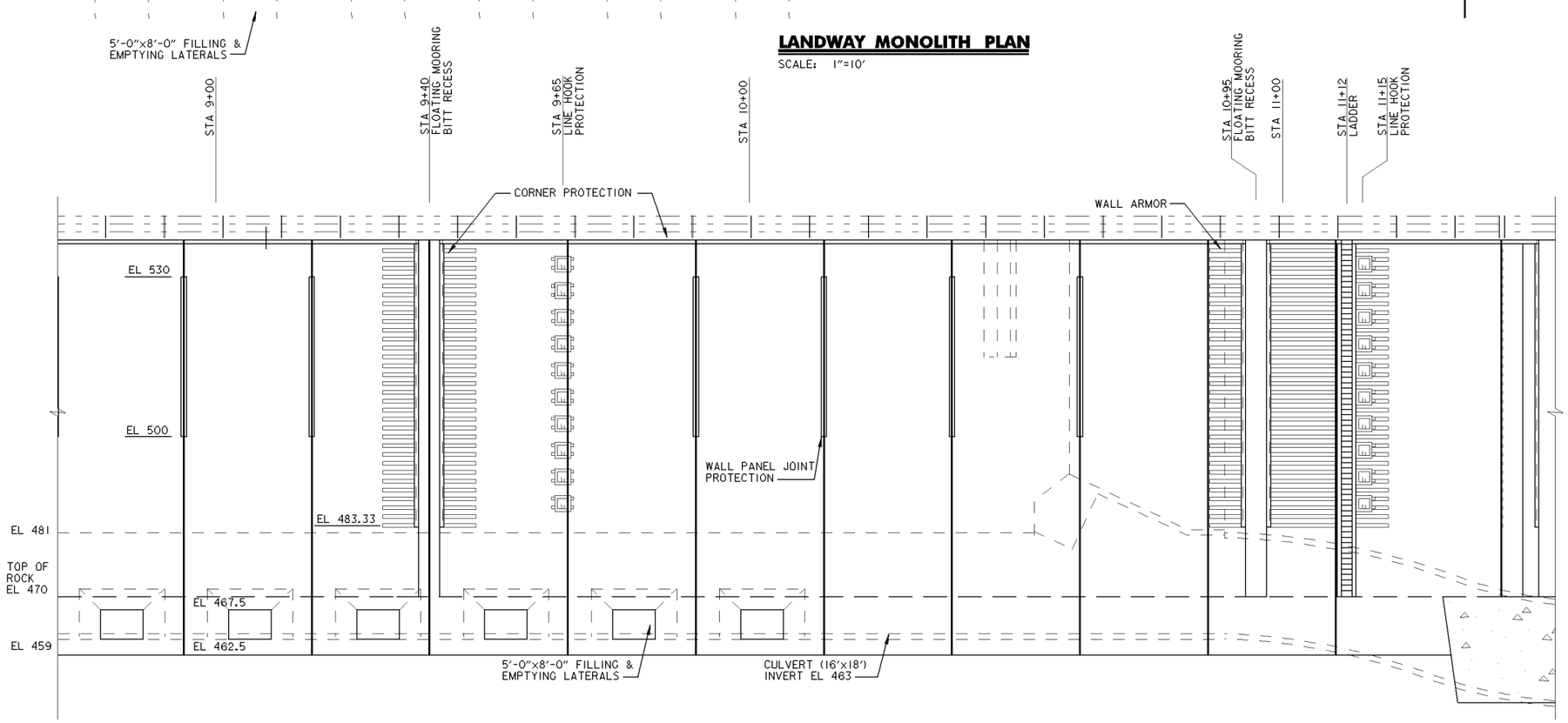


LANDWAY MONOLITH PLAN

SCALE: 1"=10'



SECTION A-A

SCALE: 1"=10'

PLATE 2-20

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

PLANS 2,3&4
LANDSIDE PLAN & ELEVATION
W/AUX F/E SYSTEM

Designed by: P.P	Scale: AS SHOWN	Sheet reference number:	GLD_2-20.DGN
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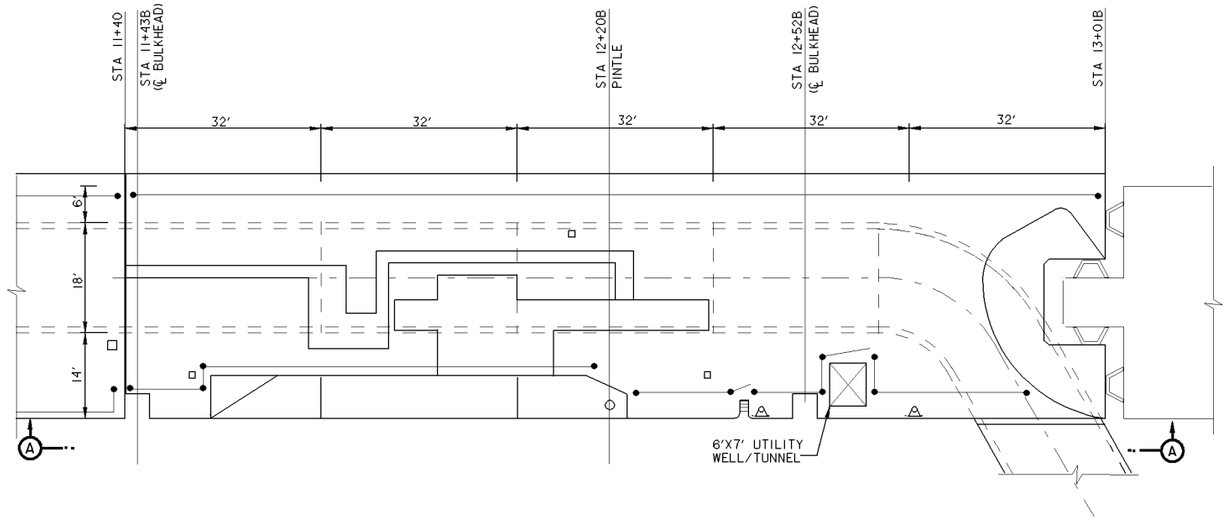
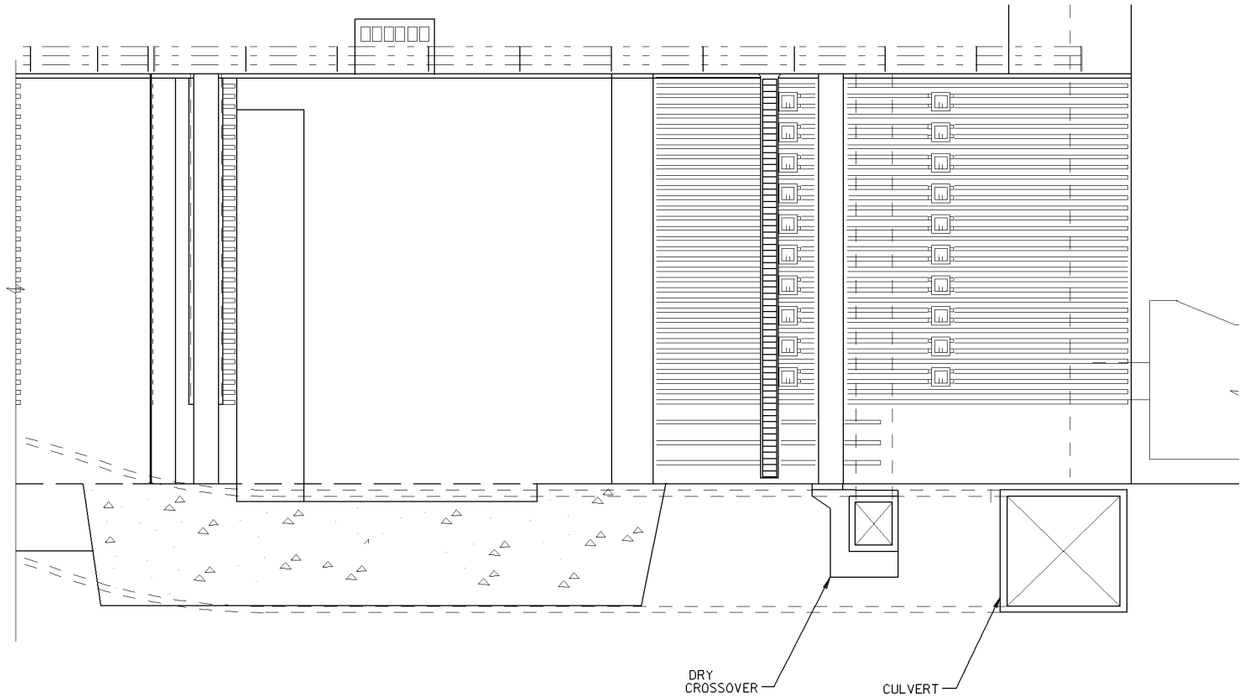


LANDSIDE GATE MONOLITH PLAN

SCALE: 1"=10'



SECTION A-A

SCALE: 1"=10'

PLATE 2-21

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDSIDE GATE PLAN & ELEVATION
W/AUX F/E SYSTEM

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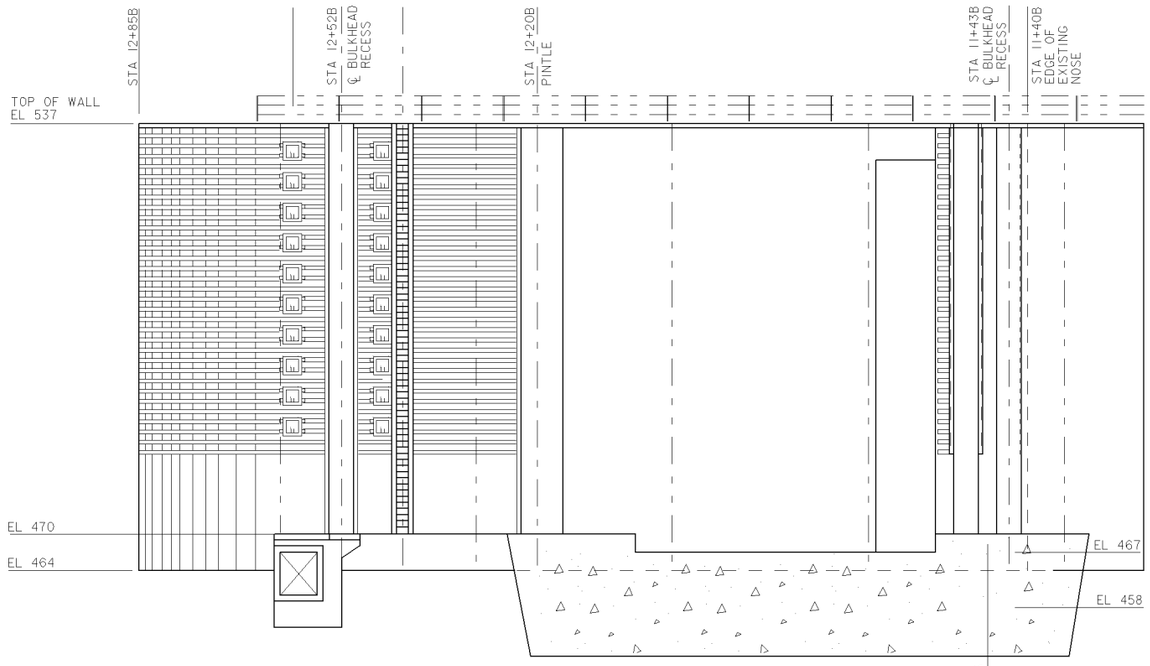
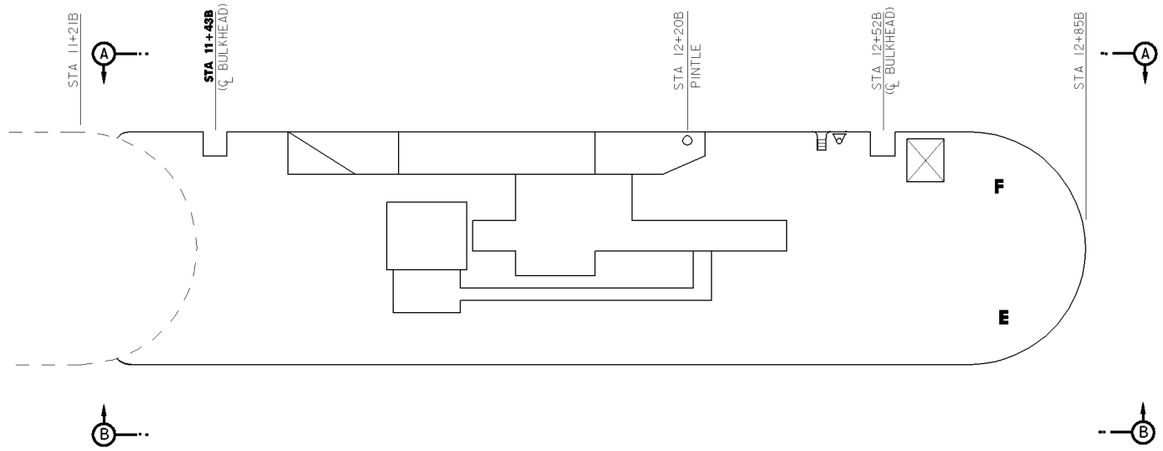
Reviewed by: XX			
Approved by: XX			



ELEVATION A–A



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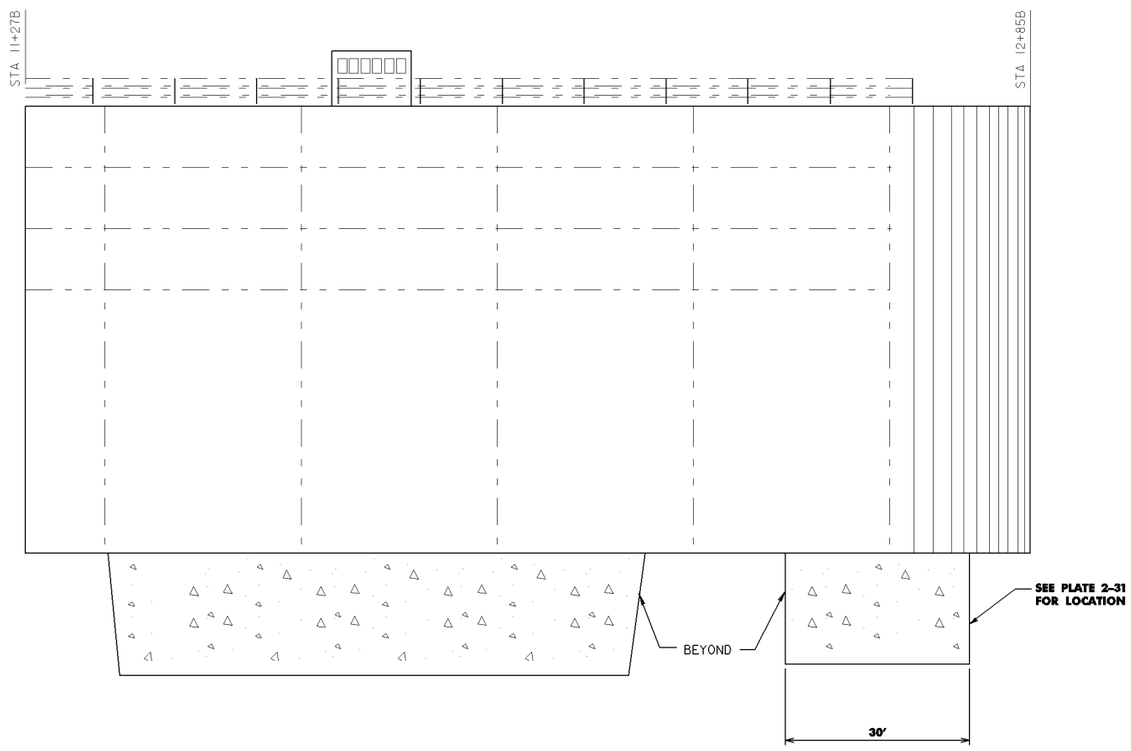

ELEVATION B–B

PLATE 2–22

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

MIDDLE WALL PLAN & ELEVATIONS

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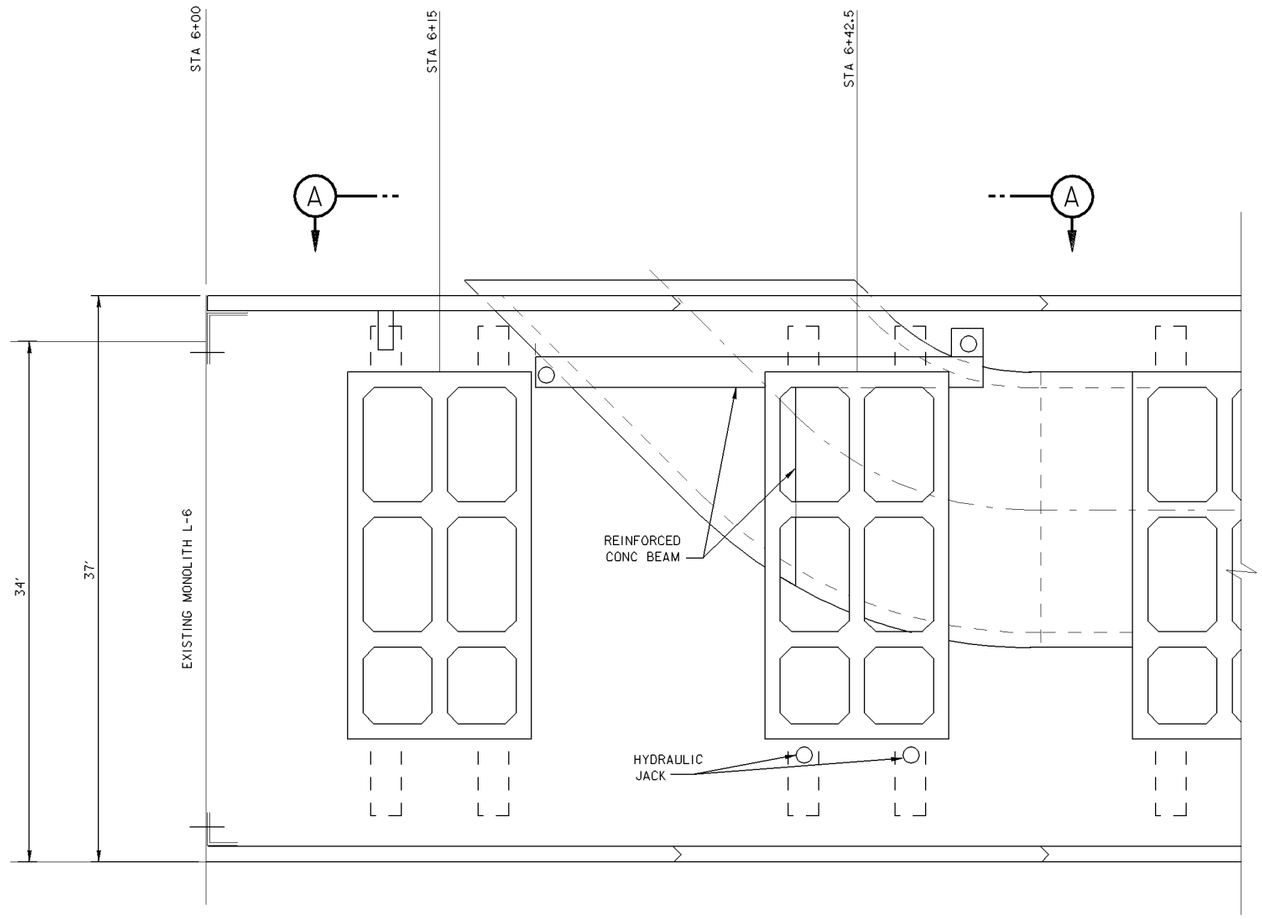
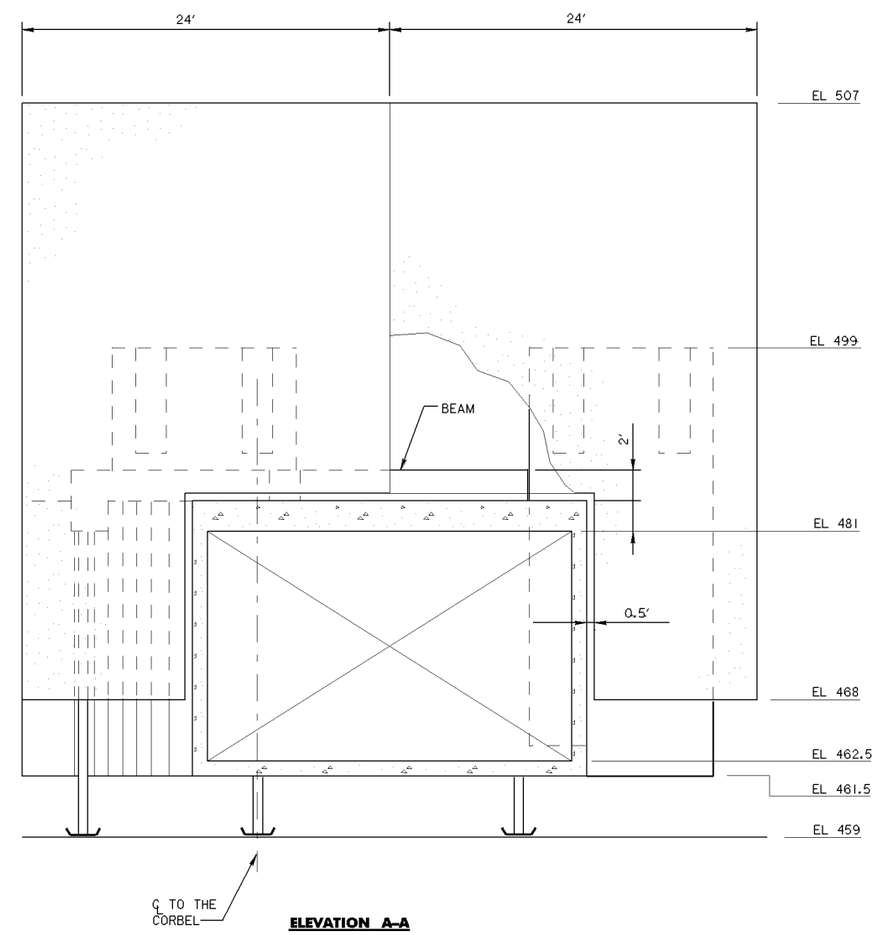


PARTIAL PLAN



ELEVATION A-A

LANDWALL MONOLITHS-PLANS 2,3,4

SCALE: 1"=4'

PLATE 2-23

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3,4
LANDWALL MONOLITH PLAN
W/AUX F/E SYSTEM

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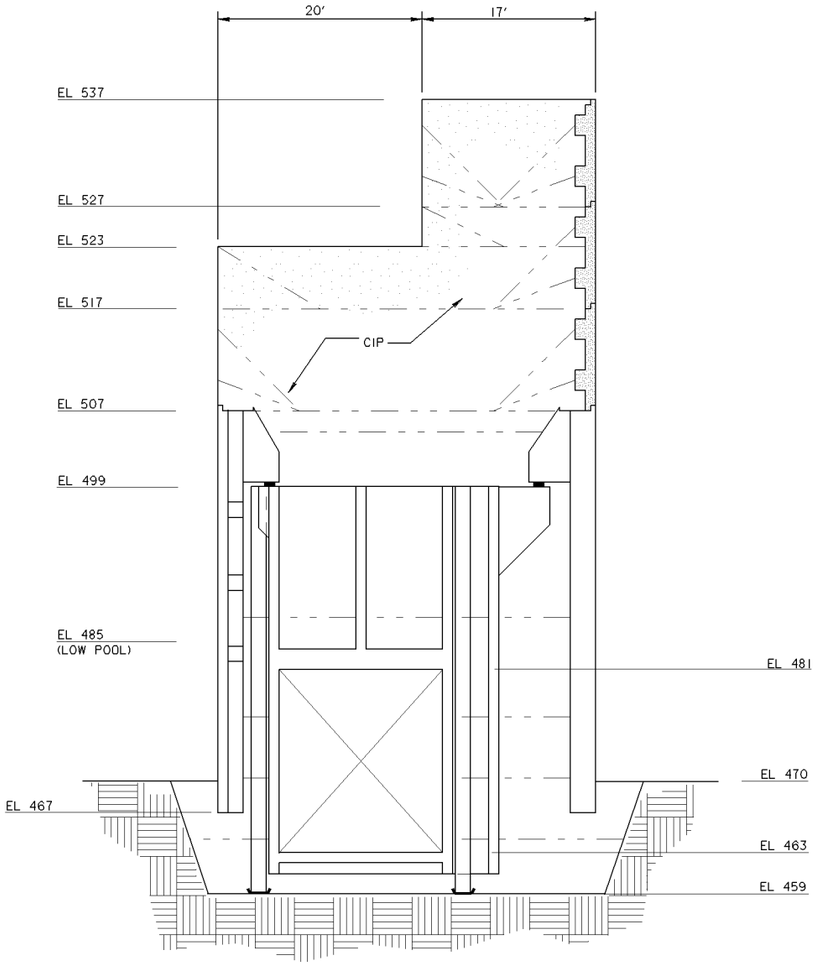
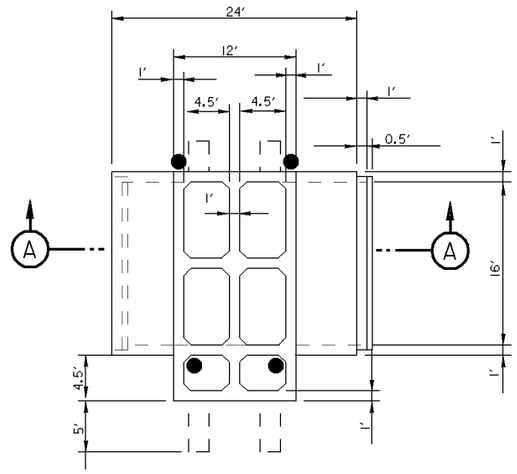
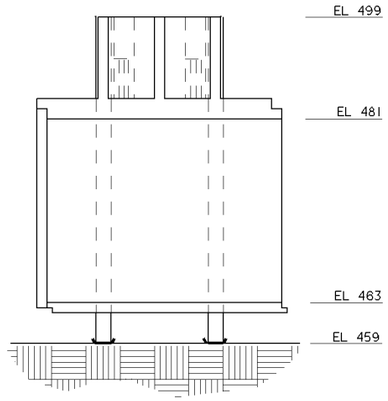


SECTION L-L (FROM PLATE 2-16)



PLAN



ELEVATION

SECTION A-A

NOTES:

1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.

PLATE 2-24

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDWALL MONOLITH SECTIONS
W/AUX F/E SYSTEM

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Drawn by: L.T.	Date: JUNE 1999		b.ptb
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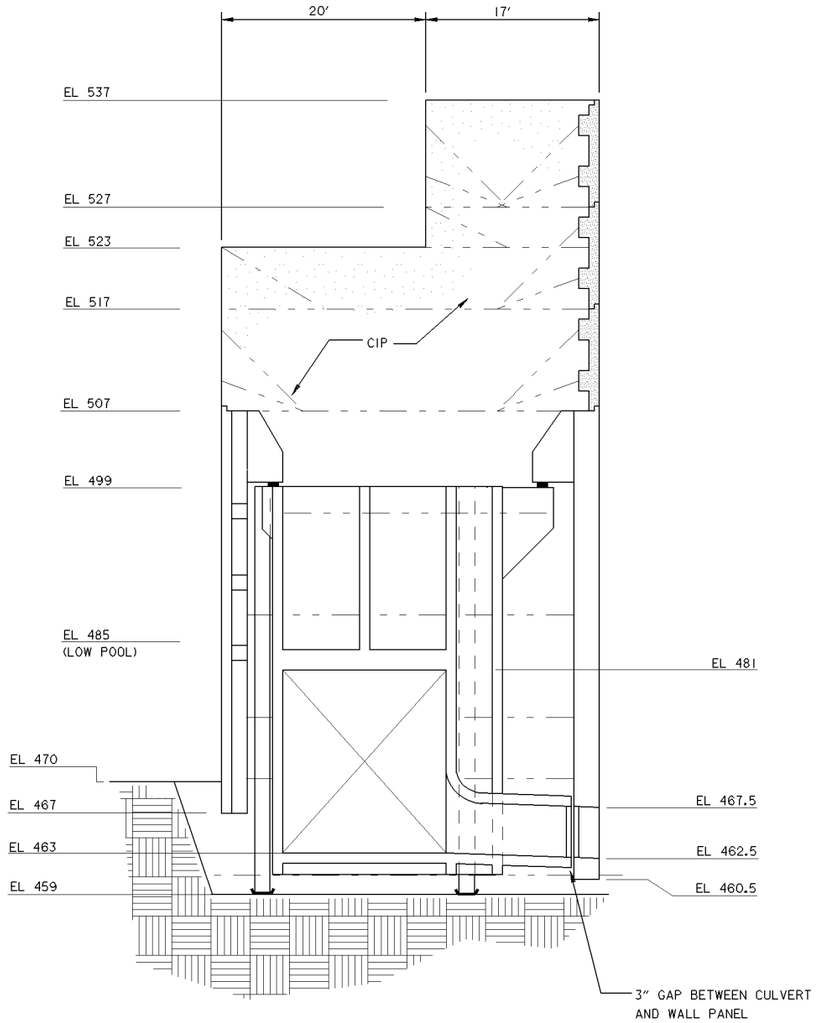
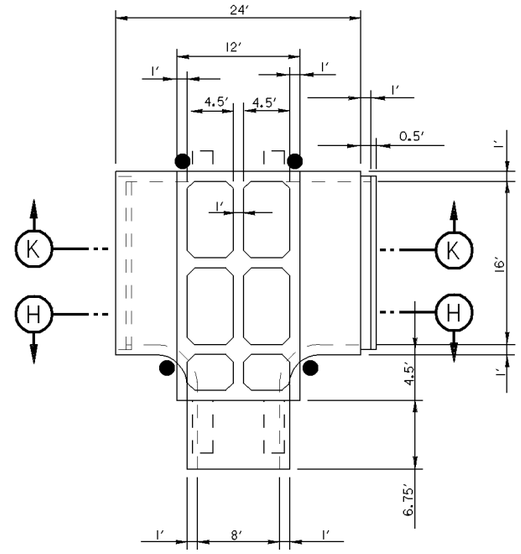
Reviewed by: XX			
Approved by: XX			



SECTION M–M (FROM PLATE 2–16)



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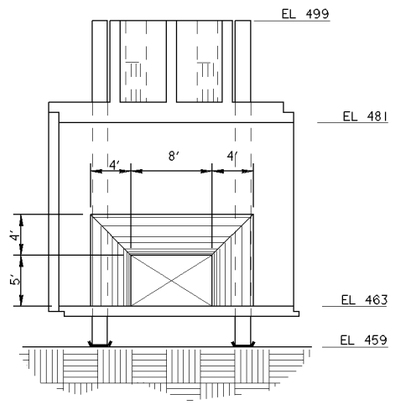

ELEVATION

SECTION H–H

NOTES:

1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.
4. PROVIDE KNOCKOUT PANELS AT THE END OF THE CULVERT OUTLET TO THE LATERAL, AND IN THE WALL PANEL. REMOVE KNOCKOUTS AND 3″ GAP AFTER TREMIE HAS SET.

PLATE 2–25

Revisions			
Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDWALL MONOLITH SECTIONS
W/AUX F/E SYSTEM

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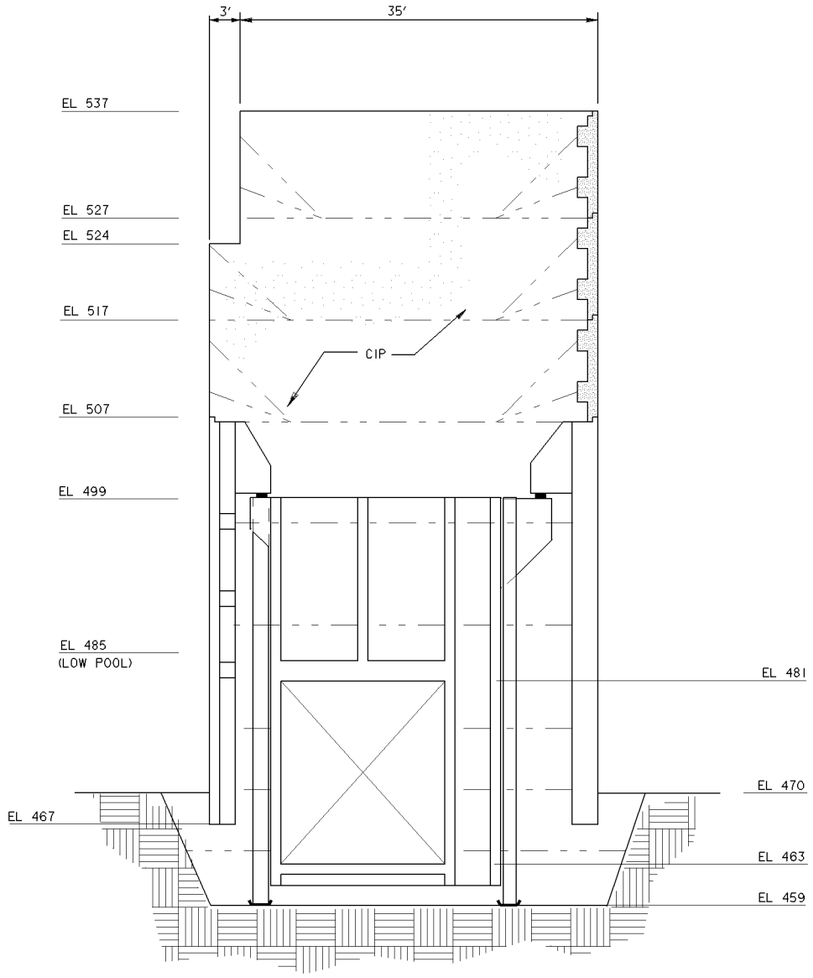

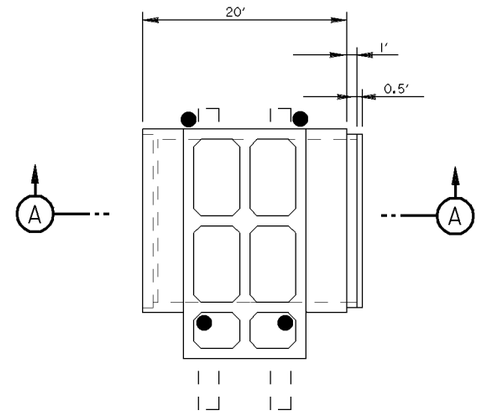

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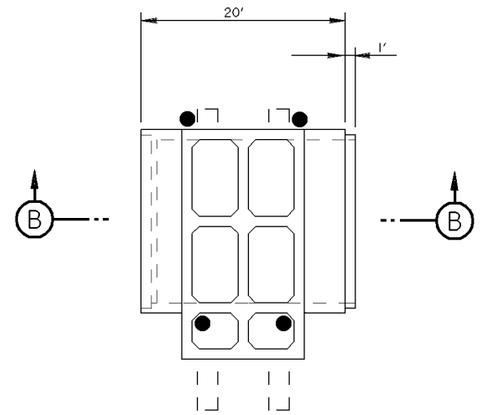

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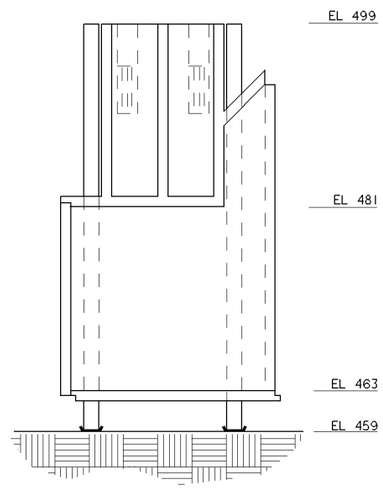
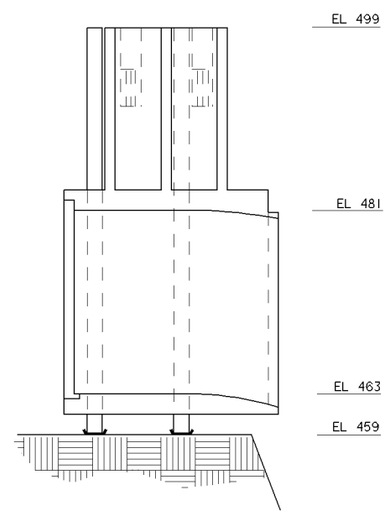


ELEVATION

SECTION A-A



ELEVATION

SECTION B-B

NOTES:

1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.

SECTIONS J-J & R-R (FROM PLATE 2-16)

PLATE 2-26

Revisions

Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDWALL MONOLITH SECTIONS
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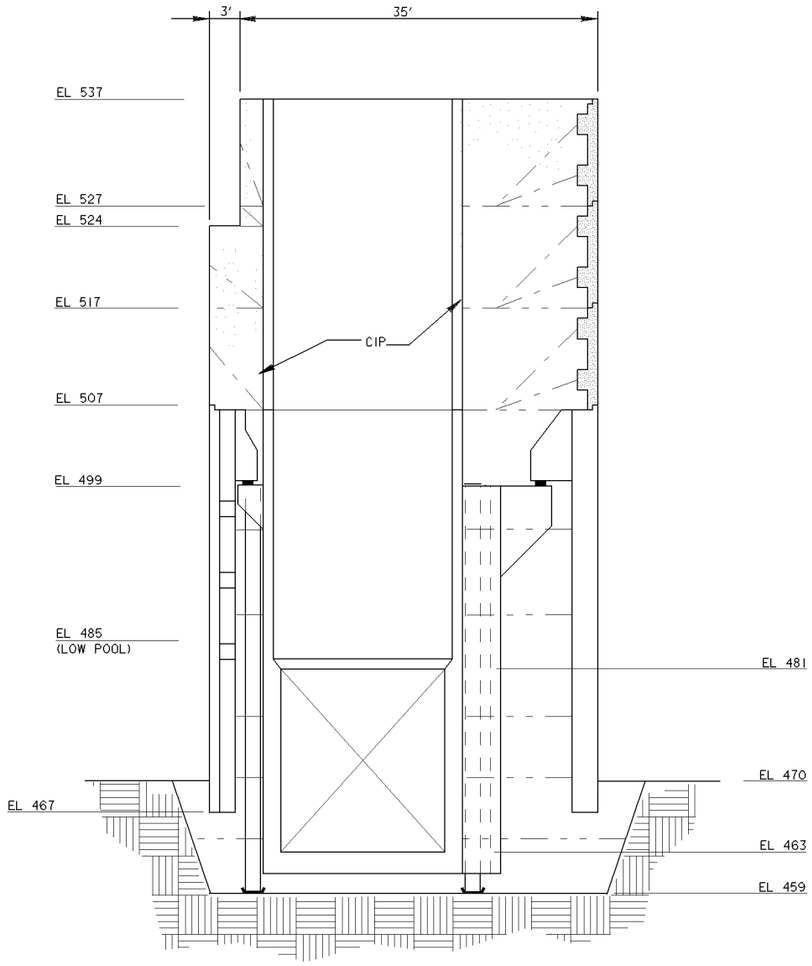

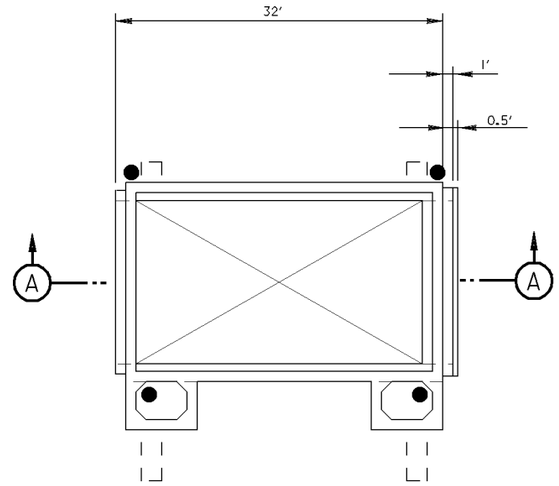

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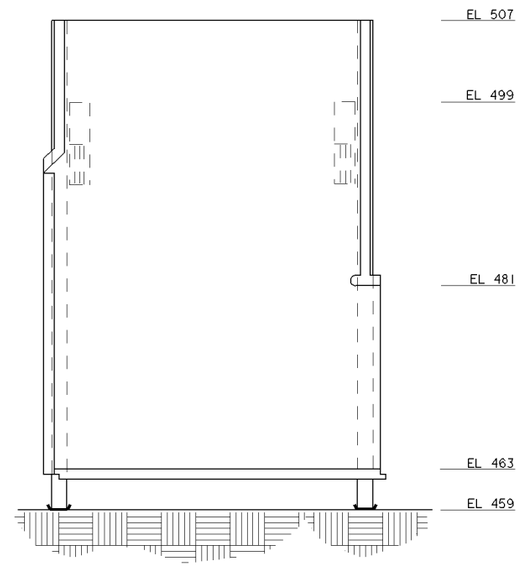

ELEVATION

SECTION A-A

NOTES:

1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.

SECTION Q-Q (FROM PLATE 2-16)

PLATE 2-27

Revisions			
Symbol	Descriptions	Date	Approved

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US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDWALL MONOLITH SECTIONS
W/AUX. F/E SYSTEM

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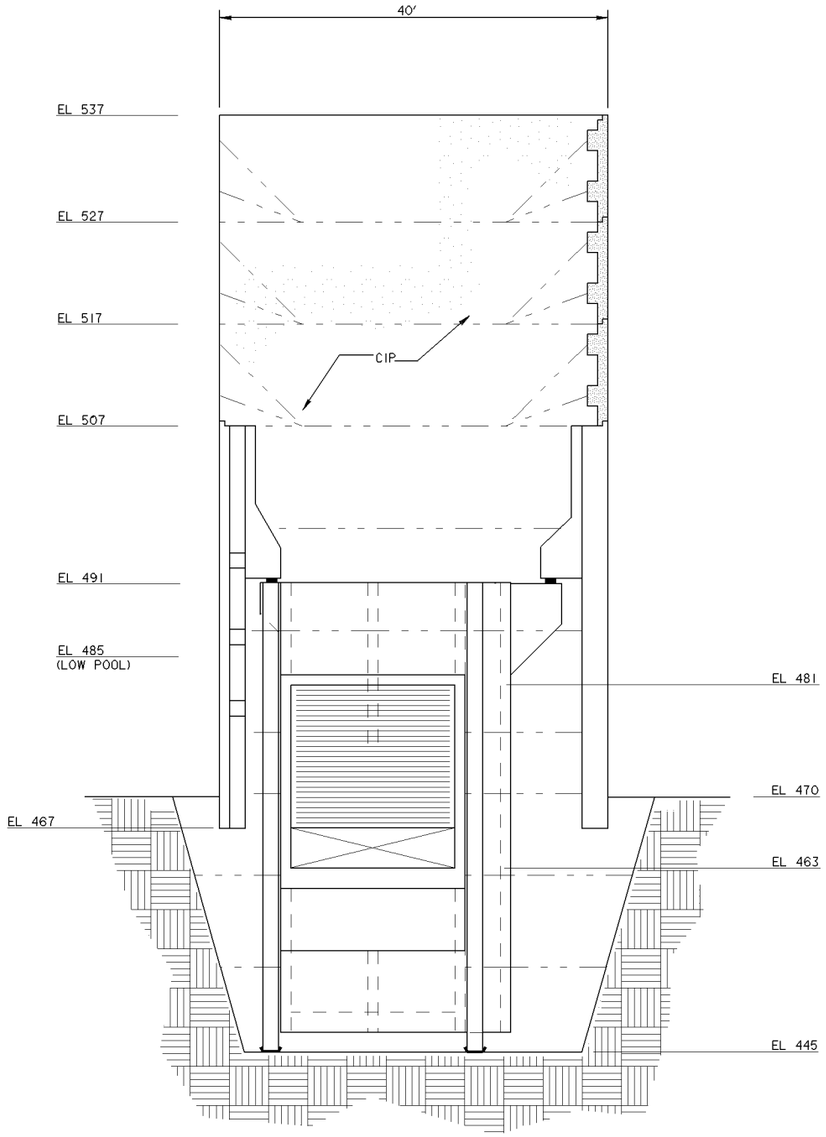
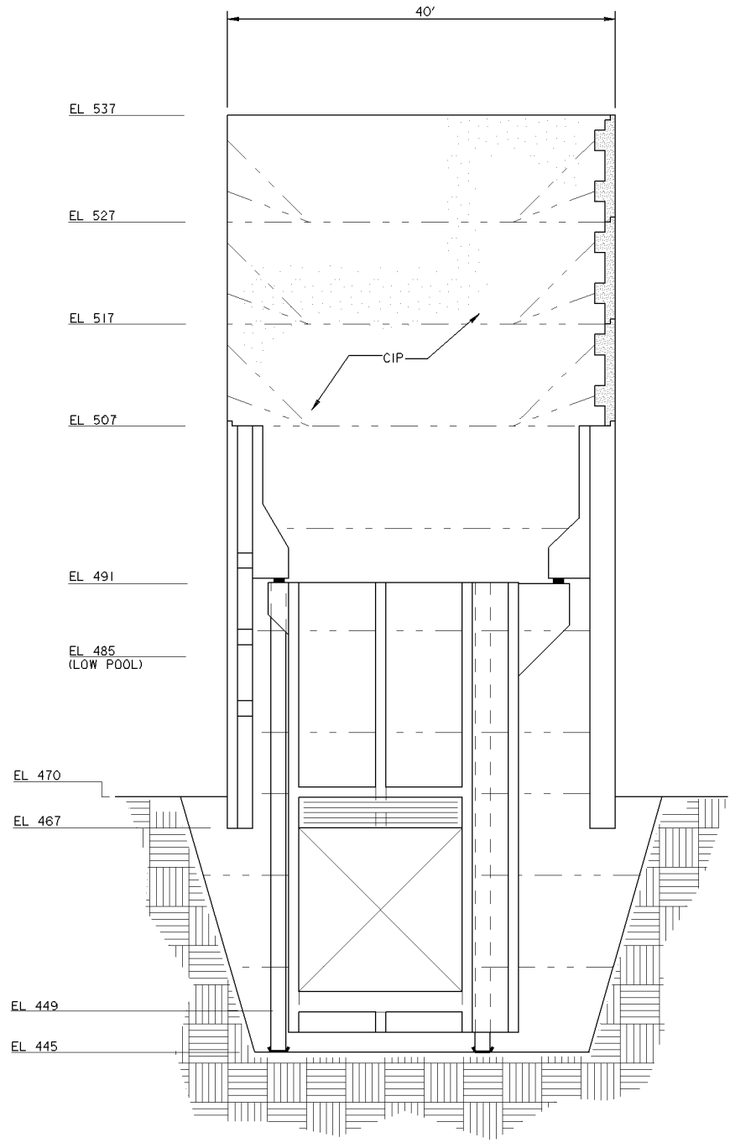
Approved by: XX			



NOTES:

1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.

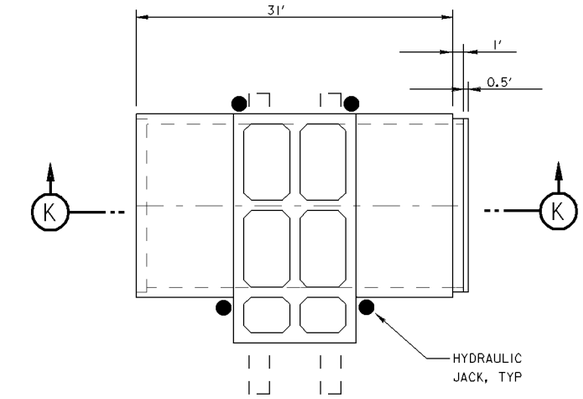
SECTION N-N (FROM PLATE 2-16)



NOTES:

1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.

SECTION P-P (FROM PLATE 2-16)



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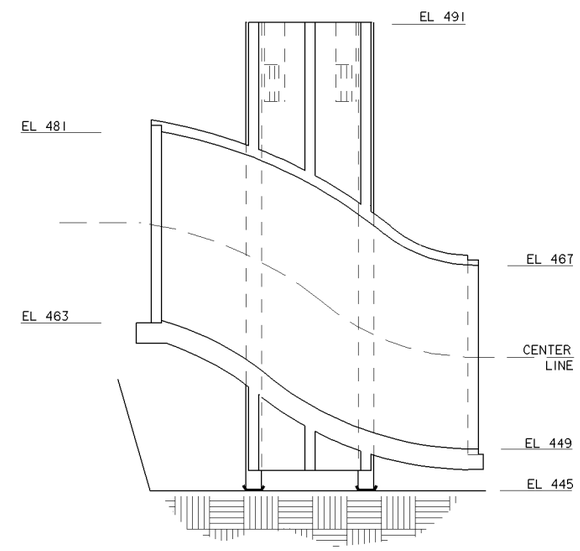

ELEVATION

SECTION K-K

PLATE 2-28

Revisions			
Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDWALL MONOLITH SECTIONS
W/AUX F/E SYSTEM

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Date: JUNE 1999
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Sheet reference number: GLD_2-28.DGN
b.ptb
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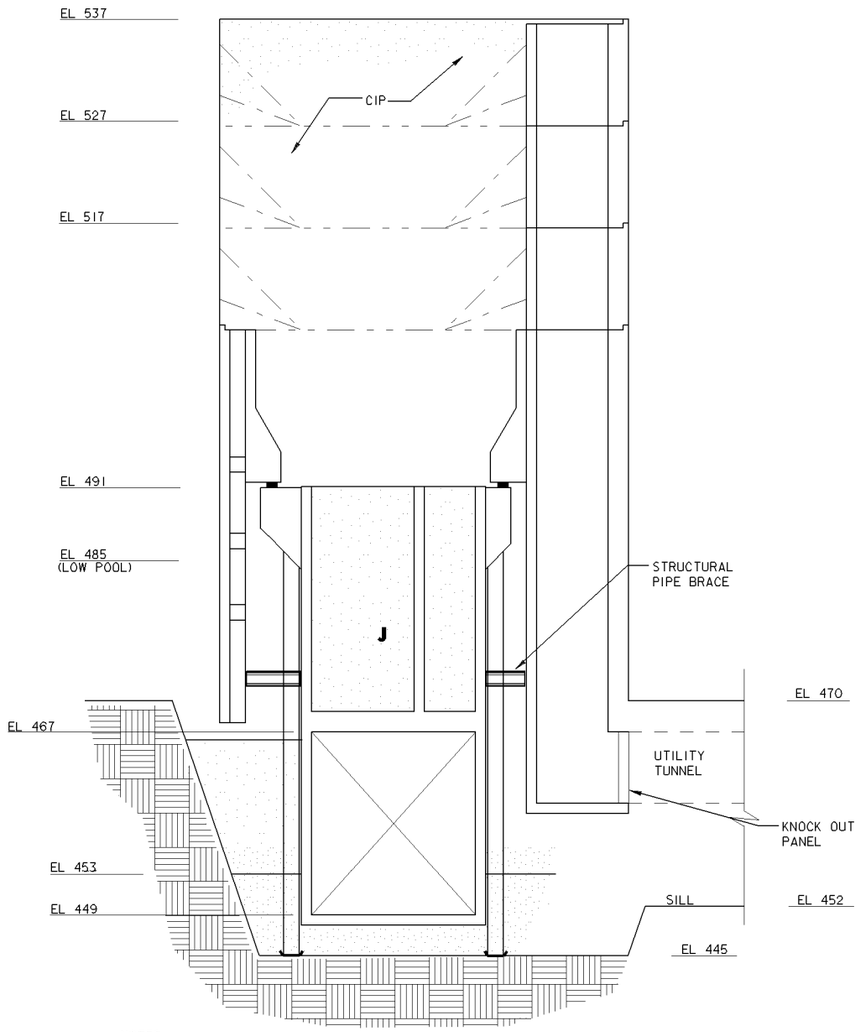
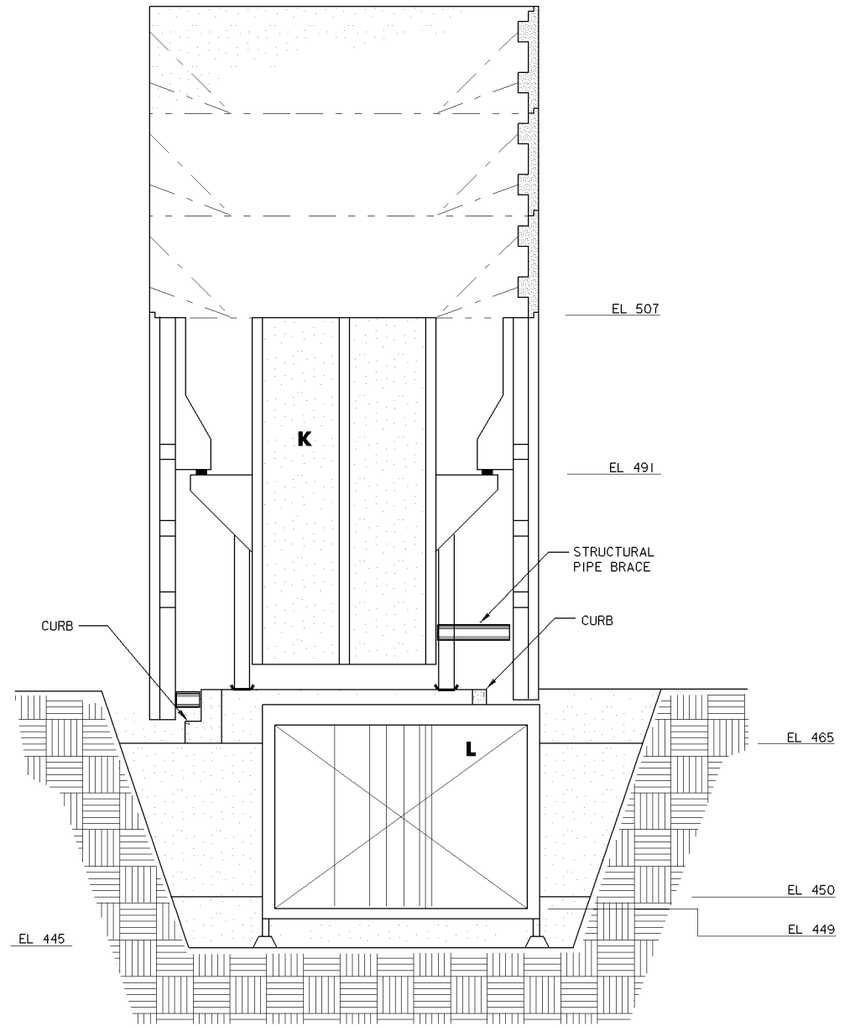


NOTES:

1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.

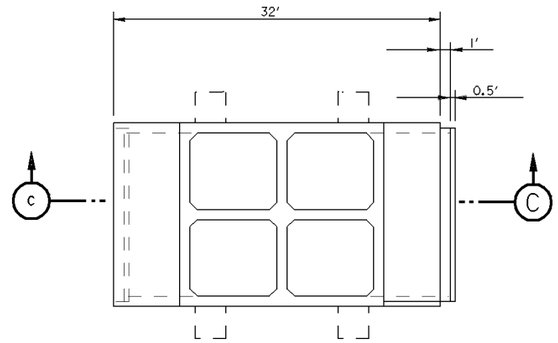
SECTION A–A (FROM PLATE 2–17)



NOTES:

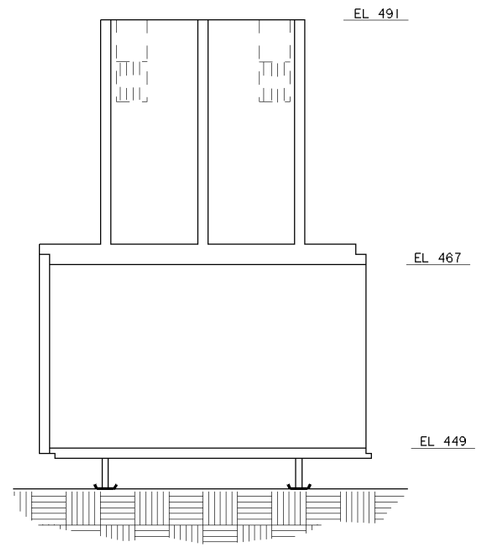
1. FIRST LIFT TREMIE SHALL NOT BE MORE THAN 8 FT IN ORDER TO OVERCOME BUOYANCE.
2. REMAINING LIFTS SHALL BE BY INCREASING ELEVATION, BUT NOT MORE THAN 10 FT EACH.
3. PROVIDE TEMPORARY BRACING INSIDE CULVERT DURING CONSTRUCTION.

SECTION B–B (FROM PLATE 2–17)



NOTE:
PLAN FOR BLOCKS G,H,I

PLAN



ELEVATION

SECTION C–C

PLATE 2–29

Revisions			
Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
PLANS 2,3&4
LANDSIDE GATE SECTIONS
W/AUX F/E SYSTEM

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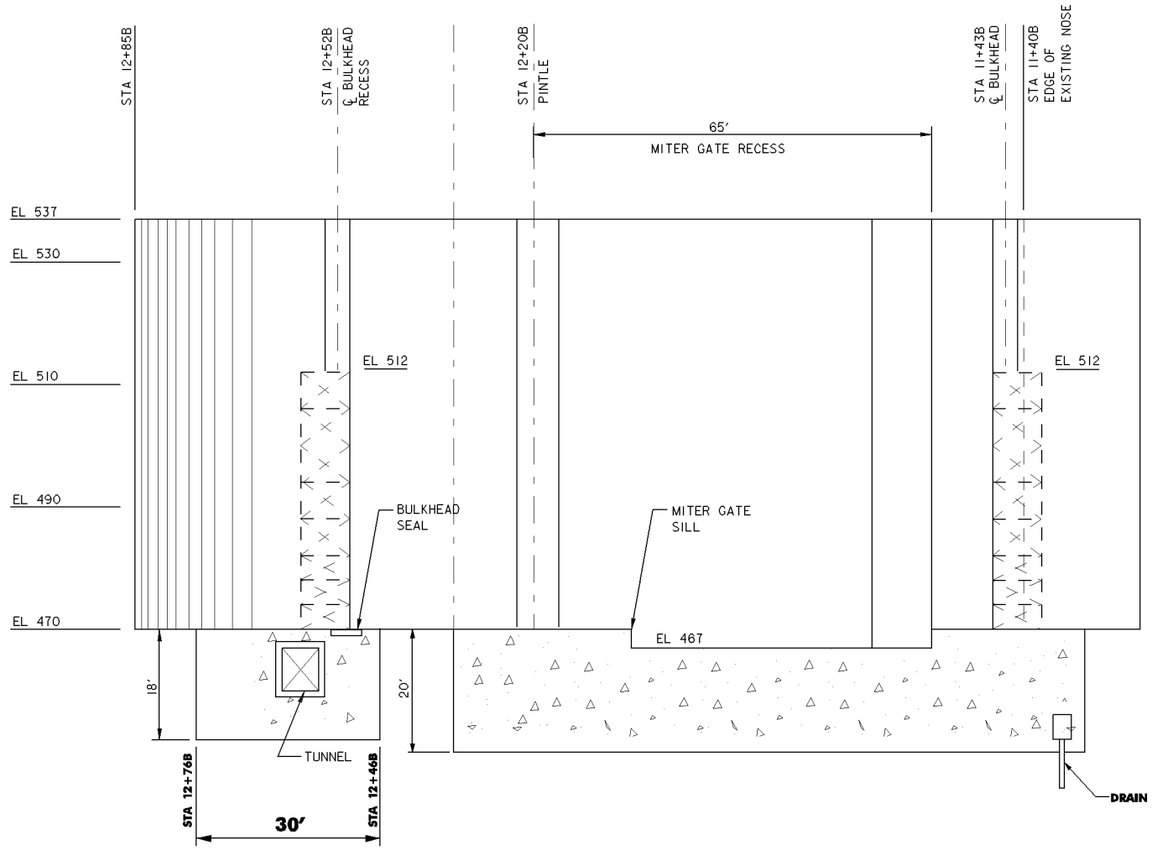
Drawn by: L.T.	Date: JUNE 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet X of X
Reviewed by: XX			
Approved by: XX			



MITER GATE ELEVATION B–B (FROM PLATE 2–5 & 2–18)

PLATE 2–30

Revisions			
Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

LIFT–IN MITER GATE ELEVATION

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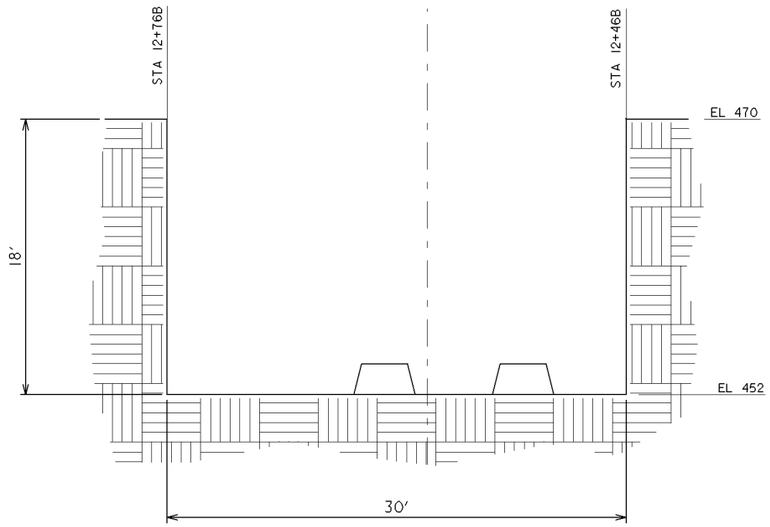
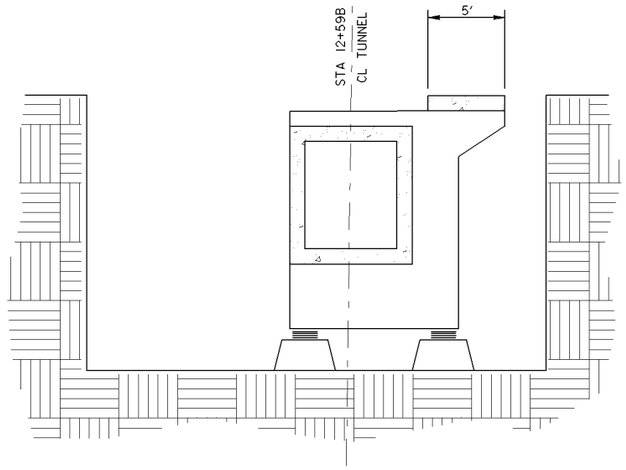
Drawn by: L.T.	Date: JUNE 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet 1 of 1
Reviewed by: XX			
Approved by: XX			

BULKHEAD SILL CONSTRUCTION SEQUENCE



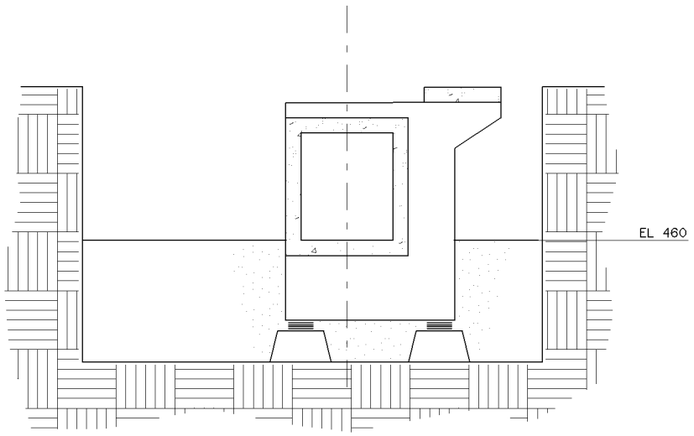
STEP 1

EXCAVATE TRENCH AND INSTALL PEDESTALS



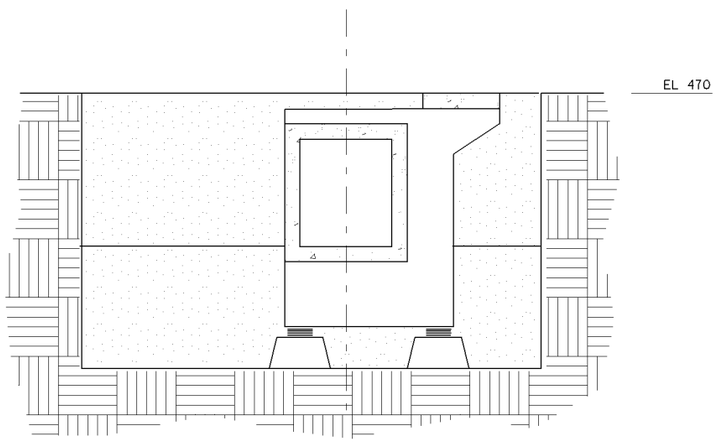
STEP 2

LIFT-IN PRECAST TUNNEL AND SILL SLAB UNITS
(2 PIECES)



STEP 3

SEAL THE JOINT AND TREMIE CONCRETE THE
FIRST LIFT TO EL 460



STEP 4

TREMIE CONCRETE THE SECOND LIFT TO EL 470

PLATE 2-31

Revisions			
Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

BULKHEAD SILL CONSTRUCTION SEQUENCE

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Drawn by: MP	Date: JUNE 1999		bptb
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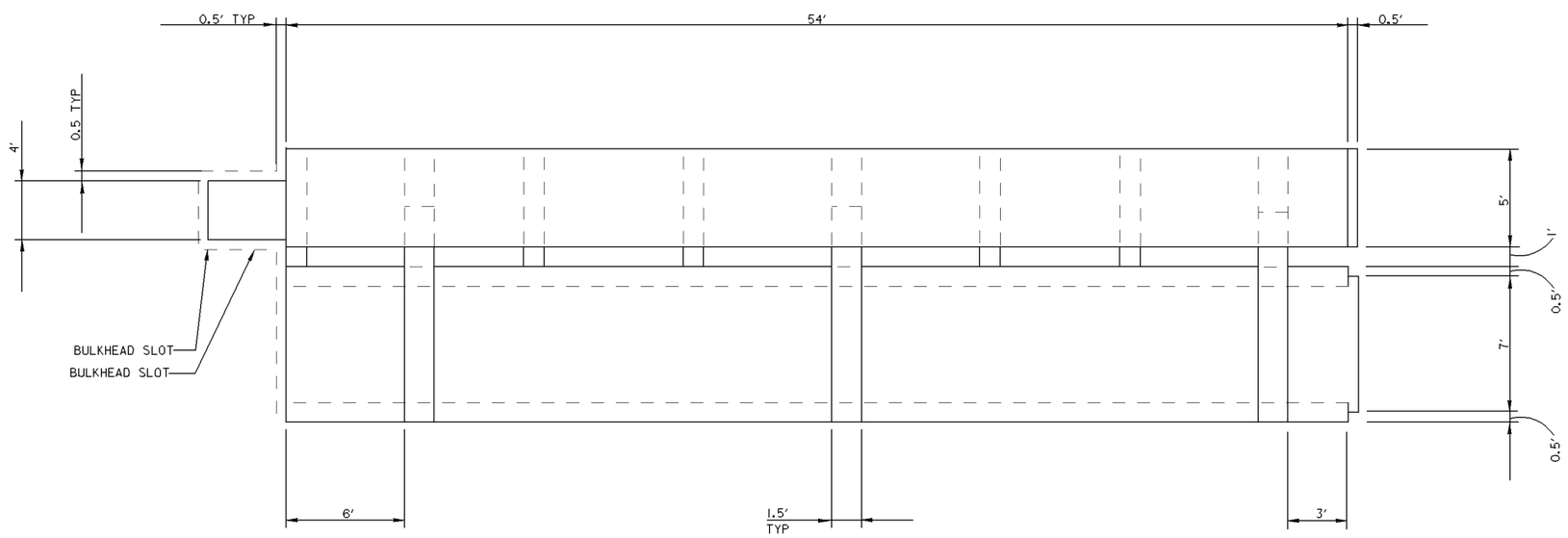
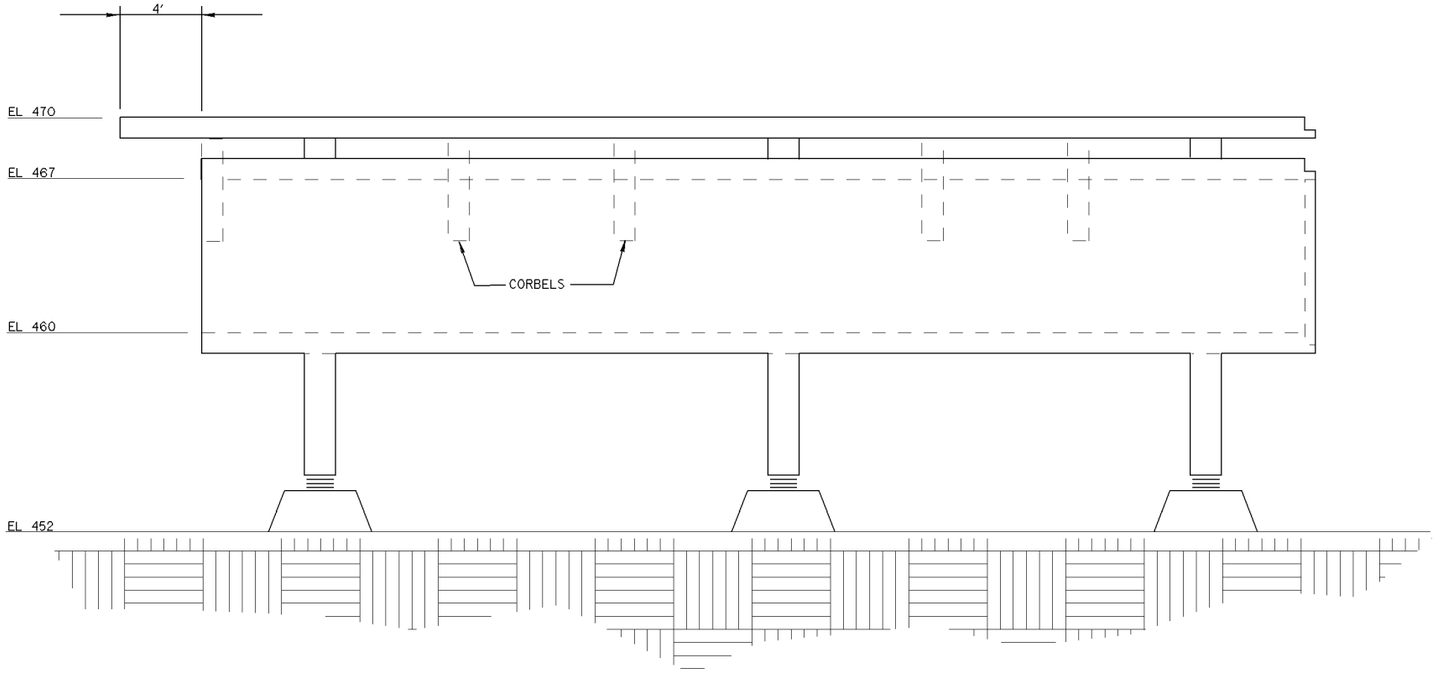


TOP VIEW



SIDE VIEW

UTILITY TUNNEL

PLATE 2–32

Revisions			
Symbol	Descriptions	Date	Approved

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US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

UTILITY TUNNEL PLAN & ELEVATION

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Drawn by: MP	Date: JUNE 1999		b.ptb
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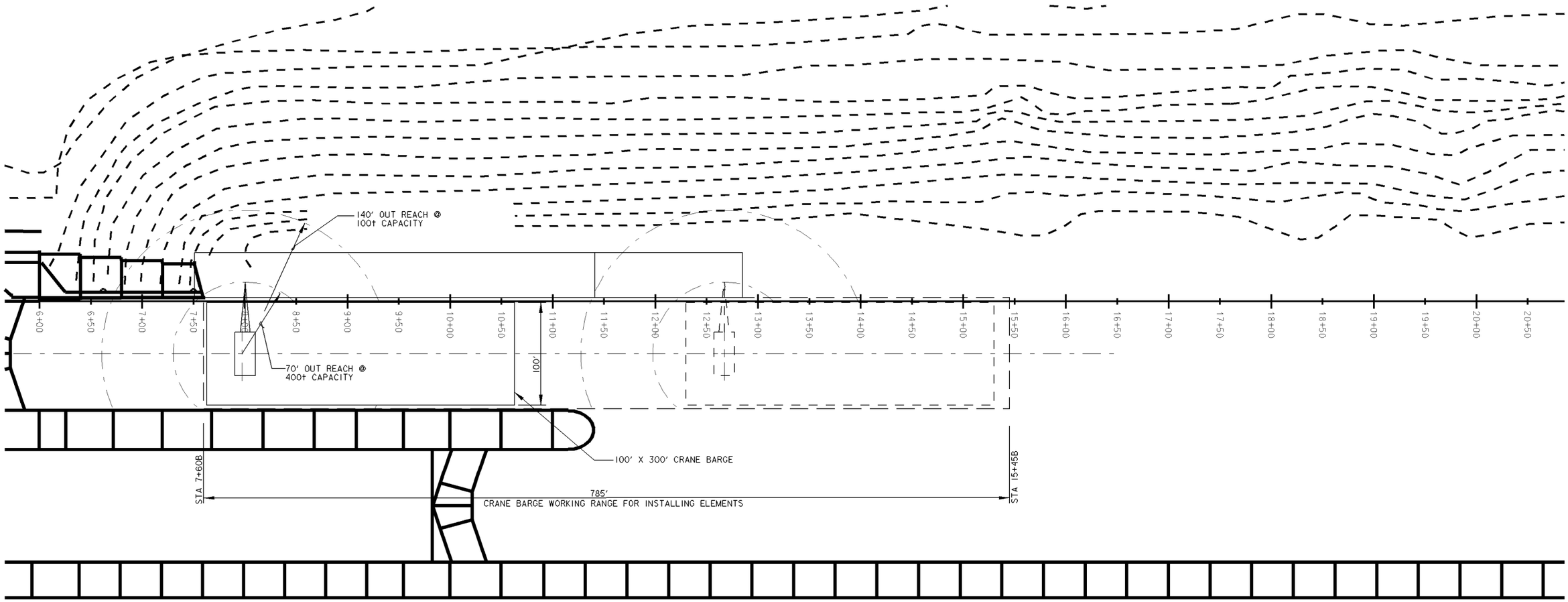

LAND WALL CONSTRUCTION
(LIFT-IN METHOD)

CONSTRUCTION SEQUENCE:

1. START FROM LEFT SIDE, LIFT IN BLOCKS THEN WALL PANELS, SEGMENT BY SEGMENT
2. DURING INSTALLATION, THE AUXILIARY LOCK WILL BE SHUT DOWN, MAIN LOCK WILL BE OPEN.

LEGEND

CRANE BARGE WORKING RANGE

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

PLATE 2-33

Revisions			
Symbol	Descriptions	Date	Approved

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US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
LAND WALL CONSTRUCTION

Designed by: XX	Scale: AS SHOWN	Sheet reference number:	GLD_2-33.DGN
Drawn by: M.W.M.	Date: JUNE 1999		b.ptb
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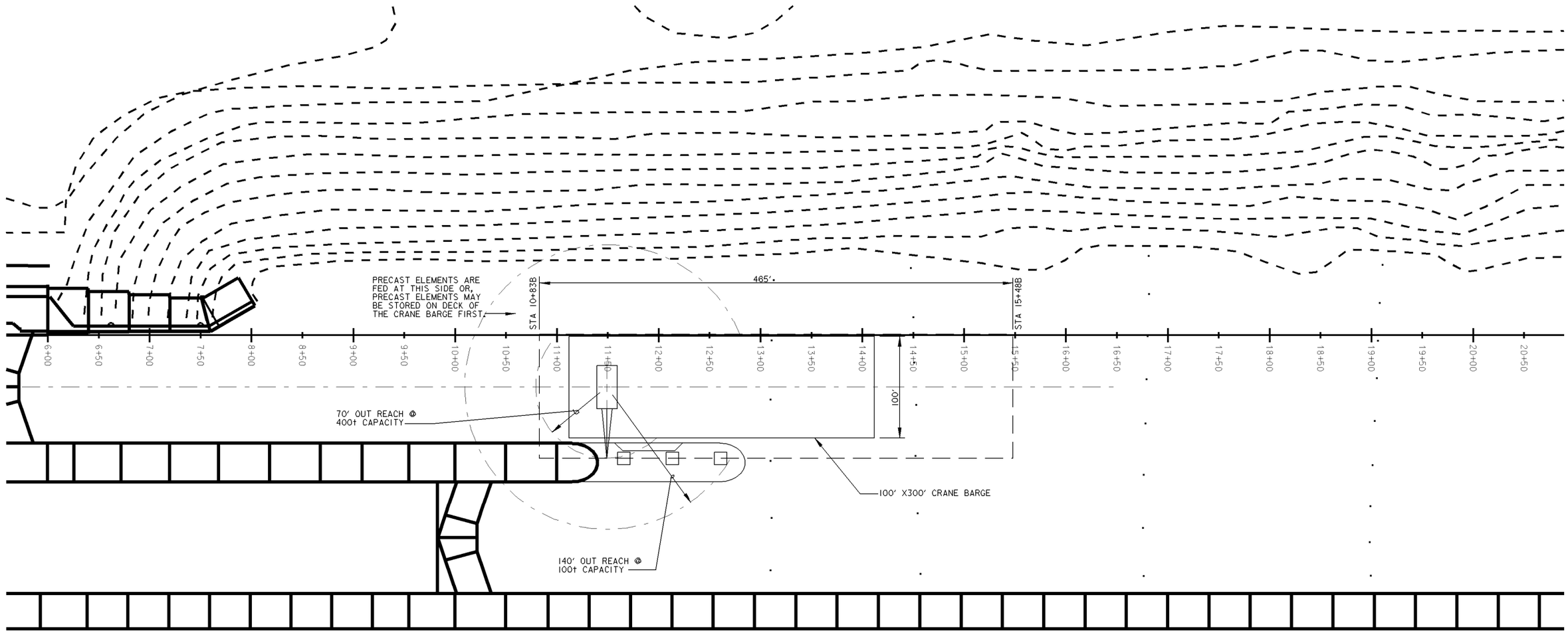

MIDDLE WALL CONSTRUCTION

(LIFT-IN METHOD)

LEGEND

CRANE BARGE WORKING RANGE

SCALE: 1" = 40'

40' 0 40'

PLATE 2-34

Revisions			
Symbol	Descriptions	Date	Approved

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
MIDDLE WALL CONSTRUCTION

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Checked by: XX	Drawing Code:		Sheet X of X
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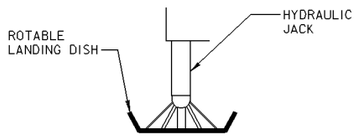
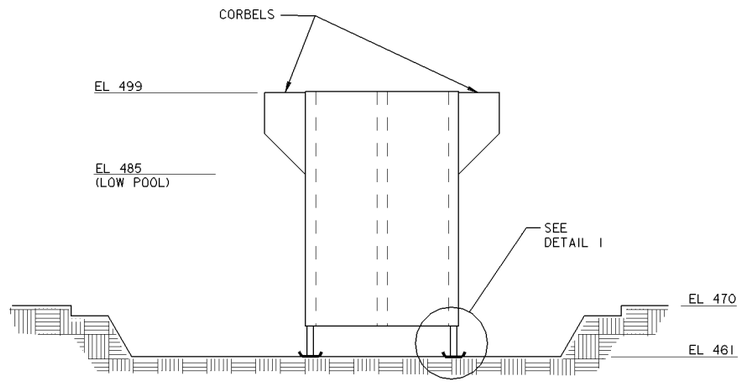
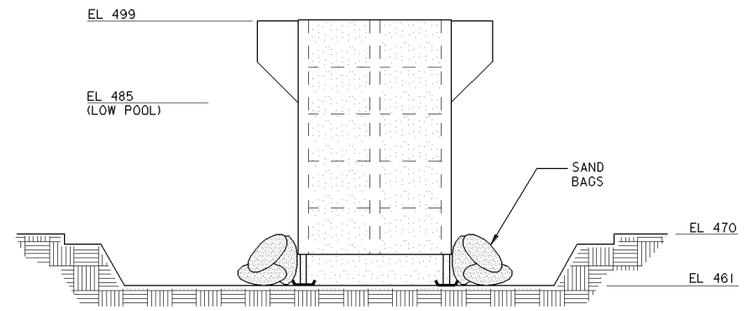


BUILT-IN LEG

DETAIL 1





STEP 3

3a. USE 400 TON FLOATING CRANE BARGE TO LIFT IN THE BASE BLOCK.

NOTE: TOP OF THE BLOCK WILL BE ABOVE THE WATER SURFACE DURING A SELECTED CONSTRUCTION WINDOW (SEE TABLE BELOW), WHICH ALLOWS PRECISE POSITIONING

STEP 4

4a. USE SAND BAGS TO SEAL BOTTOM.
4b. CAST TREMIE CONCRETE IN 10 FT LIFTS TO TOP.

CONSTRUCTION SEQUENCE
LIFT-IN GATE MONOLITH

MONTH	EXPECTED PERIOD WATER BELOW EL 499	MONTH	EXPECTED PERIOD WATER BELOW EL 499
JAN.	68%	JULY	96%
FEB..	60%	AUG.	98%
MAR.	44%	SEPT.	98%
APR.	52%	OCT.	98%
MAY	76%	NOV.	90%
JUNE	90%	DEC.	72%

PLATE 2-35

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

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OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

LIFT-IN CONSTRUCTION SEQUENCE

Designed by: XX
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Checked by: XX
Reviewed by: XX
Approved by: XX

Scale: 1:8
Date: JUNE 1999
Drawing Code:
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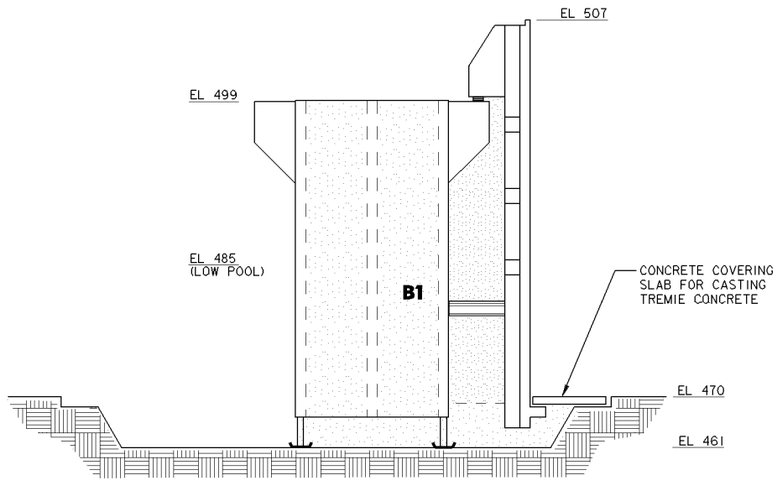

STEP 6

6a. PRECISELY SURVEY BRACKET POSITION AND ELEVATION PADDING OR RAZING IF NECESSARY FOR PANEL ELEVATION CONTROL

6b. USE CRANE BARGE TO INSTALL WALL PANEL

6c. ADJUST PANEL PLUMB AND TRUE

6d. FASTEN AND BRACE PANEL WITH BRACING ABOVE AND UNDER WATER.

6e. INSTALL COVERING SLABS AND BULKHEADS (BACK AND SIDE)

6f. CAST TREMIE CONCRETE (1st LIFT TO EL 470) TO STABILIZE THE PANEL.

6g. CAST REMAINDER OF TREMIE CONCRETE TO EL 499

CONSTRUCTION SEQUENCE

LIFT-IN GATE MONOLITH

PLATE 2-36

Revisions			
Symbol	Descriptions	Date	Approved

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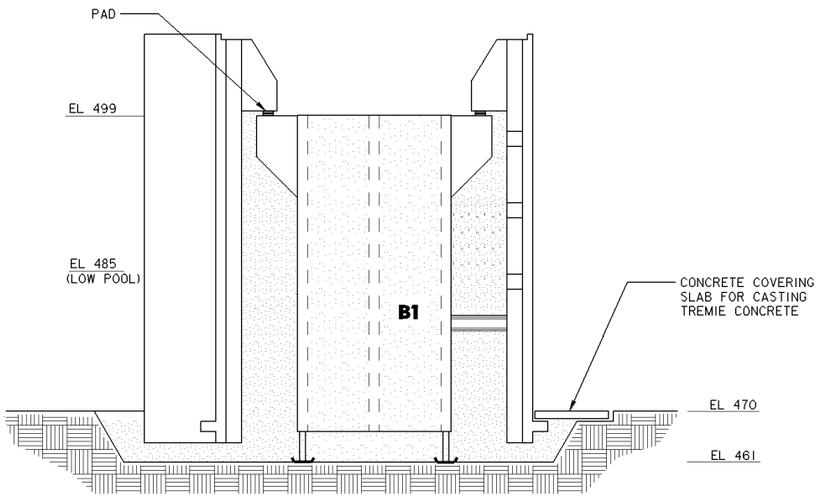
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

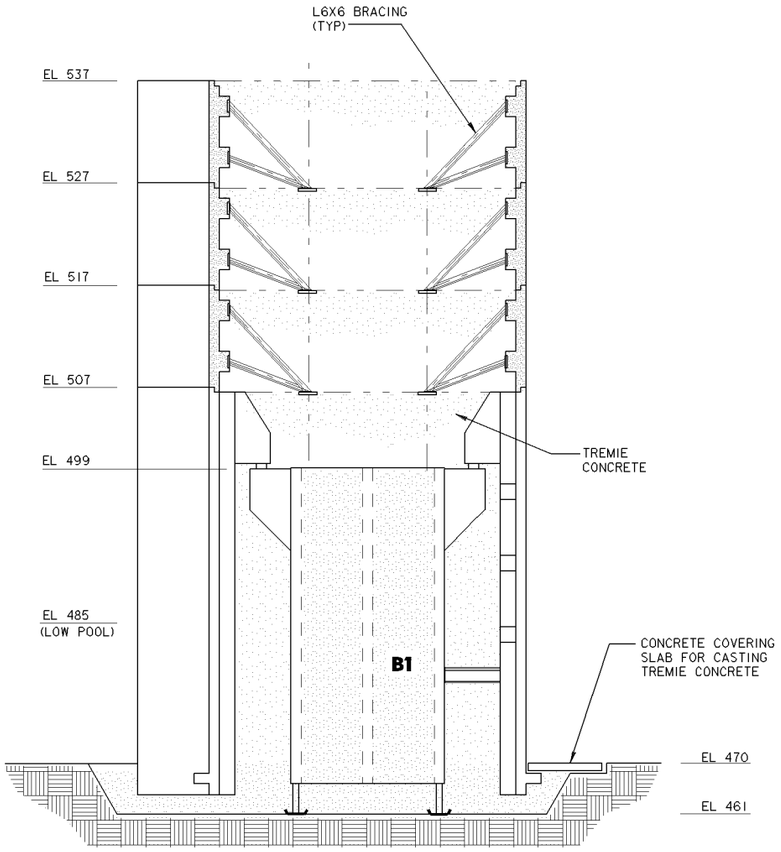
LIFT-IN CONSTRUCTION SEQUENCE

Designed by:	XX
Drawn by:	L.T.
Checked by:	XX
Reviewed by:	XX
Approved by:	XX
Scale:	NOT TO SCALE
Date:	JUNE 1999
Drawing Code:	
Sheet reference number:	GLD_2-36.DGN
	b.ptb
Sheet	X of X



STEP 7

7a. REPEAT STEP 4 TO INSTALL THE OTHER SIDE WALL PANEL AND FILL IN WITH CONCRETE



STEP 8

CONSTRUCTION SEQUENCE

PLATE 2–37

Revisions			
Symbol	Descriptions	Date	Approved

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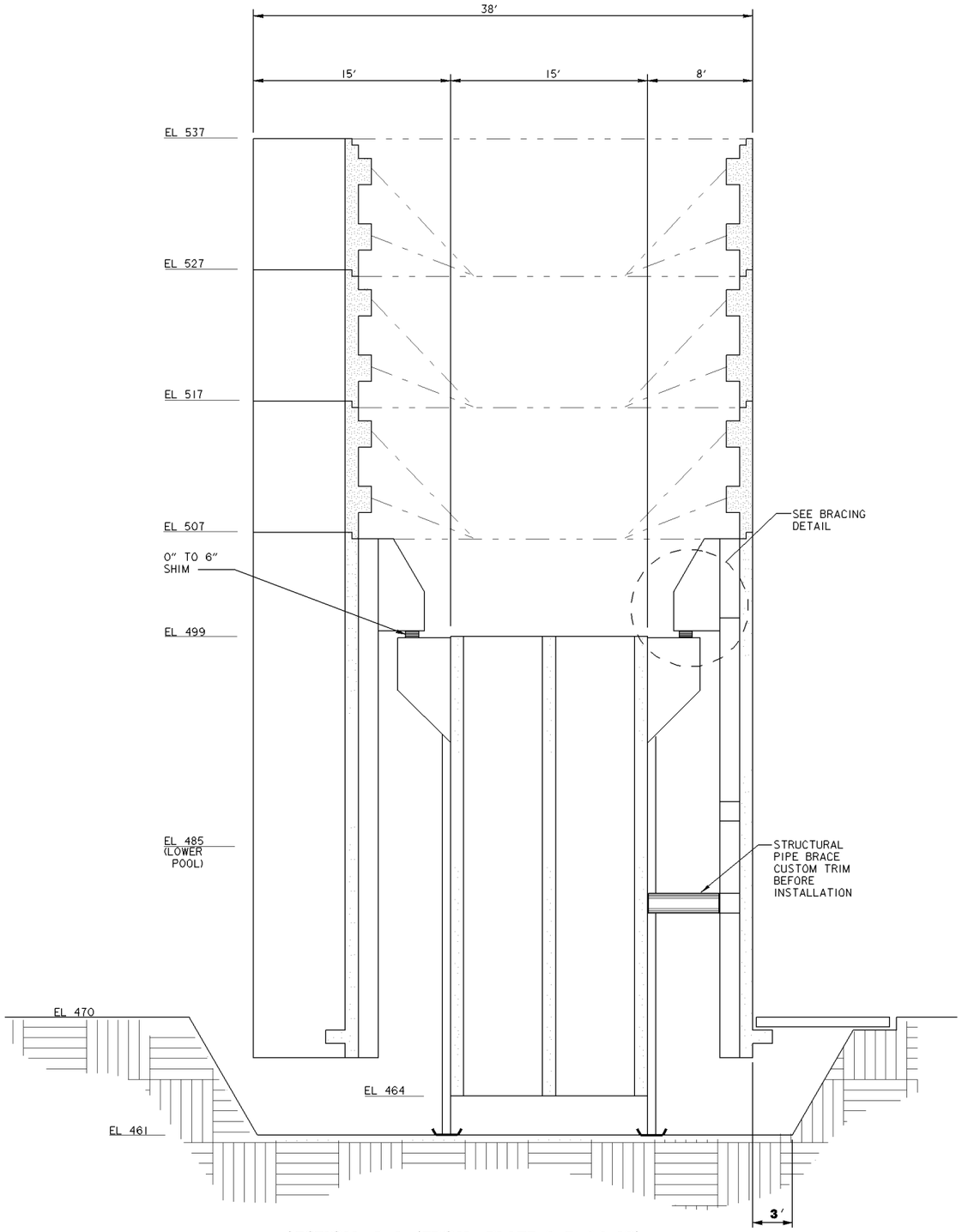
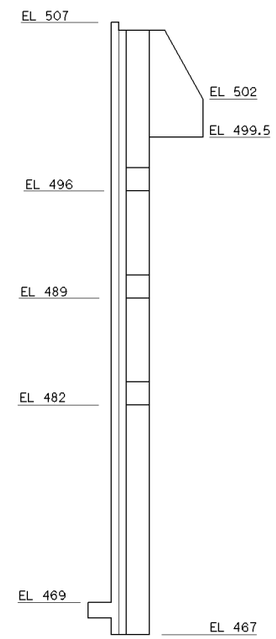
MAIN STEM STUDY
GREENUP LOCKS AND DAM

LIFT–IN CONSTRUCTION SEQUENCE

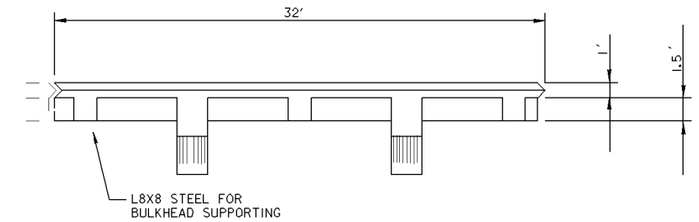
Designed by: XX	Scale: 1:6	Sheet reference number:	GLD_2-37.DGN
Drawn by: L.T.	Date: JUNE 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet X of X
Reviewed by: XX			
Approved by: XX			



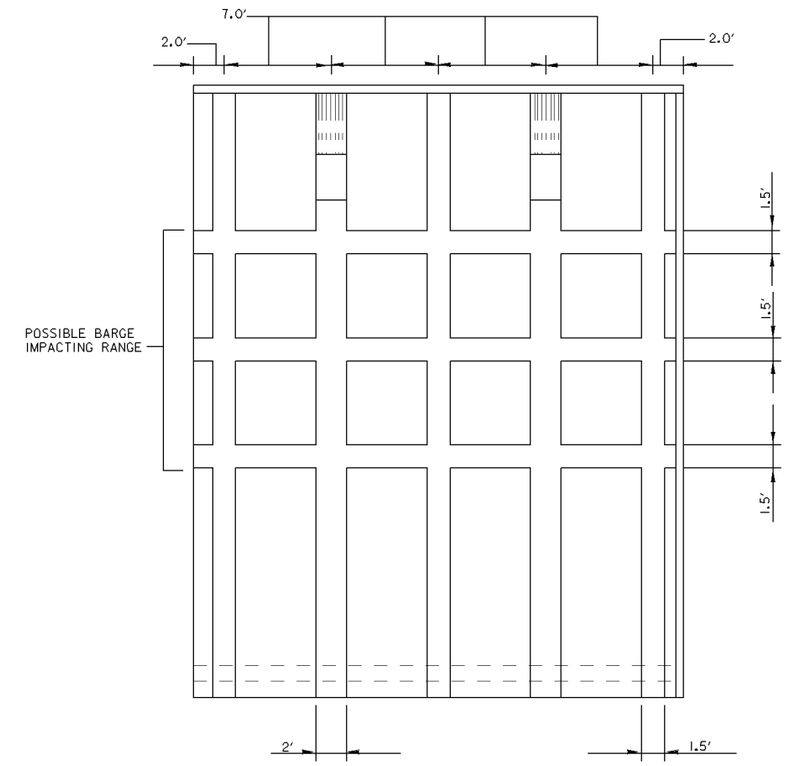
SECTION A-A (FROM PLATE 2-5 &2-18)



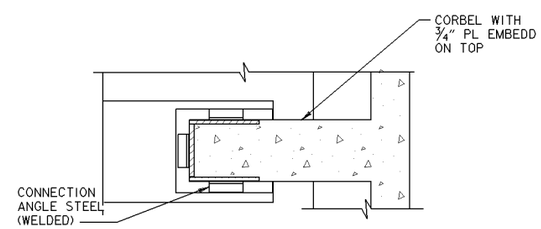
SIDE VIEW



TOP VIEW



PANEL PLAN VEW



TOP VIEW

BRACING DETAIL

PLATE 2-38

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

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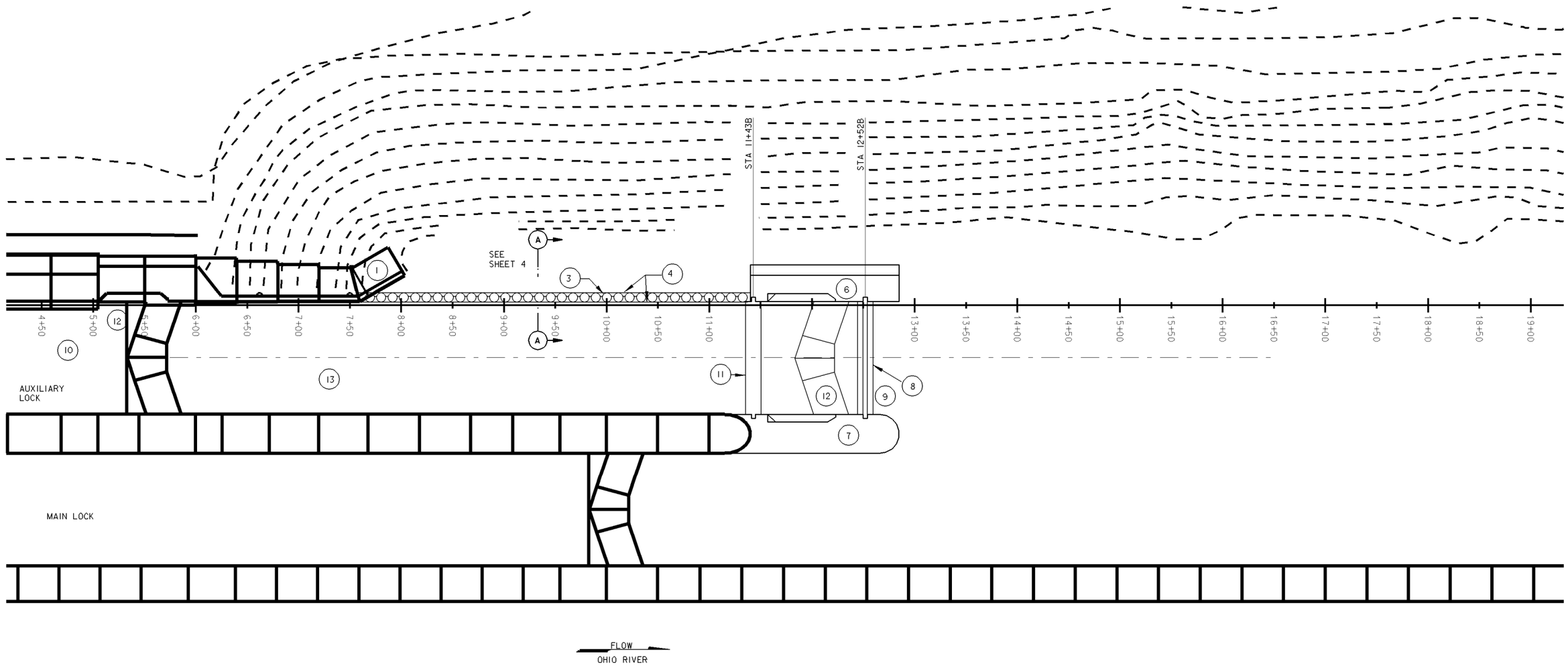
OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

LIFT-IN STRUCTURE PLAN & SECTION

Designed by: XX			
Drawn by: L.T.			
Checked by: XX			
Reviewed by: XX	Scale: 1:4	Sheet reference number:	GLD_2-38.DGN
Approved by: XX	Date: JUNE 1999		b.ptb
	Drawing Code:		Sheet X of X



CONSTRUCTION OVERVIEW
(DRILLED CAISSON METHOD)

STEPS:

1. DEMOLISH EXISTING MONOLITH L1
2. DREDGE (SEE DREDGING PLAN)
3. DRILL AND PLACE CAISSON LANDWALL TO EL 500'
4. PLACE WALL PANELS TO EL 500'
5. CAST AND COMPLETE LANDWALL TO EL 537'
6. LIFT-IN LANDSIDE GATE WALL
7. LIFT-IN MIDDLE WALL
8. INSTALL BULKHEAD SILL AT STA 12+52B
9. INSTALL BULKHEAD
10. DEWATER AUXILIARY LOCK
11. INSTALL MITER GATE SILL AND BULKHEAD SILL AT STA 11+43B
12. RELOCATE MITER GATE LEAVES AND MECHANICAL EQUIPMENT
13. FLOOD AUXILIARY LOCK, REMOVE BULKHEAD

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

PLATE 2-39

Revisions			
Symbol	Descriptions	Date	Approved

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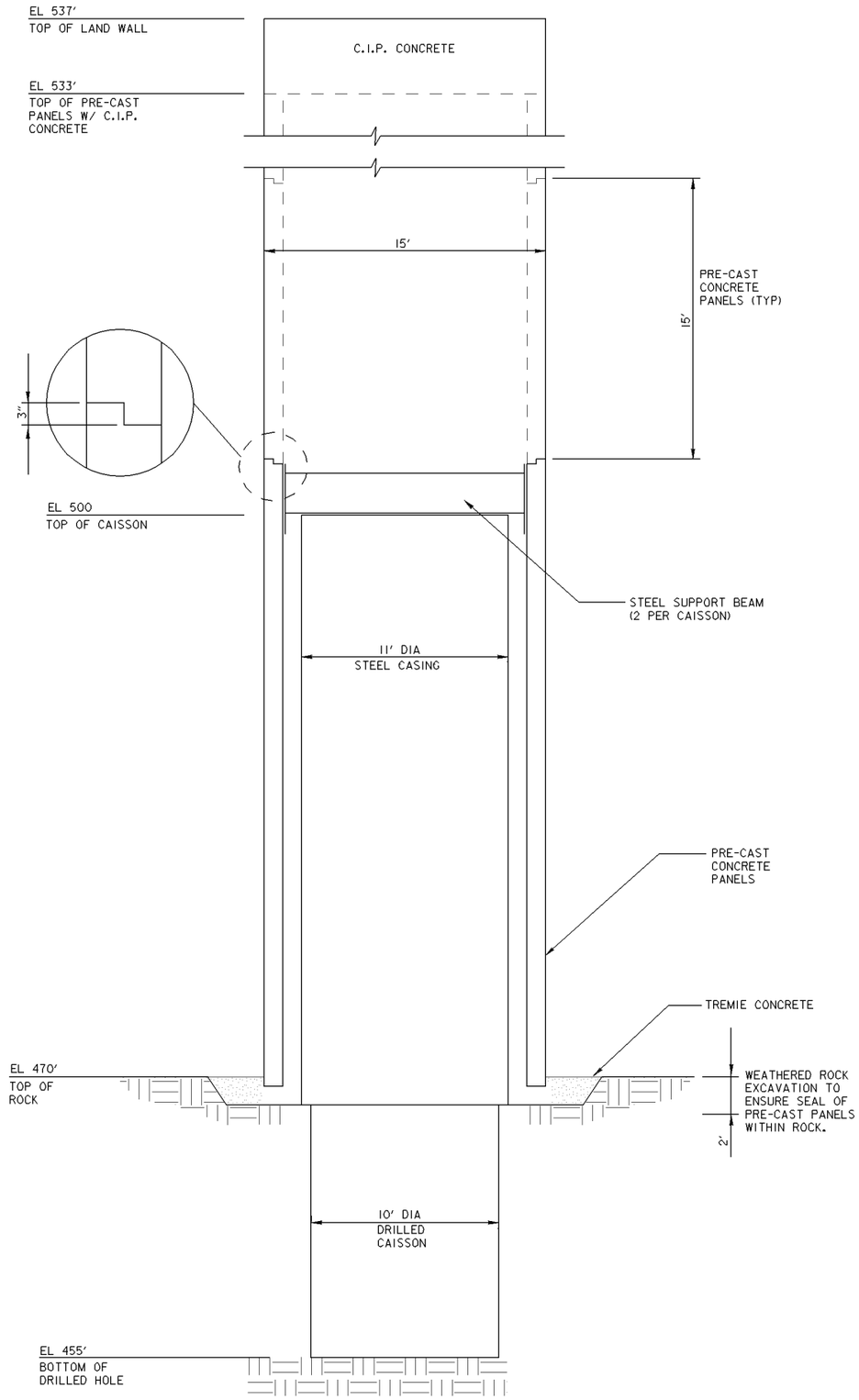
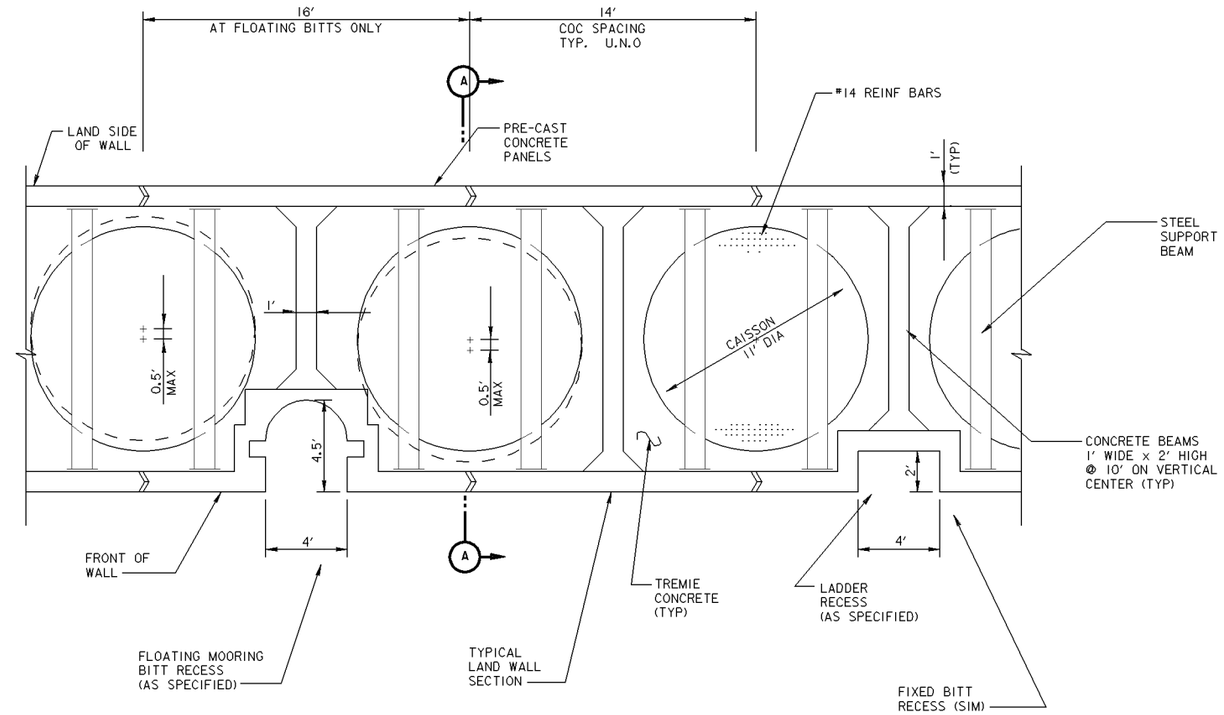
OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
DRILLED CAISSON OVERVIEW

Designed by: P.P.	Scale: AS SHOWN	Sheet reference number:	GLD_2-39.DGN
Drawn by: L.T.	Date: JUNE 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet X of X
Reviewed by: XX			
Approved by: XX			



SECTION A-A



NOTE:
TOP OF CAISSON @ EL 500'
CAST-IN-PLACE CONCRETE FROM EL 500' TO EL 537'.

DRILLED CAISSON PLAN

PLATE 2-40

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

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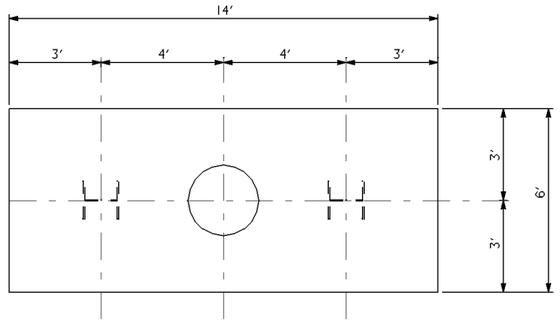
OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

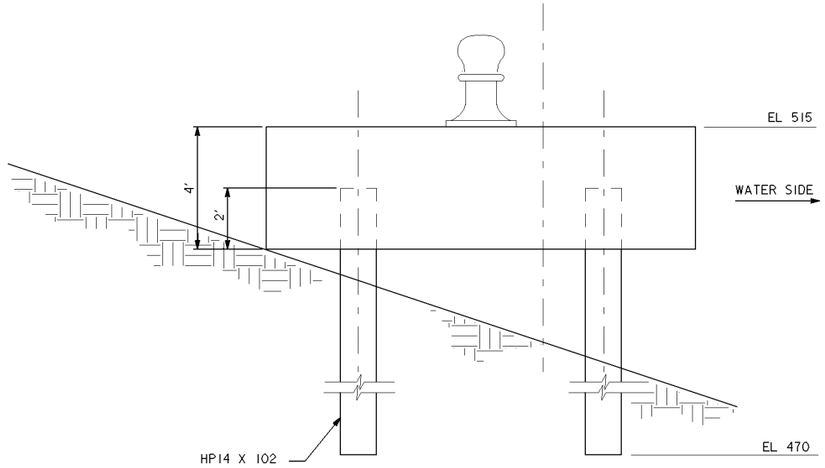
DRILLED CAISSON PLAN & SECTION

Designed by: RW, PP
Drawn by: MM, PP
Checked by: XX
Reviewed by: XX
Approved by: XX

Scale: 1:3
Date: JUNE 1999
Drawing Code:
Sheet reference number: GLD_2-40.DGN
b.ptb
Sheet of



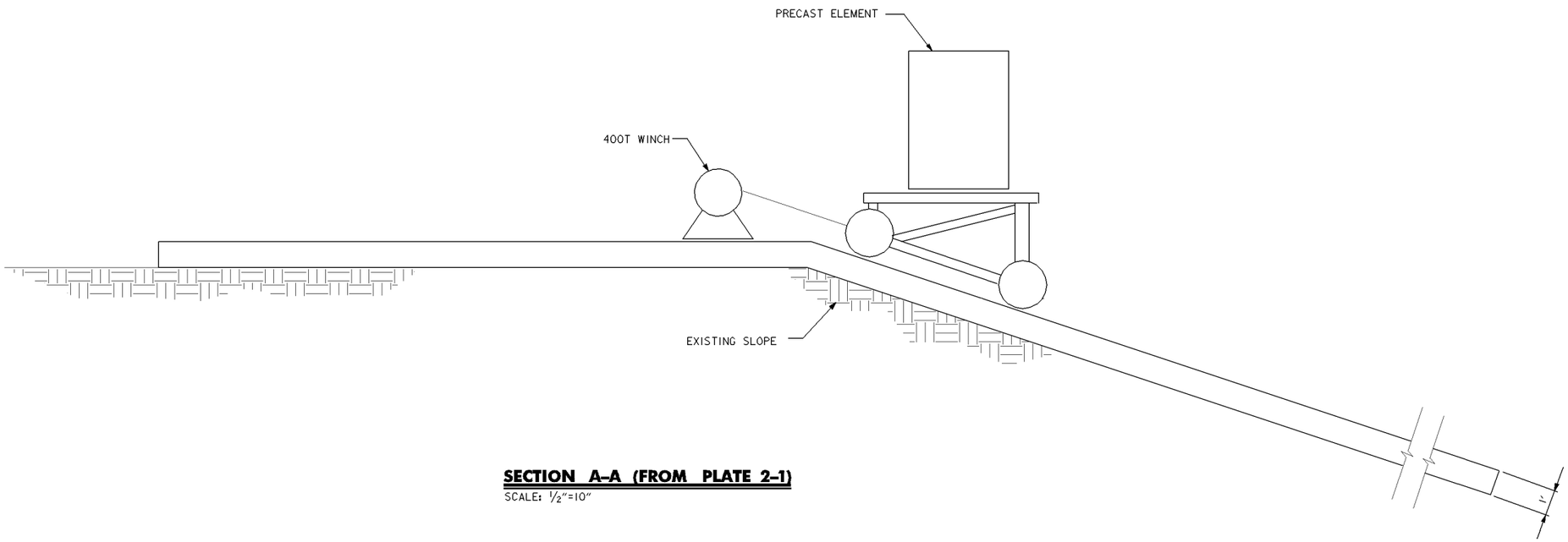
PLAN



ELEVATION

MOORING DOLPHIN

SCALE: 1/2"=10"



SECTION A–A (FROM PLATE 2–1)

SCALE: 1/2"=10"

PLATE 2–41

Revisions			
Symbol	Descriptions	Date	Approved

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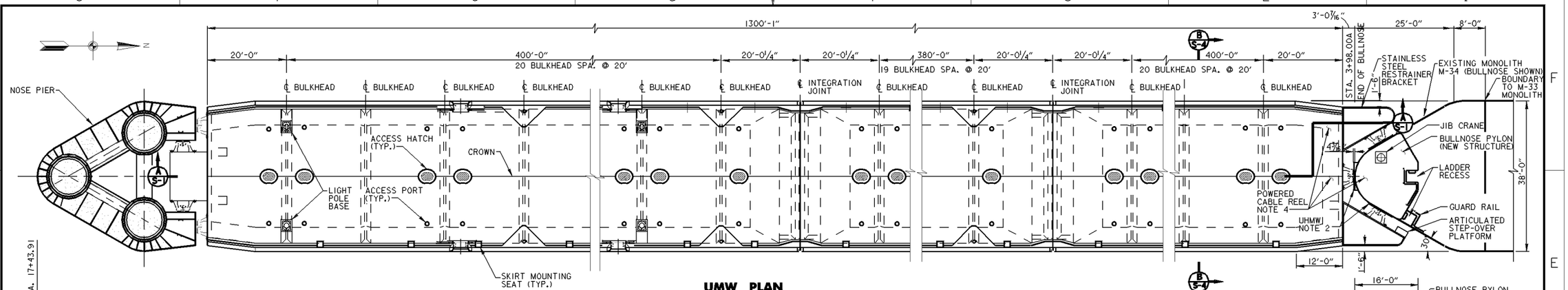
OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

FITOUT AREA
PLAN AND ELEVATION

Designed by: XX	Scale: AS SHOWN	Sheet reference number:	GLD_2-41.DGN
Drawn by: L.T.	Date: XXXX 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet of
Reviewed by: XX			
Approved by: XX			

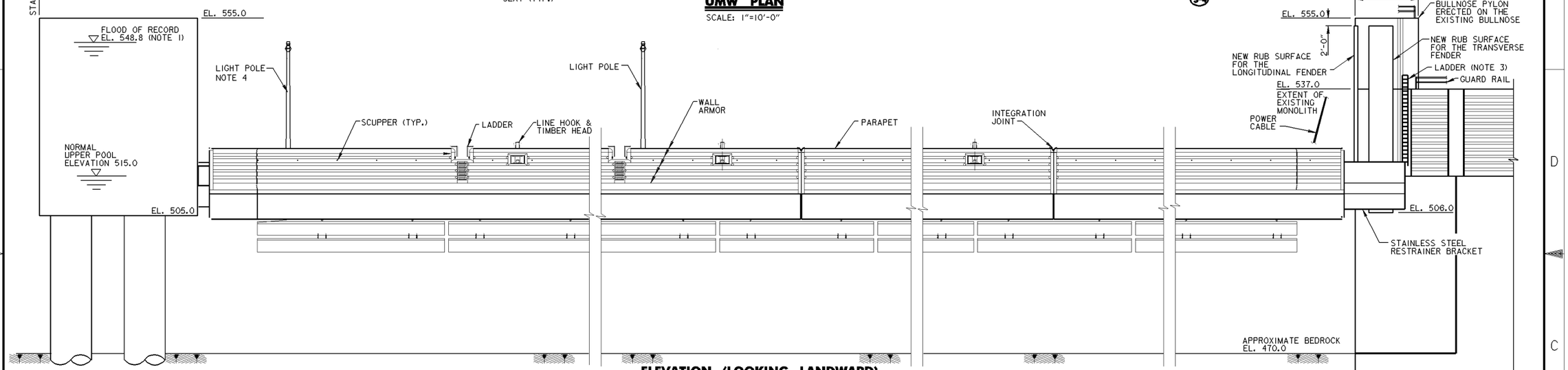
26.4.3 Approach Walls

PLATE (3-1) UMW PONTOON PLAN, SECTION & ELEVATION
PLATE (3-2) UMW PONTOON PLAN, SECTION & ELEVATION
PLATE (3-3) UMW PONTOON PLAN, SECTION & ELEVATION
PLATE (3-4) URW & UMW PONTOON CROSS SECTIONS
PLATE (3-5) CROSS SECTIONS
PLATE (3-6) LLW PLANS & ELEVATION (FIXED WALL ALTERNATIVE)
PLATE (3-7) LLW SECTIONS & CONSTRUCTION SEQUENCE (FIXED WALL ALTERNATIVE)
PLATE (3-8) LLW NOSE PIER
PLATE (3-9) UMW & URW NOSE PIERS & PYLONS
PLATE (3-10) PONTOON CONSTRUCTION & INSTALLATION
PLATE (3-11) NOSE PIER CONSTRUCTION SEQUENCE
PLATE (3-12) DRW PONTOON PLAN, SECTION & ELEVATION



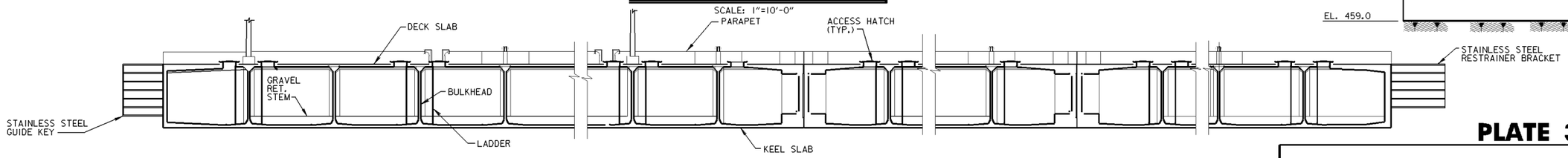
UMW PLAN

SCALE: 1"=10'-0"



ELEVATION (LOOKING LANDWARD)

SCALE: 1"=10'-0"



SECTION

SCALE: 1"=10'-0"

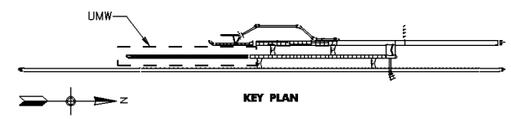
NOTES:

1. THE PROBABLE MAXIMUM FLOOD (PMF) ELEVATION HAS NOT BEEN DETERMINED PRESENTLY.
2. UHMW BOLTED ONTO STAINLESS STEEL FRAME. FRAME ATTACHED TO CONCRETE BY S.S. SCREWS.
3. LADDER POSITIONED IN THE RECESS CUT INTO THE EXISTING BULLNOSE.
4. FOR TRANSFER OF POWER ONTO PONTOON THE FOLLOWING FEATURES ARE REQUIRED: CABLE DRUM (ON TOP OF THE BULLNOSE PYLON), POWERED CABLE REEL AND ELECTRICAL CABINET ON THE PONTOON DECK. LIGHT POLES @ ABOUT 200 FEET SPACING ARE CENTERED ON BULKHEADS.
5. POWER WINCH OPERATED JIB CRANE WITH A RATED CAPACITY OF 2 TONS LOAD AT A "HOOK REACH" OF 22 FEET MINIMUM, "HOOK HEIGHT" MINIMUM (I.E., HORIZONTAL BOOM POSITION) OF 6'-0", "MAXIMUM LIFT" (I.E., BELOW MAST BASE PLATE) OF 40 FEET, AND SMOOTH 360° (MAST & BOOM ROTATION) LOAD MOVEMENT.

GRAPHIC SCALE

10 5 0 10 20FT

SCALE: 1"= 10'



KEY PLAN

PLATE 3-1

Revisions			
Symbol	Descriptions	Date	Approved

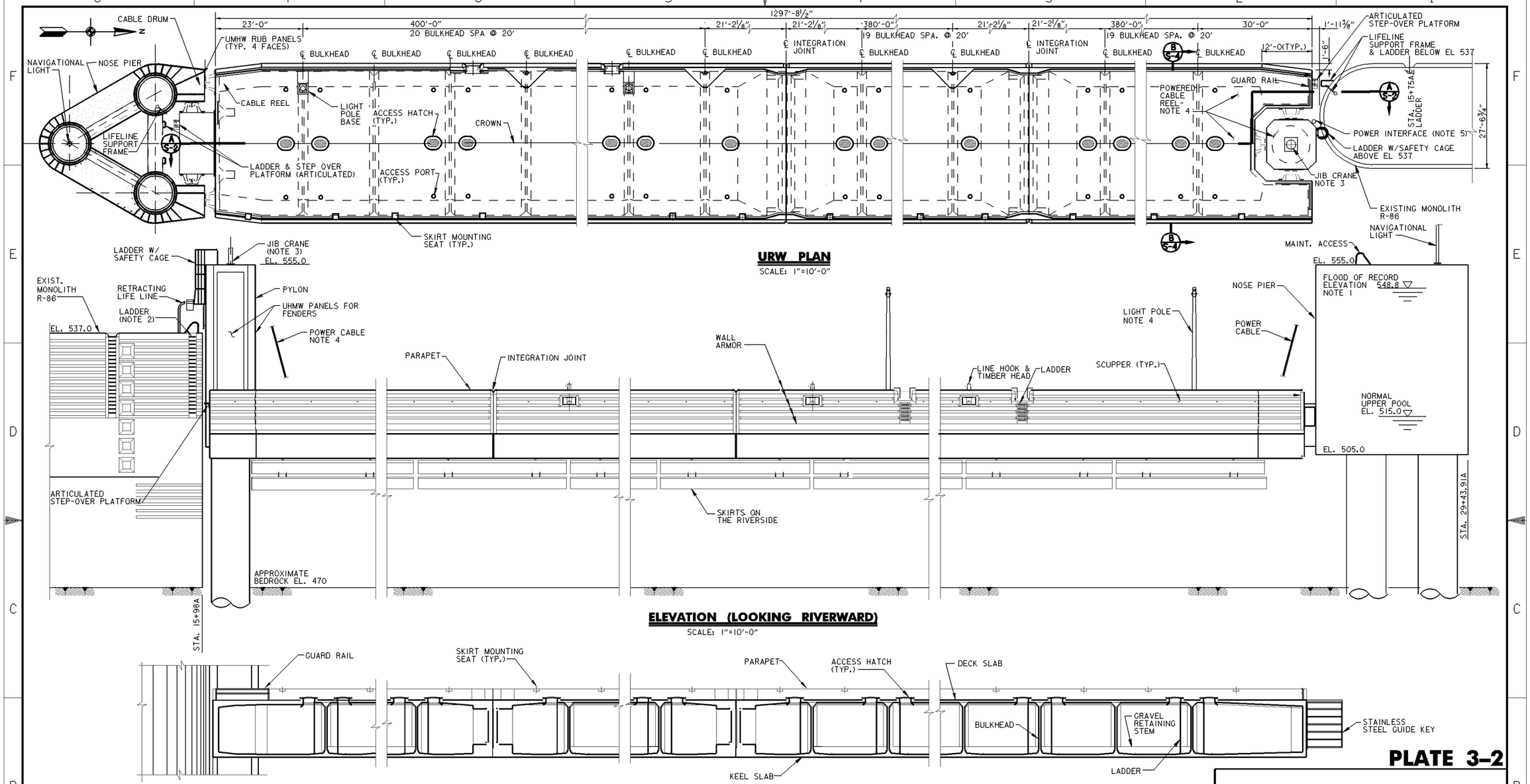
INCA ENGINEERS INC.

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

UMW PONTOON PLAN, SECTION & ELEV.

Designed by: MBR	Scale: AS SHOWN	Sheet reference number: S-1	FILENAME: GPS001.DGN PEN TABLE:
Drawn by: GFM	Date: JUNE 1999		
Checked by: DEM	Drawing Code:		Sheet of
Reviewed by:			
Approved by:			



URW PLAN
SCALE: 1"=10'-0"

ELEVATION (LOOKING RIVERWARD)
SCALE: 1"=10'-0"

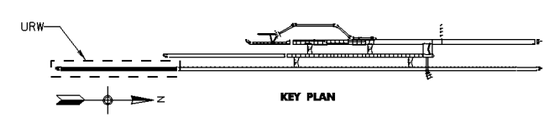
NOTE: SKIRTS NOT SHOWN

SECTION A S-2
SCALE: 1"=10'-0"

NOTES:

1. THE PROBABLE MAXIMUM FLOOD (PMF) ELEVATION HAS NOT BEEN DETERMINED PRESENTLY.
2. INDIVIDUAL RUNG LADDER MOUNTED ON THE FACE OF THE EXISTING CONCRETE STRUCTURE BY STAINLESS STEEL SCREWS.
3. POWER WINCH OPERATED JIB CRANE WITH A RATED CAPACITY OF 2 TONS LOAD AT A "HOOK REACH" OF 22 FEET MINIMUM, "HOOK HEIGHT" MINIMUM (I.E., HORIZONTAL BOOM POSITION) OF 6'-0", "MAXIMUM LIFT" (I.E., BELOW MAST BASE PLATE) OF 40 FEET, AND SMOOTH 360° (MAST & BOOM ROTATION) LOAD MOVEMENT.
4. FOR TRANSFER OF POWER ONTO PONTOON THE FOLLOWING FEATURES ARE REQUIRED: CABLE DRUM (ON TOP OF THE PYLON), POWERED CABLE REEL AND ELECTICAL CABINET ON THE PONTOON DECK. LIGHT POLES @ ABOUT 200 FEET SPACING ARE CENTERED ON BULKHEAD.
5. POWER AND COMMUNICATION LINES INTERFACE FOR LOCK EXTENSION APPROACH WALL.

GRAPHIC SCALE
10 5 0 10 20FT
SCALE: 1"= 10'



KEY PLAN

PLATE 3-2

Revisions			
Symbol	Descriptions	Date	Approved

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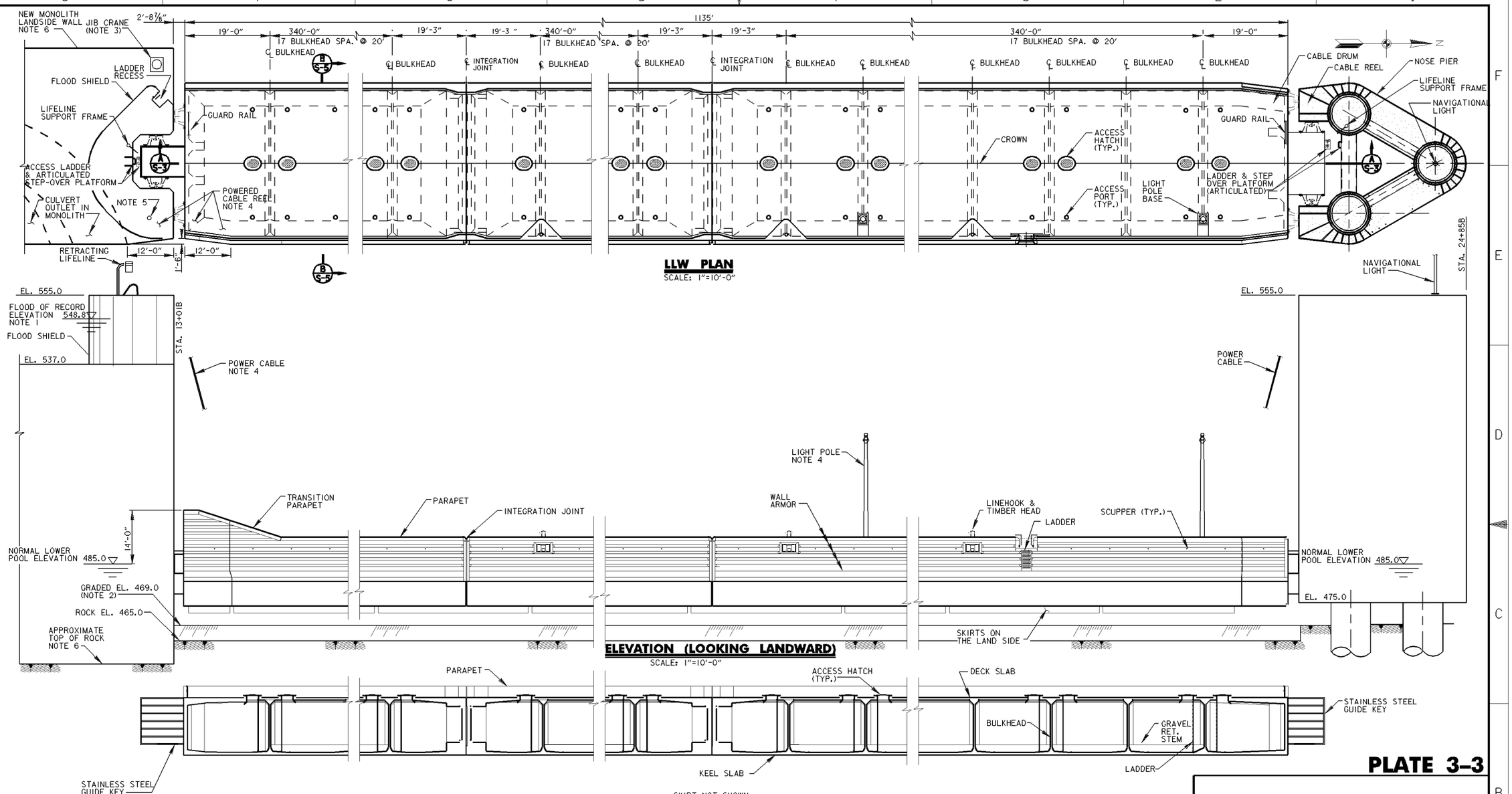
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

URW PONTOON PLAN, SECTION & ELEV.

Designed by: MBR	Scale: AS SHOWN	Sheet reference number: S-2	FILENAME: GPS002.DGN
Drawn by: GM	Date: JUNE 1999		PEN TABLE:
Checked by: DEM	Drawing Code:		Sheet of
Reviewed by:			
Approved by:			



NOTES:

1. THE PROBABLE MAXIMUM FLOOD (PMF) ELEVATION HAS NOT BEEN DETERMINED PRESENTLY.
2. BEDROCK UNDER PONTOON FOOTPRINT EXCAVATED TO ELEVATION 465.0 AND REPLACED AND GRADED WITH NATURAL RIVER BED SILT AND SILTY SAND MATERIAL TO ELEVATION 469.0. HORIZONTAL EXTENT OF THE EXCAVATION & BACKFILL SHALL BE:
   - 1160' IN LENGTH BEGINNING AT STA. 13+01B AND CONTINUING DOWNSTREAM.
   - 52' IN WIDTH CENTERED ABOUT THE PONTOON CROWN LINE.
3. POWER WINCH OPERATED JIB CRANE WITH A RATED CAPACITY OF 2 TONS LOAD AT A "HOOK REACH" OF 25 FEET MINIMUM, "HOOK HEIGHT" MINIMUM (I.E., HORIZONTAL BOOM POSITION) OF 6'-0", "MAXIMUM LIFT" (I.E., BELOW MAST BASE PLATE) OF 50 FEET, AND SMOOTH 360° (MAST & BOOM ROTATION) LOAD MOVEMENT.
4. FOR TRANSFER OF POWER ONTO PONTOON THE FOLLOWING FEATURES ARE REQUIRED: CABLE DRUM (ON TOP OF THE PYLON), POWERED CABLE REEL AND ELECTICAL CABINET ON THE PONTOON DECK. LIGHT POLES @ ABOUT 200 FEET SPACING ARE CENTERED ON BULKHEADS.
5. POWER AND COMMUNICATION LINES INTERFACE FOR LOCK EXTENSION APPROACH WALL.
6. GEOMETRY OF THE NEW LANDSIDE MONOLITH AND TOP OF THE ROCK ELEVATION TO BE COMPLETED AFTER THE 75% SUBMITTAL PER INFORMATION PROVIDED BY THE CORPS.

PLATE 3–3

Revisions			
Symbol	Descriptions	Date	Approved

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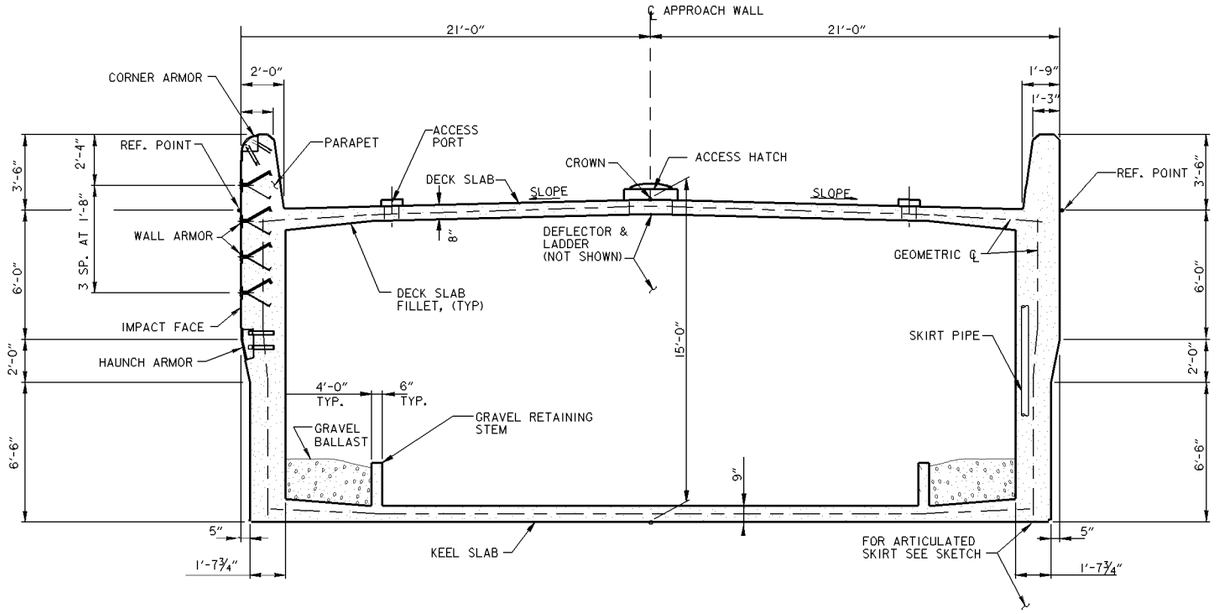
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

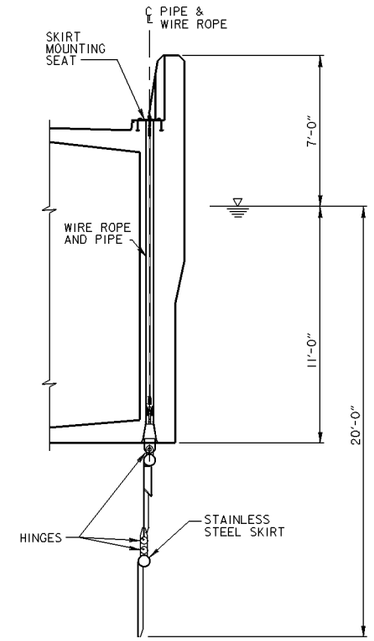
LLW PONTOON PLAN, SECTION & ELEV.

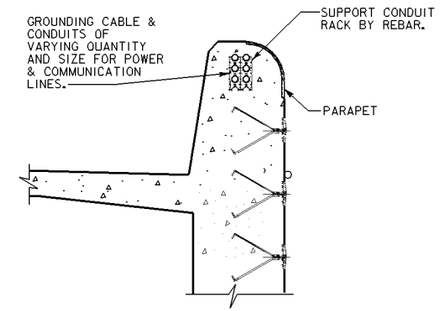
Designed by: MBR	Scale: AS SHOWN	Sheet reference number: S–3	FILENAME: GPS003.DGN
Drawn by: GFM	Date: JUNE 1999		PEN TABLE:
Checked by: DEM	Drawing Code:		Sheet of
Reviewed by:			
Approved by:			



CROSS SECTION URW (B S-1)

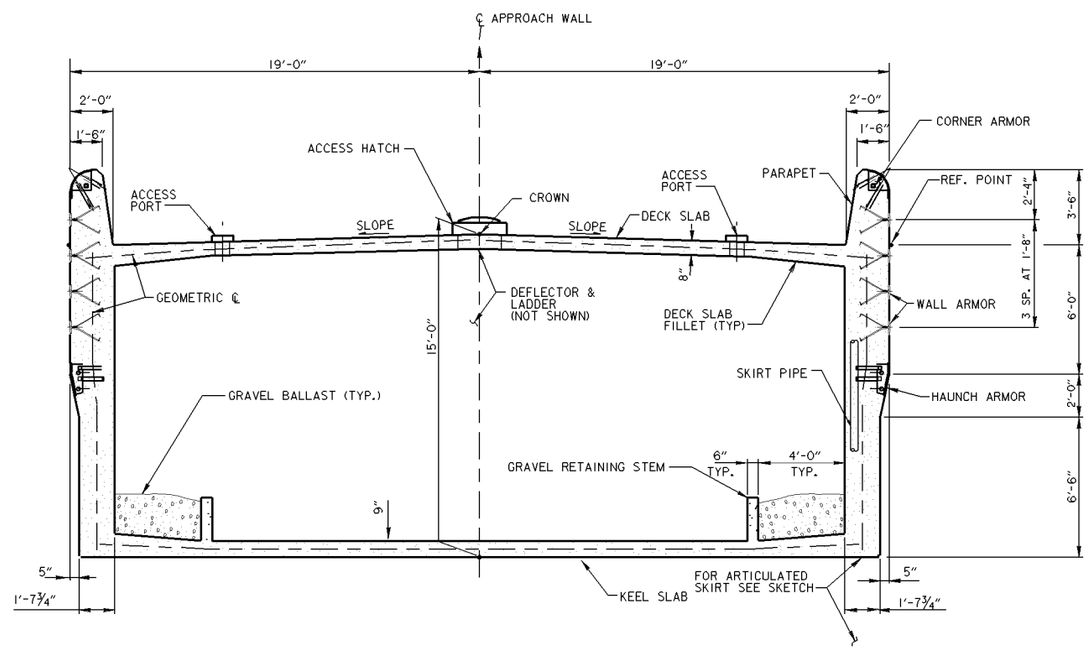
SCALE: ⅜"=1'-0"





CONDUIT & GROUNDING CABLE IN PARAPET

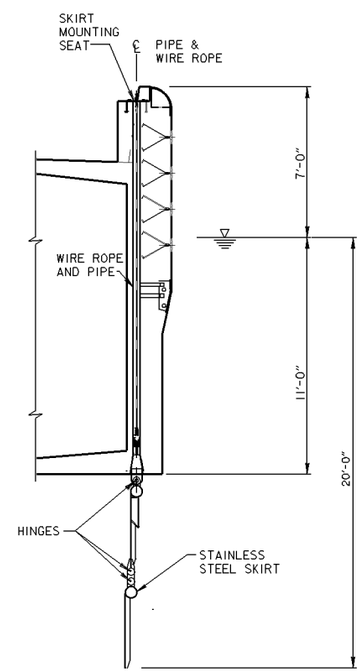
SCALE: NTS



NOTE: RIVER BED ELEVATION VARIES FROM EL. 470 (APPROACH TO RIVER SIDE LOCK) TO EL. 492 (APPROACH TO LAND SIDE LOCK).

CROSS SECTION UMW (B S-1)

SCALE: ⅜"=1'-0"



GRAPHIC SCALE

2 0 2 4FT

SCALE: 3/8"= 1'-0"

PLATE 3–4

Revisions			
Symbol	Descriptions	Date	Approved

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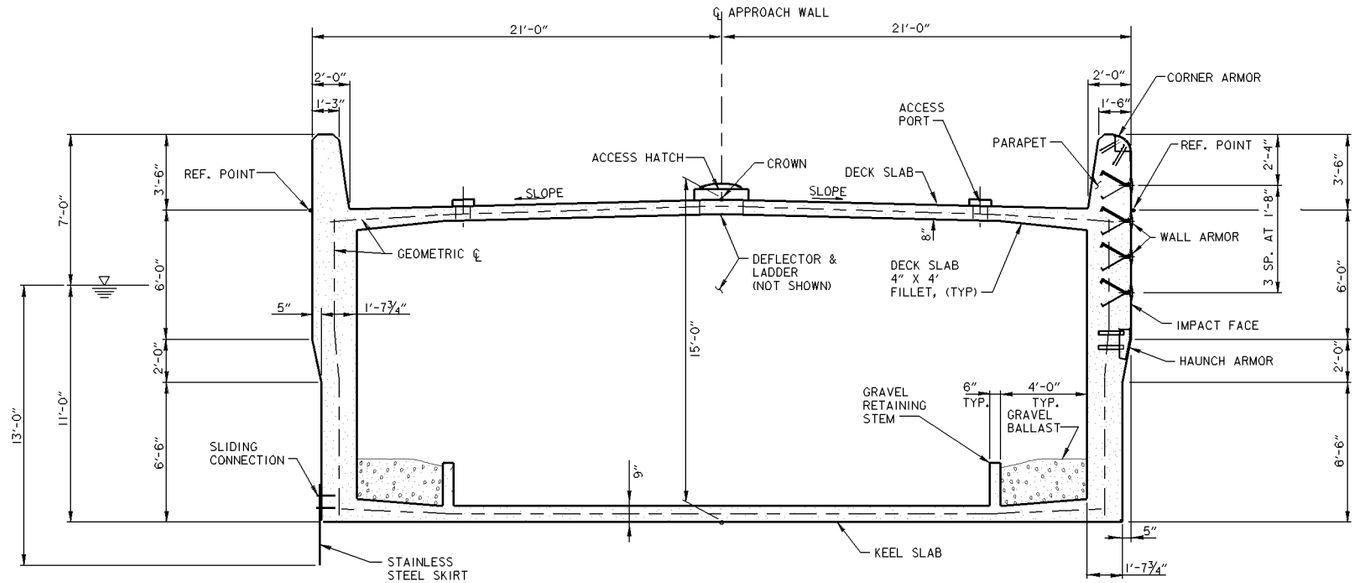
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

URW & UMW PONTOON CROSS SECTIONS

Designed by: MBR
Drawn by: JG
Checked by: DEM
Reviewed by:
Approved by:
Scale: AS SHOWN
Date: JUNE 1999
Drawing Code:
Sheet reference number: S-4
FILENAME:
PEN TABLE:
Sheet of



CROSS SECTION LLW

SCALE: ⅜" = 1'-0"

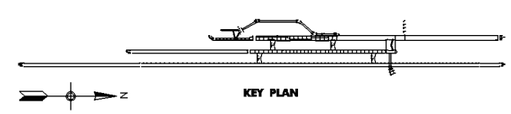
NOTE:

FOR ELECTRICAL & COMMUNICATION LINE CONDUITS EMBEDDED IN THE PONTOON PARAPET SEE DWG. S-4

GRAPHIC SCALE

2 0 2 4FT

SCALE: 3/8" = 1'-0"



KEY PLAN

PLATE 3–5

Revisions			
Symbol	Descriptions	Date	Approved

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HUNTINGTON, WEST VIRGINIA

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OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

LLW PONTOON CROSS SECTION

Designed by: MBR			
Drawn by: JG			
Checked by: DEM			
Reviewed by:	Scale: AS SHOWN	Sheet reference number:	FILENAME: PEN TABLE:
Approved by:	Date: JUNE 1999	S–5	
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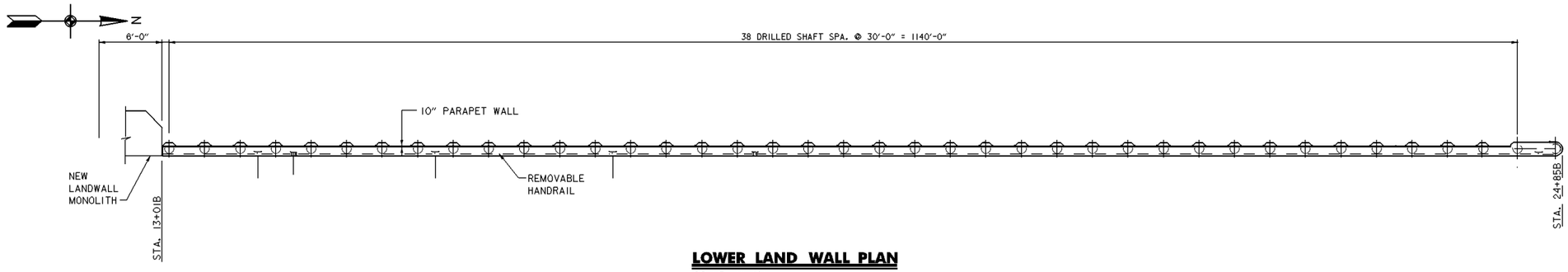
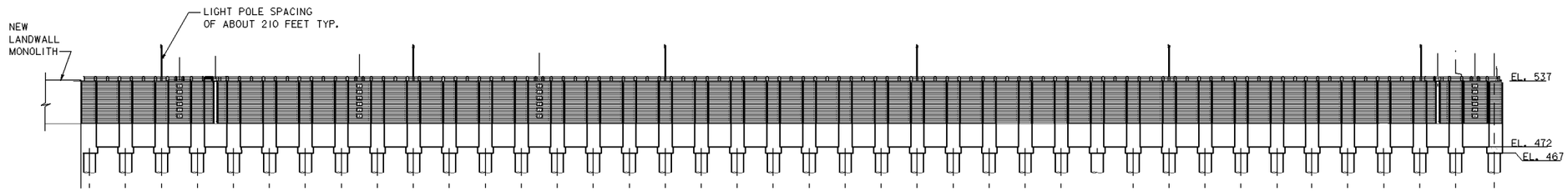


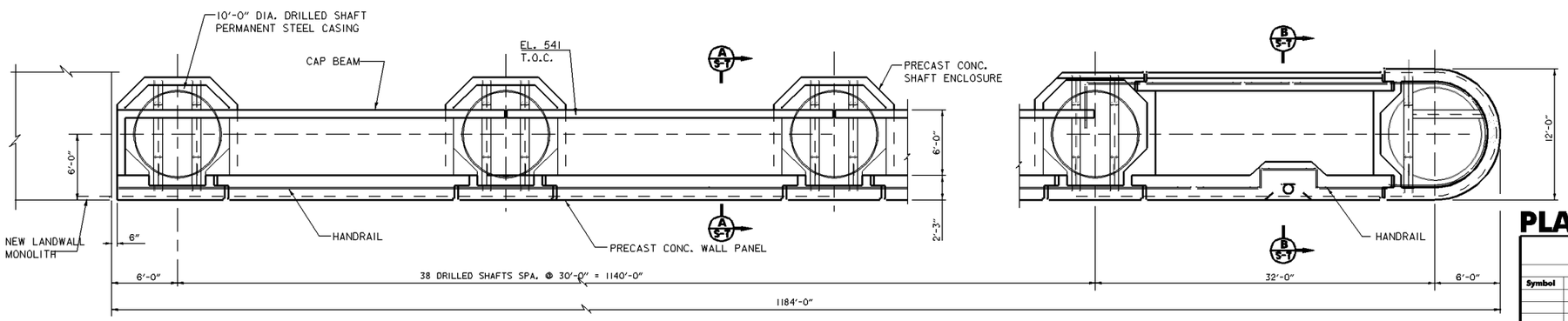
LOWER LAND WALL PLAN

SCALE: 1"=40'



ELEVATION

SCALE: 1"=40'



PLAN AT ELEVATION 537

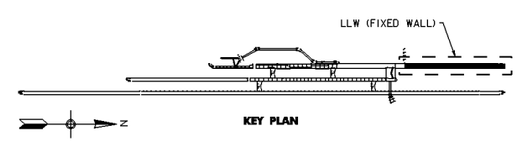
SCALE: 3/16"=1'-0"

GRAPHIC SCALE

4 0 4 8FT
SCALE: 3/16"= 1'-0"

20 0 40
SCALE: 1"= 40'

PLATE 3-6



KEY PLAN

Revisions			
Symbol	Descriptions	Date	Approved

INCA ENGINEERS INC.

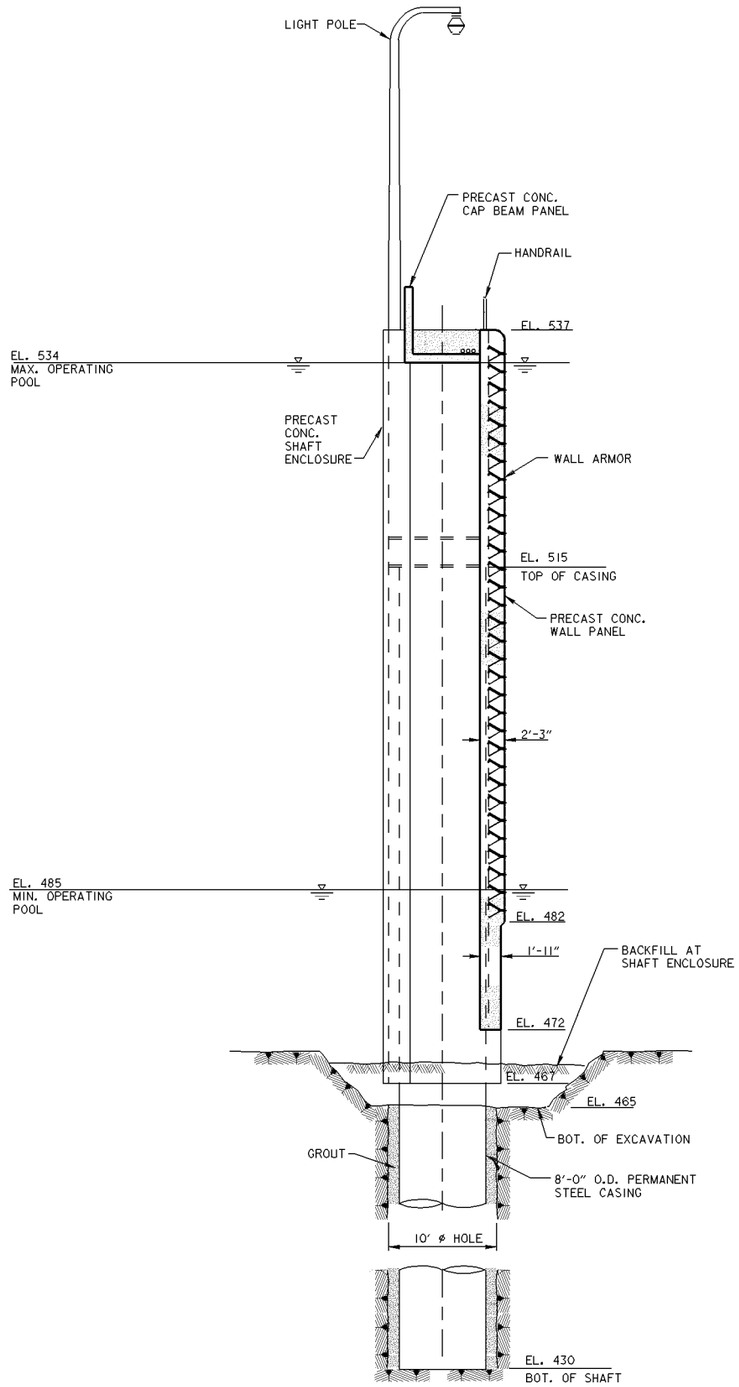
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

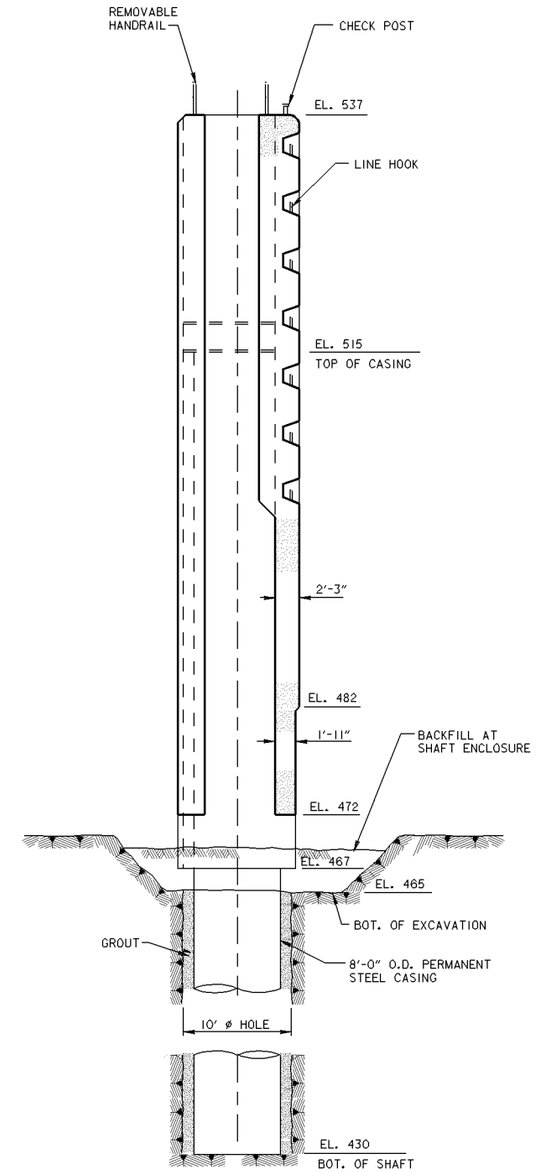
OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

LLW PLANS & ELEVATION
(FIXED WALL ALTERNATIVE)

Designed by: MI	Scale: AS SHOWN	Sheet reference number:	FILENAME: GP5006.DGN PEN TABLE:
Drawn by: KT	Date: JUNE 1999	S-6	
Checked by: DEM	Drawing Code:		Sheet of
Reviewed by:			
Approved by:			



SECTION A S-8
SCALE: 3/16"=1'-0"



SECTION B S-8
SCALE: 3/16"=1'-0"

LANDWALL CONSTRUCTION SEQUENCE

DRILLED SHAFT CONSTRUCTION SEQUENCE:

1. EXCAVATE RIVERBED TO ELEV. 465 AT SHAFT ENCLOSURE AREAS. ENTIRE LAND AREA MAY BE EXCAVATED AT THE CONTRACTOR'S OPTION.
2. INSTALL 10' DIA. TEMPORARY CASING AT LEAST 2 FEET MINIMUM INTO THE ROCK LAYER. EXCAVATE INSIDE CASING AS REQUIRED TO LOWER THE CASING.
3. DRILL 10' DIA. HOLE IN THE LOCK LAYER TO THE FINAL SHAFT TIP ELEVATION.
4. INSTALL 8' DIA. PERMANENT STEEL CASING.

   NOTE: THE 10' DIA. TEMPORARY STEEL CASING MAY BE REMOVED EITHER PRIOR TO STEP 4 OR STEP 5 AT THE CONSTRACTOR'S OPTION.
5. PRESSURE GROUT AROUND THE 8' DIA. CASING.
6. INSTALL THE REINFORCING CAGE AND PLACE TREMIE CONCRETE TO ELEV. 510, 5 FEET BELOW THE TOP OF CASING.
7. INSTALL THE SHAFT ENCLOSURE SUPPORTS AT THE TOP OF SHAFT.

SUPERSTRUCTURE CONSTRUCTION SEQUENCE:

1. LIFT PRECAST CONCRETE SHAFT ENCLOSURE AND INSTALL THE ENCLOSURE ON THE ENCLOSURE SUPPORT AT THE TOP OF DRILLED SHAFT AT ELEV. 515.
2. BACKFILL AROUND THE SHAFT ENCLOSURE TO SEAL THE GAP AT THE BOTTOM TO ELEV. 470.
3. PLACE TREMIE CONCRETE INSIDE THE ENCLOSURE TO ELEV. 472 AND ALLOW THE CONCRETE TO REACH 2000 PSI MINIMUM STRENGTH.
4. PLACE TREMIE CONCRETE INSIDE THE ENCLOSURE NOT MORE THAN 15 FEET DEEP AT ONE POUR AND ALLOW THE CONCRETE TO REACH 2000 PSI MINIMUM STRENGTH. REPEAT THIS STEP AS REQUIRED TO FILL CONCRETE INSIDE THE SHAFT ENCLOSURE TO ELEV. 533.
5. LIFT THE PRECAST CONCRETE WALL PANEL AND INSTALL THE PANEL THROUGH THE KEYS PROVIDED AT THE SHAFT ENCLOSURES.
6. INSTALL CAP BEAM PANELS.
7. INSTALL ELECTRICAL CONDUITS AND PLACE CONCRETE INSIDE THE SHAFT ENCLOSURE AND CAP BEAM PANELS.

GRAPHIC SCALE
4 0 4 8FT
SCALE: 3/16"= 1'-0"

PLATE 3-7

Revisions			
Symbol	Descriptions	Date	Approved

INCA ENGINEERS INC.

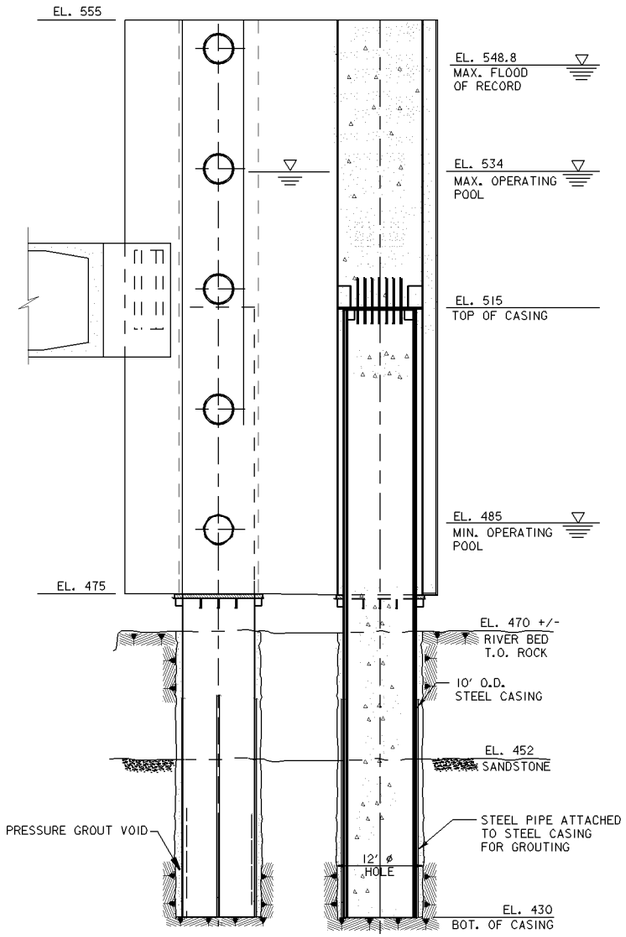
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

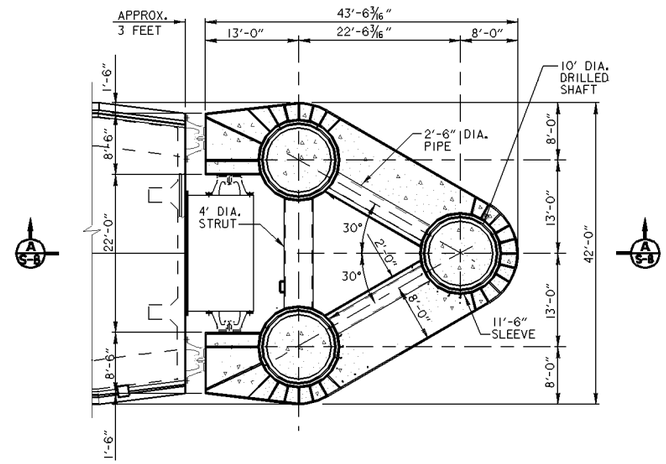
LLW SECTIONS & CONSTRUCTION SEQUENCE (FIXED WALL ALTERNATIVE)

Designed by: MI	Scale: AS SHOWN	Sheet reference number: S-7	FILENAME: GPS007.DGN PEN TABLE:
Drawn by: KT	Date: JUNE 1999		
Checked by: DEM	Drawing Code:		Sheet of
Reviewed by:			
Approved by:			



SECTION A S-8

SCALE: 1/8"=1'-0"
(LOOKING LANDWARD)



PLAN AT ELEV. 520

SCALE: 1/8"=1'-0"

GRAPHIC SCALE

8 6 4 2 0 8 16FT

SCALE: 1/8"=1'-0"

PLATE 3–8

Revisions			
Symbol	Descriptions	Date	Approved

INCA ENGINEERS INC.

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

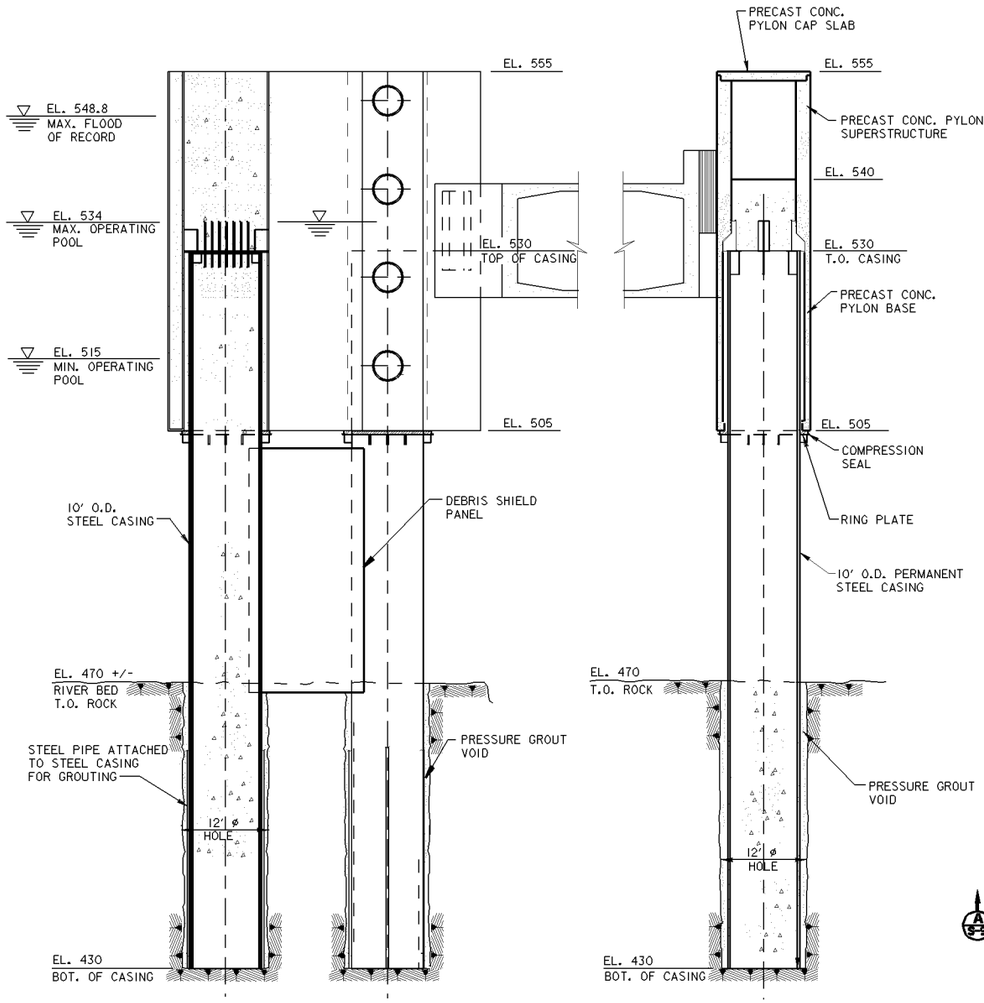
US Army Corps of Engineers

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

LLW
NOSE PIER

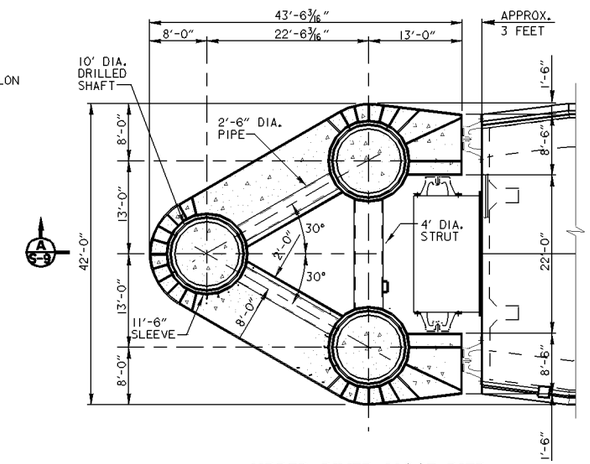
Designed by: MI
Drawn by: JG
Checked by: DEM
Reviewed by:
Approved by:

Scale: AS SHOWN
Date: JUNE 1999
Drawing Code:
Sheet reference number: S–8
FILENAME: PEN TABLE:
Sheet of



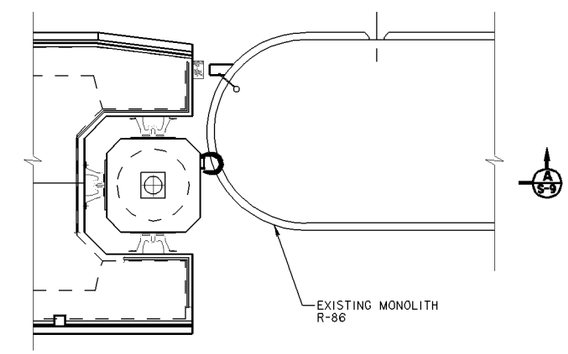
SECTION A S-9
SCALE: 1/8"=1'-0"

NOTE: PYLON EXISTS ONLY AT UPPER RIVER WALL.



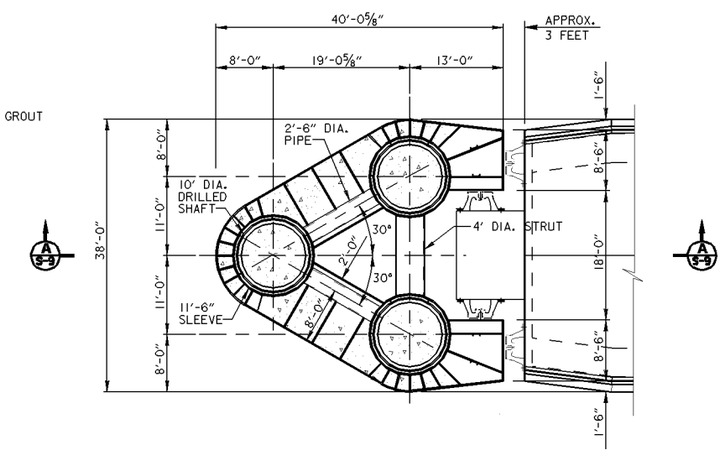
UPPER RIVER NOSE PIER

PLAN AT ELEV. 520
SCALE: 1/8"=1'-0"



UPPER RIVER PYLON

N



UPPER MIDDLE NOSE PIER

PLAN AT ELEV. 520
SCALE: 1/8"=1'-0"

GRAPHIC SCALE
8 6 4 2 0 8 16FT
SCALE: 1/8"=1'-0"

PLATE 3-9

Revisions			
Symbol	Descriptions	Date	Approved

INCA ENGINEERS, INC.

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

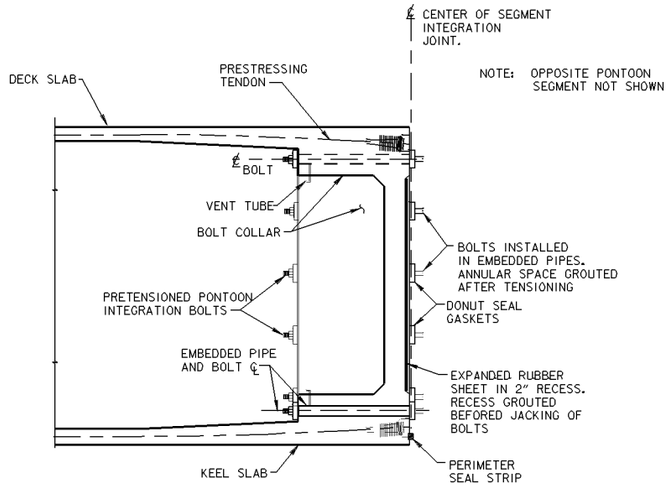
US Army Corps of Engineers

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

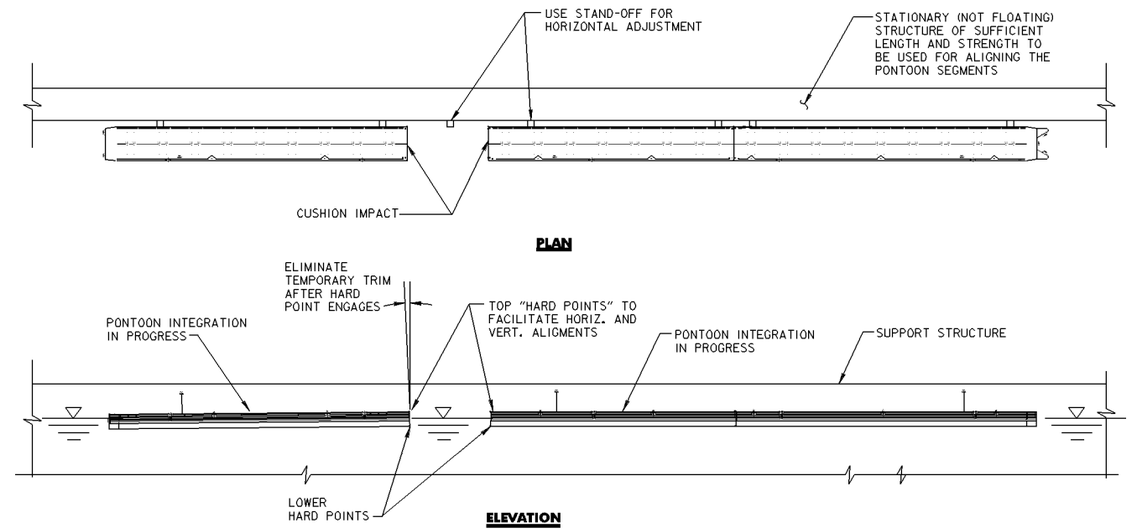
UMW & URW
NOSE PIERS & PYLONS

Designed by: MI
Drawn by: JG
Checked by: DEM
Reviewed by:
Approved by:

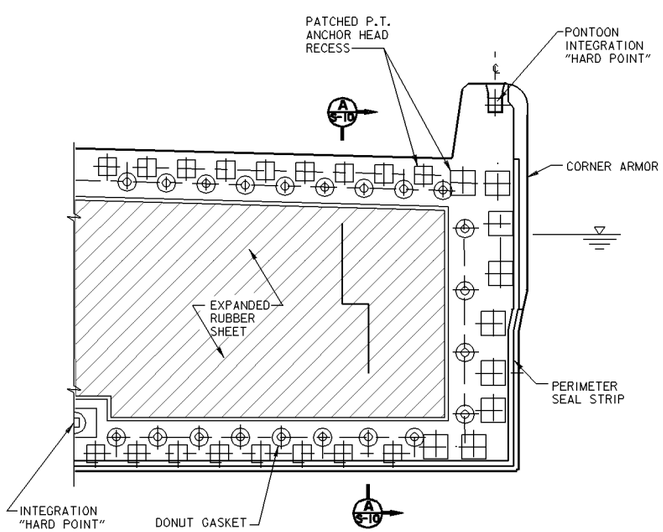
Scale: AS SHOWN
Date: JUNE 1999
Drawing Code:
Sheet reference number: S-9
FILENAME: PEN TABLE:
Sheet of



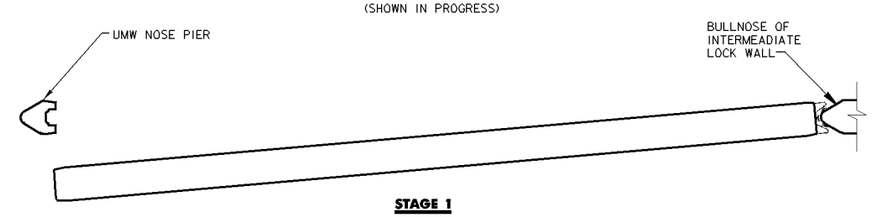
SECTION S-10
NO SCALE



PONTOON INTEGRATION
NO SCALE
(SHOWN IN PROGRESS)

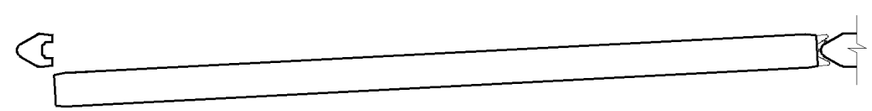


ESSENTIAL ELEMENTS AT THE PONTOON SEGMENT JOINT
NO SCALE



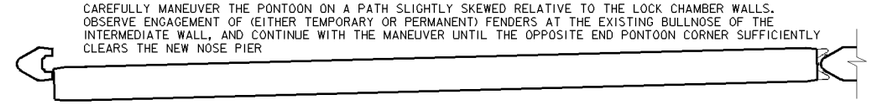
STAGE 1

MANEUVER THE PONTOON INTO SHOWN POSITION. EMPLOY CARE AND PROVIDE TEMPORARY FENDERS IN AREAS EXPOSED AND PRONE TO IMPACT



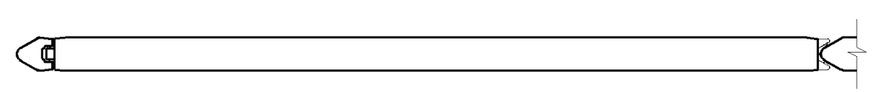
STAGE 2

CAREFULLY MANEUVER THE PONTOON ON A PATH SLIGHTLY SKEWED RELATIVE TO THE LOCK CHAMBER WALLS. OBSERVE ENGAGEMENT OF (EITHER TEMPORARY OR PERMANENT) FENDERS AT THE EXISTING BULLNOSE OF THE INTERMEDIATE WALL, AND CONTINUE WITH THE MANEUVER UNTIL THE OPPOSITE END PONTOON CORNER SUFFICIENTLY CLEARS THE NEW NOSE PIER



STAGE 3

MANEUVER THE PONTOON ON A PATH PIVOTING (YAWING) ABOUT THE EXISTING NOSE OF THE INTERMEDIATE WALL AFTER AN INCREMENTAL YAWING MOTION. REPEAT THE MOVEMENT ON A PATH NEARLY PARALLEL TO THE LOCK CHAMBER WALL. REPEAT YAWING AND PARALLEL MOTION UNTIL THE PONTOON IS IN ITS FINAL POSITION



STAGE 4

INSTALL STAINLESS STEEL GUIDE KEY AT THE NOSE PIER. INSTALL PERMANENT FENDERS AND REMOVE TEMPORARY FENDERS IF NECESSARY.

PONTOON INSTALLATION STAGES
NO SCALE
(SHOWN FOR THE INSTALLATION OF THE UMW PONTOON)

PLATE 3–10

Revisions			
Symbol	Descriptions	Date	Approved

INCA ENGINEERS INC.

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

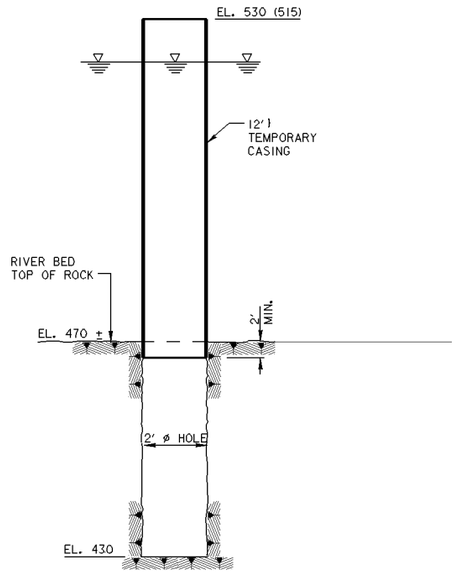
OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

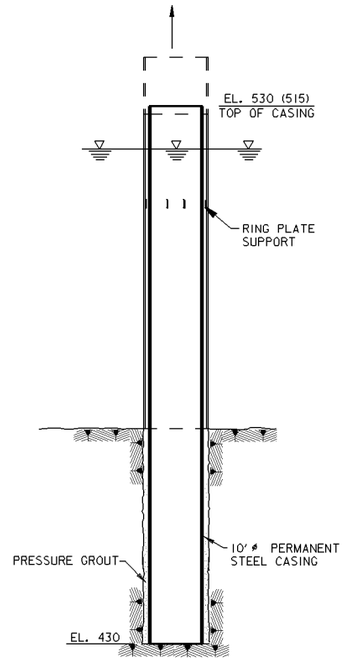
PONTOON CONSTRUCTION & INSTALLATION

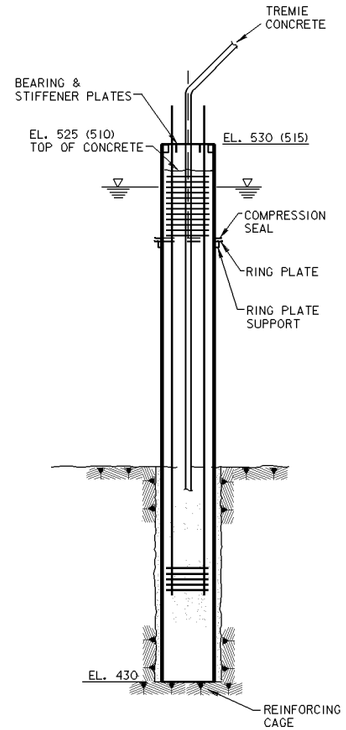
Designed by: MBR
Drawn by: JG
Checked by: DEM
Reviewed by:
Approved by:
Scale: AS SHOWN
Date: JUNE 1999
Drawing Code:
Sheet reference number: S–10
FILENAME: GPS011.DGN
PEN TABLE:
Sheet of

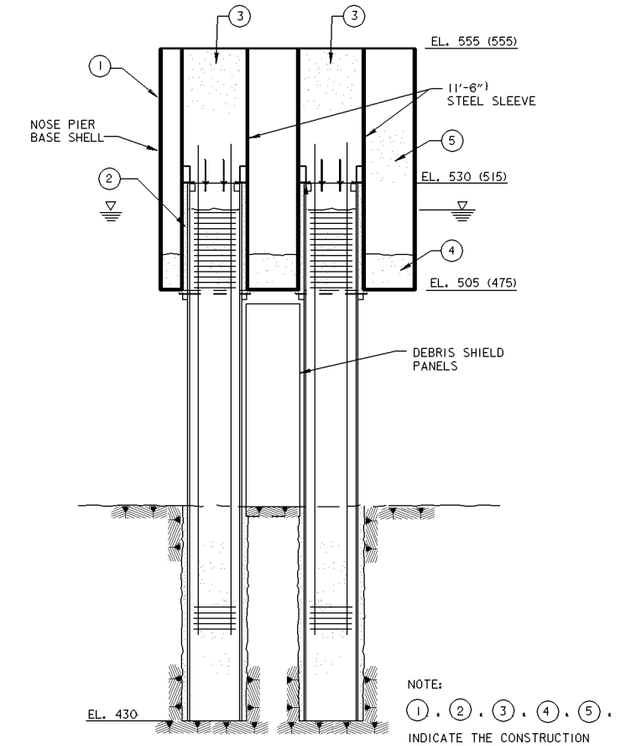
NOTES:

THE DRILLED SHAFT & SUPERSTRUCTURE SEQUENCE SHOWN ARE FOR THE UPPER MIDDLE & UPPER RIVER WALL NOSE PIERS. THE CONSTRUCTION SEQUENCE FOR THE LOWER LANDWALL NOSE PIER IS THE SAME AS THE UPSTREAM NOSE PIERS EXCEPT THE DESIGNATED ELEVATIONS. THE ELEVATIONS FOR THE LOWER LANDWALL NOSE PIER ARE SHOWN IN ( ).









NOTE:
1, 2, 3, 4, 5,
INDICATE THE CONSTRUCTION SEQUENCE STEP NUMBERS.

DRILLED SHAFT CONSTRUCTION SEQUENCE

1. INSTALL 12' DIA. TEMPORARY STEEL CASING AT LEAST 2 FEET MINIMUM INTO THE ROCK LAYER. EXCAVATE INSIDE THE CASING AS REQUIRED TO LOWER THE CASING.
2. DRILL 12' DIA. HOLE IN THE ROCK LAYER TO THE FINAL SHAFT TIP ELEVATION.
3. INSTALL 10' DIA. PERMANENT STEEL CASING WITH THE RING PLATE SUPPORTS (FIELD WELD OR SHOP WELD AT THE CONTRACTOR'S OPTION). IF THE RING PLATE SUPPORTS ARE INSTALLED IN THE FIELD, THE SUPPORTS SHALL BE INSTALLED ABOVE WATER DURING THE CASING INSTALLATION.

   NOTE: THE 12' DIA. TEMPORARY STEEL CASING MAY BE REMOVED EITHER PRIOR TO STEP 3 OR STEP 4 AT THE CONTRACTOR'S OPTION.
4. PRESSURE GROUT AROUND THE 10' DIA. CASING.
5. INSTALL THE RING PLATE.
6. INSTALL THE REINFORCING CAGE AND PLACE TREMIE CONCRETE TO ELEV. 525 (ELEV. 510), 5 FEET BELOW THE TOP OF CASING.
7. DEWATER INSIDE THE CASING AND INSTALL BEARING AND STIFFENER PLATES.
8. CONSTRUCT REMAINING TWO SHAFTS FOR THE NOSE PIER.
9. INSTALL THE DEBRIS SHIELD PANELS. THE DEBRIS SHIELD PANELS SHALL BE INSTALLED PRIOR TO THE NOSE PIER SUPERSTRUCTURE INSTALLATION (DEBRIS SHIELD PANELS ARE NOT REQUIRED AT THE LOWER LANDWALL NOSE PIER).

SUPERSTRUCTURE CONSTRUCTION SEQUENCE

1. INSTALL THE BASE SHELL STRUCTURE ON THE DRILLED SHAFTS.
2. PLACE GROUT IN THE GAP BETWEEN 10' DIA. CASING AND 11'-6" DIA. STEEL SLEEVES TO ELEV. 530 (ELEV. 515), TOP OF STEEL CASING.
3. AFTER THE GROUT IN STEP 2 IS SET, PLACE CONCRETE INSIDE THE 11'-6" DIA. SLEEVES TO ELEV. 555 (ELEV. 555).
4. PLACE CONCRETE INSIDE THE BASE SHELL TO APPROXIMATELY ELEV. 510 (ELEV. 480), ABOUT 5 FEET DEEP AND ALLOW THE CONCRETE TO REACH 2000 PSI MINIMUM STRENGTH.
5. PLACE CONCRETE INSIDE THE BASE SHELL (NOT MORE THAN 8 FEET DEEP) AND ALLOW THE CONCRETE TO REACH 2000 PSI MINIMUM STRENGTH. REPEAT THIS STEP AS REQUIRED TO FILL CONCRETE INSDE THE STEEL SHELL TO ELEV. 555 (ELEV. 555).

GRAPHIC SCALE
8 0 8 16FT
SCALE: 3/32"= 1'-0"

PLATE 3–11

Revisions			
Symbol	Descriptions	Date	Approved

INCA ENGINEERS INC.

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

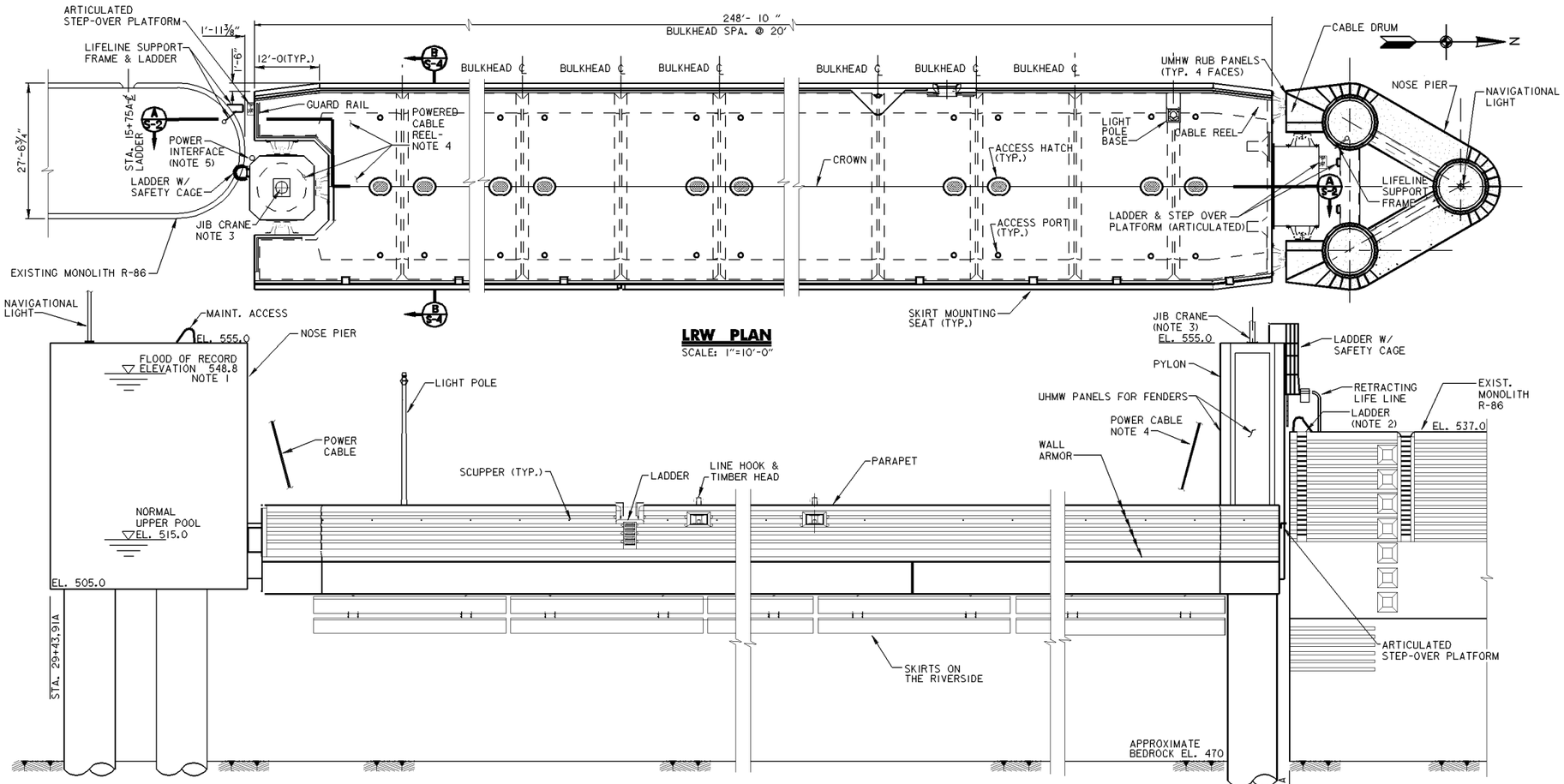
US Army Corps of Engineers

OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

Designed by: MI
Drawn by: KT
Checked by: DEM
Reviewed by:
Approved by:

NOSE PIER
CONSTRUCTION SEQUENCE

Scale: AS SHOWN
Date: JUNE 1999
Drawing Code:
Sheet reference number: S–11
FILENAME: PIER TABLE:
Sheet of

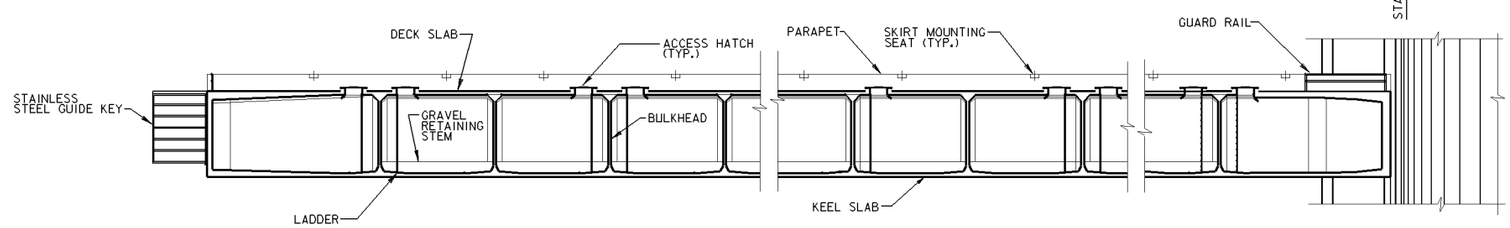


LRW PLAN

SCALE: 1"=10'-0"

ELEVATION (LOOKING RIVERWARD)

SCALE: 1"=10'-0"



NOTE: SKIRTS NOT SHOWN

SECTION A S-2

SCALE: 1"=10'-0"

NOTES:

1. THE PROBABLE MAXIMUM FLOOD (PMF) ELEVATION HAS NOT BEEN DETERMINED PRESENTLY.
2. INDIVIDUAL RUNG LADDER MOUNTED ON THE FACE OF THE EXISTING CONCRETE STRUCTURE BY STAINLESS STEEL SCREWS.
3. POWER WINCH OPERATED JIB CRANE WITH A RATED CAPACITY OF 2 TONS LOAD AT A "HOOK REACH" OF 22 FEET MINIMUM, "HOOK HEIGHT" MINIMUM (I.E., HORIZONTAL BOOM POSITION) OF 6'-0", "MAXIMUM LIFT" (I.E., BELOW MAST BASE PLATE) OF 40 FEET, AND SMOOTH 360° (MAST & BOOM ROTATION) LOAD MOVEMENT.
4. FOR TRANSFER OF POWER ONTO PONTOON THE FOLLOWING FEATURES ARE REQUIRED: CABLE DRUM (ON TOP OF THE PYLON), POWERED CABLE REEL AND ELECTICAL CABINET ON THE PONTOON DECK.
5. POWER AND COMMUNICATION LINES INTERFACE FOR LOCK EXTENSION APPROACH WALL.

GRAPHIC SCALE

10 5 0 10 20FT

SCALE: 1"= 10'

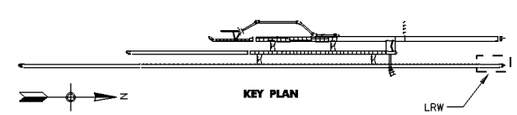


PLATE 3-12

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

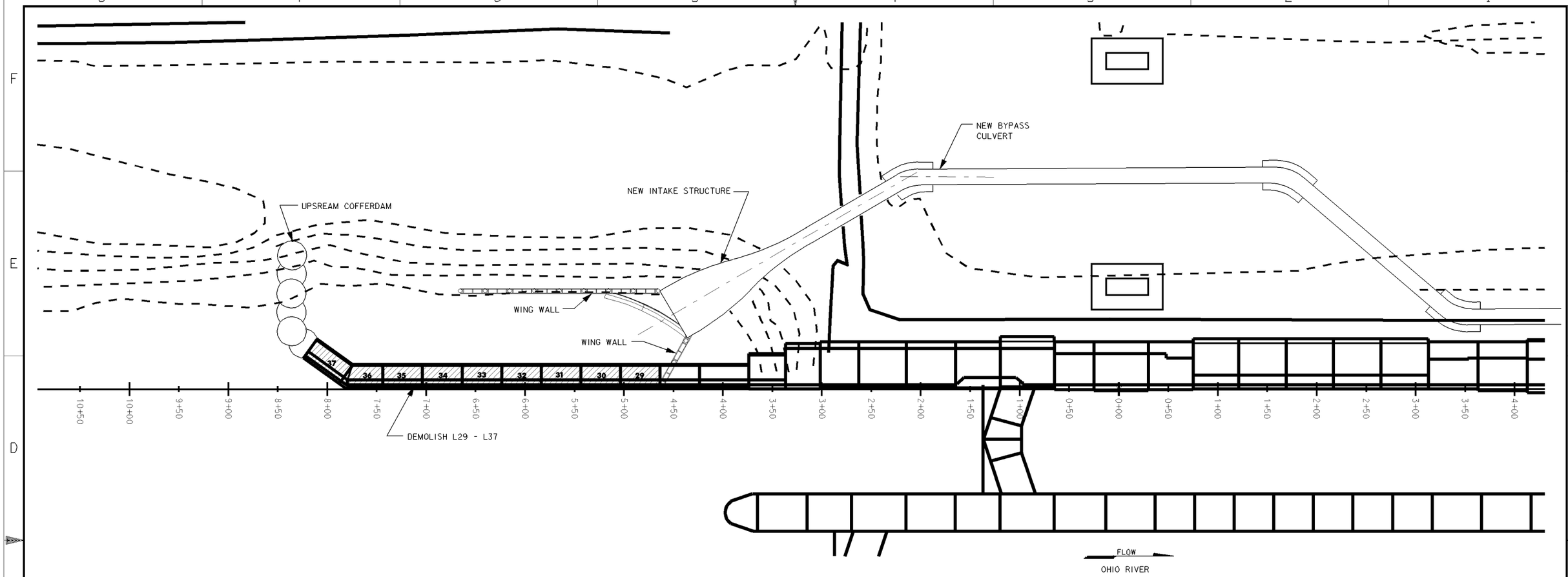
OHIO RIVER
MAINSTEM SYSTEMS STUDY
GREENUP LOCKS AND DAM

LRW PONTOON PLAN, SECTION & ELEV.

Designed by:	XXX
Drawn by:	GLC
Checked by:	DLC WLW LLM
Reviewed by:	
Approved by:	
Scale:	AS SHOWN
Date:	JUNE 1999
Drawing Code:	
Sheet reference number:	S-12
Sheet	of
FILENAME:	PLATE 3-12.DGN
PEN TABLE:	b.pnb

26.4.4 Filling and Emptying System

PLATE (4-1) UPSTREAM DEMOLITION PLAN
PLATE (4-2) AUX. EXTENSION W/CULVERT
PLATE (4-3) F/E SYSTEM DEWATERING PLAN
PLATE (4-4) F/E SYSTEM DEWATERING PLAN
PLATE (4-5) CULVERT INTAKE STRUCTURE PLAN & SECTION
PLATE (4-6) OUTLET STRUCTURE PLAN & SECTION
PLATE (4-7) UPSTREAM CULVERT VALVE STRUCTURE PLAN & ELEVATION



UPSTREAM DEMOLITION

PLAN

CONSTRUCTION SEQUENCE

STEP 1

1a. INSTALL COFFERDAM

1b. DEWATER TO ELEV 480

STEP 2

2a. DRILL AND INSTALL WING WALL CAISSONS

2b. CONSTRUCT INTAKE STRUCTURE

2c. PLACE WING WALL PANELS

2d. CAST INITIAL SECTIONS OF BYPASS CULVERT

STEP 3

3a. BACHFILL AGAINST INTAKE STRUCTURE AND FIRST 150 FT OF CULVERT

3b. REMOVE COFFERDAM

3c. DEMOLISH MONOLITHS L29 - L37

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

PLATE 4–1

Revisions			
Symbol	Descriptions	Date	Approved

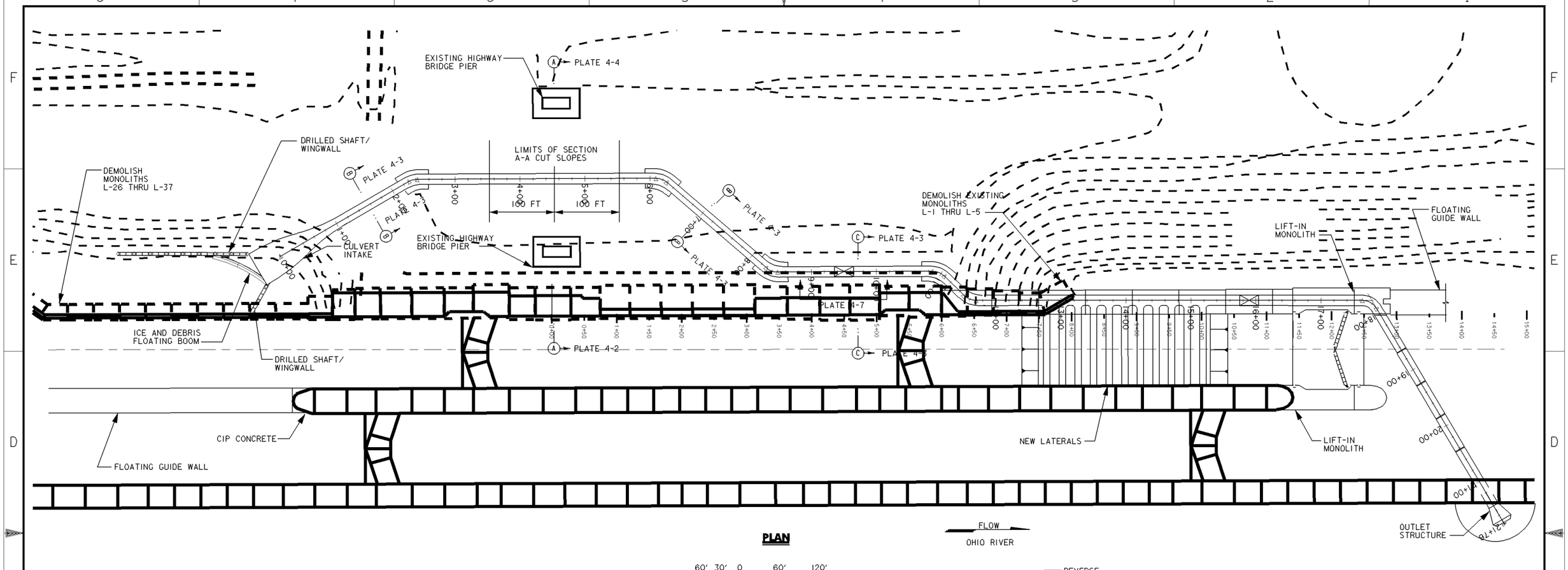
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

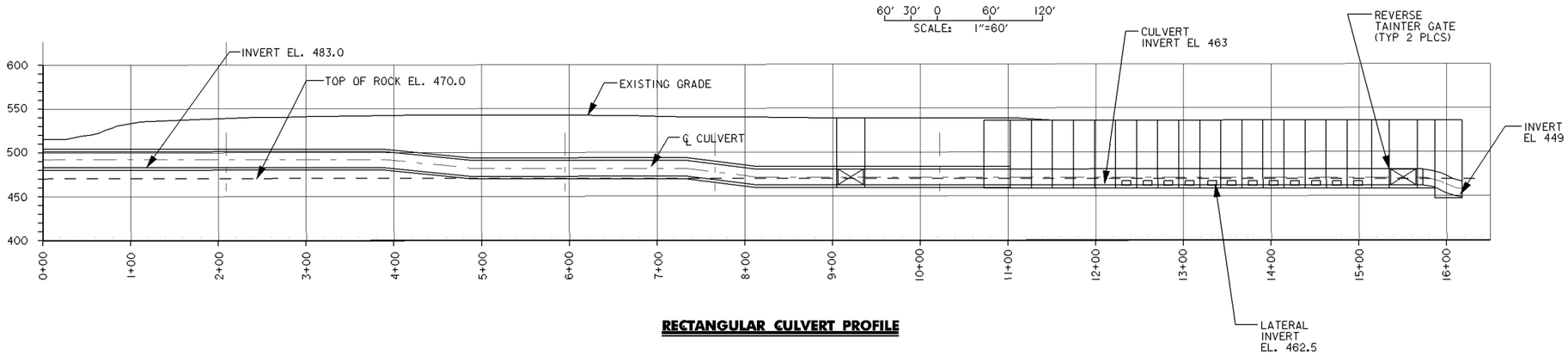
UPSTREAM DEMOLITION PLAN

Designed by: XX	Scale: AS SHOWN	Sheet reference number:	GLD_4-1.DGN
Drawn by: L.T.	Date: XXXX 1999		D.PTD
Checked by: XX	Drawing Code:		Sheet X of X
Reviewed by: XX			
Approved by: XX			

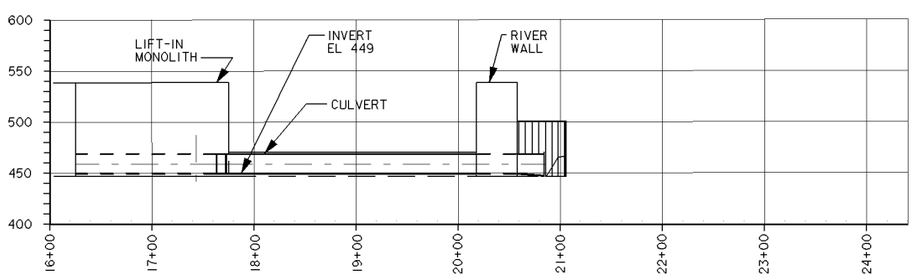


PLAN

60′ 30′ 0 60′ 120′
SCALE: 1″=60′



RECTANGULAR CULVERT PROFILE



RECTANGULAR CULVERT PROFILE

PLATE 4–2

Revisions			
Symbol	Descriptions	Date	Approved

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U.S.ARMY ENGINEER DISTRICT
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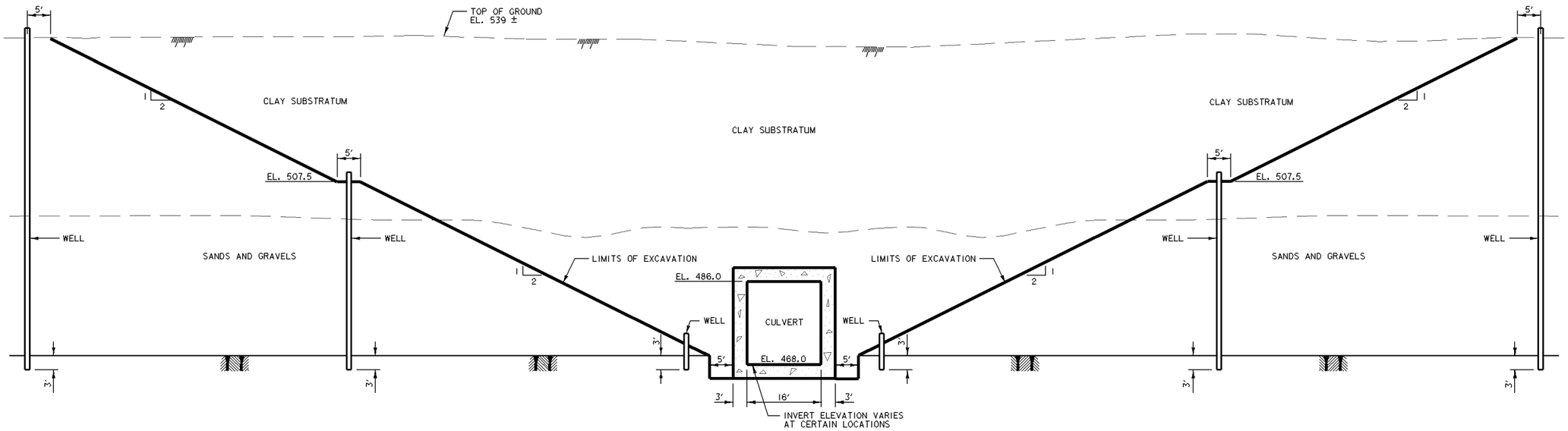
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

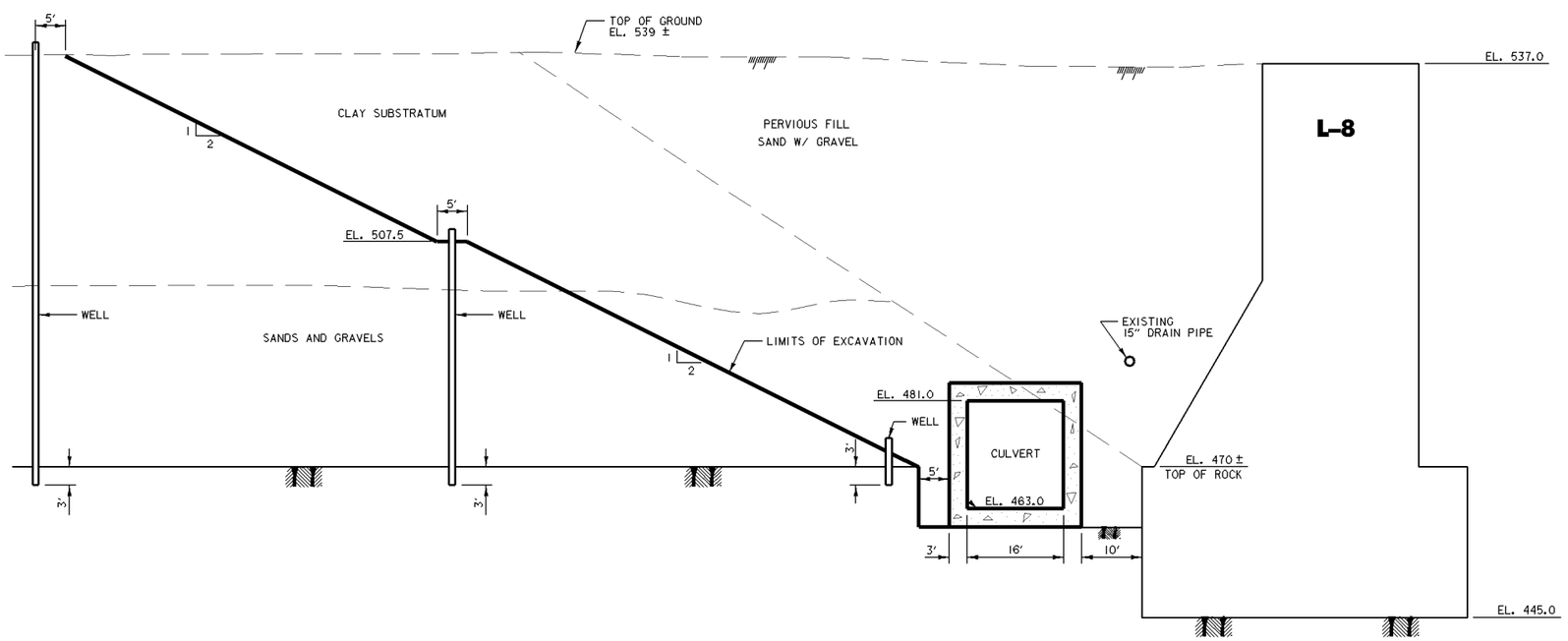
III AUX. EXTENSION W/CULVERT
PROPOSED 600′ LOCK EXTENSION

Designed by: P.P.			
Drawn by: L.E.N.			
Checked by: XX			
Reviewed by:	Scale: AS SHOWN	Sheet reference numbers	GLD_4-2.DGN
Approved by:	Date: JUNE 1999		b.ptb
	Drawing Code:		Sheet X of X



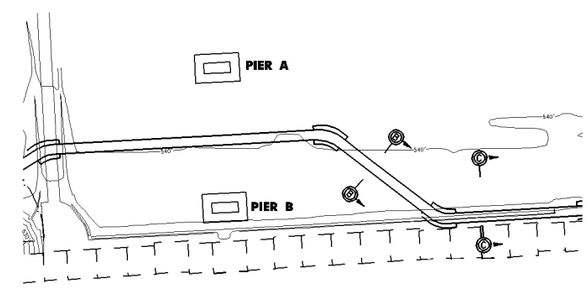
SECTION B–B

SCALE: 1" = 20'



SECTION C–C

SCALE: 1" = 20'



PLAN

100' 0 100' 200'

PLATE 4–3

Revisions			
Symbol	Descriptions	Date	Approved

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U.S.ARMY ENGINEER DISTRICT
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HUNTINGTON, WEST VIRGINIA

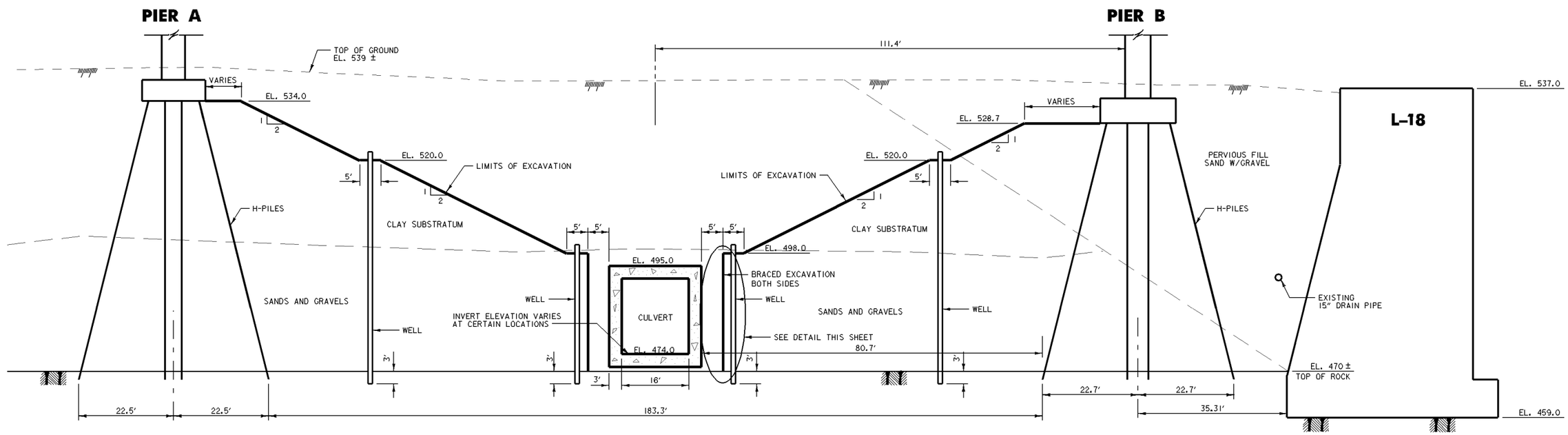
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
600' AUX. LOCK EXTENSION W/ ADDITIONAL FILL/EMPTY SYSTEM

F/E SYSTEM DEWATERING PLAN

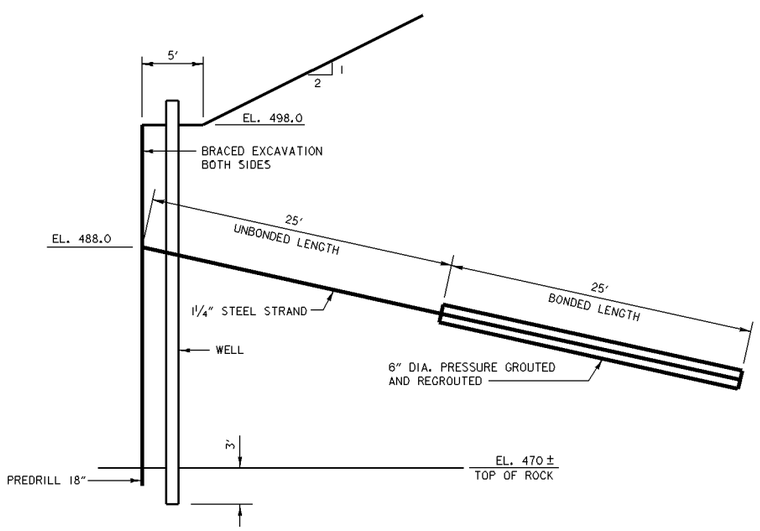
Designed by: TLR
Drawn by: TLR
Checked by: AFW
Reviewed by:
Approved by:

Scale: AS SHOWN
Date: APRIL 1999
Drawing Code:
Sheet reference number:
FILENAME: Greenup L&D Project Directory 600 Ft. Lock Extension p:\edgs\dewatr.dgn
Sheet 2 of 2



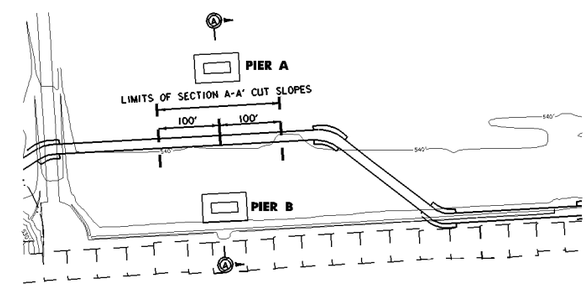
SECTION A-A

SCALE: 1" = 20'



EXCAVATION SUPPORT

SCALE: 1" = 10'



PLAN

100' 0 100' 200'

PLATE 4-4

Revisions			
Symbol	Descriptions	Date	Approved

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U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

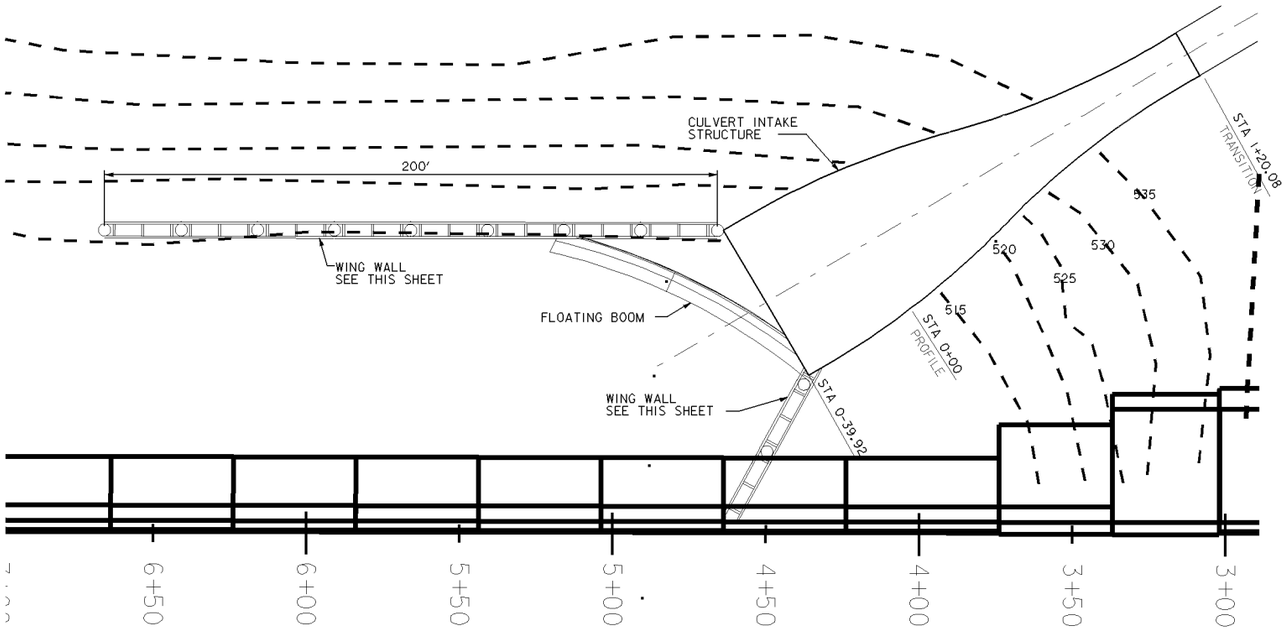
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
600' AUX. LOCK EXTENSION W/ ADDITIONAL FILL/EMPTY SYSTEM

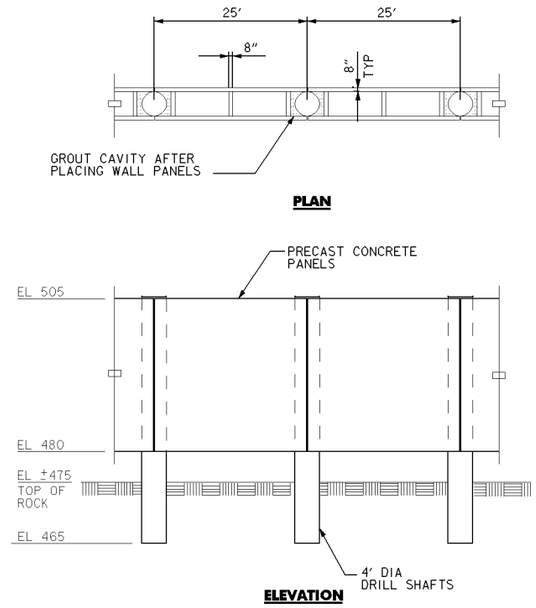
F/E SYSTEM DEWATERING PLAN

Designed by:
Drawn by: TLR
Checked by:
Reviewed by:
Approved by:

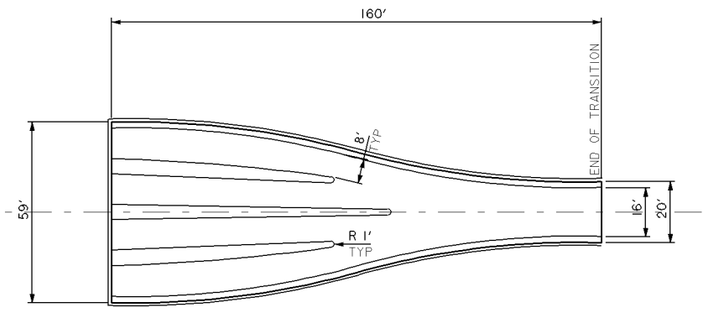
Scale: AS SHOWN
Date: APRIL 1999
Drawing Code:
Sheet reference number:
FILENAME: Greenup L&D Project Directory 600 Ft. Lock Extension p:\edgs\dewatr.dgn
Sheet 1 of 2



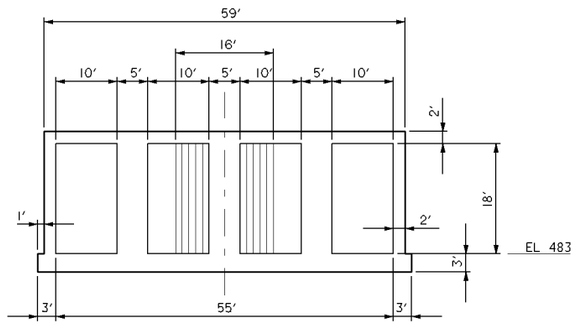
CULVERT INTAKE
PARTIAL SITE PLAN
SCALE: 1"=20'



WING WALL
SCALE: 1"=10'



PLAN
SCALE: 1"=20'



ELEVATION
SCALE: 1"=10"

CULVERT INTAKE STRUCTURE

PLATE 4–5

Revisions			
Symbol	Descriptions	Date	Approved

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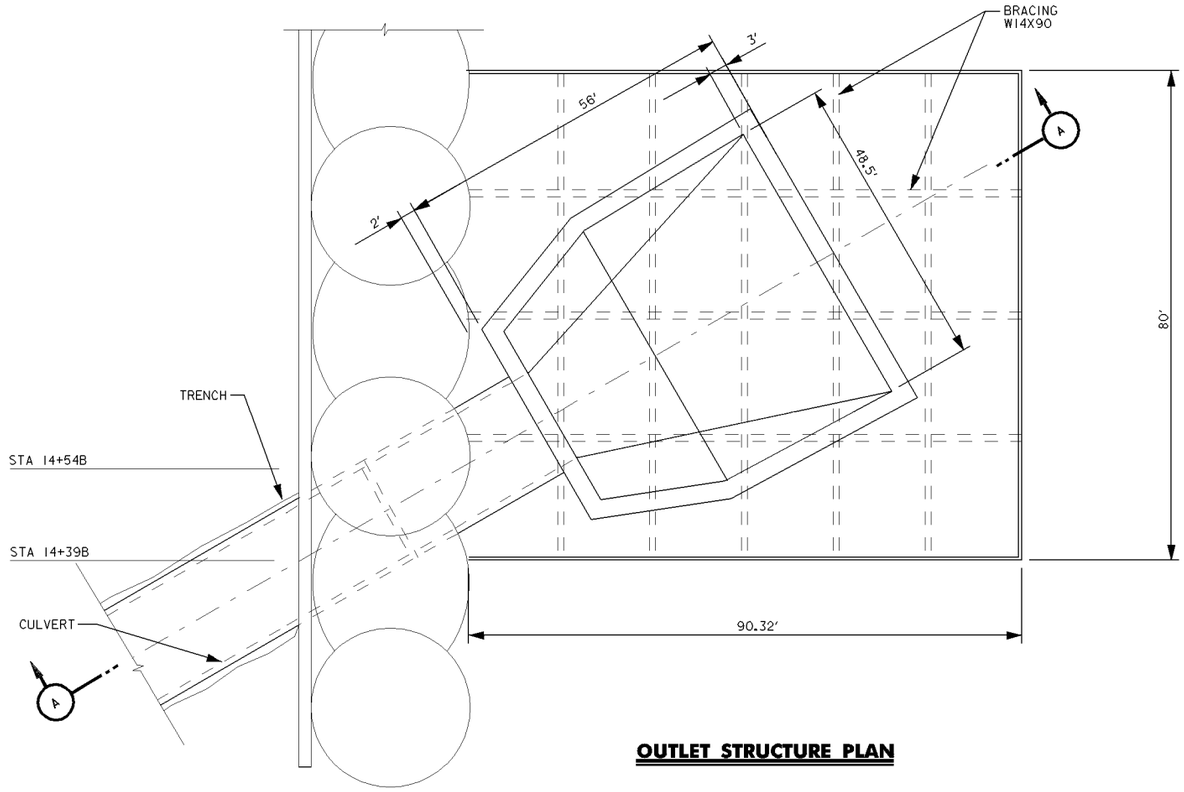
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

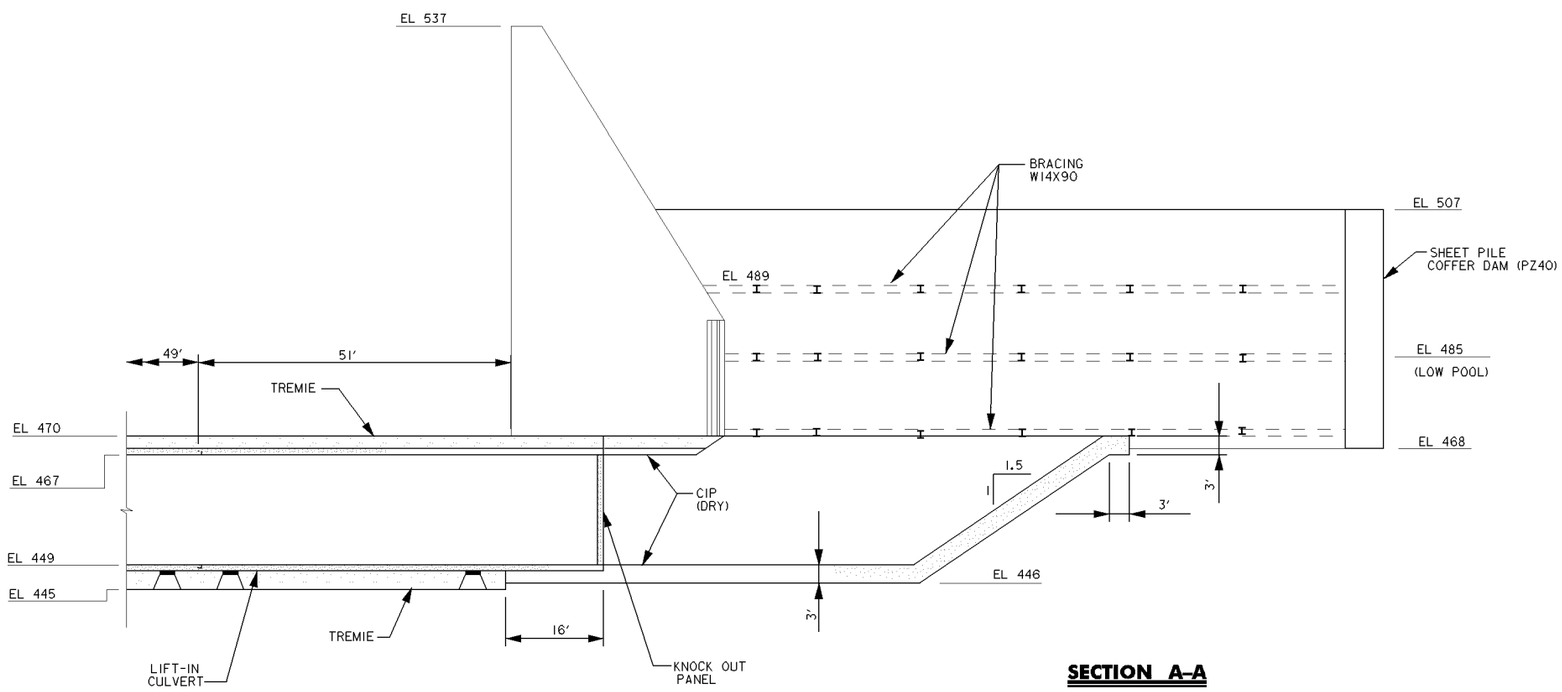
US Army Corps of Engineers

OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM
CULVERT INTAKE STRUCTURE
PLAN & SECTION

Designed by: XX	Scale: 1:20	Sheet reference number:	GLD_4-5.DGN
Drawn by: LT	Date: XXXX 1999		b.ptb
Checked by: XX	Drawing Code:		Sheet of
Reviewed by: XX			
Approved by: XX			



OUTLET STRUCTURE PLAN



SECTION A-A

PLATE 4-6

Revisions			
Symbol	Descriptions	Date	Approved

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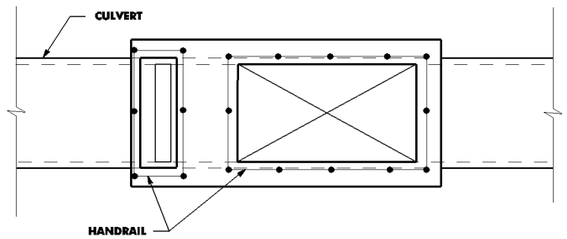
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

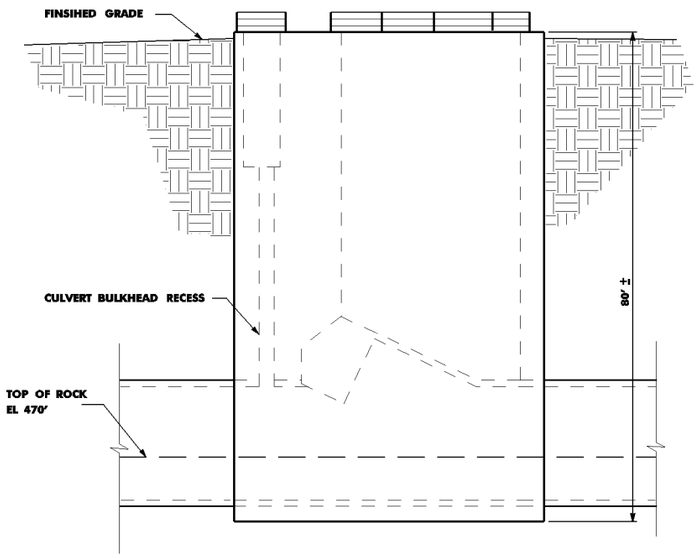
OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

OUTLET STRUCTURE PLAN & SECTION

Designed by: XX	Scale: 1:10	Sheet reference number:	GLD_4-6.DGN
Drawn by: LT	Date: JUNE 1999		b.ptb
Checked by: XX	Drawing Codes:		Sheet of
Reviewed by: XX			
Approved by: XX			



PLAN



ELEVATION

UPSTREAM CULVERT VALVE STRUCTURE

SCALE: 1"=10'

PLATE 4–7

Revisions			
Symbol	Descriptions	Date	Approved

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U.S.ARMY ENGINEER DISTRICT
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HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

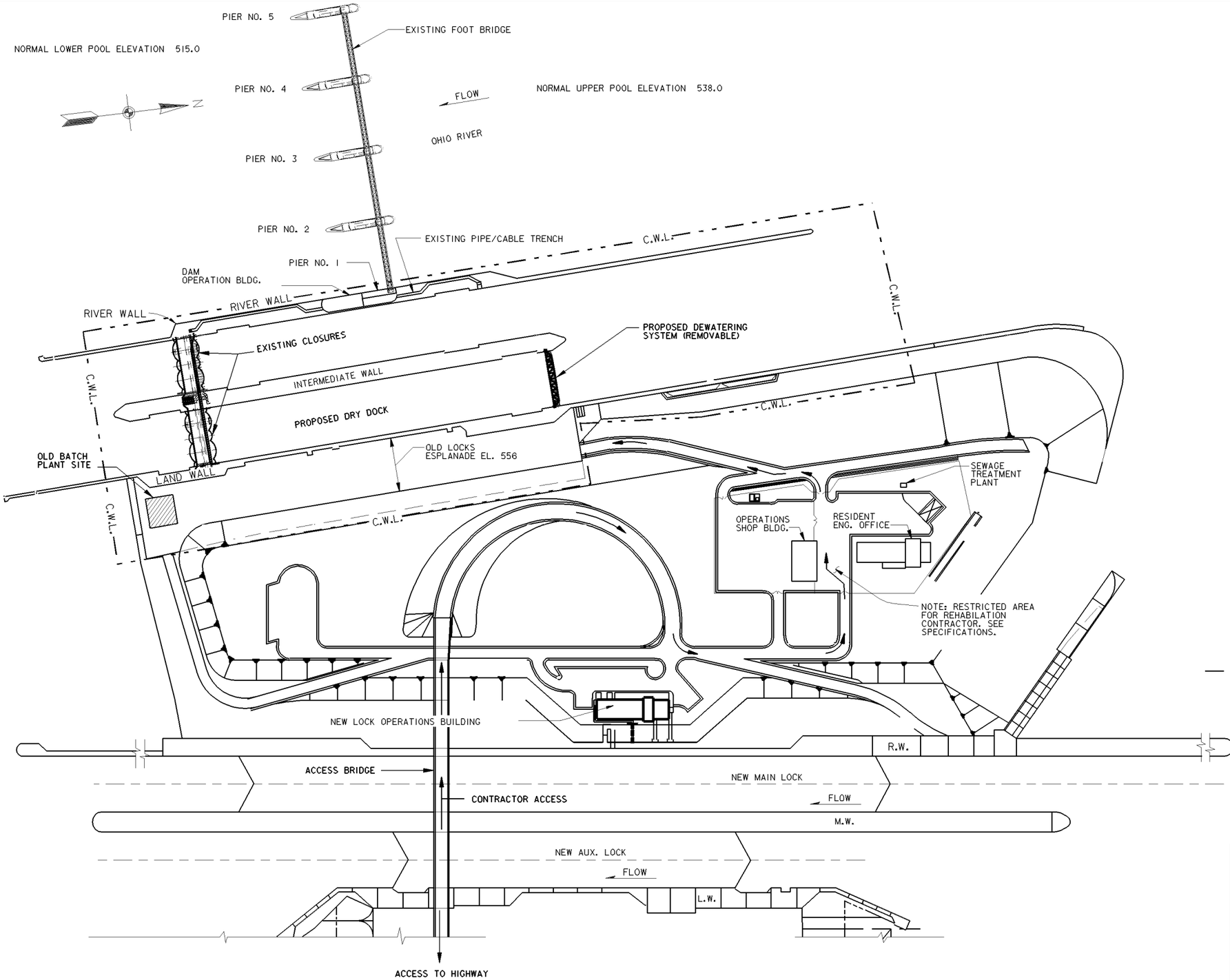
OHIO RIVER
MAIN STEM STUDY
GREENUP LOCKS AND DAM

UPSTREAM CULVERT VALVE STRUCTURE
PLAN & ELEVATION

Designed by:	P.P
Drawn by:	L.T.
Checked by:	XX
Reviewed by:	XX
Approved by:	XX
Scale:	AS SHOWN
Date:	XXXX 1999
Drawing Code:	
Sheet reference number:	GLD_4-7.DGN
	b.ptb
Sheet	of

26.4.5 R.C. Byrd Dry Dock

PLATE (5-1) RCB – DRY DOCK - OVERALL SITE PLAN
PLATE (5-2) RCB – DRY DOCK – PLAN AND SECTION
PLATE (5-3) RCB – DRY DOCK – MAINTENANCE BULKHEAD
PLATE (5-4) RCB – DRY DOCK - PROFILE



SITE PLAN

NOT TO SCALE

LEGEND

— - - - C.W.L. — - - CONTRACTOR'S WORK LIMITS

PLATE NO. 5–1

Revisions			
Symbol	Descriptions	Date	Approved

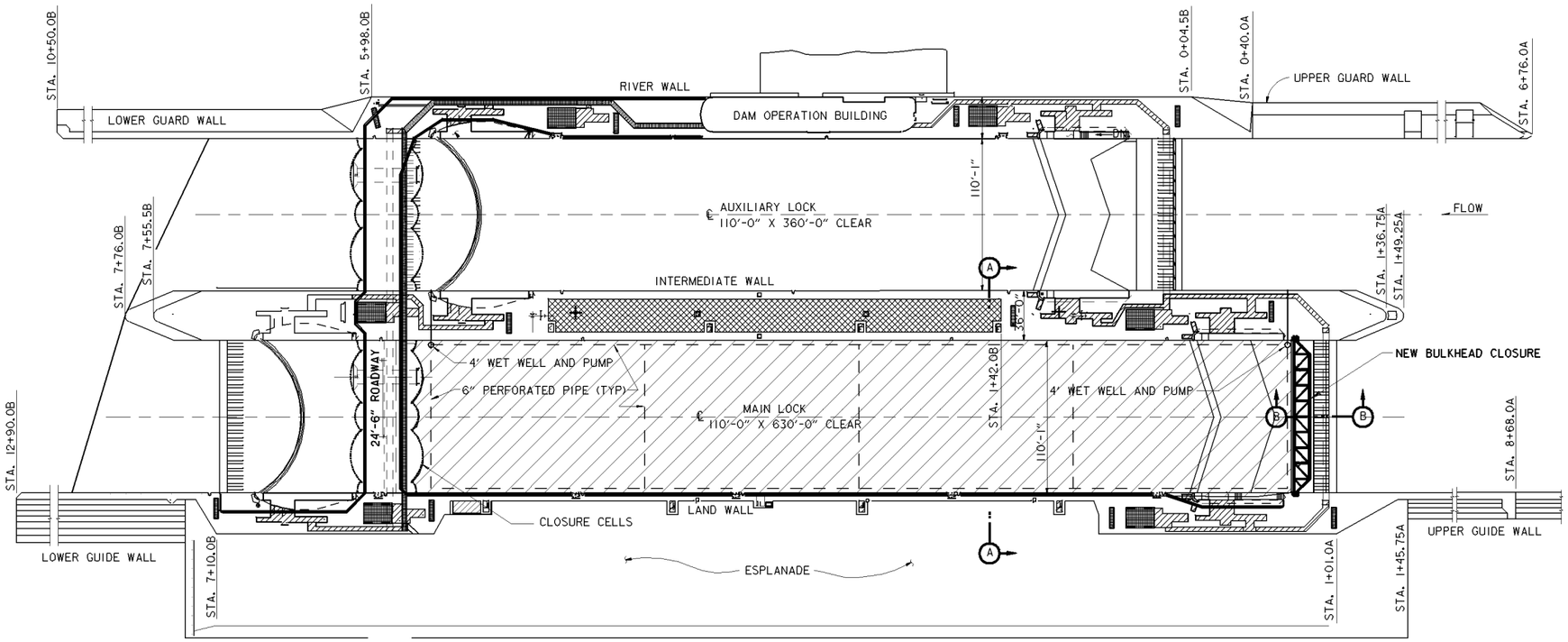
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS AND DAM
R.C. BYRD DRY DOCK

OVERALL SITE PLAN

Designed by: CELRP	Scale: AS SHOWN	Sheet reference number:	FILENAME: 00ctp101.dgn
Drawn by: CELRP	Date: JUNE 1999		PEN TABLE: NONE
Checked by:	Drawing Codes:		
Reviewed by: D.L.C. W.R.W., L.L.M.			Sheet of
Approved by:			



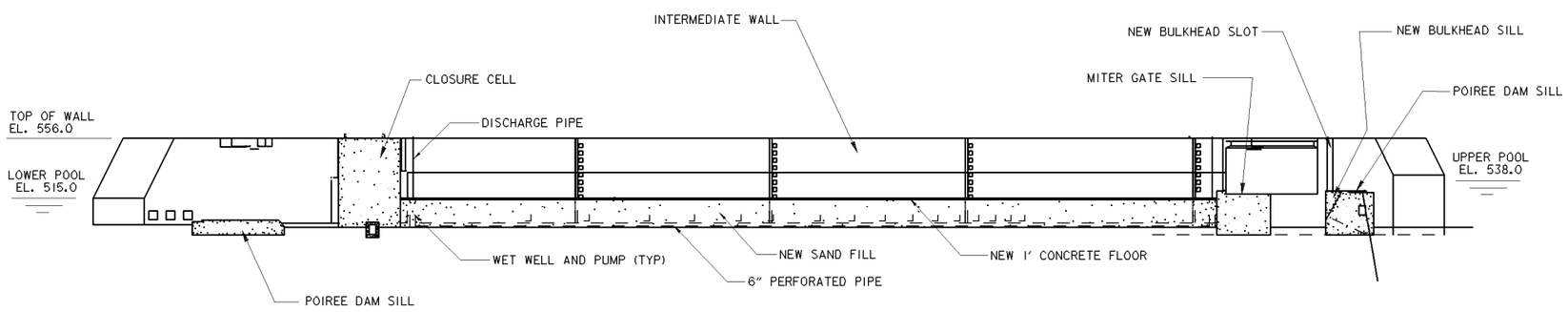
PLAN

LEGEND

NEW REINFORCED CONCRETE FLOOR (1' THICK)

NOTES

1. FOR SECTIONS A-A AND B-B SEE PLATE 5-4.



PROFILE

PLATE NO. 5-2

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

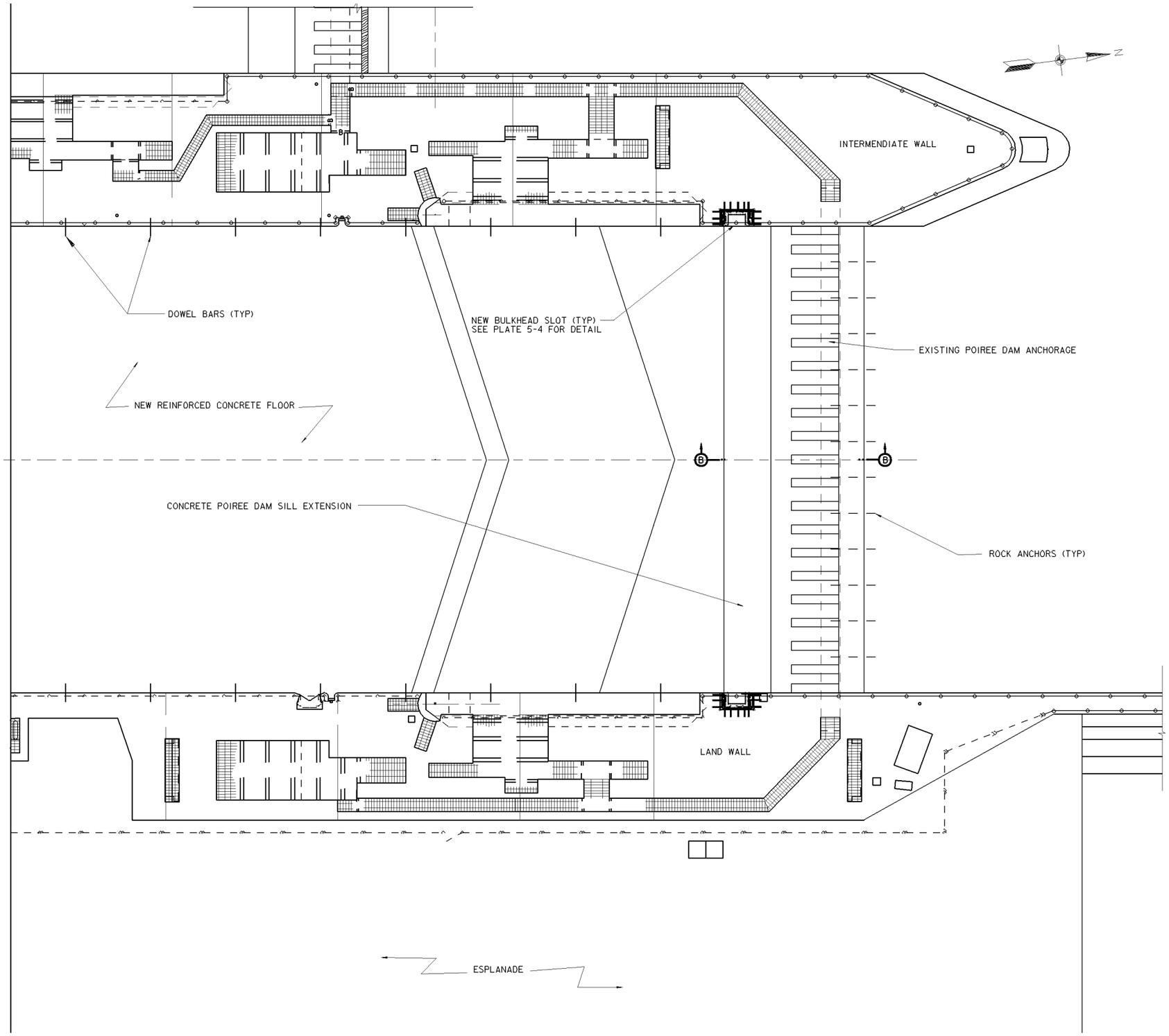
OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS AND DAM
R.C. BYRD DRY DOCK

PLAN AND PROFILE

Designed by:			
Drawn by:	CELRP		
Checked by:	CELRP		
Reviewed by:	DLC. W.R.W., L.L.M.	Scale: 1"=40'	Sheet reference number:
Approved by:		Date: JUNE 1999	
		Drawing Code:	

FILENAME: 00a1pp01.dgn
PEN TABLE: b.pltb f.pltb

Sheet 1 of 1



PLAN

NOTES

1. BULKHEADS ARE NOT SHOWN ON THIS PLAN.
2. FOR SECTION B-B, SEE PLATE 5-4.

PLATE NO. 5-3

Revisions			
Symbol	Descriptions	Date	Approved

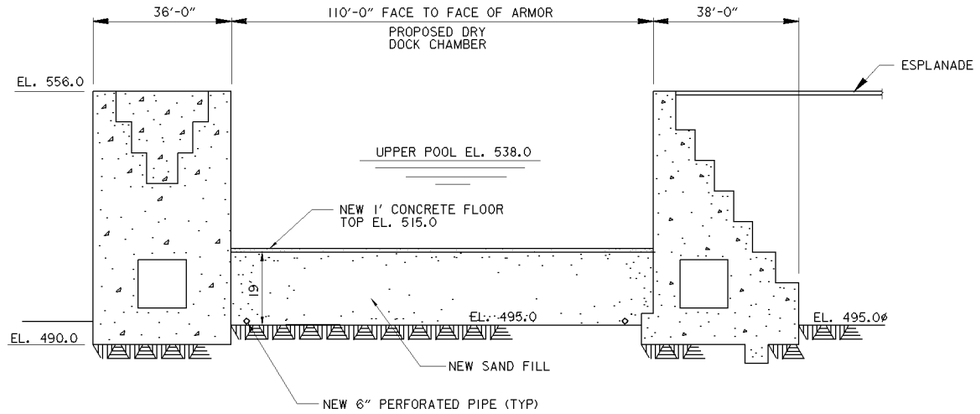
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS AND DAM
R. C. BYRD DRY DOCK

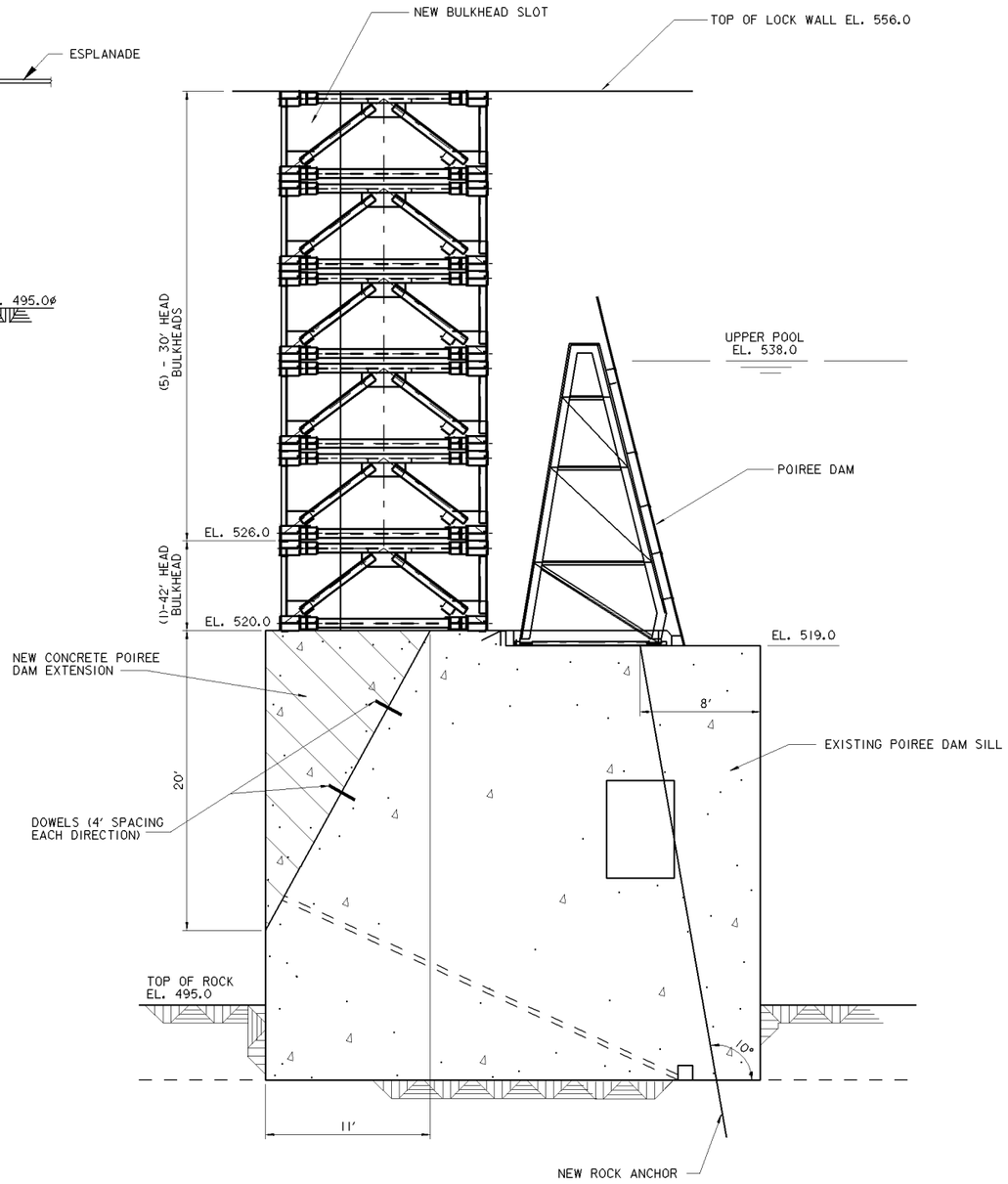
BULKHEAD SILL PLAN

Designed by: CELRP
Drawn by: CELRP
Checked by:
Reviewed by: D.L.C. W.L.M., L.L.M.
Approved by:
Scale: AS SHOWN
Date: JUNE 1999
Drawing Code:
Sheet reference number:
FILENAME: 00c1d101.dgn
PIN TABLE: b.ptb f.ptb
Sheet 3 of 4



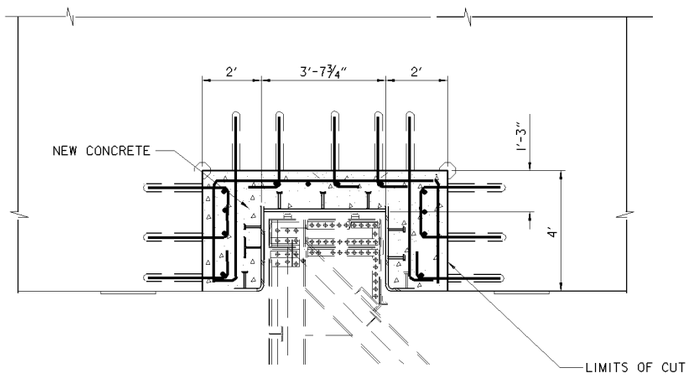
SECTION A-A

SCALE: 1/16" = 1'-0"



SECTION B-B

SCALE: 1/4" = 1'-0"



BULKHEAD SLOT PLAN

SCALE: 1/2" = 1'-0"

PLATE NO. 5-4

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS AND DAM
R.C. BYRD DRY DOCK

SECTIONS AND DETAILS

Designed by:
Drawn by: CELRP
Checked by: CELRP
Reviewed by: DL.C. W.R.W., L.L.M.
Approved by:

Scale: AS SHOWN
Date: JUNE 1999
Drawing Code:
Sheet reference number:
FILENAME: 00ai5c07.dgn
PEN TABLE: b.pnb f.pnb

Sheet 1 of 1

26.4.6 Hydrology & Hydraulics

PLATE (6-1) PLAN AND PROFILE OF THE OHIO RIVER LOCK & DAM SYSTEM

PLATE (6-2) NOT USED

PLATE (6-3) R.C. BYRD UPPER GAGE (1963-1998) ANNUAL STAGE DURATION

PLATE (6-4) R.C. BYRD LOWER GAGE (1963-1998) ANNUAL STAGE DURATION

PLATE (6-5) HUNTINGTON GAGE (1963-1998) ANNUAL STAGE DURATION

PLATE (6-6) ASHLAND GAGE (1963-1998) ANNUAL STAGE DURATION

PLATE (6-7) GREENUP 600' EXTENSION W/O SUPPLEMENTAL F/E SYSTEM – FILLING CURVE

PLATE (6-8) GREENUP 600' EXTENSION W/O SUPPLEMENTAL F/E SYSTEM – EMPTYING CURVE

PLATE (6-9) EFFECT OF VALVE TIME ON FILL TIME FILLING WITH EXISTING VALVE AND 600' EXTENSION

PLATE (6-10) GREENUP L&D 600' EXTENSION W/O SUPP. F/E SYSTEM - FILLING PRESSURES

PLATE (6-11) GREENUP L&D 600' EXTENSION W/O SUPP. F/E SYSTEM - EMPTYING PRESSURES

PLATE (6-12) GREENUP L&D 600' EXTENSION WITH SUPPLEMENTAL F/E SYSTEM – FILLING CURVE

PLATE (6-13) GREENUP L&D 600' EXTENSION WITH SUPP. F/E SYSTEM EMPTYING – EMPTYING CURVE

PLATE (6-14) EFFECT OF VALVE TIME ON FILL TIME FILLING WITH EXISTING AND PROPOSED VALVE

PLATE (6-15) GREENUP 600' EXTENSION WITH SUPP. F/E SYSTEM EXISTING CULVERT FILLING PRESSURES

PLATE (6-16) GREENUP 600' EXTENSION WITH SUPP. F/E SYSTEM EXISTING CULVERT EMPTYING PRESSURES

PLATE (6-17) GREENUP 600' EXTENSION WITH SUPP. F/E SYSTEM PROPOSED CULVERT FILLING PRESSURES

PLATE (6-18) GREENUP 600' EXTENSION WITH SUPP. F/E SYSTEM PROPOSED CULVERT EMPTYING PRESSURES

PLATE NO. 6-1
Plan and Profile of the Ohio River Lock & Dam System

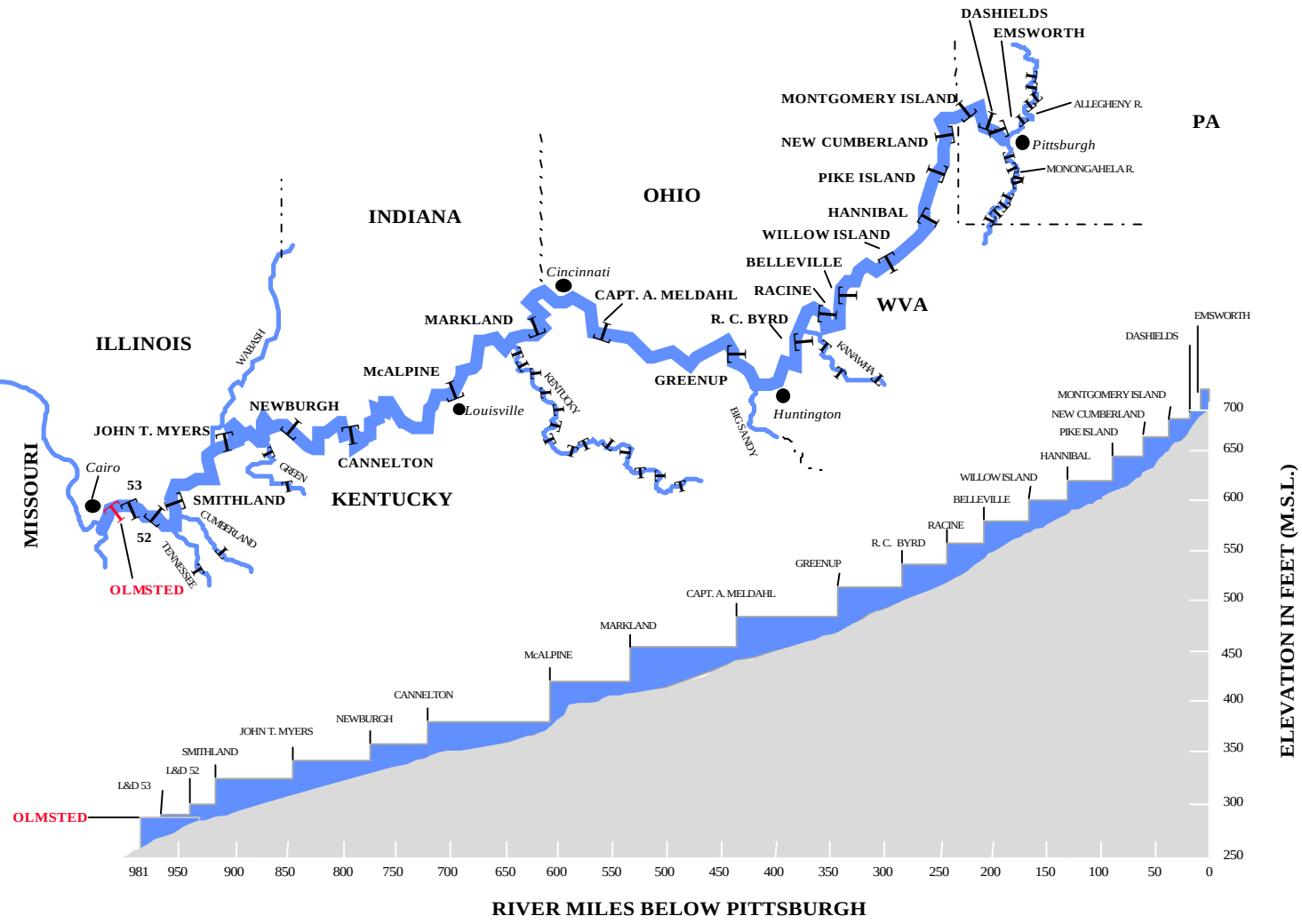


PLATE NO. 6-3

R.C. BYRD UPPER GAGE
1963-1998

DURATION	STAGE
0.01	49.83
0.05	46.29
0.10	43.21
0.20	39.27
0.50	32.94
1.00	27.57
2.00	22.05
5.00	15.60
10.00	13.02
15.00	12.81
20.00	12.71
30.00	12.48
40.00	12.36
50.00	12.28
60.00	12.23
70.00	12.18
80.00	12.11
85.00	12.07
90.00	12.03
95.00	11.95
98.00	11.85
99.00	11.77
99.50	11.70
99.80	11.61
99.90	11.55
99.95	11.49
99.99	11.35

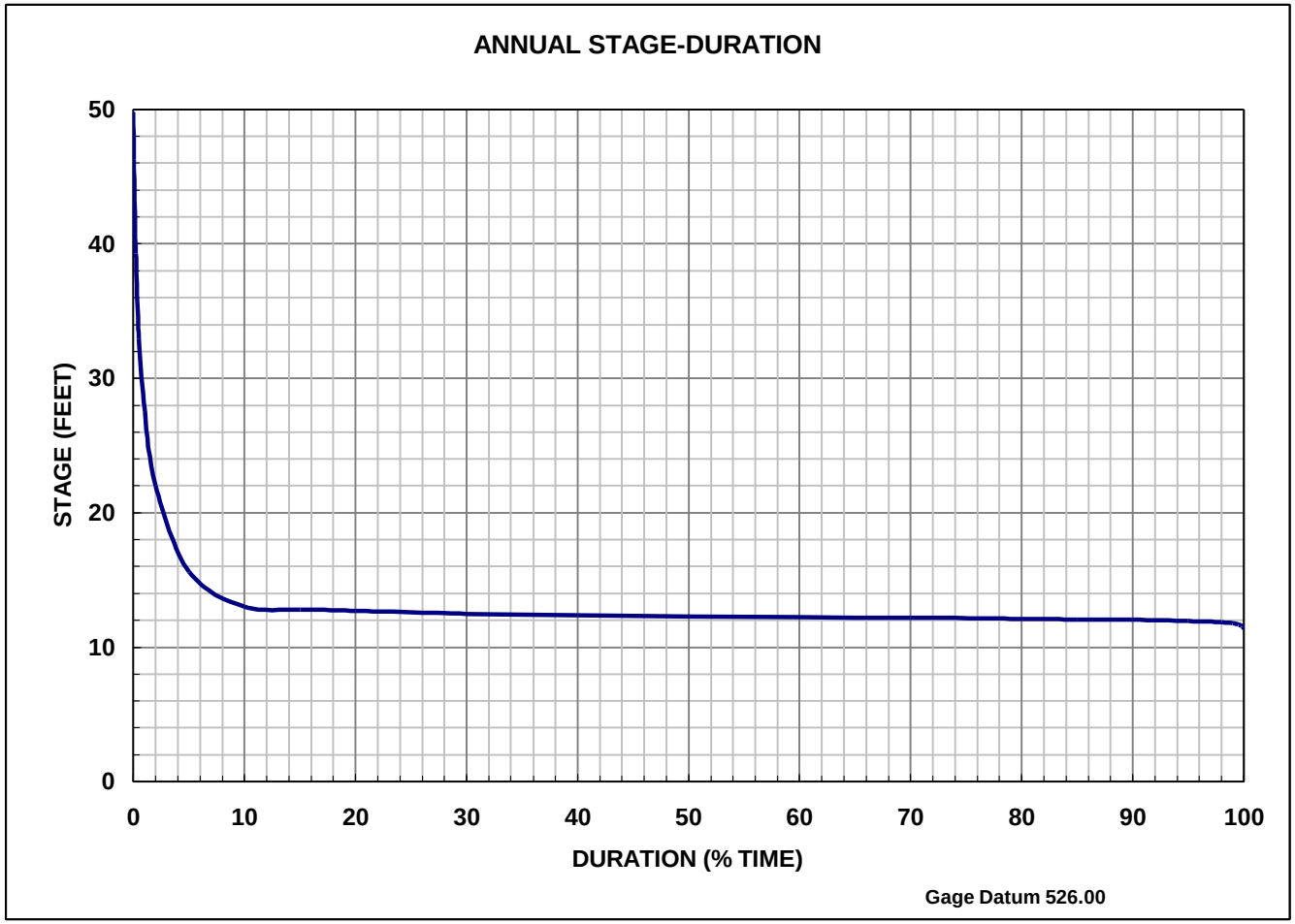


PLATE NO. 6-4

R.C. BYRD LOWER GAGE
1963-1998

DURATION	STAGE
0.01	54.97
0.05	53.22
0.10	51.65
0.20	49.56
0.50	46.01
1.00	42.75
2.00	39.01
5.00	33.48
10.00	29.10
15.00	26.39
20.00	24.20
30.00	20.70
40.00	18.01
50.00	16.16
60.00	14.74
70.00	13.85
80.00	13.24
85.00	12.96
90.00	12.71
95.00	12.49
98.00	12.26
99.00	12.13
99.50	12.01
99.80	11.88
99.90	11.79
99.95	11.71
99.99	11.55

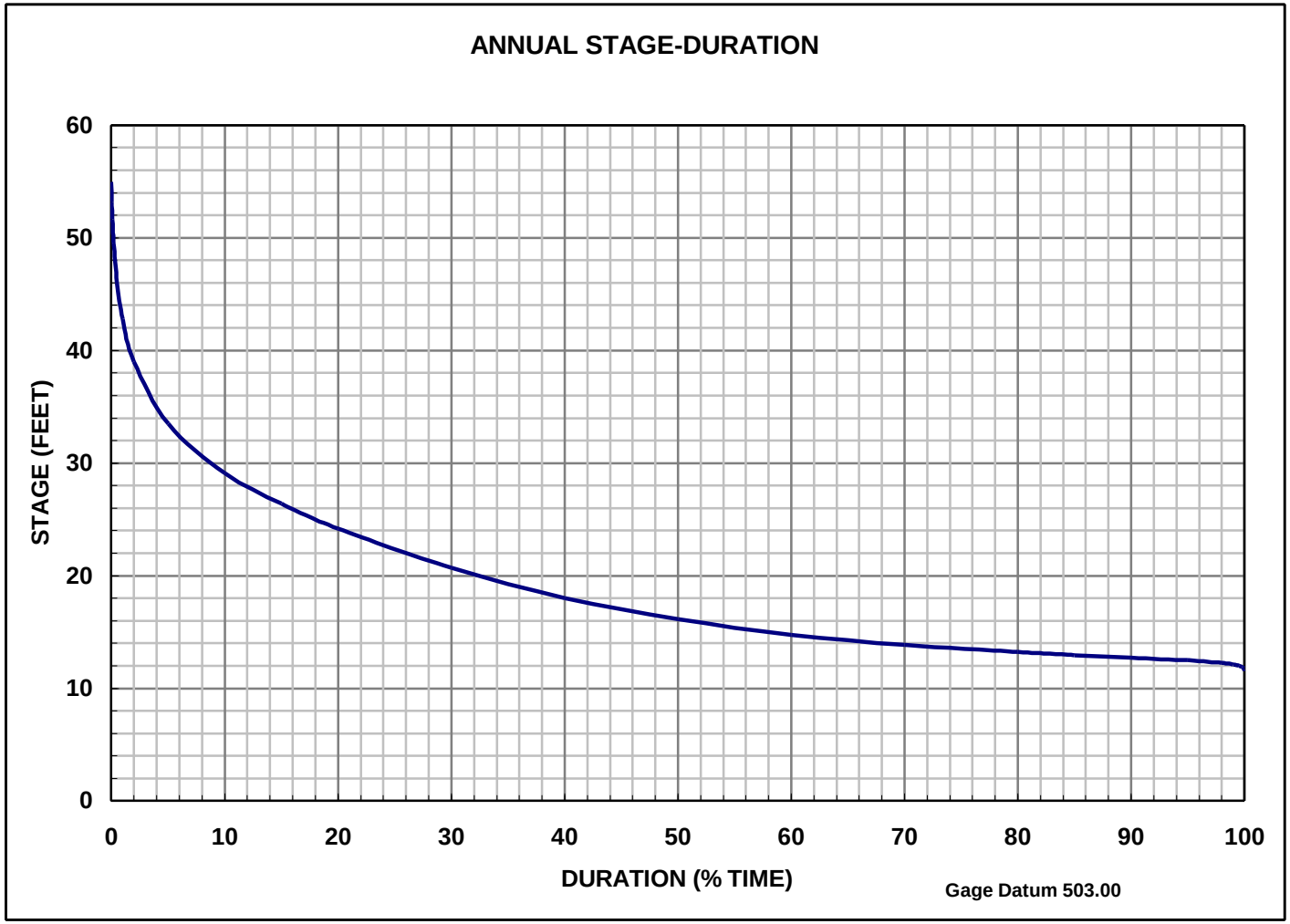


PLATE NO. 6-5

HUNTINGTON GAGE
1963-1998

DURATION	STAGE
0.01	57.45
0.05	55.54
0.10	53.83
0.20	51.59
0.50	47.86
1.00	44.51
2.00	40.79
5.00	35.60
10.00	31.96
15.00	30.12
20.00	28.90
30.00	27.32
40.00	26.48
50.00	26.08
60.00	25.80
70.00	25.56
80.00	25.32
85.00	25.21
90.00	25.04
95.00	24.71
98.00	24.29
99.00	23.98
99.50	23.68
99.80	23.30
99.90	23.02
99.95	22.75
99.99	22.14

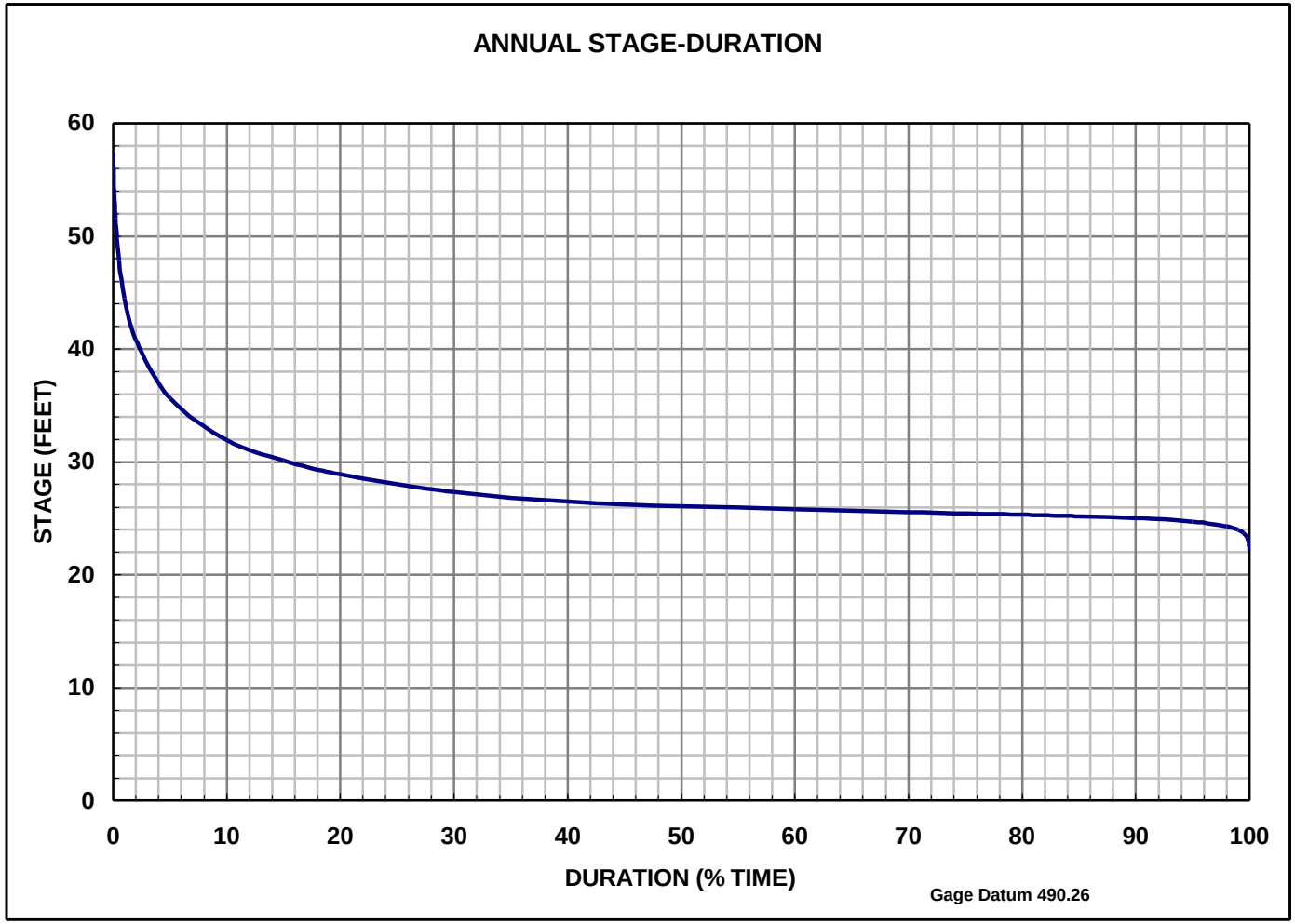


PLATE NO. 6-6

ASHLAND GAGE
1963-1998

DURATION	STAGE
0.01	61.10
0.05	59.17
0.10	57.46
0.20	55.24
0.50	51.59
1.00	48.38
2.00	44.89
5.00	40.29
10.00	37.45
15.00	36.32
20.00	35.69
30.00	35.01
40.00	34.69
50.00	34.47
60.00	34.29
70.00	34.10
80.00	33.87
85.00	33.77
90.00	33.59
95.00	33.27
98.00	32.87
99.00	32.58
99.50	32.31
99.80	31.95
99.90	31.69
99.95	31.44
99.99	30.88

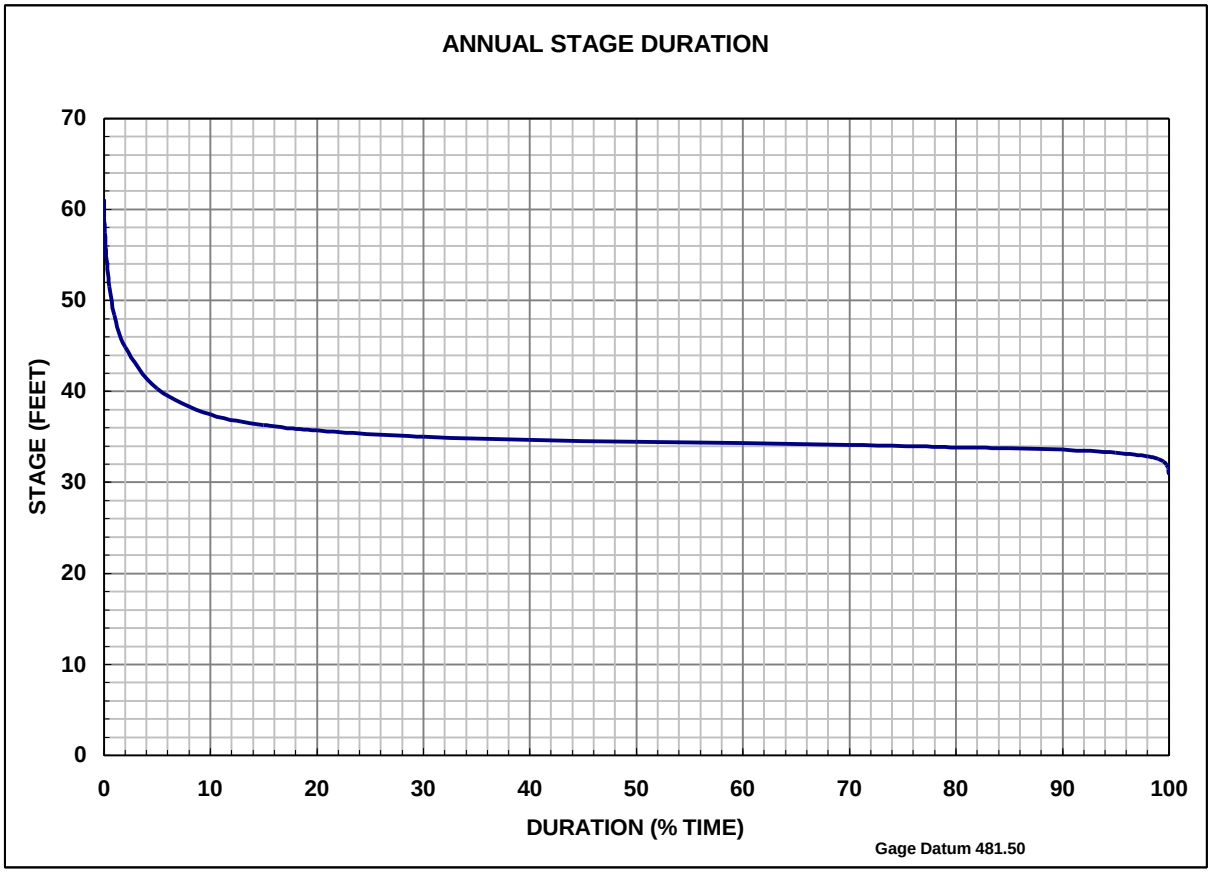


PLATE NO. 6-7

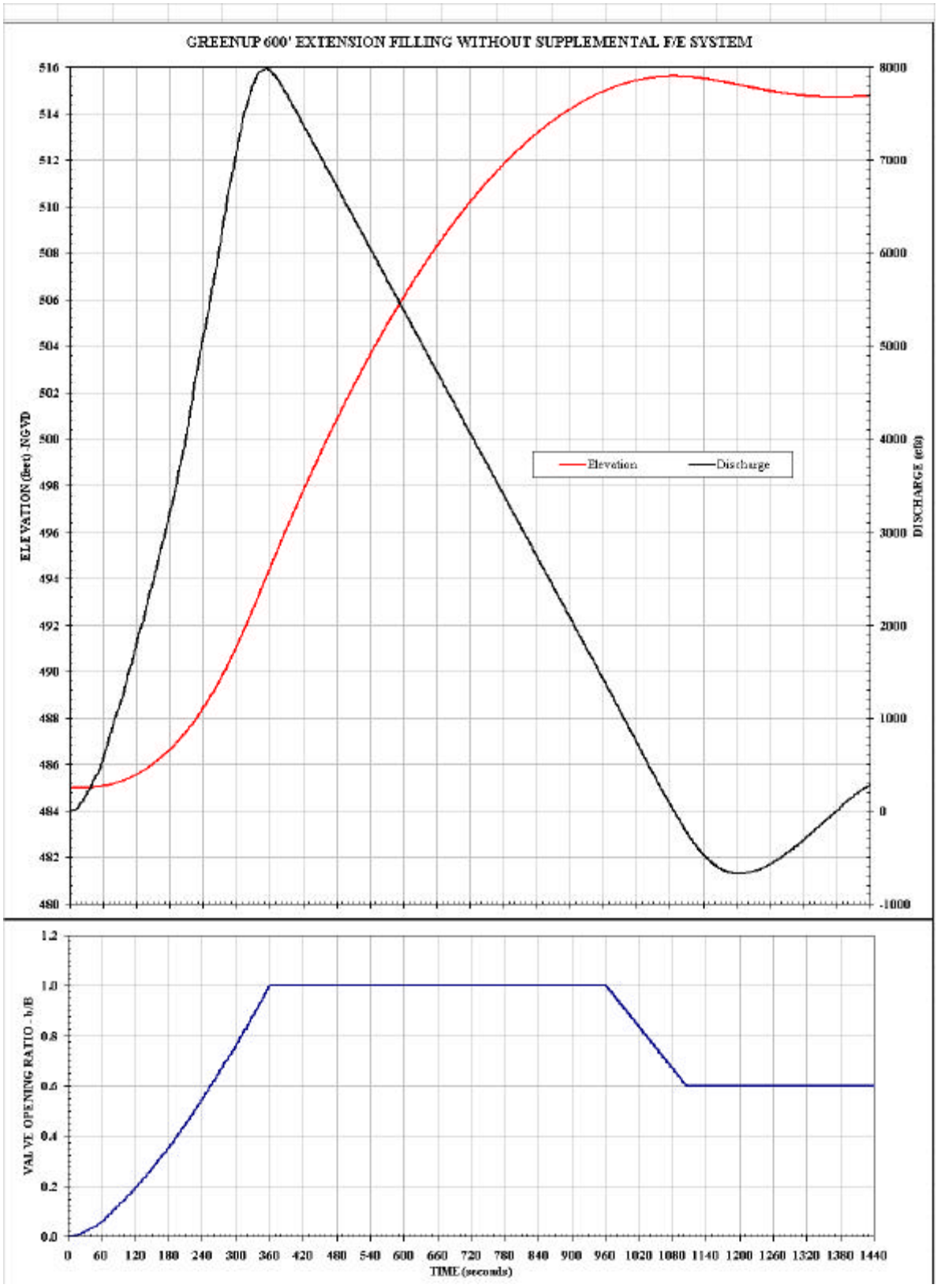

GREENUP 600' EXTENSION FILLING WITHOUT SUPPLEMENTAL F/E SYSTEM
ELEVATION (feet) NGVD
DISCHARGE (cfs)
Elevation
Discharge
VALVE OPENING RATIO - b/B
TIME (seconds)

PLATE NO. 6-8

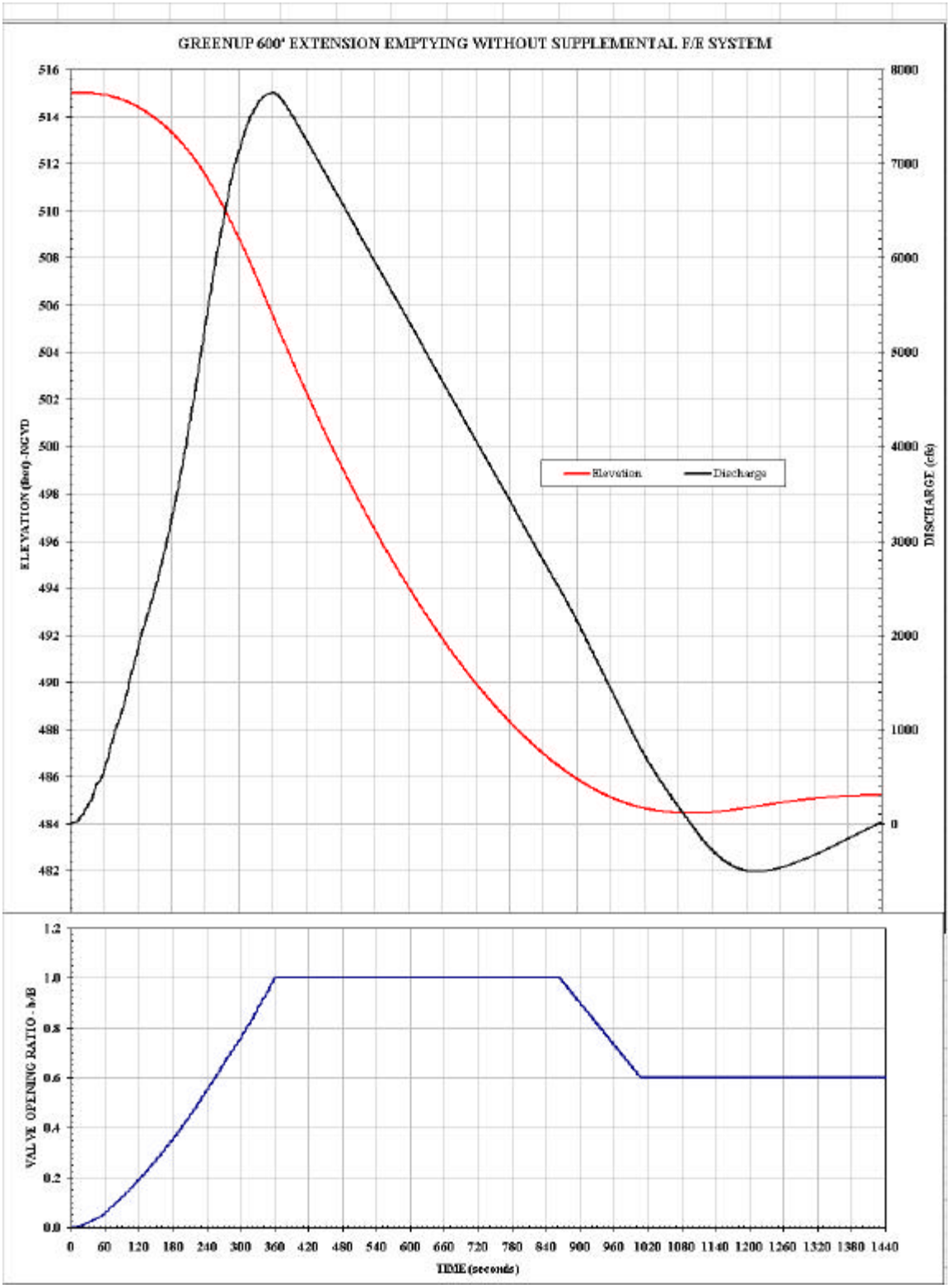
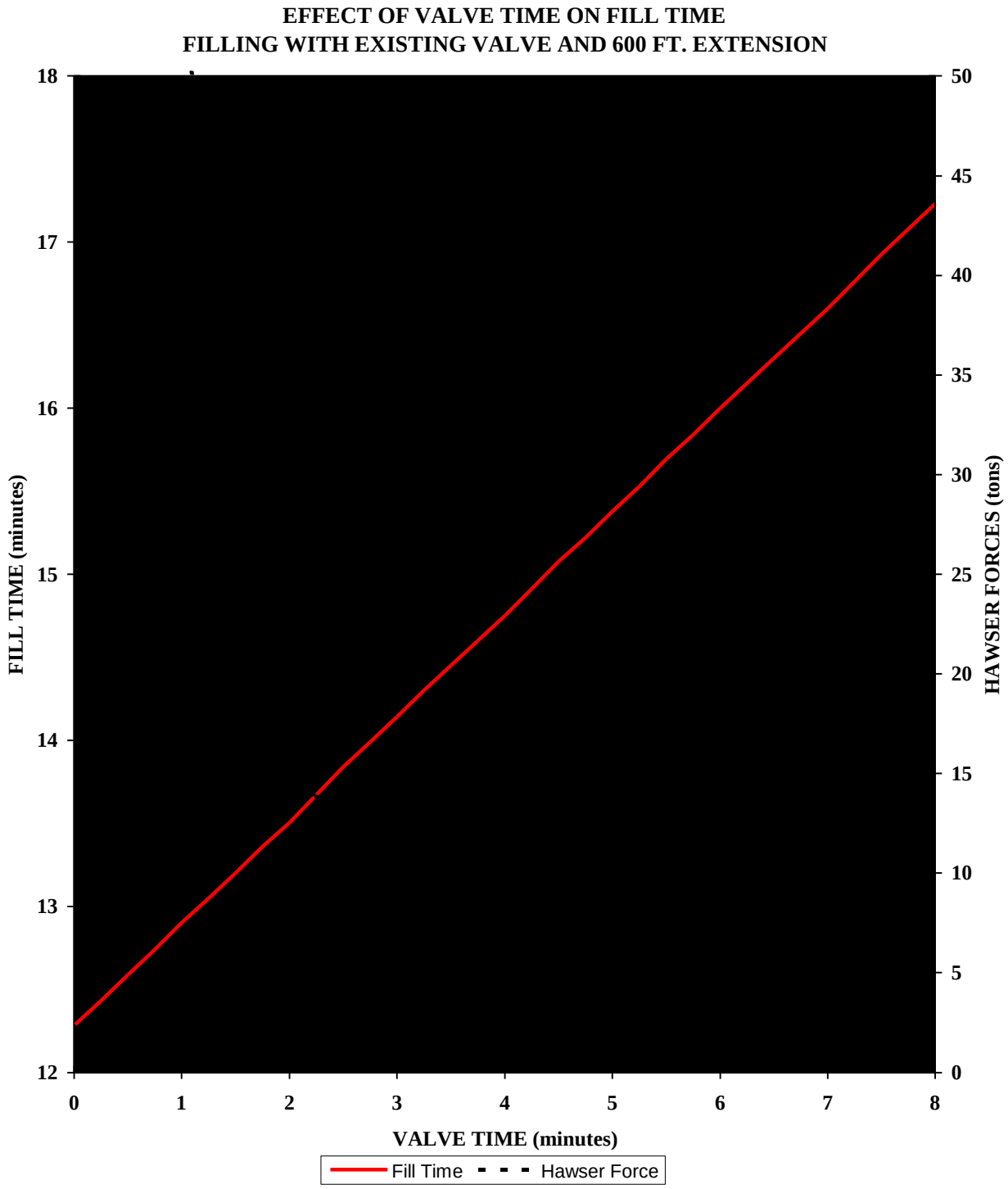

GREENUP 600' EXTENSION EMPTYING WITHOUT SUPPLEMENTAL F/R SYSTEM
ELEVATION (feet) - NGVD
DISCHARGE (cfs)
Elevation
Discharge
VALVE OPENING RATIO - h/B
TIME (seconds)

PLATE NO. 6-9



Note: The fill times are not indicative of those imposed by overtravel control. Overtravel control will yield an overall increase to the fill times. Graphic based upon normal upper and lower pool conditions.

PLATE NO. 6-10

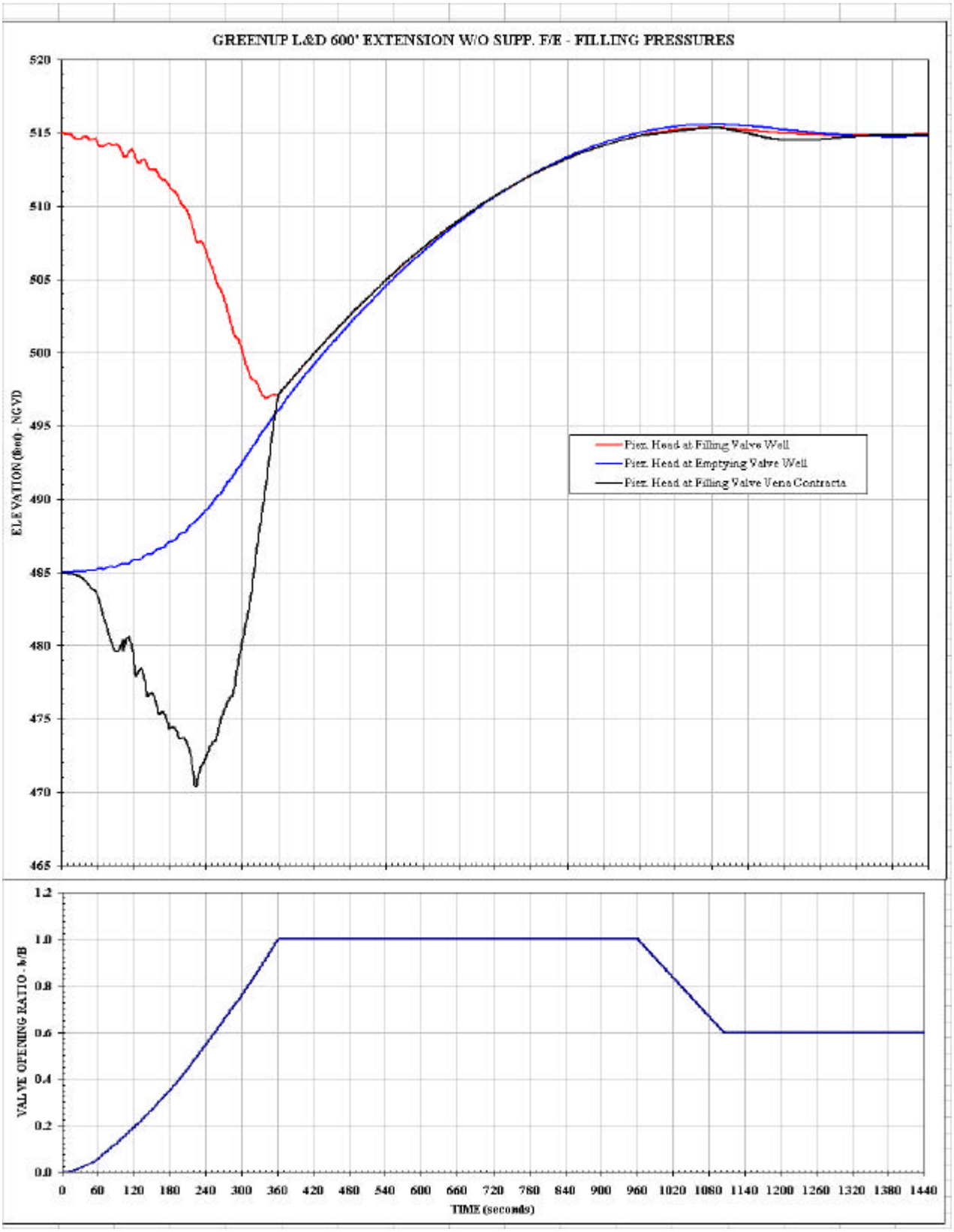

GREENUP L&D 600' EXTENSION W/O SUPP. F/E - FILLING PRESSURES
ELEVATION (feet) - NGVD
520
515
510
505
500
495
490
485
480
475
470
465
Piez. Head at Filling Valve Well
Piez. Head at Emptying Valve Well
Piez. Head at Filling Valve Vena Contracta
VALVE OPENING RATIO - h/B
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
1080
1140
1200
1260
1320
1380
1440
TIME (seconds)

PLATE NO. 6-11

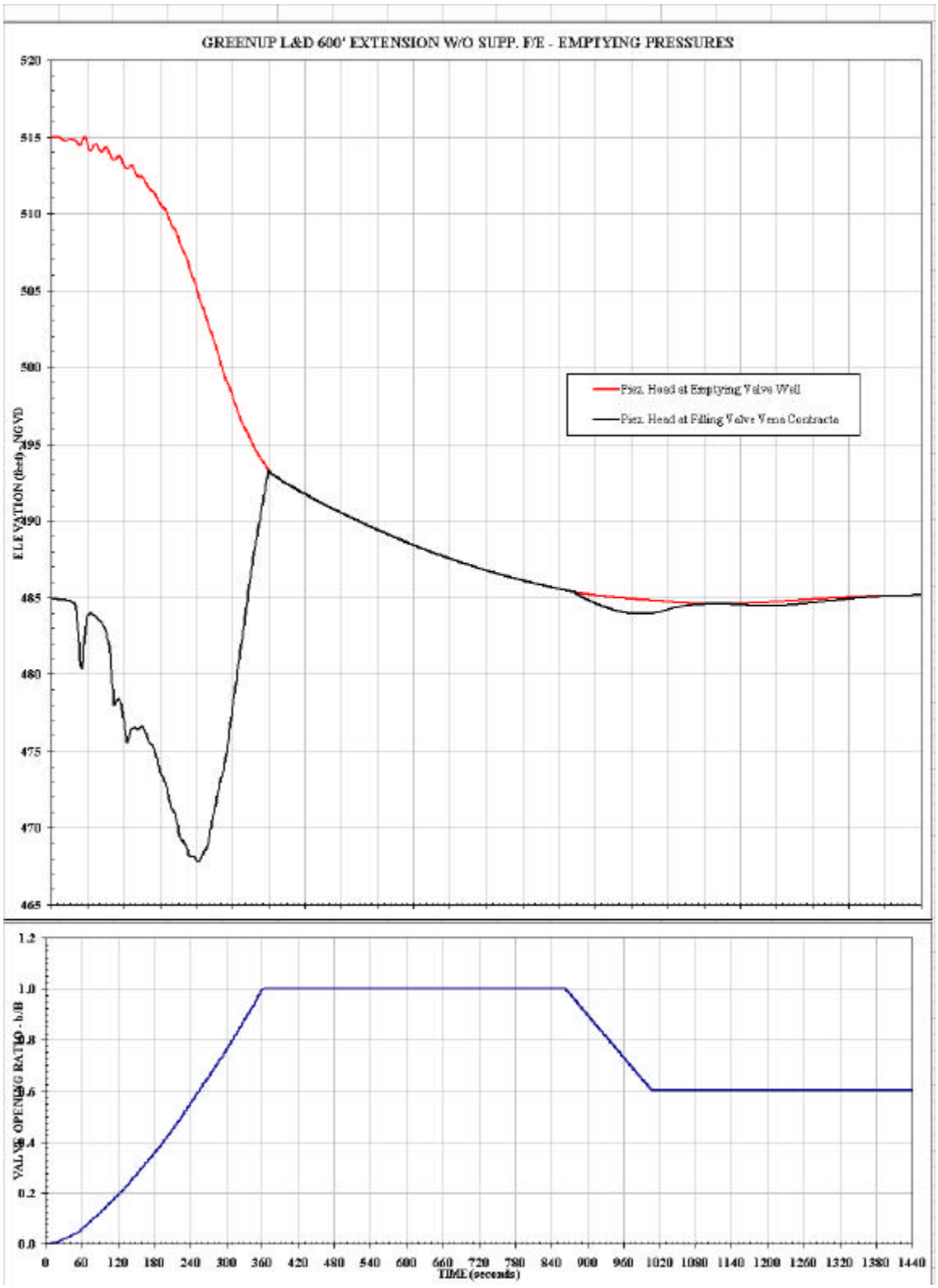

GREENUP L&D 600' EXTENSION W/O SUPP. F/E - EMPTYING PRESSURES
ELEVATION (feet) - NGVD
Piez. Head at Emptying Valve Well
Piez. Head at Filling Valve Vena Contracta
VALVE OPENING RATIO - b/B
TIME (seconds)

PLATE NO. 6-12

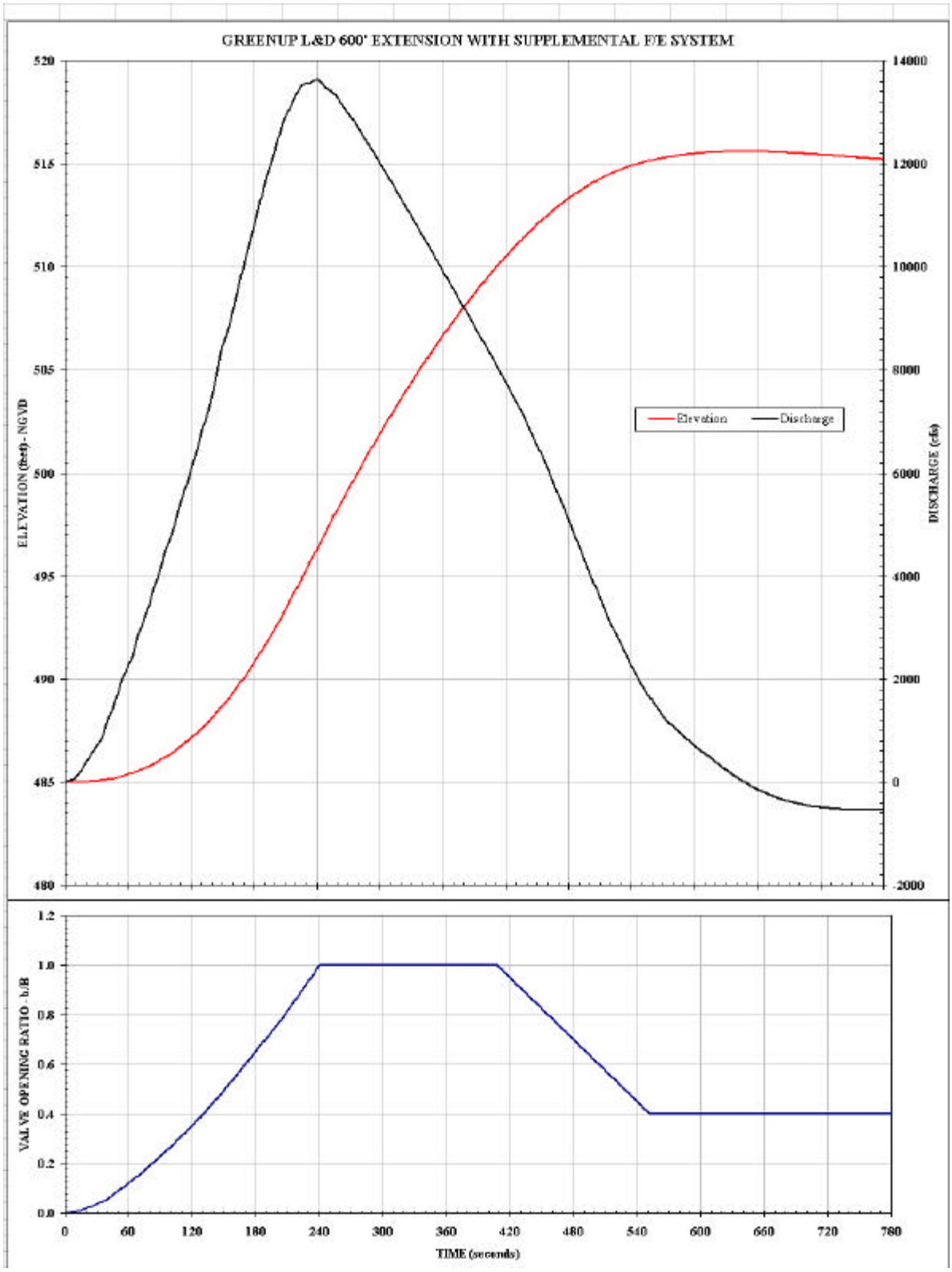

GREENUP L&D 600' EXTENSION WITH SUPPLEMENTAL F/E SYSTEM
ELEVATION (feet) - NGVD
DISCHARGE (cfs)
Elevation
Discharge
520
515
510
505
500
495
490
485
480
14000
12000
10000
8000
6000
4000
2000
0
-2000
VALVE OPENING RATIO - b/B
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
TIME (seconds)

PLATE NO. 6-13

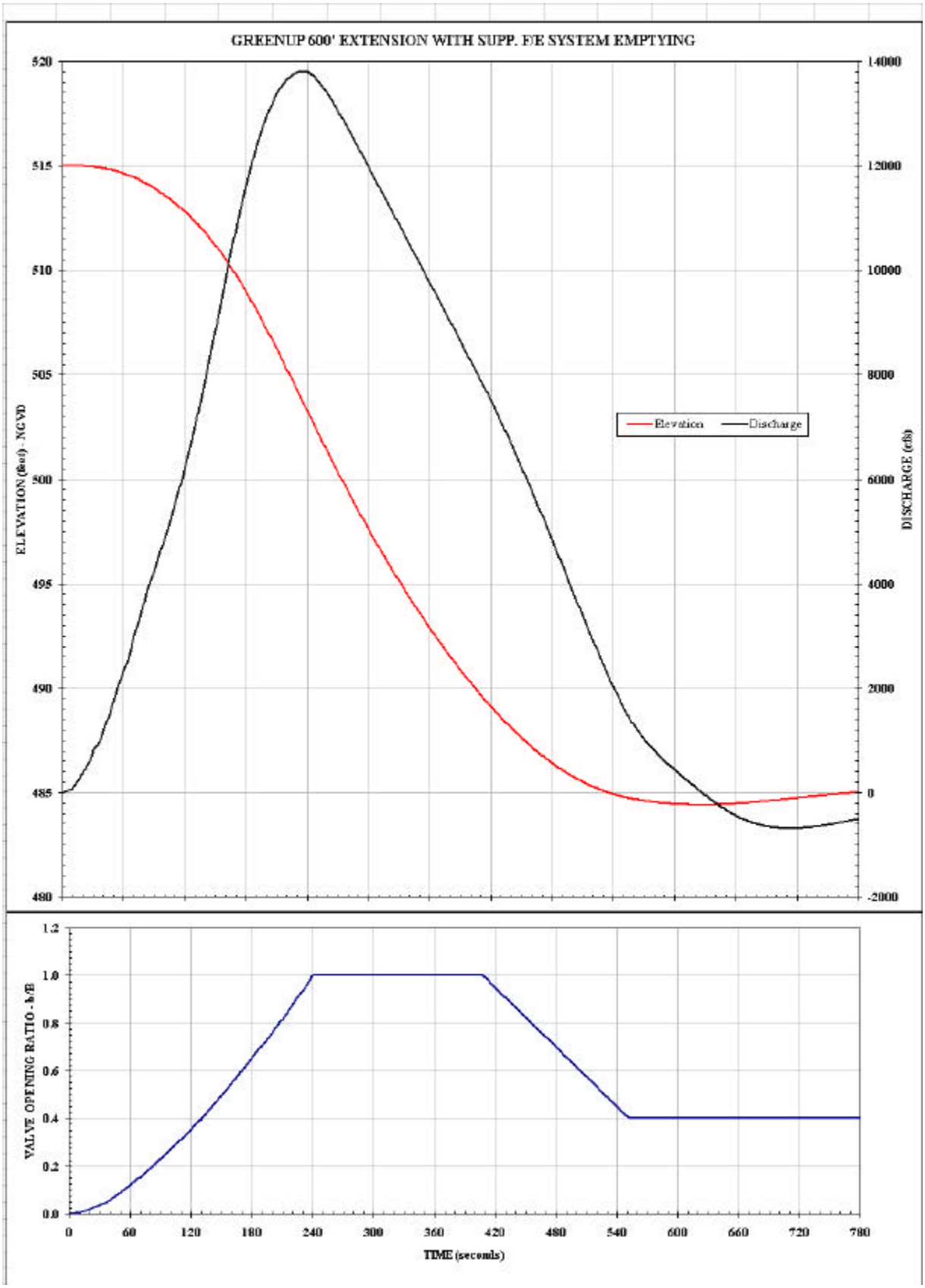
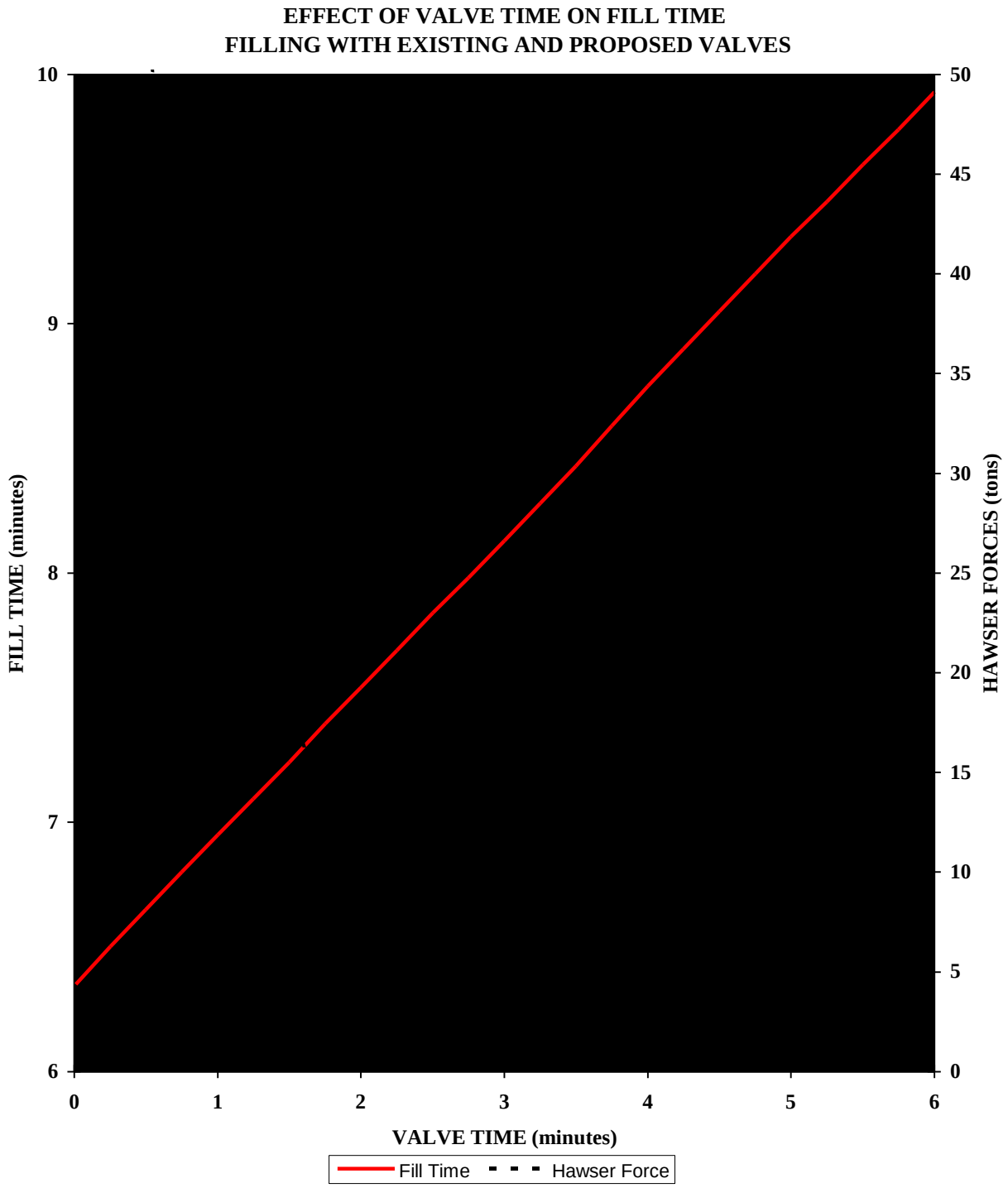

GREENUP 600' EXTENSION WITH SUPP. F/E SYSTEM EMPTYING
ELEVATION (feet) - NGVD
DISCHARGE (cfs)
Elevation
Discharge
520
515
510
505
500
495
490
485
480
14000
12000
10000
8000
6000
4000
2000
0
-2000
VALVE OPENING RATIO - h/B
TIME (seconds)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
60
120
180
240
300
360
420
480
540
600
660
720
780

PLATE NO. 6-14



Note: The fill times are not indicative of those imposed by overtravel control. Overtravel control will yield an overall increase to the fill times. Graphic based upon normal upper and lower pool conditions.

PLATE NO. 6-15

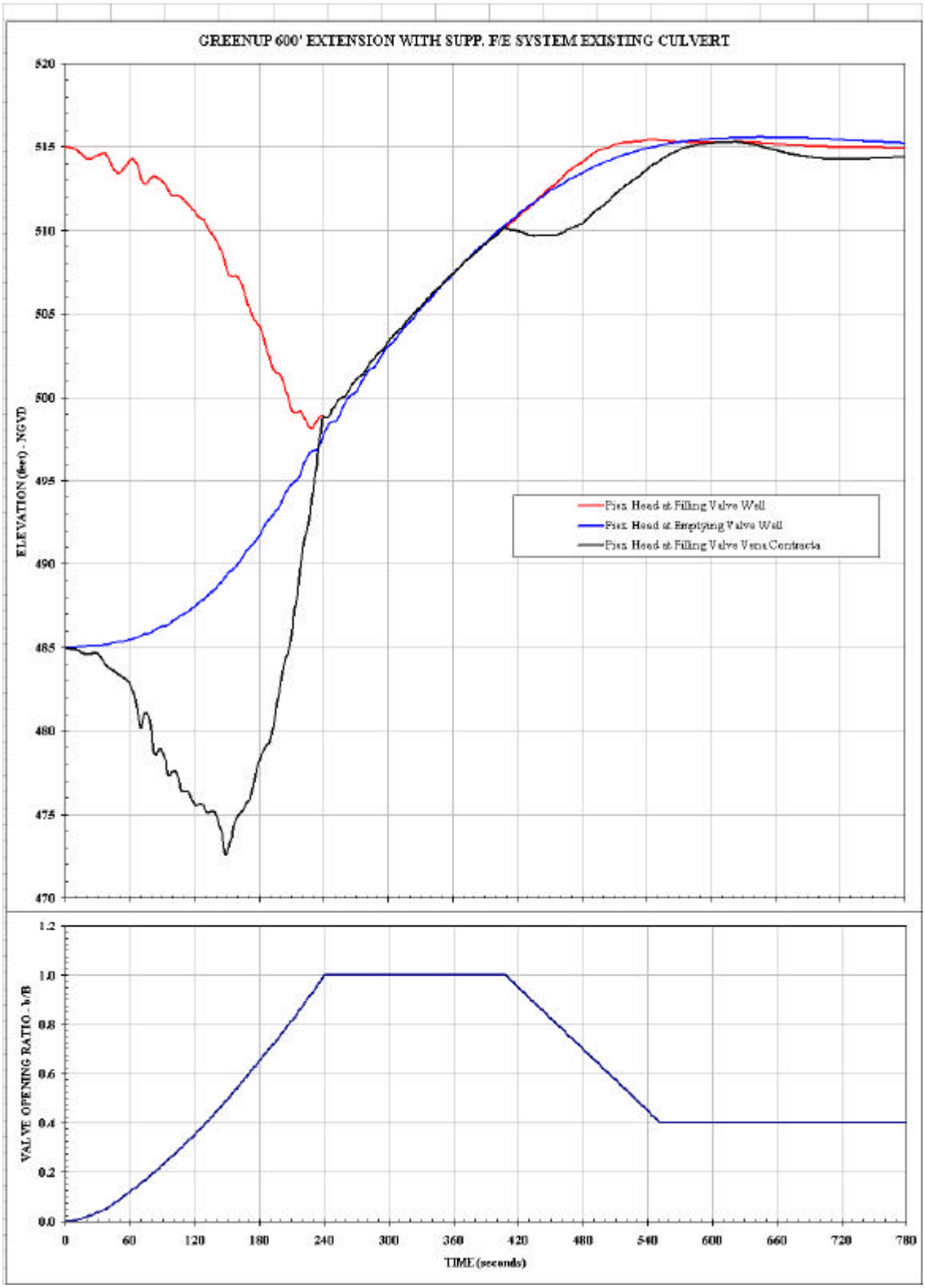

GREENUP 600' EXTENSION WITH SUPP. F/E SYSTEM EXISTING CULVERT
ELEVATION (feet) - NGVD
520
515
510
505
500
495
490
485
480
475
470
Piez. Head at Filling Valve Well
Piez. Head at Emptying Valve Well
Piez. Head at Filling Valve Vena Contracta
VALVE OPENING RATIO - h/B
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
TIME (seconds)

PLATE NO. 6-16

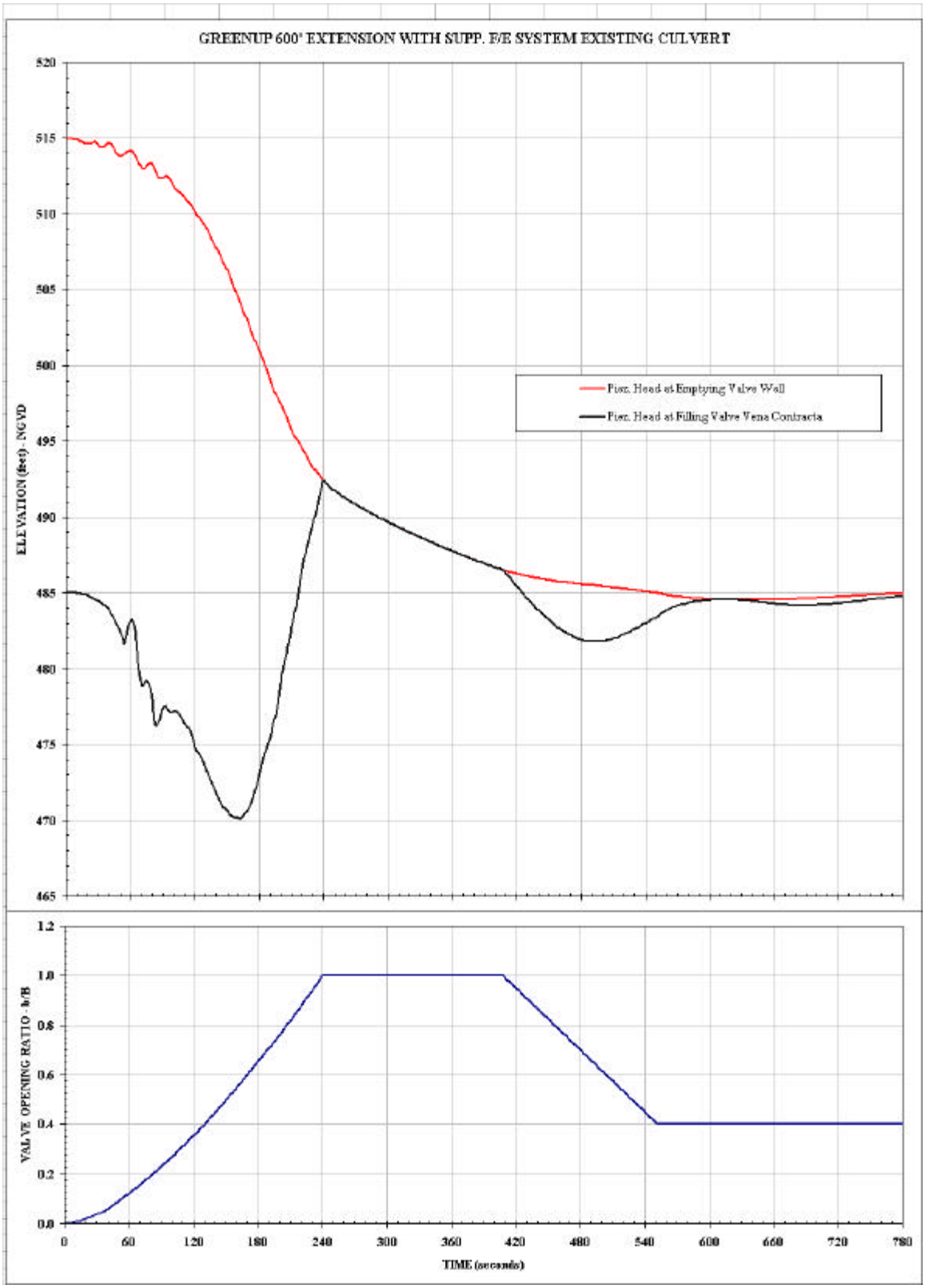

GREENUP 600' EXTENSION WITH SUPP. E/E SYSTEM EXISTING CULVERT
ELEVATION (feet) - NGVD
520
515
510
505
500
495
490
485
480
475
470
465
Piez. Head at Emptying Valve Well
Piez. Head at Filling Valve Vena Contracta
VALVE OPENING RATIO - h/B
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
TIME (seconds)

PLATE NO. 6-17

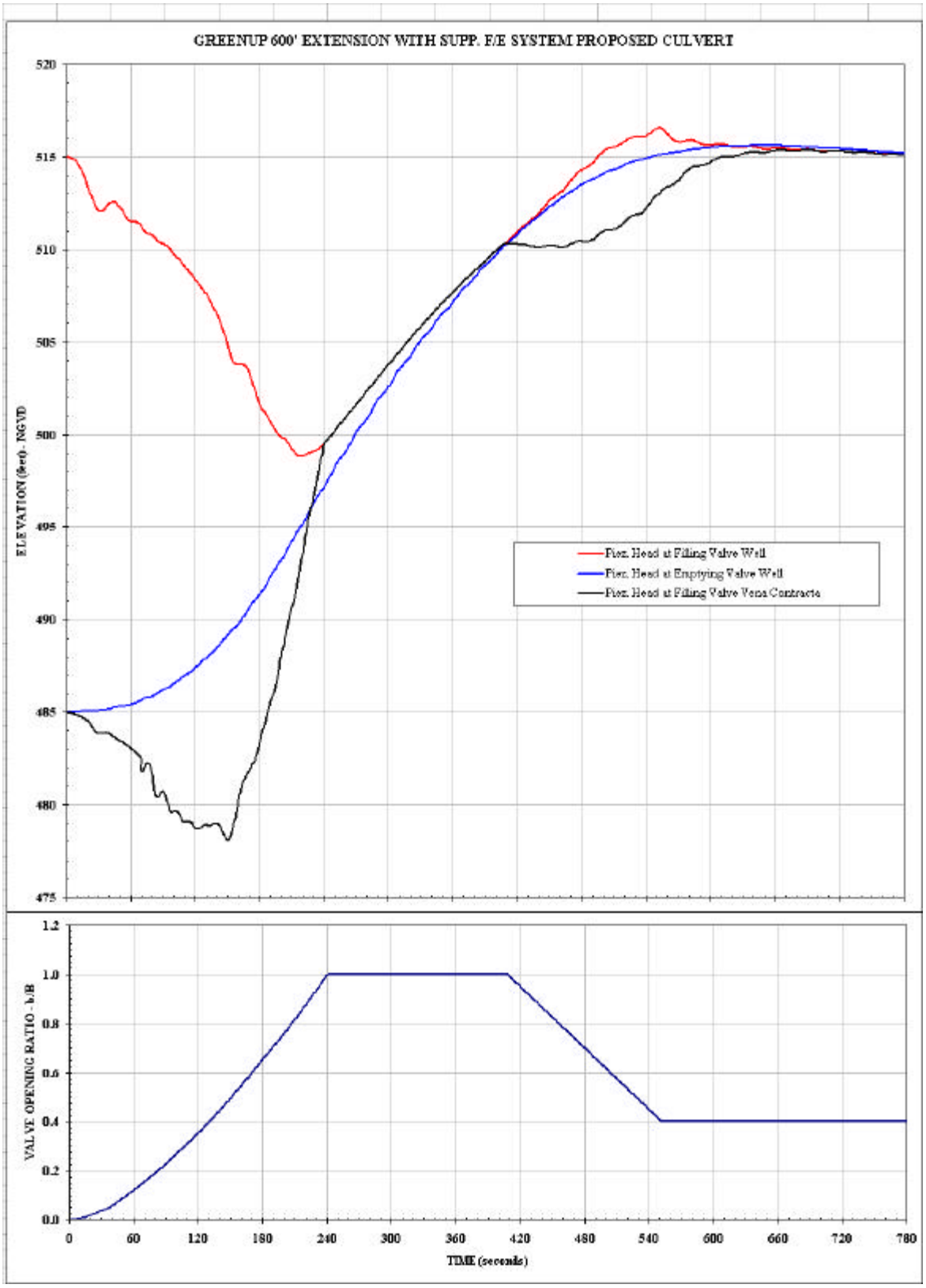
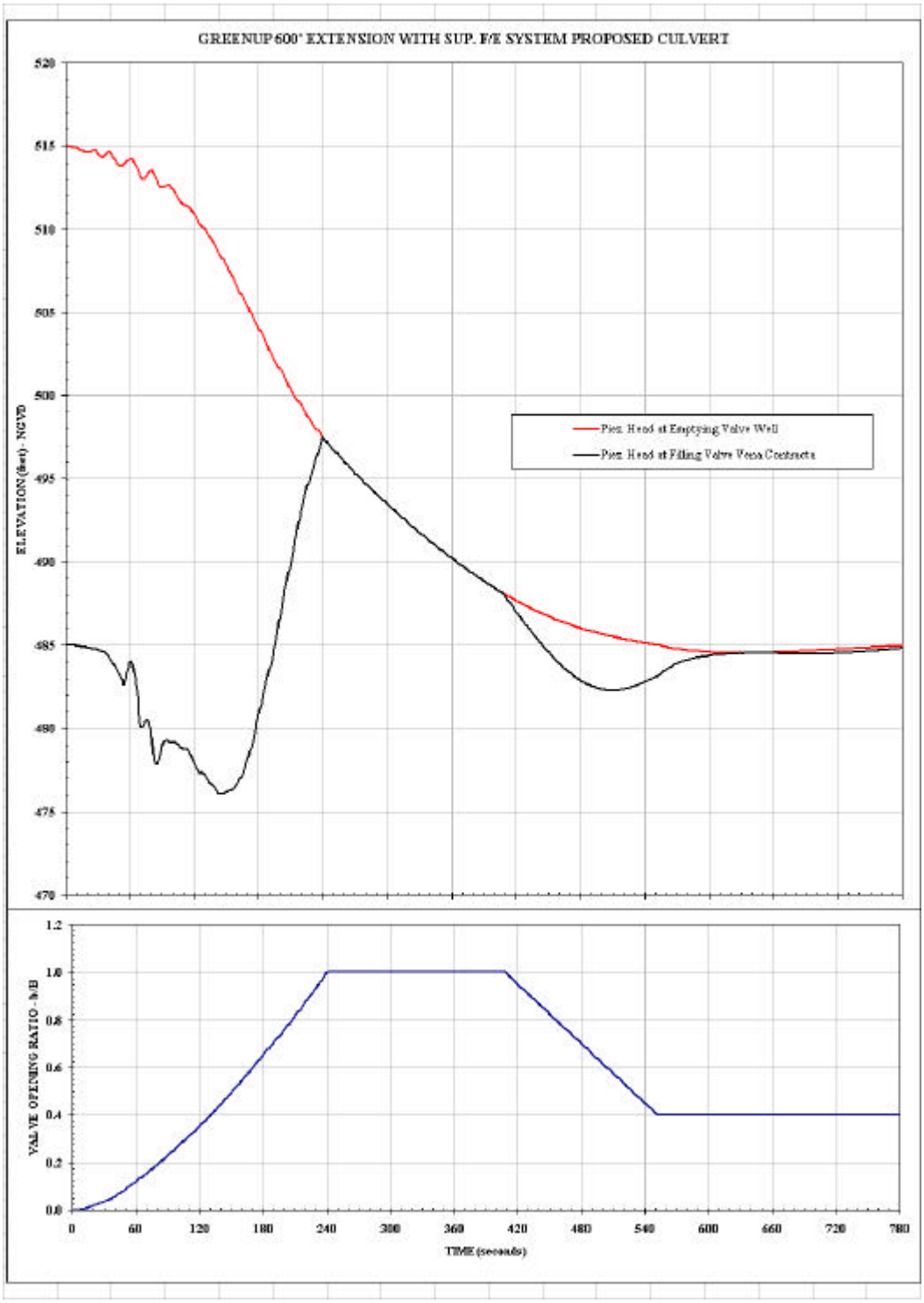

GREENUP 600' EXTENSION WITH SUPP. F/E SYSTEM PROPOSED CULVERT
ELEVATION (feet) - NGVD
520
515
510
505
500
495
490
485
480
475
Piez. Head at Filling Valve Well
Piez. Head at Emptying Valve Well
Piez. Head at Filling Valve Vena Contracta
VALVE OPENING RATIO - h/B
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
TIME (seconds)

PLATE NO. 6-18


GREENUP 600' EXTENSION WITH SUP. F/E SYSTEM PROPOSED CULVERT
ELEVATION (feet) - NGVD
520
515
510
505
500
495
490
485
480
475
470
Piez. Head at Emptying Valve Well
Piez. Head at Filling Valve Vena Contracta
VALVE OPENING RATIO - h/H
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
60
120
180
240
300
360
420
480
540
600
660
720
780
TIME (seconds)

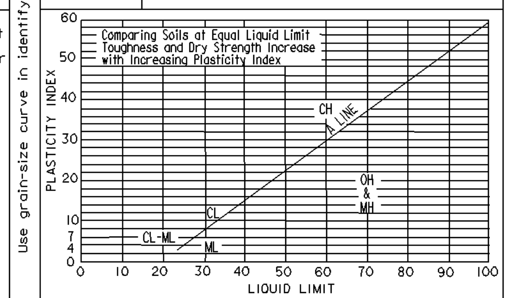
26.4.7 Soils and Geology

PLATE (7-1) GEOLOGY AND SOILS LEGEND
PLATE (7-2) BORING PLAN
PLATE (7-3) TOP OF ROCK MAP
PLATE (7-4) BORING SURVEY DATA
PLATE (7-5) GRAPHIC LOGS D-98-1 TO C-98-3: SHEET 1 OF 4
PLATE (7-6) GRAPHIC LOGS UD-98-3 TO C-98-6: SHEET 2 OF 4
PLATE (7-7) GRAPHIC LOGS UD-98-6 TO C-98-9: SHEET 3 OF 4
PLATE (7-8) GRAPHIC LOGS C-98-10 TO C-98-11: SHEET 4 OF 4
PLATE (7-9) GEOLOGIC SECTIONS: SHEET 1 OF 4
PLATE (7-10) GEOLOGIC SECTIONS: SHEET 2 OF 4
PLATE (7-11) GEOLOGIC SECTIONS: SHEET 3 OF 4
PLATE (7-12) GEOLOGIC SECTIONS: SHEET 4 OF 4
PLATE (7-13) TRIAXIAL TEST RESULTS: UNCONSOLIDATED-UNDRAINED STRENGTHS
PLATE (7-14) TRIAXIAL TEST RESULTS: CONSOLIDATED-UNDRAINED STRENGTHS
PLATE (7-15) TRIAXIAL TEST RESULTS: CONSOLIDATED-DRAINED STRENGTHS
PLATE (7-16) PRELIMINARY STABILITY ANALYSIS

UNIFIED SOIL CLASSIFICATION

Including Identification and Description

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES Excluding particles larger than 3 inches and basing fractions on estimated weights			INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA		
1	2		3	4	5			6	7		
COARSE - GRAINED SOILS More than half of materials is larger than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to the naked eye.)	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the 1/4-inch sieve size may be used as equivalent to the No. 4 sieve size.)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics.	Determine percentages of gravel and sand from grain size curves. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5%: GW, GP, SW, SP; More than 12%: GM, GC, SM, SC; 5% to 12%: Borderline cases requiring use of dual symbols. (Use grain-size curve in identifying the fractions as given under field conditions.)	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} D_{60}}$ Between one and 3	
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.					Not meeting all gradation requirements for GW	
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			Give typical name; indicate approximate percentage sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.		Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).					Atterberg limits above "A" line with PI greater than 7	
	SANDS More than half of coarse fractions is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.					$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} D_{60}}$ Between one and 3	
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			EXAMPLE Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. max. size; rounded and subangular sand grains coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand (SM).		Not meeting all gradation requirements for SW	
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).					Atterberg limits below "A" line or PI less than 4	Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).					Atterberg limits above "A" line with PI greater than 7	
					Fraction Smaller than No. 40 Sieve Size						
					DRY STRENGTH (crushing)	DILATANCY (reaction to shaking)	TOUGHNESS (consistency near PL)				
FINE - GRAINED SOILS More than half of materials is smaller than No. 200 sieve size	SILTS AND CLAYS	Liquid Limit Less than 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses.	PLASTICITY CHART (see below)		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to slow	Medium				
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.			
	SILTS AND CLAYS	Liquid Limit Greater than 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium				
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High	EXAMPLE Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess (ML)			
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium				
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.						



PLASTICITY CHART
For laboratory classification of fine-grained soils

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder (2) All sieve sizes on this chart are U.S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. for field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

DILATANCY (reaction to shaking)
After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.
Place the pat in the open palm of one hand and shakehorizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.
Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour show a moderately quick reaction.

DRY STRENGTH (crushing characteristics)
After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water, if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking or crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic of clays in the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

TOUGHNESS (consistency near plastic limit)
After removing particles larger then the No. 40 sieve size, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must beadded and if sticky, the specimen should be spread in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.
After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.
The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.
Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by the Corps of Engineers and Bureau of Reclamation, January 1952.

ABBREVIATIONS

a.	angle	f.	fine	mot.	mottled	str.	stringer(s)
alt.	alternate(ly)(ing)	fer.	ferruginous	mst.	moist	sty.	stylolite(ic)
amt.	amount	fis.	fissile	mtx.	matrix	t.	thin
ang.	angular	fil.	fill(ed)(ing)	n.	near	tho.	throughout
approx.	approximate(ly)	fm.	firm	nod.	nodule(s)	tk.	thick
ar.	argillaceous	fos.	fossil(iferous)	num.	numerous	tr.	trace
aren.	arenaceous	frac.	fracture(d)	o.	open	v.	variably
asp.	asphaltic	frags.	fragment(s)(al)	od.	odor	va.	variegated
b.	bone	fri.	friable	occ.	occasional(ly)	ve.	very
ba.	banded(ing)	FP	fixed-piston	occu.	occurring	veg.	vegetation
bd.	bed(ed)(ing)	FW	free water	org.	organic	ver.	vertical(ly)
bdr.	bedrock	g.	grain(ed)	pa.	parting(s)	vu.	vuggy
bf.	buff	gen.	generally	part.	particle(s)	w.	water
bk.	black	gn.	green(ish)	%	percent(age)	w/	with
bky.	blocky	gr.	gray	pi.	piece	w/o	without
bkn.	broken	gra.	gravelly	pl.	plastic	WC	water content
bl.	blue	grad.	grading(ed)	PL	plastic limit	wd.	weathered
bot.	bottom	GW	groundwater	peb.	pebble(s)	WH	weight of hammer
bou.	boulder(s)	h.	hard	pk.		whi.	white
bre.	breccia(ted)	ha.	high angle	pkt.	pocket(s)	WL	water level
br.	brown(ish)	hi.	high(er)(ly)	pit.	pit(ted)(ting)	wo.	wood
c.	coarse	hor.	horizontal(ly)	pn.	plane(s)	x-bd.	cross-bedded(ing)
ca.	calcareous	IC	initial contact	po.	porous	y.	yellow(ish)
carb.	carbonaceous	inc.	included, inclusions	pt.	part(ly)	z.	zone
cav.	cavern, cavity	incr	increasing(ly)	pyr.	pyrite(ic)		
cbl.	cobble(y)	inla.	interlaminated	q.	quartz(itic)		
ch.	chert	int.	intercalations	R.	red(dish)		
cl.	clay(ey)	intbd.	interbedded	ro.	rock(s)		
clb.	claybands	irr.	irregular	rot.	rotted(en)		
cle.	clean	jt.	joint(ed)	rou.	round(ed)		
coa.	coat(ed)(ing)	l.	low	rt.	root(s)(let)		
comp.	compact(ed)	li.	little	s.	soft		
con.	contains	LA.	low angle	SS	split spoon		
conc.	concretion	las.	laminate(ed)(ions)	sa.	sandy		
cong.	conglomerate(ic)	lay.	layer(s)	sat.	saturated		
cont.	continuous	le.	lean	scat.	scattered		
cr.	crushed	lea.	leached	se.	seams		
crm.	crumbly	len.	lense(s)	sev.	severe(ly)		
cst.	crystal(line)	lg.	large	sevr.	several		
cem.	cement(ed)	LL	liquid limit	sh.	shaly		
dc.	decayed	los.	loose	she.	shells		
di.	dirty	lt.	light	sil.	siliceous		
dia.	diameter	m.	medium	sl.	silty		
diag.	diagonal	ma.	many	slk.	slickensided		
dis.	disintegrated	mas.	massively	sm.	small		
disc.	discontinuous	mat.	material	so.	some		
diss.	disseminated	mic.	micaceous	sol.	solution		
dk.	dark	min.	mineralized	sta.	stain(ed)		
dn.	dense	mod.	modedate(ly)	stf.	stiff		
dmp.	damp	mos.	mostly	stks.	streak(s)		
ext.	extremely						
elem.	elements						

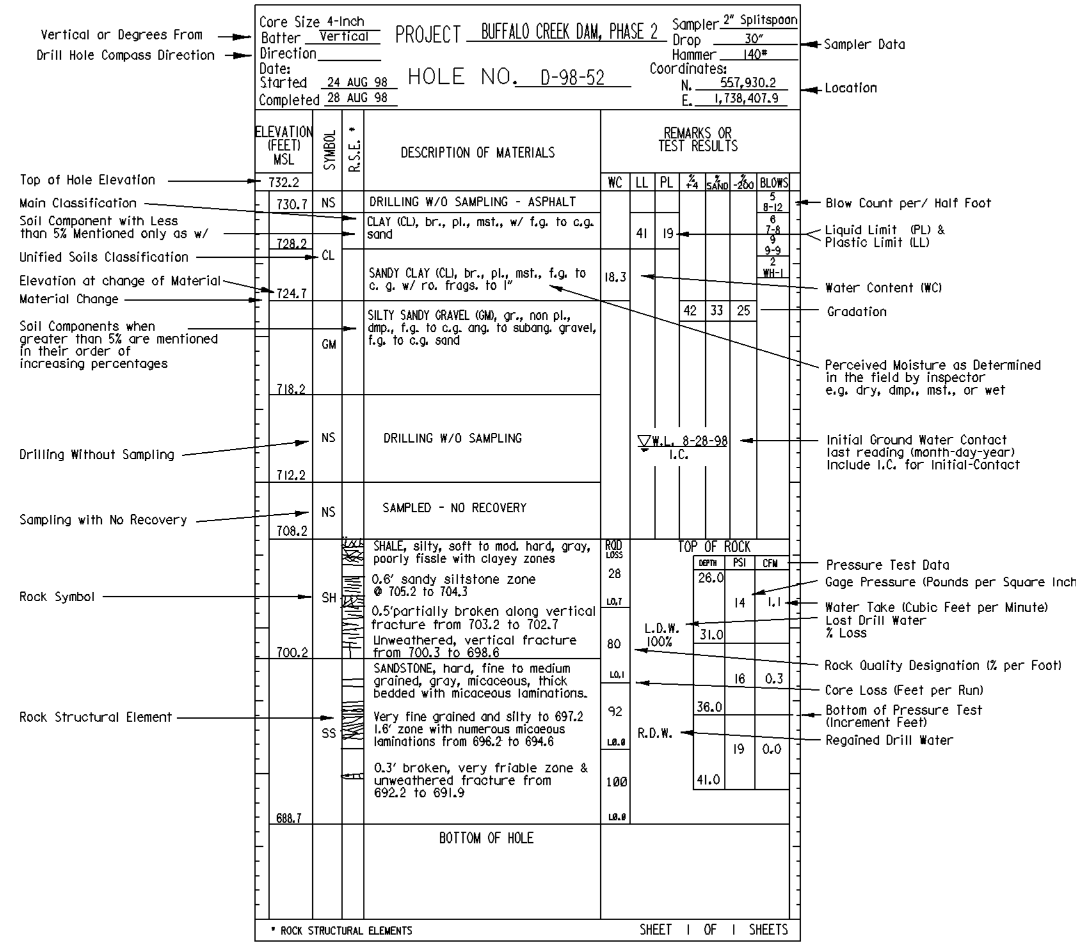
ROCK

NAME	ABBREVIATION
SANDSTONE	SS
CONGLOMERATE	CONG
SHALE	SH
SILTSTONE	SLS
CLAYSTONE	CLS
LIMESTONE	LS
COAL	C
INDURATED CLAY	ICL
DOLOMITE	DO
ORTHOQUARTZITE	OQ
CONCRETE	CON

ROCK LEGEND FOR GRAPHIC LOG OF BORING

- Broken in drilling or handling
- Natural break bedding plane or fracture
- Core loss
- Natural joint or fracture
- Core fragments, insitu breaks or broken in drilling or handling
- Shaly (fissile)
- F - Mylonite, fault-plane
- Intact core

GRAPHIC LOG OF BORING



NUMBER AND TYPE OF EXPLORATIONS

CODE	YEAR	HOLE NO.	DESIGNATION
C	98	52	Core hole in bedrock
D	98	31	Disturbed sample boring
CD	98	69	Disturbed sample boring (Percussion Drill/Cable Tool Drill)
UD	98	31	Undisturbed sample boring
A	98	25	Auger hole, hand or power auger, 2" to 24" diameter
			Core hole in bedrock, hydraulic pressure tested
			Indicates angle boring and direction
			Boring with Piezometer
			Boring with Inclinometer
TP	98	15	Test Pit in overburden
TT	98	6 - 135	Test Trench in overburden (TT-98-6), soils classified at stationing as shown (135 feet)
UD	98	39	Undisturbed sample boring with Piezometer

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

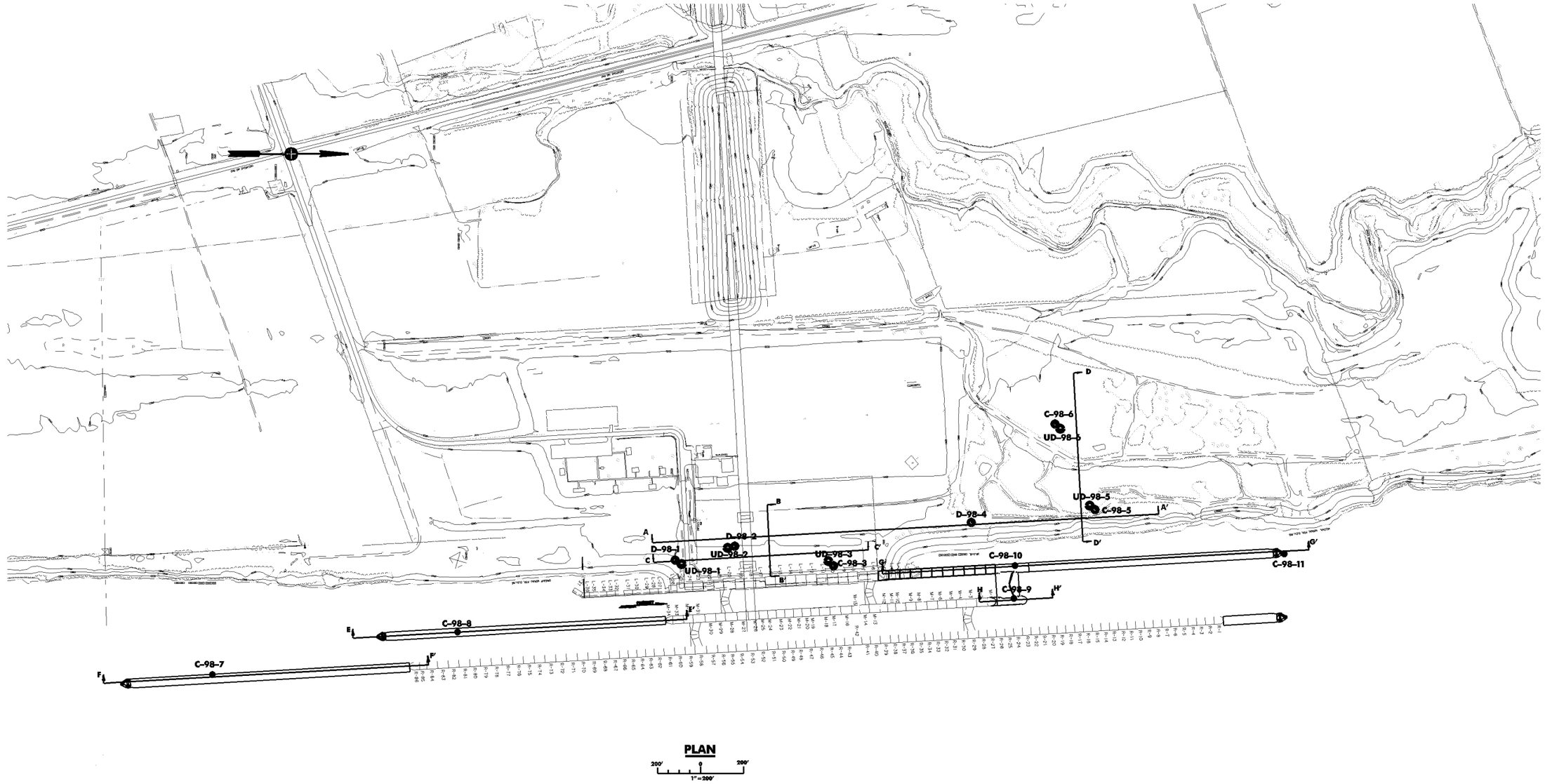
US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

GEOLOGY AND SOILS LEGEND

Designed by:	
Drawn by:	DKJ
Checked by:	GAH
Reviewed by:	HSB DLB
Approved by:	
Scale:	NOT TO SCALE
Date:	SEPTEMBER 1998
Drawing Code:	
Sheet reference number:	Greenup L&D Project Directory 600 Ft. Lock Extension
	p:\ecgs\gslegend.dgn
	Sheet 1 of 1

PLATE NO. 7-1



Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

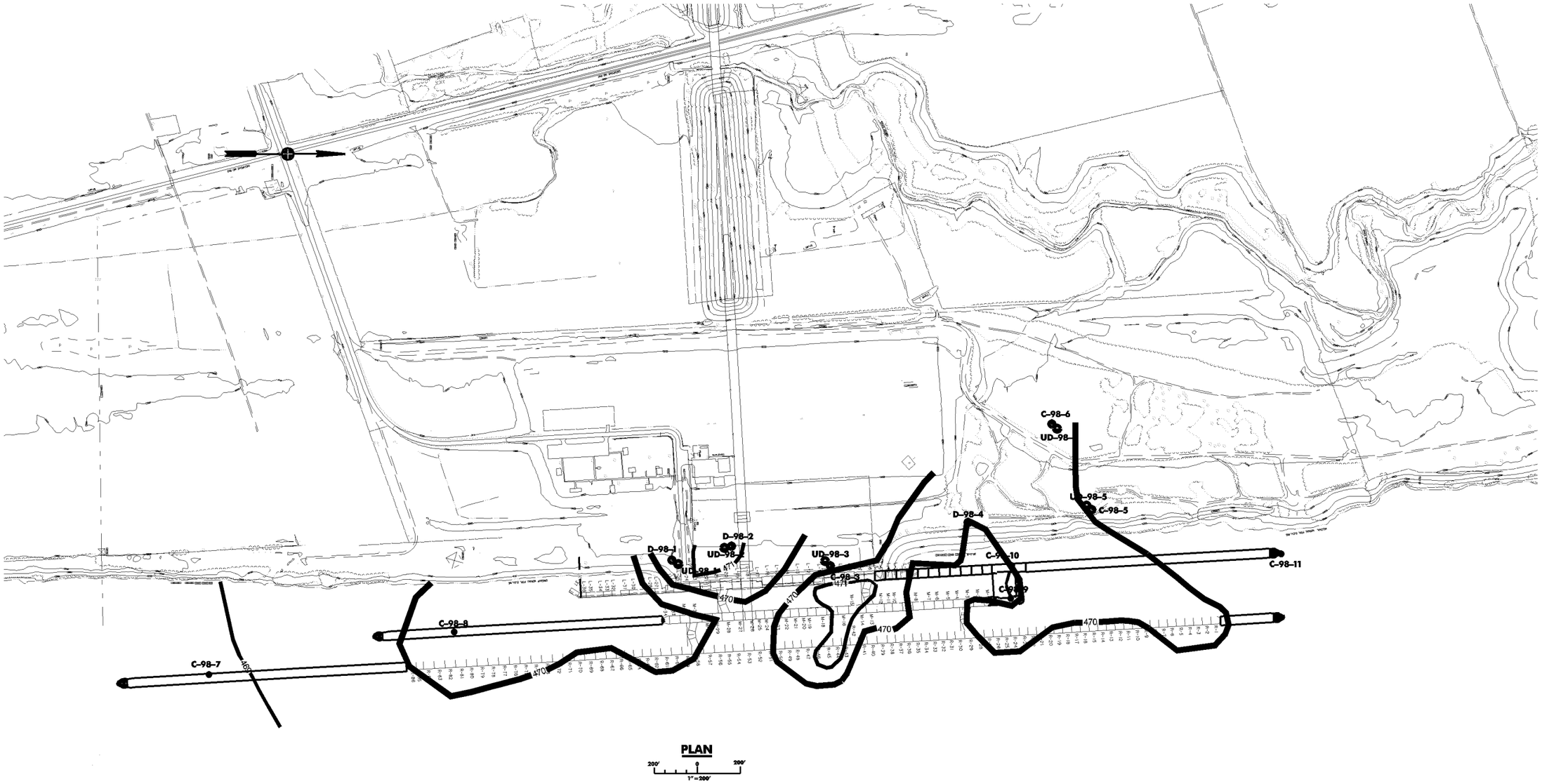
OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

BORING PLAN

Designed by: MCN TLR
Drawn by: TLR
Checked by:
Reviewed by:
Approved by:

Scale: 1" = 200'
Date: JANUARY 1999
Drawing Code:
Sheet reference number:
Greenup L&D Project Directory 600 Ft. Lock Extension
pc\edgs\boreplan.dgn
Sheet 1 of 1

PLATE NO. 7-2



Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

TOP OF ROCK MAP

Designed by: MCN TLR	Scale: 1" = 200'	Sheet reference number:	Greenup L&D Project Directory 600 Ft. Lock Extension
Drawn by: KDD	Date: APRIL 1999		pr\edgs\topofrock.dgn
Checked by:	Drawing Code:		Sheet 1 of 1
Reviewed by:			
Approved by:			

PLATE NO. 7-3

GREENUP LOCKS AND DAM
LOCK EXTENSION FEASIBILITY STUDY

SURVEY DATA - SEPTEMBER 1998

ONSHORE BORINGS				
Boring Number	**Northing**	**Easting**	**Elevation**	**Description**
D-98-1 (Piezometer)	235,443.162	1,896,566.415	540.28	Rim
	235,443.162	1,896,566.415	540.29	Riser
	235,443.162	1,896,566.415	538.80	Ground
UD-98-1	235,447.816	1,896,568.652	538.82	Ground
D-98-2 (Piezometer)	235,719.994	1,896,502.331	541.90	Rim
	235,719.994	1,896,502.331	541.89	Riser
	235,719.994	1,896,502.331	540.36	Ground
UD-98-2	235,715.307	1,896,502.491	540.37	Ground
C-98-3 (Piezometer)	236,178.572	1,896,594.112	539.64	Rim
	236,178.572	1,896,594.112	539.58	Riser
	236,178.572	1,896,594.112	538.01	Ground
UD-98-3	236,173.700	1,896,590.032	538.43	Ground
D-98-4 (Piezometer)	236,818.466	1,896,391.298	537.30	Rim
	236,818.466	1,896,391.298	537.29	Riser
	236,818.466	1,896,391.298	535.78	Ground
C-98-5 (Piezometer)	237,393.831	1,896,331.412	535.61	Rim
	237,393.831	1,896,331.412	535.56	Riser
	237,393.831	1,896,331.412	534.29	Ground
UD-98-5	237,387.612	1,896,328.086	534.91	Ground
C-98-6 (Piezometer)	237,206.820	1,895,933.709	543.23	Rim
	237,206.820	1,895,933.709	542.88	Riser
	237,206.820	1,895,933.709	541.34	Ground
UD-98-6	237,209.144	1,895,941.437	541.36	Ground

OFFSHORE BORINGS				
Boring Number	**Northing**	**Easting**	**Elevation Casing Rim**	**Elevation Water Surface**
C-98-7	233,291.399	1,897,097.721	520.34	515.68
C-98-8	234,431.184	1,896,900.572	520.54	515.67
C-98-9	237,017.298	1,896,744.049	488.72	486.25
C-98-10	237,011.154	1,896,589.704	490.19	485.30
C-98-11	238,273.675	1,896,537.324	489.82	485.59

Elevations are in Ohio River Datum.

CORE SIZE ____ BATTER VERTICAL DIRECTION ____ DATE: STARTED 7/28/98 COMPLETED 7/30/98
PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT
HOLE NO. D-98-1
SAMPLER 2" SPLITSPOON DROP 30" HAMMER 140 lbs. COORDINATES: N 235443.162 E 1896568.415

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
538.80									
538.5	ML	SANDY SILT (ML), br., nonpl., f.g. sand, w/roots							8-50*
	NS	NO SAMPLE, RIPRAP							-
535.8									
535.2	GM	SILTY SANDY GRAVEL (GM), gr., nonpl., dry, c.g. to f.g. gravel, c.g. to f.g. sand	3.8			40	35	25	9 8-8
533.4	SP	GRAVELLY SAND (SP), br., nonpl., mst., c.g. to f.g. gravel, c.g. to f.g. sand							7 6-5
	CL	SANDY CLAY (CL), r. br., low pl., dmp., f.g. gravel, c.g. to f.g. sand	18.2	26	17				5 5-6
		br. @ El. 531.3-528.3	17.1						5 5-5
									2 3-3
		gr., br., mst. to dmp., m. pl., no gravel @ El. 528.3-525.9	17.6						4 4-7
525.9			16.8	31	18				9 11-7
525.7	SS	SANDSTONE, greenish gr.							
	CL	SANDY CLAY (CL), br., m. pl., dmp., c.g. to f.g. sand	18.6						7 7-9
522.3									6 7-7
522.1	CL	GRAVELLY SANDY CLAY (CL), br., gr., low pl., dmp., f.g. gravel, c.g. to f.g. sand	13.2						29 30-47
520.5	SS	SANDSTONE, gr.							11 9-4
	CL	SANDY CLAY (CL), br., m. pl., dmp. to mst., f.g. sand	21.4						5 6-5
									3 2-3
			28.9	34	21				4 4-5
									2 3-3
			30.7						3 4-3
512.4									
509.5	SM	SILTY SAND (SM), br., nonpl., wet, m.g. and f.g. sand, w/F.W.	31.7			0	51	49	1 1-1
508.4	ML	SANDY SILT (ML), br., nonpl., wet, f.g. sand							1 2-2
	CL	SANDY CLAY (CL), gr. br., low pl., wet, f.g. sand	28.9	30	19	▽ 11-4-98			3 4-3
505.8									3 3-3
	SC-SM	SILTY CLAYEY SAND (SC-SM), gr. br., ve. low pl., wet, m.g. to f.g. sand							2 3-3
503.6									3 3-5
	CL	SANDY CLAY (CL), gr., m. pl., wet, m.g. to f.g. sand, w/F.W.							2 3-3
		f.g. sand @ El. 501.1-500.4							2 2-4
500.4			36.9	36	23				
499.8	WOOD	WOOD, decayed							
498.9	CL	SANDY CLAY (CL), br., m. pl., wet, f.g. sand	37.3						2 4-5
	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.	13.6			29	64	7	9 11-12
		f.g. gravel @ El. 498.5-493.8							28 29-14
493.8									5 9-9
	SP	GRAVELLY SAND (SP), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.							14 9-11
490.8									11 13-11
	SP-SM	SAND (SP-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand	19.2			3	91	6	6 10-11
488.8									7

SHEET 1 OF 2 SHEETS

CORE SIZE ____ BATTER VERTICAL DIRECTION ____ DATE: STARTED 7/31/98 COMPLETED 7/31/98
PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT
HOLE NO. UD-98-1
SAMPLER 5" FIXED PISTON DROP ____ HAMMER ____ COORDINATES: N 235447.816 E 1896568.652

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
538.82		DRILLING WITHOUT SAMPLING							
	NS								
517.8									
	CL-ML	SANDY SILTY CLAY (CL-ML), br., ve. low pl., f.g. sand	21.7	24	20	0	44	56	
515.3		BOTTOM OF HOLE							

SHEET 1 OF 1 SHEETS

CORE SIZE ____ BATTER VERTICAL DIRECTION ____ DATE: STARTED 8/3/98 COMPLETED 8/4/98
PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT
HOLE NO. D-98-2
SAMPLER 2" SPLITSPOON DROP 30" HAMMER 140 lbs. COORDINATES: N 235719.994 E 1896502.331

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
540.36									
538.7	ML	SANDY SILT (ML), br., nonpl., dry, f.g. sand, w/organics							4 5-8
	SP-SM	SAND (SP-SM), br., nonpl., dry to dmp., f.g. gravel, c.g. to f.g. sand	3.7			4	90	6	6 8-8
535.9									8 8-10
		GRAVELLY SAND (SP-SM), br., nonpl., dry to dmp., c.g. to f.g. gravel, c.g. to f.g. sand							5 5-4
533.3									6 8-12
		SANDY CLAY (CL), br., low pl., dmp., f.g. sand	14.9	31	19				10 10-10
531.4									6 8-7
	CL	CLAY (CL), br., m. pl., dmp., f.g. sand	22.0						8 7-8
									6 5-8
			24.0						6 8-8
		mst. @ El. 520.4-515.5	25.4						4 5-5
									6 6-7
			26.4						4 4-4
									4 4-8
			28.4						2 3-3
									3 5-5
515.5			25.9	34	20				2 3-4
		SANDY CLAY (CL), br., m. pl., mst., m.g. to f.g. sand	29.5						2 4-4
512.2		f.g. sand @ 513.4-512.2	28.5						2 2-2
510.4	SC-SM	CLAYEY SILTY SAND (SC-SM), br., ve. low pl., wet, f.g. sand, w/F.W.							1 2-2
507.4	CL-ML	SANDY SILTY CLAY (CL-ML), br., ve. low pl., wet, f.g. sand, w/F.W.							3 2-3
	SC-SM	CLAYEY SILTY SAND (SC-SM), br., ve. low pl., wet, m.g. to f.g. sand, w/F.W.							1 1-1
506.7	CL-ML	SANDY SILTY CLAY (CL-ML), br., ve. low pl., wet, m.g. to f.g. sand, w/F.W.				▽ 11-4-98			1 2-5
504.4									3 5-5
	CL	SANDY CLAY (CL), br., m. pl., wet, m.g. to f.g. sand	30.8						3 3-4
		gr., low pl. @ El. 502.2-500.5	33.8	29	20				2 5-8
500.5									5
	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.	12.6			34	55	11	24-30
498.4									10 10-28
	SM	SILTY GRAVELLY SAND (SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.							18 20-36
495.4									31 36-41
	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							11 12-12
									8 9-14
									10 10-12
490.4									7

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT
HOLE NO. D-98-2

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
490.4									
489.4	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							11-13
	SW-SM	SAND (SW-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.	18.3			5	86	9	6 6-10
488.4									6 6-9
	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.							8 12-14
483.4									11 11-12
	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand							5 6-9
480.4									5 6-8
	SP-SM	SAND (SP-SM), gr., nonpl., wet, f.g. gravel, c.g. to f.g. sand	18.1			7	86	7	5 7-10
477.4									11 11-17
	SP	GRAVELLY SAND (SP), gr., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							7 10-14
474.4									10 15-15
	SP-SM	SAND (SP-SM), gr., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.	14.0			7	85	8	10 19-18
471.8									10 17-36
471.4	SS	SANDSTONE, gr.							
		BOTTOM OF HOLE							

SHEET 2 OF 2 SHEETS

CORE SIZE ____ BATTER VERTICAL DIRECTION ____ DATE: STARTED 8/5/98 COMPLETED 8/5/98
PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT
HOLE NO. UD-98-2
SAMPLER 5" FIXED PISTON DROP ____ HAMMER ____ COORDINATES: N 235715.307 E 1896502.491

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
540.37									
	NS	DRILLING WITHOUT SAMPLING							
528.9									
	NS	NO SAMPLE RECOVERED							
524.4									
	CL	CLAY (CL), br., m. pl., stf., f.g. sand	25.0	38	22	0	4	96	
521.9									
520.4	NS	DRILLING WITHOUT SAMPLING							
	CL	CLAY (CL), br., low pl., ve. s., c.g. to f.g. sand, w/F.W.	29.0	26	17	0	7	93	
517.9									
		BOTTOM OF HOLE							

SHEET 1 OF 1 SHEETS

CORE SIZE 1.875" (NQ) BATTER VERTICAL DIRECTION N/A DATE: STARTED 8/18/98 COMPLETED 8/19/98
PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT
HOLE NO. C-98-3
SAMPLER 2" SPLITSPOON DROP 30" HAMMER 140 lbs. COORDINATES: N 236178.572 E 1896594.112

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
538.01									
537.3	CL-ML	SANDY SILTY CLAY (CL-ML), br., ve. low pl., dry, f.g. sand, w/organics							4 8-9
535.0	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., dry, c.g. to f.g. gravel, c.g. to f.g. sand, w/stale	3.2			20	73	7	12 13-18
	SP	GRAVELLY SAND (SP), br., nonpl., dry, c.g. to f.g. gravel, c.g. to f.g. sand							17 16-18
532.0									10 8-8
	SM	SILTY GRAVELLY SAND (SM), br., nonpl., dry, f.g. gravel, c.g. to f.g. sand							7 4-3
529.0									3 3-3
	SP	GRAVELLY SAND (SP), br., nonpl., dry, c.g. to f.g. gravel, c.g. to f.g. sand							5 4-5
									8 12-10
		f.g. gravel @ El. 526.0-523.0							9 9-12
									8 11-9
									14 14-9
									6 6-5
			4.4			18	79	5	10 13-16
									13 13-15
									11 12-10
									7 10-9
									7 7-7
									9 17-19
									10 18-25
508.0									16 16-21
	SP-SM	SAND (SP-SM), br., nonpl., dry, f.g. gravel, c.g. to f.g. sand	4.8			8	89	5	14 14-15
505.0									11 16-15
	SP	GRAVELLY SAND (SP), br., nonpl., moist, c.g. to f.g. gravel, c.g. to f.g. sand							13 15-16
						▽ 11-4-98			12 15-11
		wet @ El. 500.3-493.0							13 10-11
		w/F.W. @ El. 499.0-493.0							7 10-10
									4 3-2
									2 1-1
									5 3-3
493.0									4 4-5
491.9	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.	15.5			17	77	6	5 4-7
	SC	GRAVELLY CLAYEY SAND (SC), br. gr., low pl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.		25	17				4 1-8
		br. @ El. 490.0-489.3							6 2-6
		gr. br. @ El. 489.3-488.2							7
488.0									

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT
HOLE NO. C-98-3

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
488.0									
488.2	SC	GRAVELLY CLAYEY SAND (SC), gr. br., low pl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.	16.7						6-6
		m. pl., c.g. to f.g. gravel @ El. 487.0-486.2							8 14-18
484.4	CL-ML	SANDY SILTY CLAY (CL-ML), gr. br., ve. low pl., wet, f.g. gravel, c.g. to f.g. sand	19.5	24	19				11 14-15
484.0	CL	SANDY CLAY (CL), br., low pl., wet, m.g. to f.g. sand	20.5	29	18				5 4-7
481.0	SM	SILTY GRAVELLY SAND (SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand	16.8			17	71	12	6 11-14
	SP-SM	GRAVELLY SAND (SP-SM), gr., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/coal							7 4-4
									2 4-4
		br., w/F.W. @ El. 478.0-475.0							4 4-7
475.0									13 15-17
	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							6 9-16
472.0									19 21-17
	SP-SM	SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand	15.0						20 25-26
469.9									25-100*
469.7	SLS	SILTSTONE, gr.							
	SLS	SILTSTONE: Gray to light gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, scattered sand- to gravel-sized carbonaceous inclusions, gradational lower contact, thin to thick bedded with broken planes at 0.1' to 1.9' spacing.	64	R.Q.D.					
			L 0.0	LOSS					
		Slightly broken and thin bedded from 469.7-468.5	93						
		High angled (65°) fracture with rough and planar surface at 413.5-483.3	L 0.0						
		Severely broken and clay coated at 462.5-462.4							
		Clay coated bedding planes (clayey gray, sandy with rock fragments) at 460.4, 460.9, 459.4, 459.3	89						
453.5									
	SS	SANDSTONE: Light gray, mod. hard, fine grained, silty, scattered dark gray siltstone stringers throughout, gradational upper contact, medium to thick bedded with broken planes at 0.3'-2.3' spacing.	L 0.0						
			97						
443.9			L 0.0						

(463.8) L.O.W. 100%
TOP OF ROCK
BEGAN CORING
BOTTOM OF HOLE

SHEET 2 OF 2 SHEETS

Revisions			
Symbol	Descriptions	Date	Approved

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

Designed by: MCN TLR
Drawn by: KDD TLR JBS
Checked by:
Reviewed by:
Approved by:

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

GRAPHIC LOGS D-98-1 TO C-98-3

Scale: 1" = 5'
Date: JANUARY 1999
Drawing Code:
Sheet reference number:
Greenup L&D Project Directory 600 Ft. Lock Extension
pr\ecgs\borelogsord.dgn
Sheet 1 of 4

PLATE NO. 7-5

CORE SIZE ____ BATTER VERTICAL DIRECTION ____ DATE: STARTED 8/25/98 COMPLETED 8/25/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. UD-98-3

SAMPLER 5" FIXED PISTON DROP ____ HAMMER ____ COORDINATES: N. 236173.700 E. 1896590.032

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
538.43		DRILLING WITHOUT SAMPLING							
	NS								
488.9									
488.4	CL	SANDY CLAY (CL), br., low pl., q.g. to f.g. gravel, c.g. to f.g. sand							

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. UD-98-3

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
486.4									
486.0	SC	GRAVELLY CLAYEY SAND (SC), br., low pl., firm, q.g. to f.g. gravel, c.g. to f.g. sand	16.8	24	17	1	42	57	
486.8	CL-ML	SANDY SILTY CLAY (CL-ML), br., ve. low pl., f.g. gravel, c.g. to f.g. sand							
		BOTTOM OF HOLE							

SHEET 2 OF 2 SHEETS

CORE SIZE N/A BATTER VERTICAL DIRECTION N/A DATE: STARTED 8/5/98 COMPLETED 8/6/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. D-98-4

SAMPLER 2" SPLITSPOON DROP 30" HAMMER 140 lbs. COORDINATES: N. 236818.466 E. 1896391.298

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
535.78									
	SC-SM	GRAVELLY CLAYEY SILTY SAND (SC-SM), br., ve. low pl., dry, q.g. to f.g. gravel, c.g. to f.g. sand, w/organics							9 12-15
534.8									12 9-8
	SM	SILTY SAND (SM), br., nonpl., dry, q.g. to f.g. gravel, c.g. to f.g. sand	5.2			12	75	13	10 8-8
532.8									11 8-8
		SILTY GRAVELLY SAND (SM), br., nonpl., dry, c.g. to f.g. gravel, c.g. to f.g. sand							6 7-14
529.8									48 13-8
		SILTY SAND (SM), br., nonpl., dry, c.g. to f.g. gravel, c.g. to f.g. sand							5 4-5
526.8									5 4-4
	SP	GRAVELLY SAND (SP), br., nonpl., dry, f.g. gravel, c.g. to f.g. sand							5 4-3
523.8									4 3-2
	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., dmp. to mst., c.g. to f.g. gravel, c.g. to f.g. sand	6.3			15	78	7	2 4-5
520.8									9 9-9
		GRAVELLY SAND (SP), br., nonpl., dmp. to mst., c.g. to f.g. gravel, c.g. to f.g. sand							9 9-10
									10 10-8
									12 15-15
									15 16-17
									10 14-21
									19 15-13
									9 9-17
505.8		wet @ El. 506.2							19 14-18
503.5	SW-SM	GRAVELLY SAND (SW-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand							2 6-9
	SC	GRAVELLY CLAYEY SAND (SC), gr., br., m. pl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/sandstone	12.9			20	71	9	8 11-11
501.7		Br., low pl., f.g. gravel, w/F.W. @ El. 502.87-501.67							9 14-11
499.8	SP-SM	SAND (SP-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand							19 28-31
498.9	SC	CLAYEY SAND (SC), br., low pl., wet, c.g. to f.g. gravel, c.g. to f.g. sand							29 26-28
498.7	SS	SANDSTONE, gr., weathered	14.7	22	14				50 67-72
497.3	CL	SANDY CLAY (CL), gr., br., low pl., mst., c.g. to f.g. sand, w/weathered sandstone							22 24-31
496.8	SS	SANDSTONE, gr., weathered	12.8	25	18				16 17-21
496.1	SC	GRAVELLY CLAYEY SAND (SC), gr., br., low pl., mst., f.g. gravel, c.g. to f.g. sand, w/sandstone							6 9-12
	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand				▽ 11-4-98			26 50-50
493.8									7 11-14
492.9	SM	SILTY SAND (SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.	15.6			15	71	14	7 11-7
491.3	SC	GRAVELLY CLAYEY SAND (SC), br., low pl., wet, f.g. gravel, c.g. to f.g. sand	16.3	25	17				7 11-12
490.9	SS	SANDSTONE, gr., weathered							
489.3	SP-SM	GRAVELLY SAND (SP-SM), r. br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							
487.8	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							
485.8	SW-SM	SAND (SW-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.	15.8			7	83	10	11 12-12

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. D-98-4

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
485.8									
484.8	SW-SM	SAND (SW-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.	15.8			7	83	10	14-21
		GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							13 14-12
481.8									11 13-14
		SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand							8 8-8
478.8	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand							11 10-11
									12 10-11
		w/coal @ El. 476.5-474.3							13 16-18
		c.g. to f.g. gravel @ El. 474.3-471.3							13 15-17
									13 12-12
471.3									12 17-24
470.0	SP-SM	GRAVELLY SAND (SP-SM), gr., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand	9.8			28	66	6	11 20-100+
469.9	SS	SANDSTONE, gr.							
		BOTTOM OF HOLE							

SHEET 2 OF 2 SHEETS

CORE SIZE 4-INCH BATTER VERTICAL DIRECTION N/A DATE: STARTED 8/10/98 COMPLETED 8/12/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-5

SAMPLER 2" SPLITSPOON DROP 30" HAMMER 140 lbs. COORDINATES: N. 237393.831 E. 1896331.412

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
534.29									
533.7	SM	SILTY SAND (SM), br., nonpl., dmp., f.g. gravel, c.g. to f.g. sand, w/roots							3 4-5
	CL	SANDY CLAY (CL), br., m. pl., dmp., f.g. sand	16.5	38	19				9 11-11
									7 10-10
			19.9						6 8-7
									8 10-8
			21.2						8 8-8
		mst. @ El. 525.3-521.1							4 3-3
			23.9						4 4-5
									3 3-5
521.1			23.7						3 4-4
519.3	SC	CLAYEY SAND (SC), br., low pl., mst., f.g. sand	22.1						4 5-7
	CL	SANDY CLAY (CL), br., m. pl., dmp., f.g. sand	24.1	32	19				4 3-5
			28.3						3 4-4
512.5			24.6						4 3-5
	SC	CLAYEY SAND (SC), br., low pl., wet, m.g. to f.g. sand	26.8						4 4-4
									3 4-4
			27.2						2 2-2
									2 2-2
			25.9						3 5-8
									4 5-7
			27.6						5 4-4
501.5									6 4-8
500.4	CL	SANDY CLAY (CL), gr., low pl., wet, m.g. to f.g. sand	28.2	29	19				3 10-56
498.3	GP-GM	SANDY GRAVEL (GP-GM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand	8.0			55	38	7	81 76-51
	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, c.g. to f.g gravel, c.g. to f.g. sand							27 24-25
495.3									21 26-29
	SP	SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand							15 17-15
492.3									12 11-13
		GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.				▽ 11-4-98			6 8-11
									8 9-14
		c.g. to f.g. gravel @ El. 489.3-486.3							11 9-14
486.3									6 10-14
484.3	SP-SM	SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.	20.5			2	88	10	8 9-12
									6

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-5

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
484.3									
483.3	SP-SM	SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.	20.5			2	88	10	6-8
482.4	SP-SC	SAND (SP-SC), br., ve. low pl., wet, c.g. to f.g. sand	22.8						4 6-10
480.3	SP-SM	SAND (SP-SM), br., nonpl., wet, m.g. to f.g. sand, w/F.W.				0	90	10	5 9-13
	SP	GRAVELLY SAND (SP), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.							8 12-15
									9 8-17
									20 22-14
									7 8-11
									8 15-19
471.3									18 18-14
469.9	SP-SM	GRAVELLY SAND (SP-SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand, w/F.W.	9.5	TOP OF ROCK		24	69	7	34 50-12
469.8	SS	SANDSTONE, gr.	0 L 0.0			BEGAN CORING			
	SLS	SILTSTONE: Gray to light gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, scattered sand- to gravel-sized carbonaceous inclusions, gradational lower contact, thin to thick bedded with broken planes at 0.2' to 2.7' spacing.	89 ◄ R.Q.D.						
			L 0.0 ◄ LOSS						
		Slightly broken and thin bedded at 469.8-488.8				(463.8)	L.O.W. 100%		
		Open shaly bedding plane, possible location of drill water loss at 463.0.	100						
		Open, slightly broken, shaly bedding plane at 453.7, 453.5	L 0.0						
			100						
			L 0.0						
			93						
451.5									
450.2	SS	SANDSTONE: Light gray, mod. hard, silty, scattered dark gray siltstone stringers throughout, gradational upper contact.	L 0.0						BOTTOM OF HOLE

SHEET 2 OF 2 SHEETS

CORE SIZE ____ BATTER VERTICAL DIRECTION ____ DATE: STARTED 8/12/98 COMPLETED 8/12/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. UD-98-5

SAMPLER 5" FIXED PISTON DROP ____ HAMMER ____ COORDINATES: N. 237387.612 E. 1896328.086

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
534.91									
	NS	DRILLING WITHOUT SAMPLING							
527.4									
	CL	CLAY (CL), br., m. pl., f.g. sand	22.8	37	21	0	14	86	
524.9									
	NS	DRILLING WITHOUT SAMPLING							
518.4									
	CL	SANDY CLAY (CL), br., low pl., m.g. to f.g. sand, w/sand seams	23.4	32	20	0	21	79	
515.9									
		BOTTOM OF HOLE							

SHEET 1 OF 1 SHEETS

CORE SIZE 1.875" (NQ) BATTER VERTICAL DIRECTION N/A DATE: STARTED 8/13/98 COMPLETED 8/17/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-6

SAMPLER 2" SPLITSPOON DROP 30" HAMMER 140 lbs. COORDINATES: N. 237206.820 E. 1895933.709

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
541.34									
	CL-ML	SANDY SILTY CLAY (CL-ML), br., ve. low pl., dry to dmp., f.g. sand							2 2-2
538.3									3 3-4
	CL	SANDY CLAY (CL), br., low pl., dry to dmp., f.g. sand	28.1	41	32				4 4-8
536.0									17 53-45
	SS	SANDSTONE, gr., dry							52 28-36
533.8		wet @ El. 534.0-533.3							22 23-33
532.3	NS	NO SAMPLE							5 8-4
530.7	SS	SANDSTONE, gr., wet							5 8-10
	CL	SANDY CLAY (CL), br., m. pl., wet, f.g. sand	17.8						7 9-8
									7 9-14
			25.1						4 5-7
									9 9-14
			25.8						4 6-7
									8 11-13
			27.1						6 7-9
									9 11-14
			28.1	43	25				7 10-11
									7 7-10
			26.5						5 5-7
									6 6-7
			28.7						4 4-4
			28.7						3 4-4
		low pl., m.g. to f.g. sand @ El. 508.3-506.0	27.1						4 6-7
									6 8-8
		gr. @ El. 506.0-504.4	31.5						7 8-8
504.4	SM	SILTY SAND (SM), gr., nonpl., wet, m.g. to f.g. sand	25.7			0	69	31	4 5-4
502.9	CL	SANDY CLAY (CL), br., gr., m. pl., wet, f.g. sand	38.0	41	26				9 14-13
501.5	SP	GRAVELLY SAND (SP), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand							12 15-19
500.2	SM	SILTY SAND (SM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand							21 37-50
497.8	SP-SM	SAND (SP-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand				▽ 11-4-98			31 50-38
494.8									13 22-22
	SM	SILTY SAND (SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand	16.2			6	81	13	12 15-21
491.8	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand							7 13-13
491.3									9

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-6

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
491.3									
	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand							12-14
									8 8-12
486.4									6 9-12
		SAND (SP), br., nonpl., wet, c.g. to f.g. sand, w/F.W.							6 10-13
484.3									10 13-13
		GRAVELLY SAND (SP), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand							5 8-17
481.3									11 20-19
	SP-SM	SAND (SP-SM), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.	19.6			3	91	6	9 11-17
478.3									11 15-18
	SP	GRAVELLY SAND (SP), br., nonpl., wet, f.g. gravel, c.g. to f.g. sand, w/F.W.							5 8-9
									8 14-22
									8 13-24
									21 33-39
470.4									11 28-37
470.2	SP-SM	SANDY GRAVEL (GP-GM), br., nonpl., wet, c.g. to f.g. gravel, c.g. to f.g. sand	5.7	TOP OF ROCK		60	33	7	38-50+
470.1	SS	SANDSTONE, gr.				BEGAN CORING			
	SLS	SILTSTONE: Gray to light gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, scattered sand- to gravel-sized carbonaceous inclusions, gradational lower contact, thin to medium bedded with broken planes at 0.1' to 1.9' spacing.	18 L 0.0						
		Thin bedded with broken planes at 0.1' spacing at 470.1-467.5.	80 ◄ R.Q.D.						
		Thin (0.07') clay seams gray, sandy with rock fragments at 454.3.	L 0.0 ◄ LOSS						
		Clay coated bedding plane at 454.8.							
		Severely broken at 453.8-453.7.	73						
452.9									
	SS	SANDSTONE: Light gray, mod. hard, fine grained, silty, scattered dark gray siltstone stringers throughout, gradational upper contact, thin to thick bedded with broken planes at 0.3'-2.3' spacing.	L 0.0						
			97						
452.9			L 0.0						BOTTOM OF HOLE

SHEET 2 OF 2 SHEETS

Revisions

Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

GRAPHIC LOGS UD-98-3 TO C-98-6

Designed by: MCN TLR
Drawn by: KDD TLR JBS
Checked by:
Reviewed by:
Approved by:

Scale: 1" = 5'
Date: JANUARY 1999
Drawing Code:
Sheet reference number:
Greenup L&D Project Directory 600 Ft. Lock Extension
pr\ecgs\borelogsord.dgn
Sheet 2 of 4

PLATE NO. 7-6

CORE SIZE ____ BATTER VERTICAL DIRECTION ____ DATE: STARTED 8/18/98 COMPLETED 8/18/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. UD-98-6

SAMPLER 5" FIXED PISTON DROP ____ HAMMER ____ COORDINATES: N 237209.144 E 1895941.437

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	WC	LL	PL	% +4	% SAND	% -200	BLOWS
541.38									
	NS	DRILLING WITHOUT SAMPLING							
527.9									
525.4	CL	CLAY (CL), br., m. hi. pl., f.q. sand	24.8	46	24	0	1	99	
	NS	DRILLING WITHOUT SAMPLING							
521.9									
519.4	CL	CLAY (CL), br., m. pl., f.q. sand	25.6	42	23	0	2	98	
	NS	DRILLING WITHOUT SAMPLING							
515.9									
513.4	CL	CLAY (CL), br., m. pl., f.q. sand	25.4	37	21	0	11	89	
		BOTTOM OF HOLE							

SHEET 1 OF 1 SHEETS

CORE SIZE 1.875" (NO) BATTER VERTICAL DIRECTION N/A DATE: STARTED 9/3/98 COMPLETED 9/4/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-7

SAMPLER N/A DROP N/A HAMMER N/A COORDINATES: N 233,291.4 E 1,897,097.7

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
520.34			TOP OF CASING
	NS	DRILL WITHOUT SAMPLING (CASING)	Drilling was performed from the surface of a barge deck at elevation 518.8
515.7			TOP OF WATER
	NS	DRILL WITHOUT SAMPLING (WATER)	
473.0			TOP OF OVERBURDEN
470.3	NS	DRILL WITHOUT SAMPLING (OVERBURDEN)	

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-7

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
470.3			
468.9			TOP OF ROCK
	SLS	SILTSTONE: Gray to light gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, scattered sand- to gravel-sized carbonaceous inclusions, gradational lower contact, thin to thick bedded with broken planes at 0.1' to 1.1' spacing.	50; L 0.0; 52; L 0.0; (465.0) L.O.W. 50%
		Slightly broken and thin bedded at 468.9-464.7.	
		Clay coated bedding planes (clays gray, sandy with rock fragments) at 467.8, 467.1	
		High angled (75°) pair of parallel fractures with a smooth and planar surface, possible location of drill water loss at 465.3-464.9	81 ← R.Q.D.
		Thin (0.01') clay seams gray, sandy with rock fragments, possible location of water loss at 464.9.	
		40° fracture with a smooth and planar surface at 462.0-461.9.	L 0.0 ← LOSS
453.8			
		Severely broken at 462.5-462.4.	
		Thin (0.02') clay seams gray, sandy with rock fragments at 459.8.	
	SS	SANDSTONE: Light gray, mod. hard, fine grained, silty, scattered dark gray siltstone stringers throughout, gradational upper contact, medium to thick bedded with broken planes at 0.3'-0.3' spacing.	100
		Slightly broken, possibly mechanical at 433.9-434.27.	L 0.0
		Iron stained at 430.87-430.37.	
		Numerous small vugs filled with a white non-calcareous chalk at 430.37-430.27.	
		Silty and gray below 430.27.	100
			L 0.0
			100
428.8			L 0.0 BOTTOM OF HOLE

SHEET 2 OF 2 SHEETS

CORE SIZE 1.875" (NO) BATTER VERTICAL DIRECTION N/A DATE: STARTED 9/8/98 COMPLETED 9/9/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-8

SAMPLER N/A DROP N/A HAMMER N/A COORDINATES: N 234,431.2 E 1,896,900.6

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
520.54			TOP OF CASING
	NS	DRILL WITHOUT SAMPLING (CASING)	Drilling was performed from the surface of a barge deck at elevation 518.8
515.6			TOP OF WATER
	NS	DRILL WITHOUT SAMPLING (WATER)	
471.7			TOP OF OVERBURDEN
470.5	NS	DRILL WITHOUT SAMPLING (OVERBURDEN)	TOP OF ROCK
470.5	SLS	SILTSTONE: (continued on next sheet)	

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-8

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
470.5			
	SLS	SILTSTONE: Light gray to gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, scattered sand- to gravel-sized carbonaceous inclusions, gradational lower contact, thin to thick bedded with broken planes at 0.1' to 2.6' spacing.	40 ← R.Q.D.; L 0.0 ← LOSS; 100
		Slightly broken and thin bedded with broken planes at 0.1' to 0.3' spacing at 470.6-468.5.	L 0.0
		Severely broken with clay coated bedding planes at 466.9-468.8	
		Severely broken with clay coated bedding planes, possible location of the drill water loss at 460.8-460.7	(460.8) L.O.W. 100%
		Numerous small scattered fossil fragments at 467.7-467.7.	99
			L 0.0
452.2			
	SS	SANDSTONE: Light gray, mod. hard, fine grained, silty, scattered dark gray siltstone stringers throughout, gradational upper contact, medium to massive bedded with broken planes at 0.6'-3.4' spacing.	100
		Numerous dark gray siltstone stringers at 450.6-450.5.	
		Moderately broken, possibly mechanical at 443.8-443.6.	L 0.0
			100
			L 0.0
430.5			100
			L 0.0 BOTTOM OF HOLE

SHEET 2 OF 2 SHEETS

CORE SIZE 4-INCH DIA BATTER VERTICAL DIRECTION N/A DATE: STARTED 9/15/98 COMPLETED 9/16/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-9

SAMPLER N/A DROP N/A HAMMER N/A COORDINATES: N 237,017.3 E 1,896,744.0

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
488.72			TOP OF CASING
	NS	DRILL WITHOUT SAMPLING (CASING)	Drilling was performed from the surface of a barge deck.
484.7			TOP OF WATER
	NS	DRILL WITHOUT SAMPLING (WATER)	Overburden was not encountered.
469.7			TOP OF ROCK
	SLS	SILTSTONE: Gray to light gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, numerous shaly bedding planes with partial clay coating throughout, scattered sand- to gravel- sized carbonaceous inclusions, gradational lower contact, thin to medium bedded with broken planes at 0.1' to 1.0' spacing.	0; L 0.5; 75 ← R.Q.D.; L 0.0 ← LOSS
		Slightly broken and thin bedded with possible 0.5' loss at 469.7-468.2	70
		Bedding plane with iron stained host rock, possible location of drill water loss at 458.5-458.3	L 0.3; 98; L.O.W. 100% (458.7); L 0.0; 98
451.9			
	SS	SANDSTONE: Light gray, mod. hard, fine grained, silty, scattered dark gray siltstone stringers throughout, gradational upper contact, medium to thick bedded with broken planes at 0.4'-3.0' spacing.	L 0.0; 100
		Medium grained sandstone with siltstone inclusions at 431.6-431.4.	L 0.0
		Iron stained at 430.7-430.5.	100
		0.3' Siltstone: dark gray, mod. hard, sandy at 429.0-428.7.	L 0.0; 100
438.7			

PRESSURE TEST RESULTS

ELEV. (FT)	PRESS. (PSI)	FLOW (CFM)
467.7		
	11.7	0.12
463.7		
462.7		
	7.5	2.08
458.7		
	16.2	0.40
453.7		
	18.7	0.00
448.7		
	21.2	0.00
443.7		
	23.7	0.00
438.7		

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-9

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
438.7			
	SS	SANDSTONE: (continued from previous sheet)	L 0.0; 84; L 0.0; 89; L 0.0
428.7			BOTTOM OF HOLE

ELEV. (FT)	PRESS. (PSI)	FLOW (CFM)
438.7		
	26.2	0.00
436.2		
433.7		
	27.5	0.00
431.2		

SHEET 2 OF 2 SHEETS

Revisions

Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

GRAPHIC LOGS UD-98-6 TO C-98-9

Designed by:	MCN TLR	Scale: 1" = 5'	Sheet reference number: Greenup L&D Project Directory 600 Ft. Lock Extension
Drawn by:	KDD TLR JBS	Date: JANUARY 1999	pt\ecgs\boreloggsord.dgn
Checked by:		Drawing Code:	Sheet 3 of 4
Reviewed by:			
Approved by:			

PLATE NO. 7-7

CORE SIZE 4-INCH DIA.
BATTER VERTICAL
DIRECTION N/A
DATE:
STARTED 9/14/98
COMPLETED 9/15/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-10

SAMPLER N/A
DROP N/A
HAMMER N/A
COORDINATES:
N 237,011.2
E 1,896,589.7

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
490.19			TOP OF CASING
	NS	DRILL WITHOUT SAMPLING (CASING)	Drilling was performed from the surface of a barge deck.
485.5			TOP OF WATER
	NS	DRILL WITHOUT SAMPLING (WATER)	
477.5			TOP OF OVERBURDEN
	NS	DRILL WITHOUT SAMPLING (OVERBURDEN)	
470.0			TOP OF ROCK
	SLS	SILTSTONE: Gray to light gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, numerous shaly bedding planes with partial clay coating throughout, scattered sand- to gravel- sized carbonaceous inclusions, gradational lower contact, thin to thick bedded with broken planes at 0.2' to 2.3' spacing.	88 R.Q.D.; L 0.0 LOSS
		Slightly broken and thin bedded at 470.0-469.0.	
		Slightly broken bedding plane, possibly mechanical at 463.4-463.3.	90; L.O.W. 100% (462.6)
		Open, partly clay coated, shaly bedding planes planes, possible locations of drill water loss at 462.5, 461.8, 461.4, 460.9.	L 0.0
		0.8' Sandstone Seam: light gray, mod. hard, fine grained at 453.7-452.9.	94
			L 0.0
452.2			100
	SS	SANDSTONE: Light gray, mod. hard, fine grained, silty, scattered dark gray siltstone stringers throughout, gradational upper contact, medium to massive bedded with broken planes at 0.3'-3.1' spacing.	L 0.0
		Iron stained carbonaceous bedding plane at 448.3	100
		Iron stained at 430.7-431.3.	L 0.0
			100
440.2			L 0.0

PRESSURE TEST RESULTS

ELEV. (FT)	PRESS. (PSI)	FLOW (CFM)
449.9		
	21.3	0.04
444.9		
	23.8	0.11

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-10

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
440.2		SANDSTONE: (continued from previous sheet)	100
	SS		L 0.0
			97
429.8			L 0.0 BOTTOM OF HOLE

ELEV. (FT)	PRESS. (PSI)	FLOW (CFM)
439.4		
	26.6	0.02
437.4		
434.9		
	27.8	0.05
432.4		

SHEET 2 OF 2 SHEETS

CORE SIZE 1.875" (NQ)
BATTER VERTICAL
DIRECTION N/A
DATE:
STARTED 9/9/98
COMPLETED 9/10/98

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-11

SAMPLER N/A
DROP N/A
HAMMER N/A
COORDINATES:
N 238,273.7
E 1,896,537.3

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
489.82			TOP OF CASING
	NS	DRILL WITHOUT SAMPLING (CASING)	Drilling was performed from the surface of a barge deck.
485.5			TOP OF WATER
	NS	DRILL WITHOUT SAMPLING (WATER)	
475.2			TOP OF OVERBURDEN
	NS	DRILL WITHOUT SAMPLING (OVERBURDEN)	
469.9			TOP OF ROCK
	SLS	SILTSTONE: Gray to light gray, mod. hard, sandy, fine grained sandstone stringers and seams throughout, scattered sand- to gravel-sized carbonaceous inclusions, gradational lower contact, thin to thick bedded with broken planes at 0.2' to 2.6' spacing.	74 R.Q.D.
		Iron stained top of rock surface at 469.9.	
		Thin bedded with broken planes at 0.1' to 0.3' spacing at 469.9-467.1.	L 0.0 LOSS
		High angled (80°) fracture with a smooth and planar surface at 469.7-469.5.	(462.8) L.O.W. 100%
		Low angled (30°) bedding plane with clay coating at 463.0-462.9.	87
		Clay coated bedding planes, possible locations of drill water loss at 462.5, 459.5, 458.8.	
		Thin (0.04') Clay seams gray, silty with rock fragments at 453.7.	
		Severely mechanically broken at 463.4-463.3.	L 0.0
452.7			
	SS	SANDSTONE: Light gray, mod. hard, fine grained, silty, scattered dark gray siltstone stringers throughout, gradational upper contact, medium to massive bedded with broken planes at 0.6'-3.2' spacing.	
		Numerous dark gray siltstone stringers at 452.0-451.9.	100
			L 0.0
439.8			

SHEET 1 OF 2 SHEETS

PROJECT GREENUP LOCKS AND DAM 600C-4 LOCK EXTENSION FEASIBILITY REPORT

HOLE NO. C-98-11

ELEVATION (FEET) MSL	SYMBOL	DESCRIPTION OF MATERIALS	REMARKS OR TEST RESULTS
439.8		SANDSTONE: (continued from previous sheet)	100
			L 0.0
			100
429.6			L 0.0 BOTTOM OF HOLE

SHEET 2 OF 2 SHEETS

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

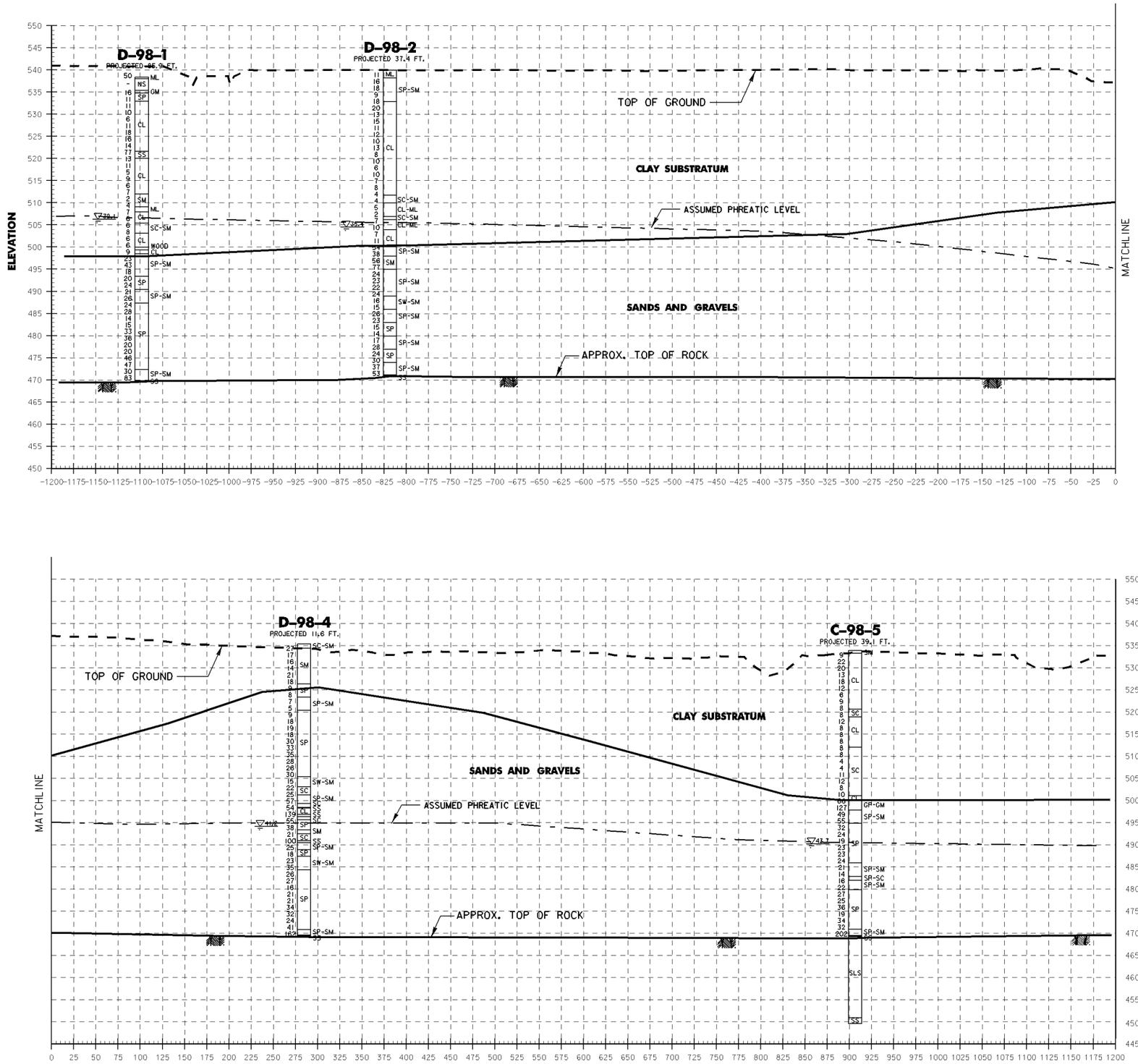
OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

Designed by: MCN TLR
Drawn by: KDD TLR JBS
Checked by:
Reviewed by:
Approved by:

GRAPHIC LOGS
C-98-10 TO C-98-11

Scale: 1" = 5'
Date: JANUARY 1999
Drawing Code:
Sheet reference number:
Greenup L&D Project Directory 600 Ft. Lock Extension
pt\ecgs\borelogsord.dgn
Sheet 4 of 4

PLATE NO. 7-8



SECTION A-A'

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

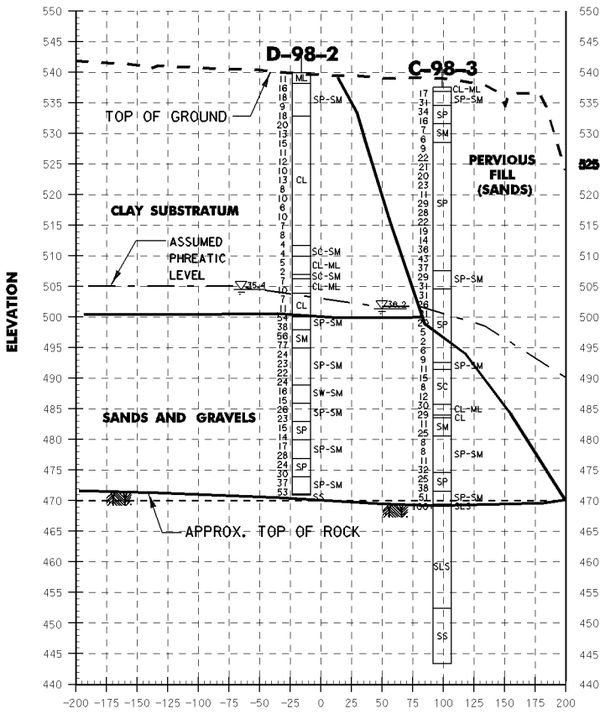
OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

GEOLOGIC SECTIONS

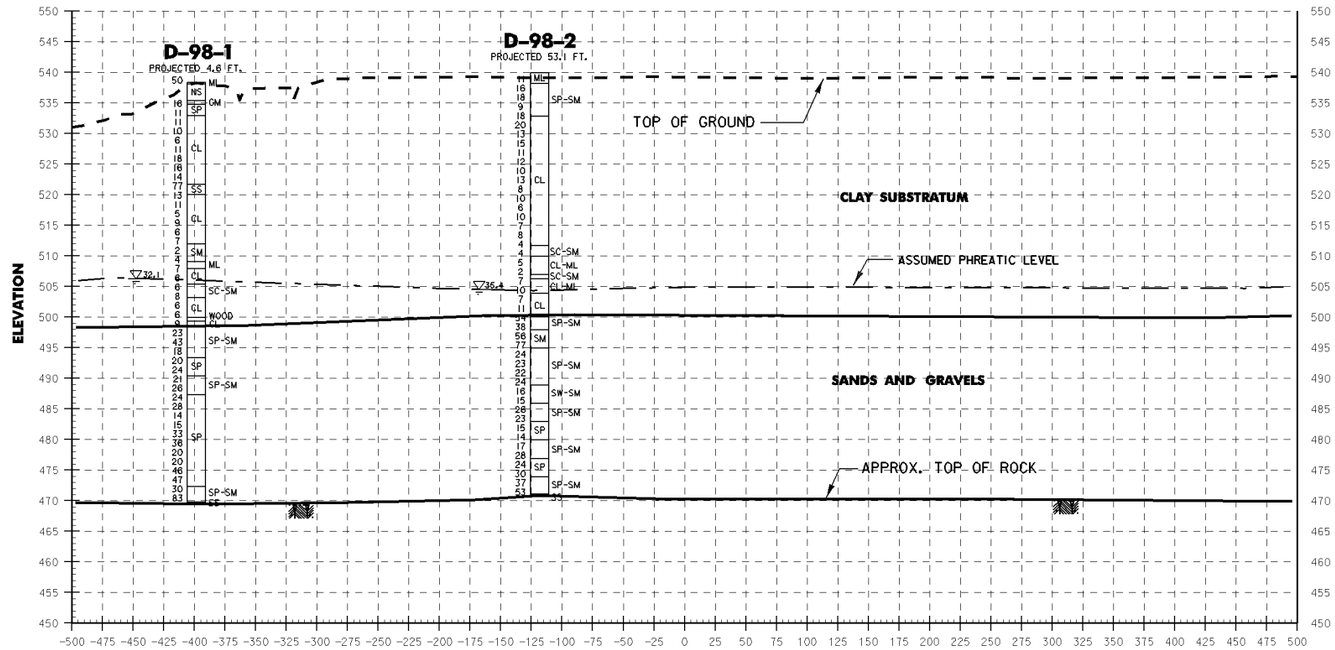
Designed by: MCN TLR
Drawn by: KDD TLR
Checked by: AFW
Reviewed by:
Approved by:

Scale: 1" = 50'
Date: OCTOBER 1998
Drawing Code:
Sheet reference number:
Greenup L&D Project Directory 600 Ft. Lock Extension
p:\ecga\sections.dgn
Sheet 1 of 4

PLATE NO. 7-9



SECTION B–B′



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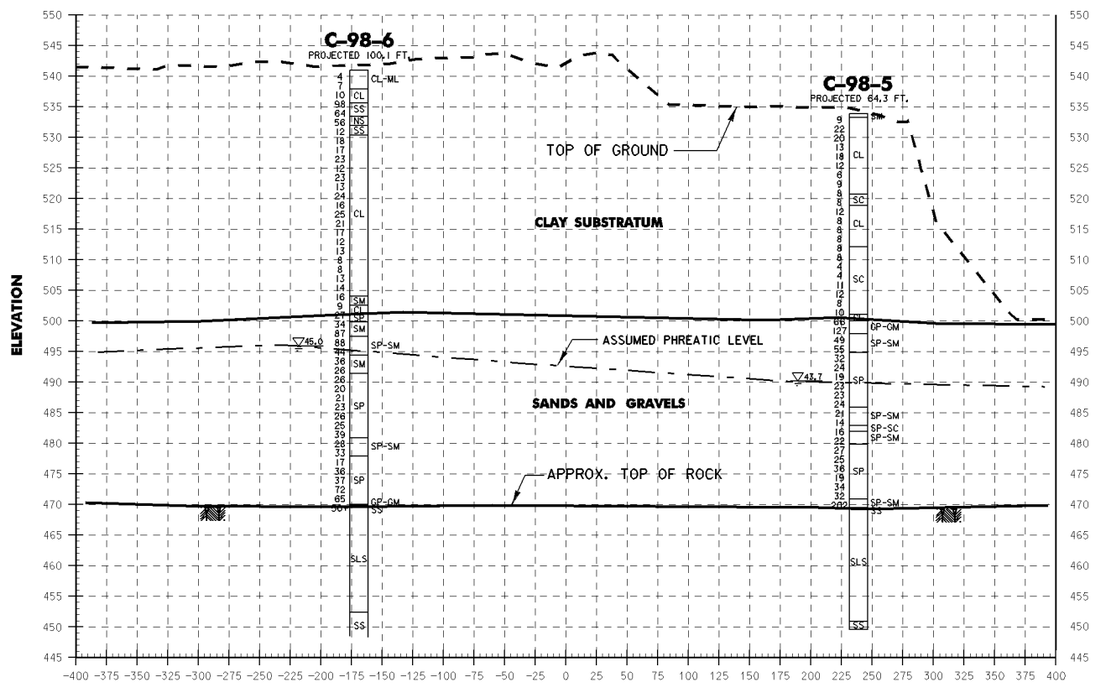


SECTION D–D′

Revisions			
Symbol	Descriptions	Date	Approved

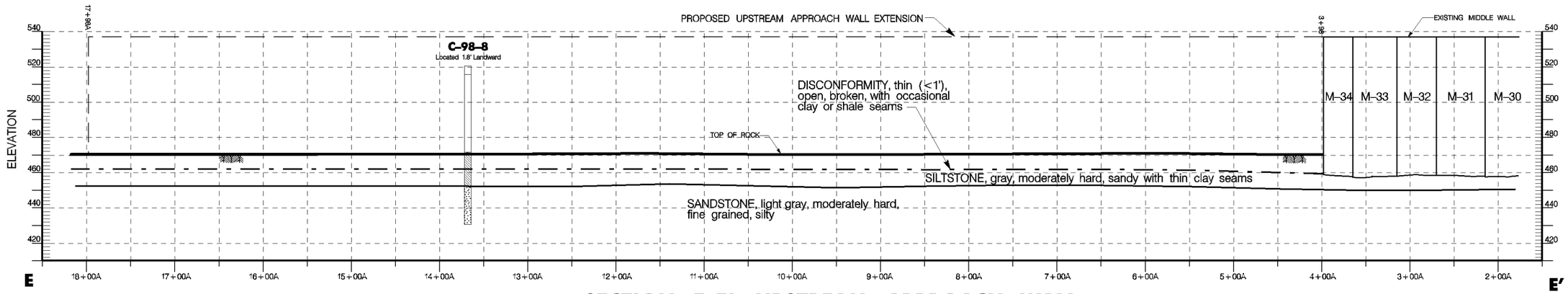
U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

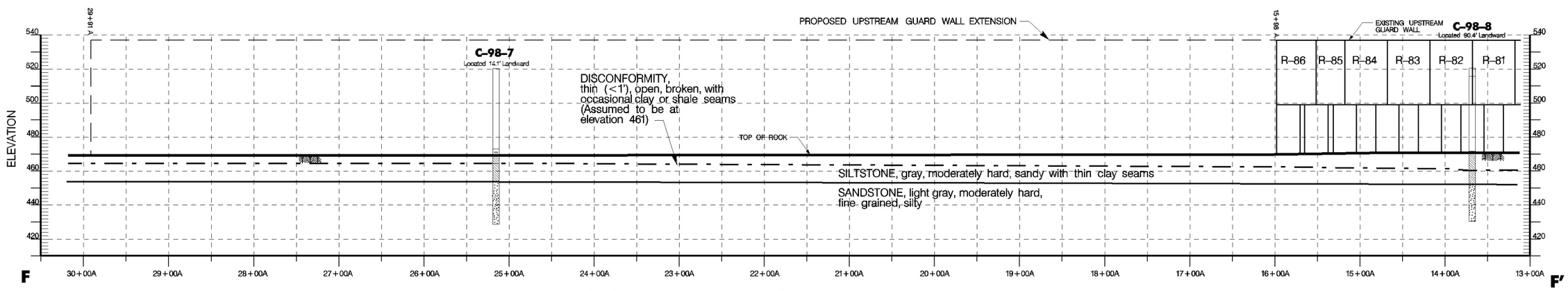
OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

GEOLOGIC SECTIONS

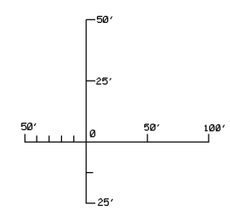
Designed by: MCN TLR	Scale: 1" = 50'	Sheet reference number:	Greenup LAD Project Directory 600 Ft. Lock Extension
Drawn by: KDD TLR	Date: OCTOBER 1998		pi\ergs\sections.dgn
Checked by: AFW	Drawing Code:		Sheet 2 of 4
Reviewed by:			
Approved by:			



SECTION E–E': UPSTREAM APPROACH WALL



SECTION F–F': UPSTREAM GUARD WALL



SCALE: 1" = 50'
VERTICAL EXAGGERATION = 2X

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

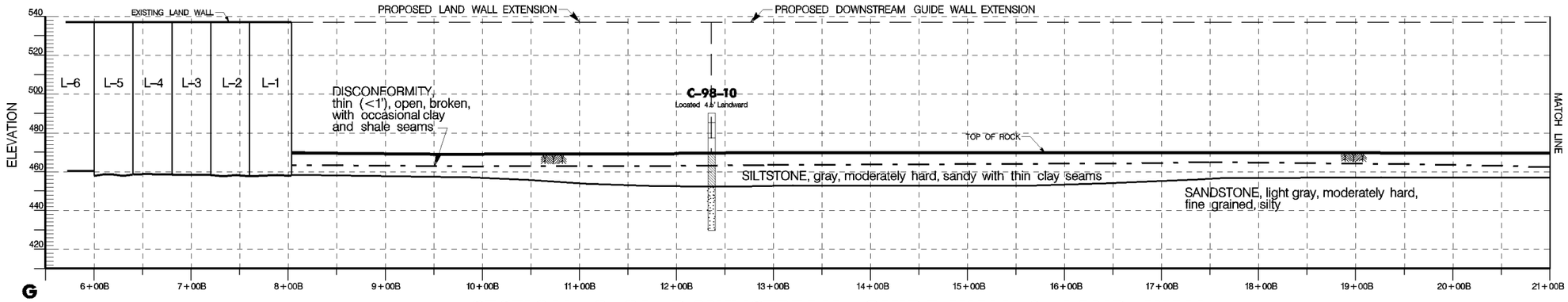
OHIO RIVER MAIN STEM STUDY
GREENUP LOCK AND DAM
LOCK EXTENSION FEASIBILITY REPORT

GEOLOGIC SECTIONS

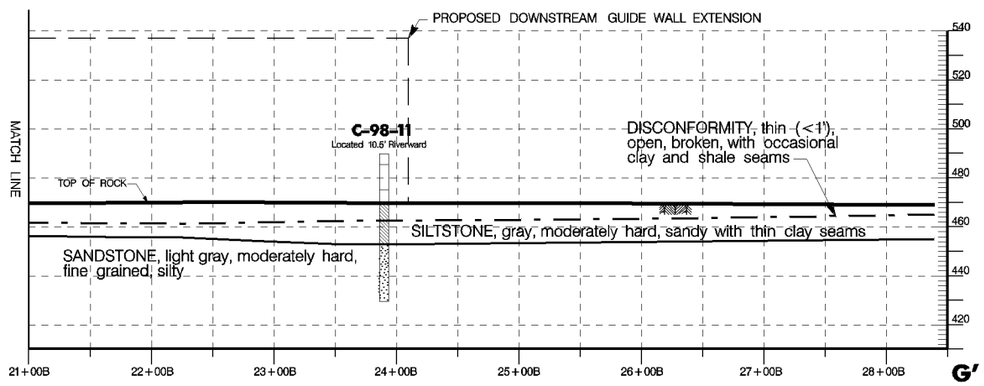
Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

Scale: 1" = 50'
Date: April 1999
Drawing Code:
Sheet reference number:
File: pvecggsections.dgn
Sheet 3 of 4

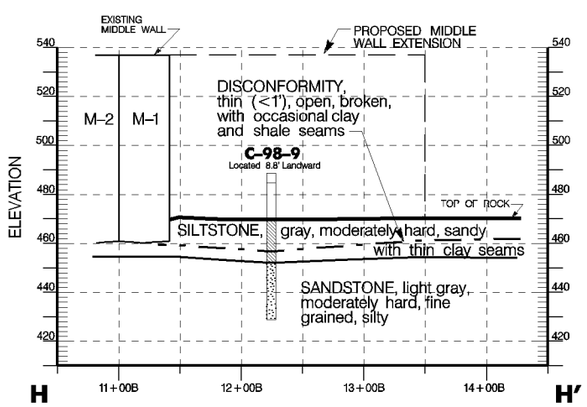
PLATE NO. 7–11



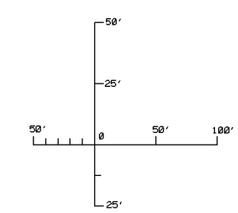
SECTION G–G′: DOWNSTREAM GUIDE WALL & LAND WALL



SECTION G–G′: DOWNSTREAM GUIDE WALL & LAND WALL



SECTION H–H′: MIDDLE WALL



SCALE: 1" = 50'
VERTICAL EXAGGERATION = 2X

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

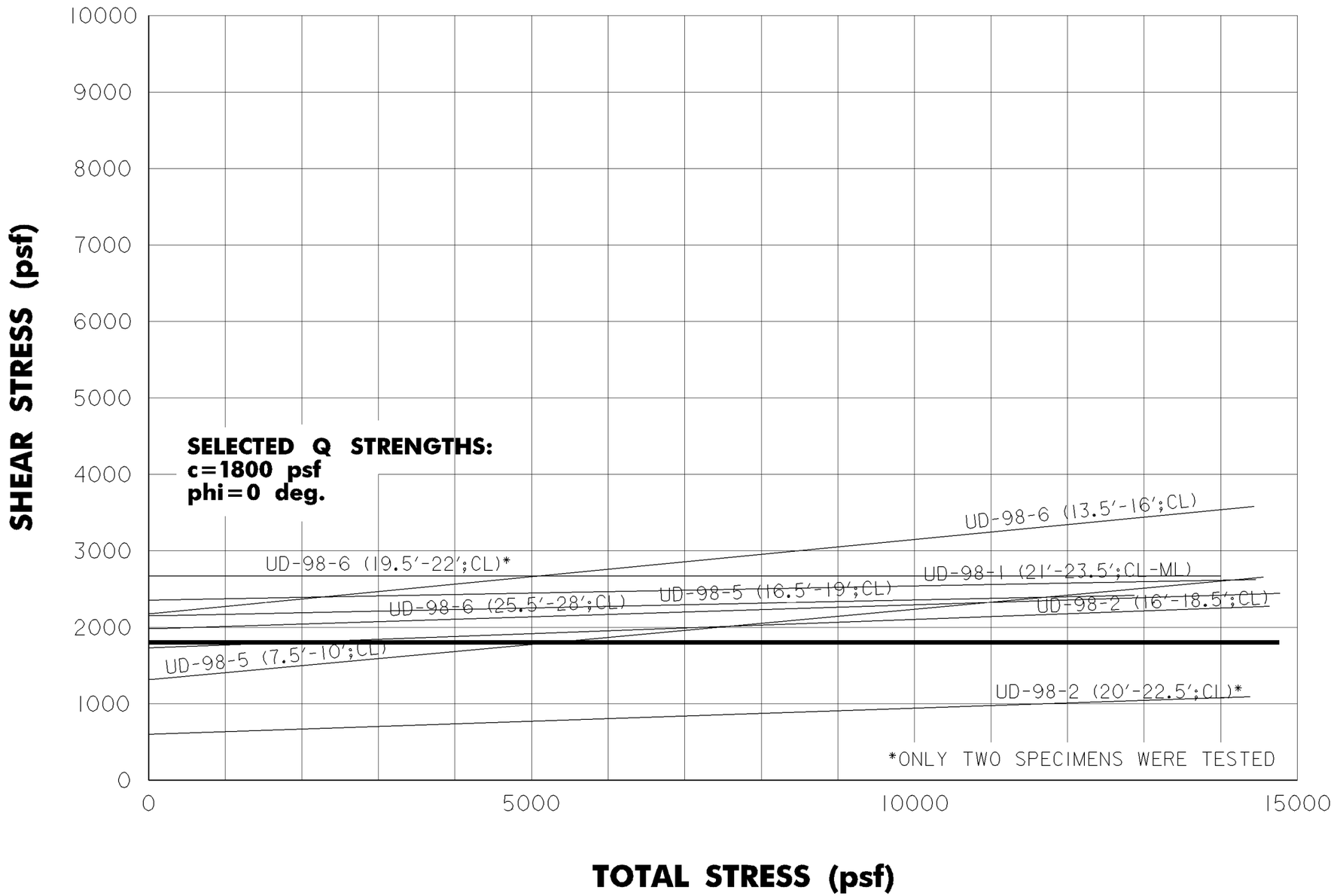
OHIO RIVER MAIN STEM STUDY
GREENUP LOCK AND DAM
LOCK EXTENSION FEASIBILITY REPORT

GEOLOGIC SECTIONS

Designed by:
Drawn by:
Checked by:
Reviewed by:
Approved by:

Scale: 1" = 50'
Date: April 1999
Drawing Code:
Sheet reference number:
File: precggsections.dgn
Sheet 4 of 4

UNCONSOLIDATED–UNDRAINED (Q STRENGTHS)



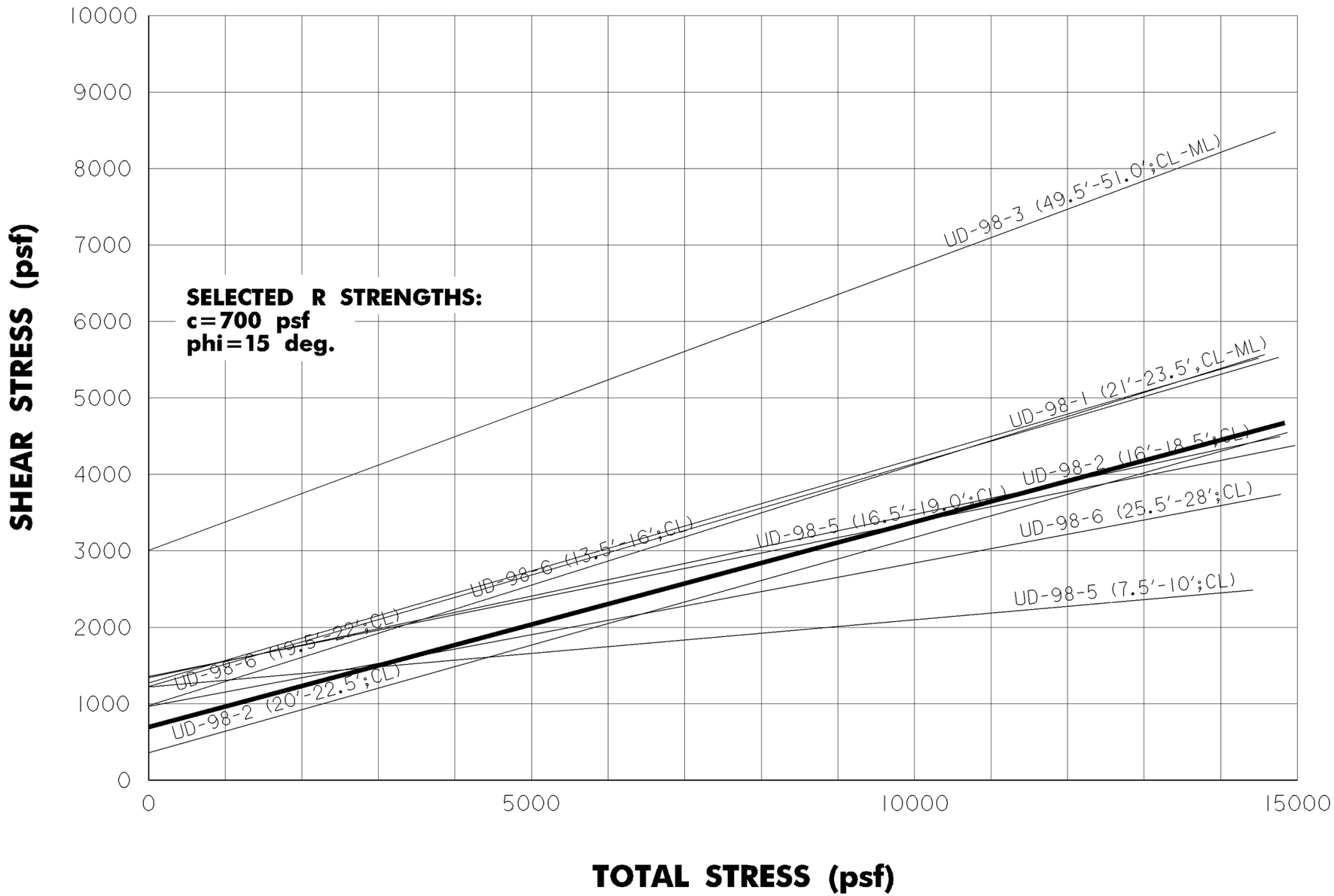
OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

TRIAXIAL TEST RESULTS

OCTOBER 1998

PLATE NO. 7–13

CONSOLIDATED–UNDRAINED (R STRENGTHS)



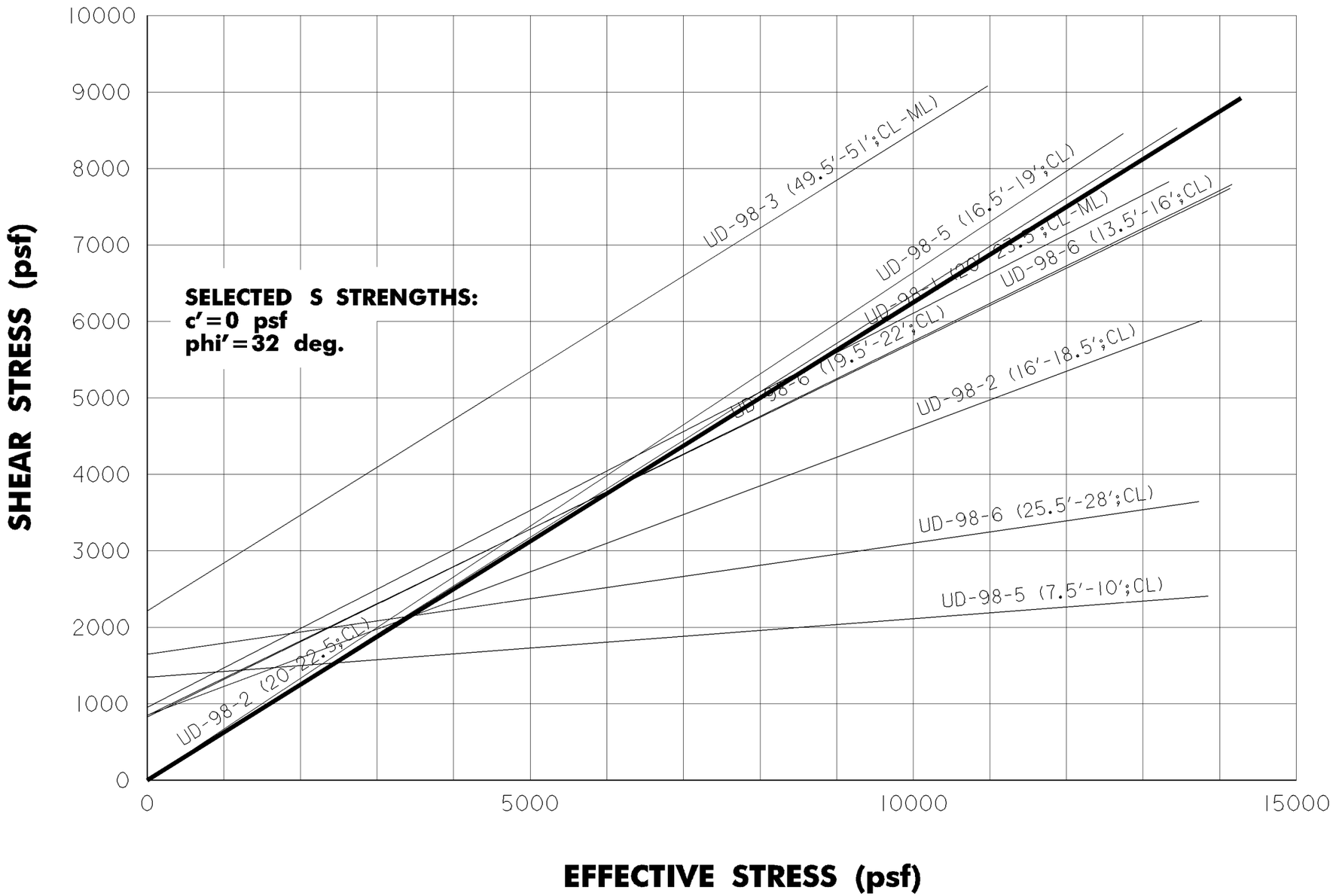
OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

TRIAXIAL TEST RESULTS

OCTOBER 1998

PLATE NO. 7–14

CONSOLIDATED–DRAINED (S STRENGTHS)

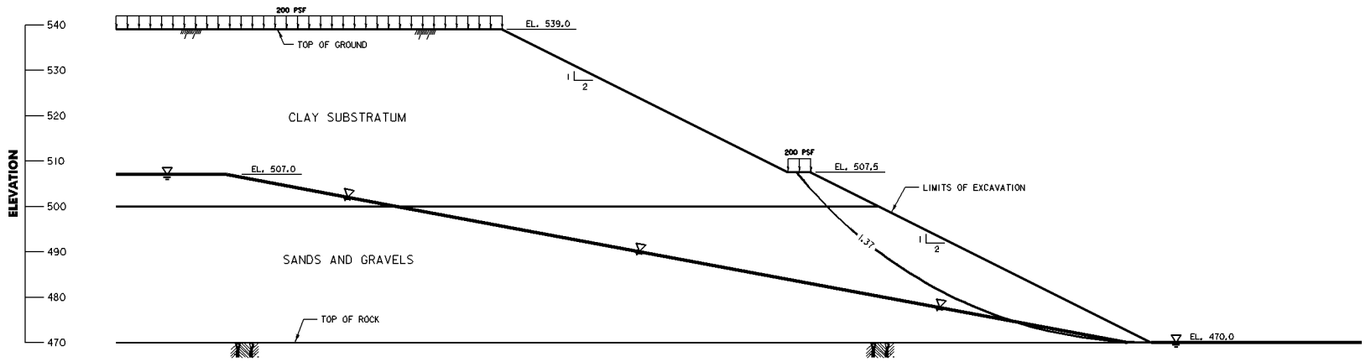


OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
LOCK EXTENSION FEASIBILITY REPORT

TRIAXIAL TEST RESULTS

OCTOBER 1998

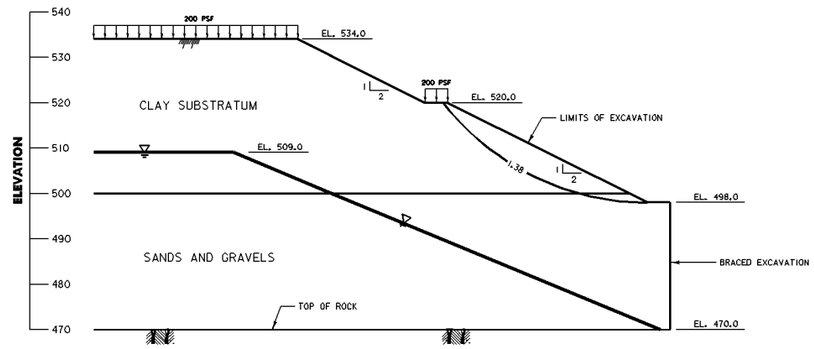
PLATE NO. 7–15



NOTES

1. COMPUTER ANALYSIS PERFORMED WITH UTEXAS3 PROGRAM USING SPENCER'S PROCEDURE.
2. GRAPHICAL ANALYSIS PERFORMED IN ACCORDANCE WITH EM-1110-2-1902 DATED 1 APRIL 1970.
3. STRENGTHS USED IN STEADY SEEPAGE ANALYSIS = (R+S)/2
4. TENSION CRACK DEPTH = 0 FT.
5. DEPTH OF WATER IN TENSION CRACK = 0 FT.
6. SIDE FORCE INCLINATION = -25.4 DEG.
7. CRITICAL FACTOR OF SAFETY = 1.37
8. REQUIRED FACTOR OF SAFETY = 1.5

SECTION 1



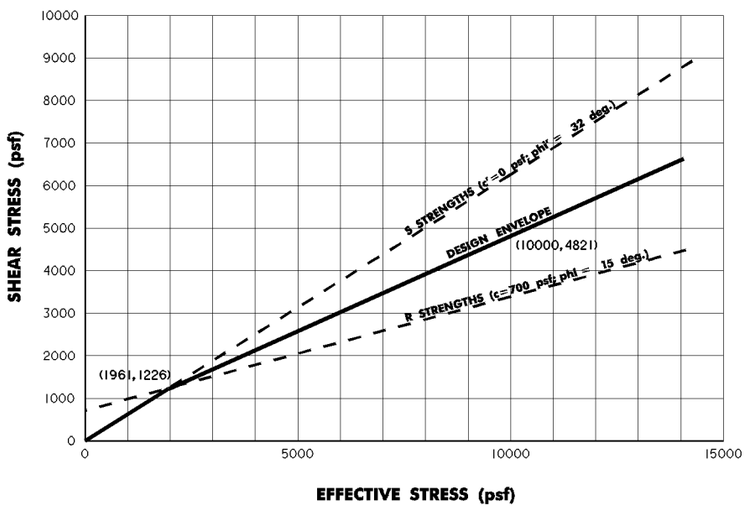
NOTES

1. COMPUTER ANALYSIS PERFORMED WITH UTEXAS3 PROGRAM USING SPENCER'S PROCEDURE.
2. GRAPHICAL ANALYSIS PERFORMED IN ACCORDANCE WITH EM-1110-2-1902 DATED 1 APRIL 1970.
3. STRENGTHS USED IN STEADY SEEPAGE ANALYSIS = (R+S)/2
4. TENSION CRACK DEPTH = 0 FT.
5. DEPTH OF WATER IN TENSION CRACK = 0 FT.
6. SIDE FORCE INCLINATION = -25.5 DEG.
7. CRITICAL FACTOR OF SAFETY = 1.38
8. REQUIRED FACTOR OF SAFETY = 1.5

SECTION 2

TYPICAL CULVERT EXCAVATION LIMITS

DESIGN ENVELOPE (R+S)/2



MATERIAL PROPERTIES

MATERIAL	S STRENGTHS		Q STRENGTHS		R STRENGTHS		UNIT WEIGHTS	
	c' (psf)	φ' (deg.)	c (psf)	φ (deg.)	c (psf)	φ (deg.)	Moist (pcf)	Saturated (pcf)
CLAY	0	32	1800	0	700	15	126	130
SANDS AND GRAVELS (including pervious fill)	0	32	0	32	0	32	120	126
FOUNDATION ROCK	0	50	0	50	0	50	165	165

NOTES

1. "SECTION 1" TAKEN FROM "SECTION B-B" ON PLATE 4-3.
2. "SECTION 2" TAKEN FROM "SECTION A-A" ON PLATE 4-2.

Revisions			
Symbol	Descriptions	Date	Approved

U.S.ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

US Army Corps of Engineers

OHIO RIVER MAIN STEM STUDY
GREENUP LOCKS & DAM
600' AUX. LOCK EXTENSION W/ ADDITIONAL FILL/EMPTY SYSTEM

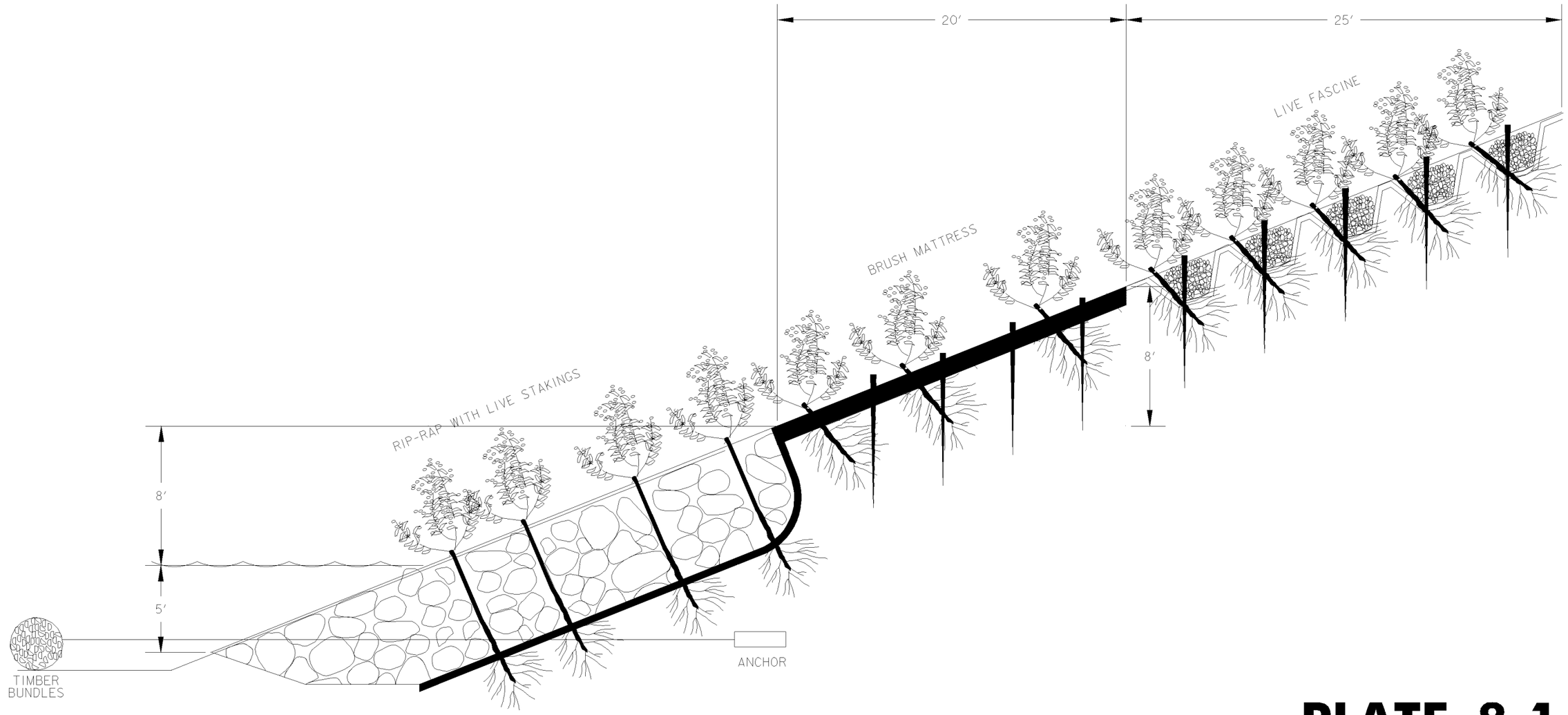
PRELIMINARY STABILITY ANALYSIS
STEADY SEEPAGE

Designed by: TLR
Drawn by: TLR
Checked by: AFW
Reviewed by:
Approved by:

Scale: NOT TO SCALE
Date: APRIL 1999
Drawing Code:
Sheet reference number:
FILENAME: Greenup L&D Project Directory 600 Ft. Lock Extension p:\edgs\stability.dgn
Sheet 1 of 1

26.4.8 Environmental Restoration

PLATE (8-1) RIVERBANK STABILIZATION PLAN
PLATE (8-2) STAKING IN RIPRAP DETAIL
PLATE (8-3) BRUSH MATRESS DETAIL
PLATE (8-4) LIVE FASCINE DETAIL
PLATE (8-5) T-DIKE DETAILS
PLATE (8-6) NOTCH DIKE DETAILS
PLATE (8-7) TAILWATER DIKE DETAILS



RIVERBANK STABILIZATION DETAIL

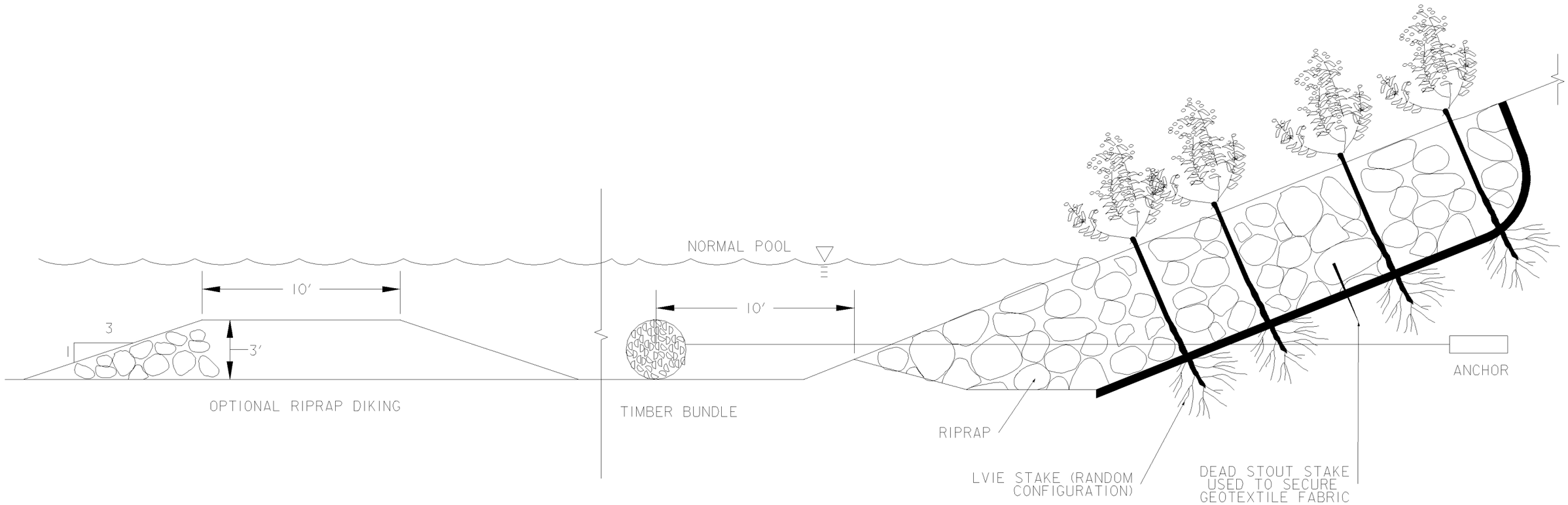
N.T.S.

PLATE 8–1

RIVERBANK STABILIZATION PLAN

8-1.dgn

BURGESS & NIPLE



TYPICAL STAKING IN RIPRAP

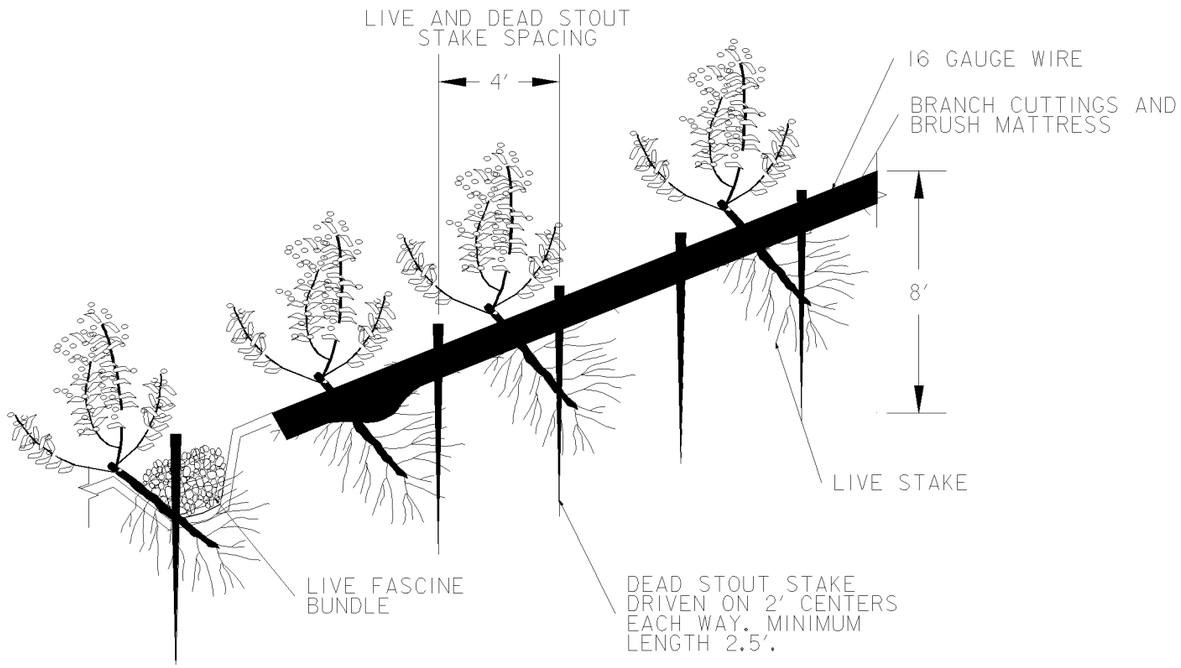
N.T.S.

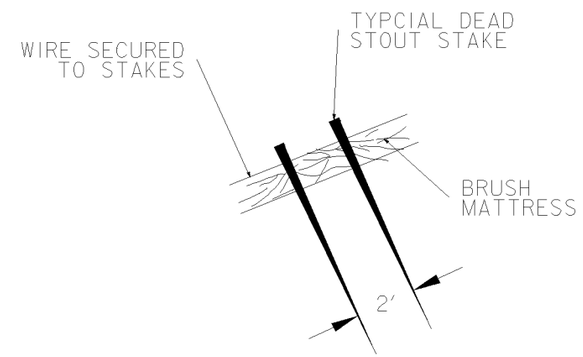
PLATE 8–2

STAKING IN RIPRAP DETAIL

8-2.DGN

BURGESS & NIPLE





TYPICAL BRUSH MATTRESS DETAIL

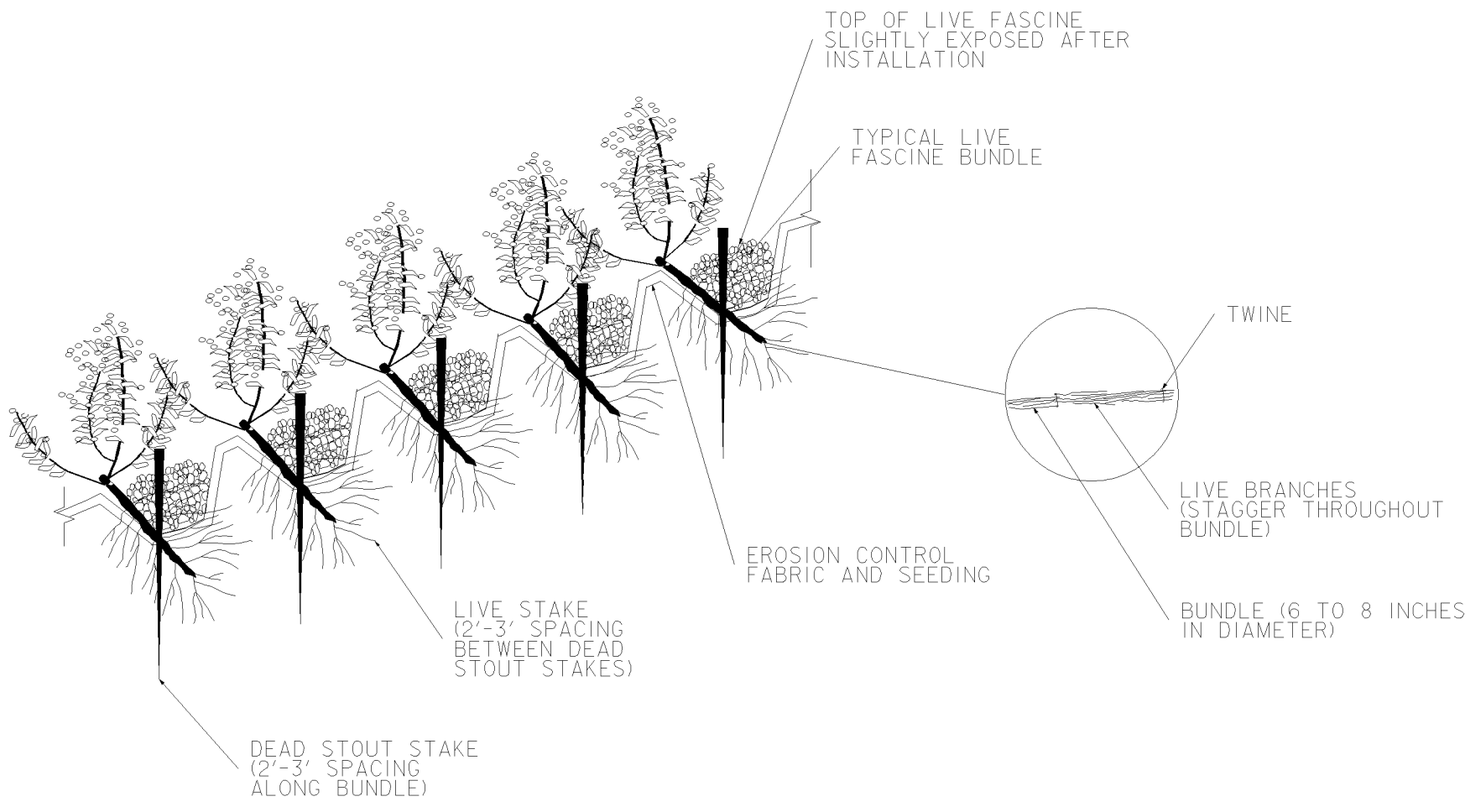
N.T.S.

PLATE 8–3

BRUSH MATTRESS DETAIL

8-3.DGN

BURGESS & NIPLE



TYPICAL LIVE FASCINE DETAIL

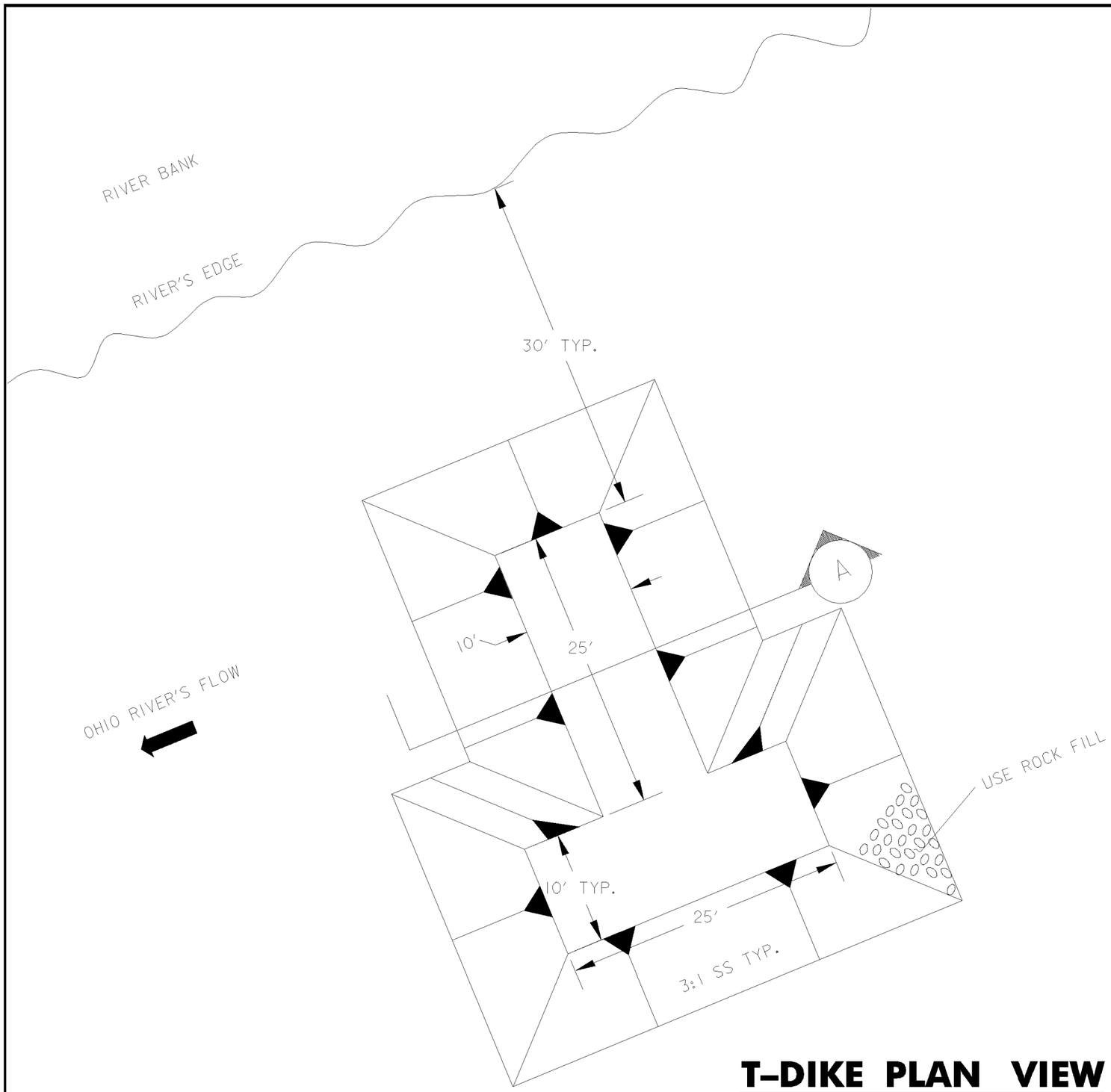
N.T.S.

PLATE 8–4

LIVE FASCINE DETAIL

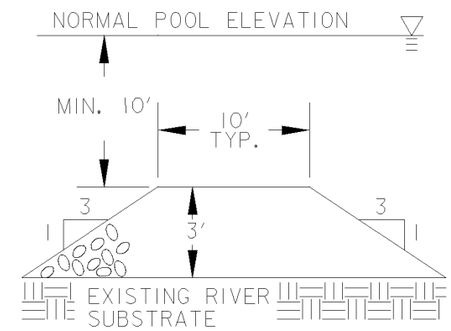
8-4.DGN

BURGESS & NIPLE



T-DIKE PLAN VIEW

N.T.S.



CROSS-SECTION A

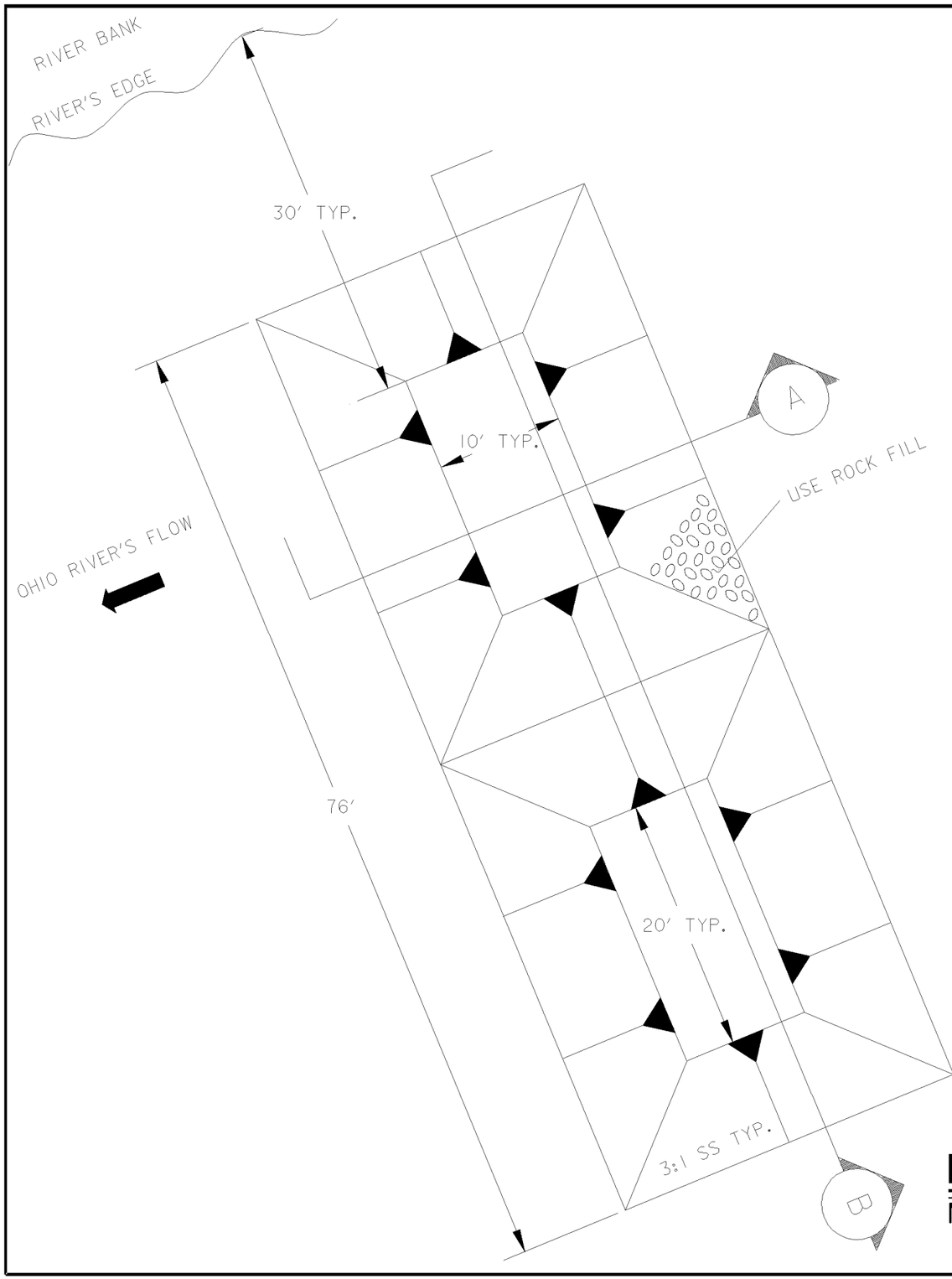
X-SCALE: 1" = 10'-0"
Y-SCALE: 1" = 5'-0"

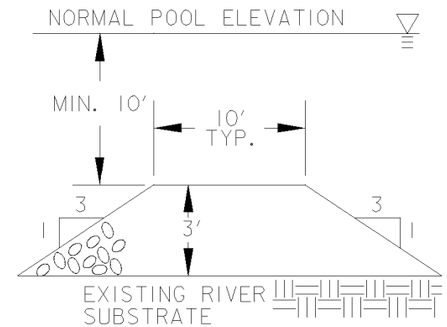
PLATE 8-5

T-DIKE DETAILS

8-5.DGN

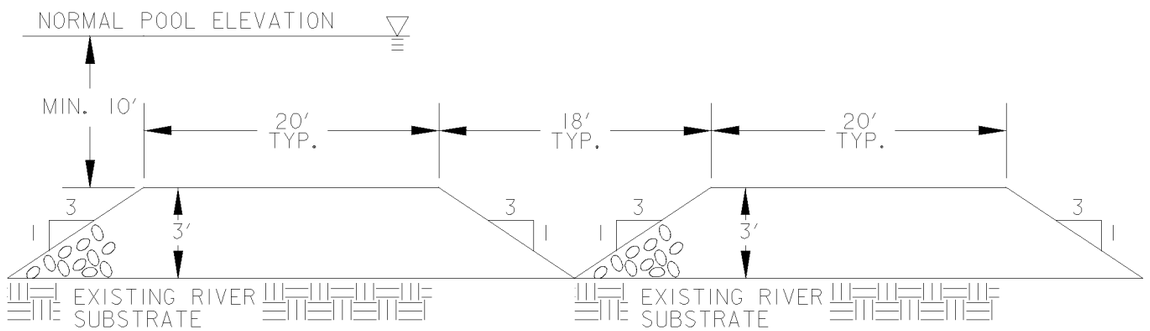
BURGESS & NIPLE





CROSS-SECTION A

X-SCALE: 1" = 10'-0"
Y-SCALE: 1" = 5'-0"



CROSS-SECTION B

X-SCALE: 1" = 10'-0"
Y-SCALE: 1" = 5'-0"

NOTCH DIKE PLAN VIEW

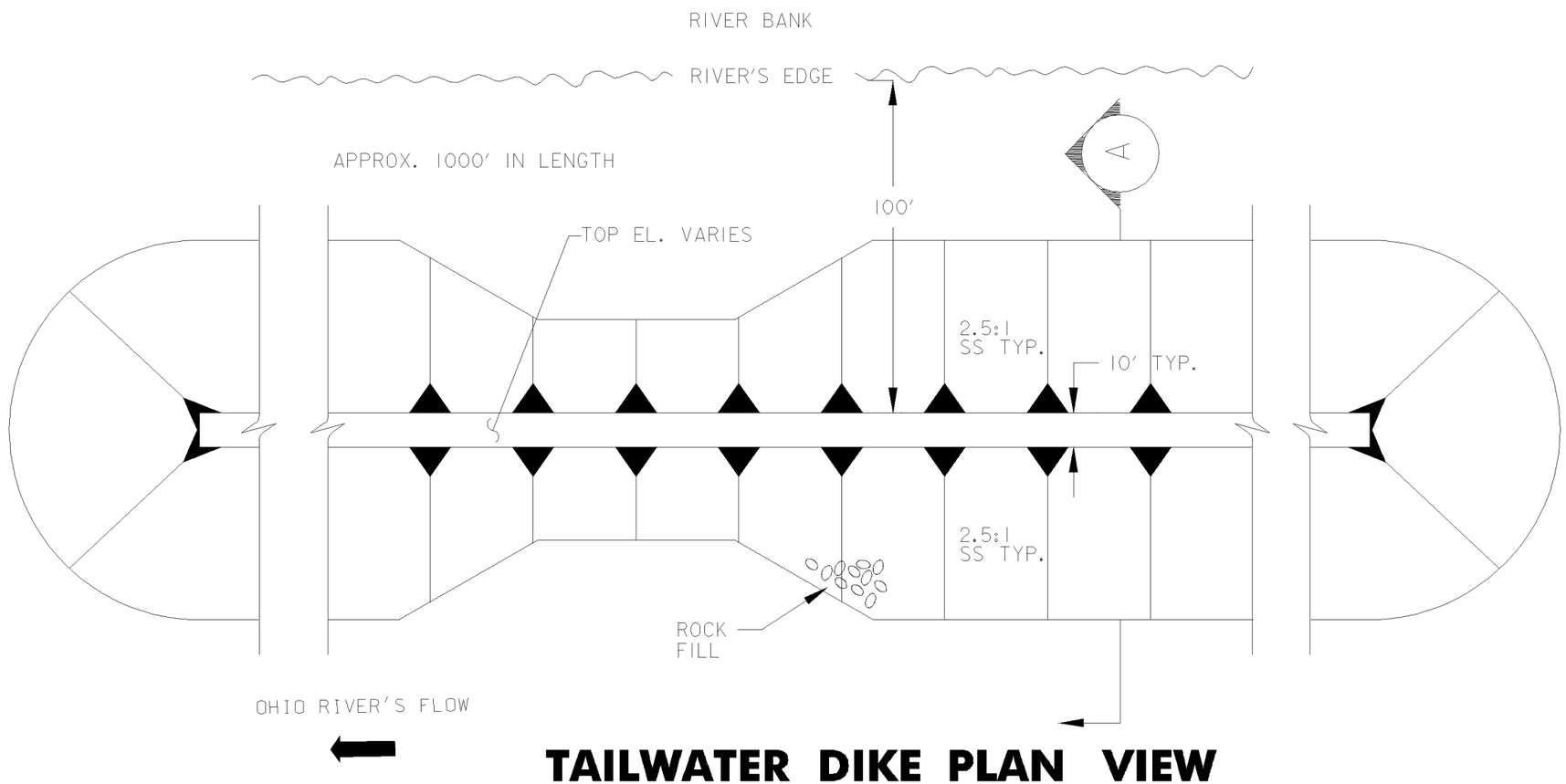
N.T.S.

PLATE 8-6

NOTCH DIKE DETAILS

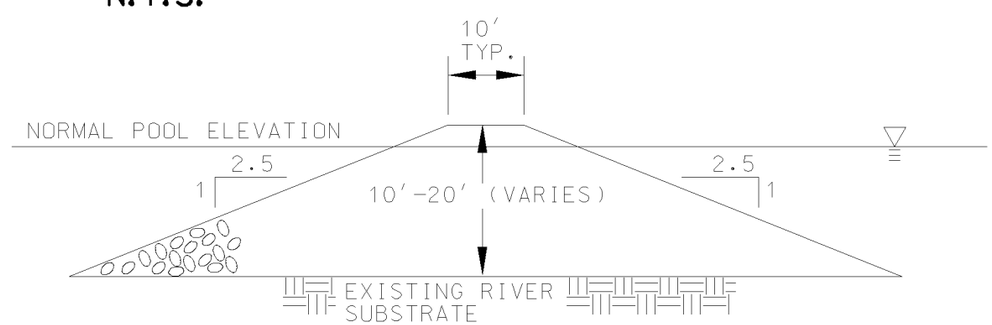
8-6.DGN

BURGESS & NIPLE



TAILWATER DIKE PLAN VIEW

N.T.S.



CROSS-SECTION

A

X-SCALE: 1" = 20'-0"
Y-SCALE: 1" = 10'-0"

PLATE 8-7

TAILWATER DIKE DETAILS

8-7.DGN

BURGESS & NIPLE