US Army Corps of Engineers®
Walla Walla District

McNary Dam Surface Passage Alternatives Development Workshop

Prepared by

U.S. Army Corps of Engineers
Walla Walla District

Pre-Workshop Draft - July 11, 2005

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1.0 Introduction

The Walla Walla District Corps of Engineers along with other Federal, State, and Tribal Fishery Management Agencies is initiating a process to develop surface passage alternatives with the goal of improving the survival of juvenile salmonids passing McNary Dam. This document contains current project configuration information, along with existing juvenile fish passage and survival data and hydraulic information. Included in Appendix A are several conceptual drawings of potential surface passage alternatives to consider at McNary Dam. These concept drawings have been included to facilitate further development of alternatives presented and creation of new alternatives.

2.0 Background

2.1 Project Data

A general layout of the dam, spillway and stilling basin are shown in Appendix A for reference. The following Tables 2.1 presents a summary of pertinent information about the McNary Project. Refer to Appendix B for information from the water control manual.

Table 2.1.— McNary Lock and Dam Project Data

Reservoir		**Dam**	
Maximum Elevation	356.5 msl	River Mile	292.0
Operating Range	335-340 msl	Overall Length	7,365 ft
Height (normal pool to tailwater)	75 ft	Powerhouse Length	1,422 ft
Spillway		Spillway Length	1,310 ft
Peak Design Discharge at 340	1,368 kcfs	Number Powerhouse Units	14
Normal Tailwater	265 msl	Number of Spillway Bays	22
Spillbay Clear Width	50 ft	**Fish Facilities**	
Spillbay Crest Elevation	291 msl	Fish Ladders	2
Spillbay Pier Width	10 ft	Fishway Entrances	3

2.2 Fish Passage Facility History

1981

- Completion of original screened juvenile fish bypass system.
    - 20' submerged traveling screens (STS's)
    - Vertical barrier screens (VBS's).
    - Juvenile fish facility (JFF) on north tailrace deck allowing transportation of juvenile salmonids. Pressure pipe system to JFF.

1994

- Completion of new JFF with open channel passage from collection channel to JFF.

1996

- Installed new VBS's along powerhouse.
- Installed extended-length submersible bar screens (ESBS's) in turbine units 1-6 to increase fish guidance efficiency (FGE).

- Raised intake gates to increase flow up bulkhead slots and increase FGE.
- Due to unexpected debris loads, delayed ESBS installation to evaluate how to handle debris with ESBS's installed.

1997

- Installed ESBS's in turbine units 7-14.

General Information

- Debris accumulation on the trashracks and in gatewells can impact fish condition periodically.
- Possible increased gatewell flow with proposed powerhouse modernization will increase the need for debris control on the trashracks and in gatewells.
- Evaluation of prototype traveling VBS to remove gatewell debris began in 2004.
- Evaluation of traveling VBS designed for higher unit discharge underway in 2005.

2.3 Current Project Operations

The National Marine Fisheries Service's 2000 Biological Opinion (NMFS 2000) calls for providing spill to the gas cap to facilitate the passage of juvenile salmonids from 1800 – 0600 hours daily, beginning in early-April and continuing through mid-June. Additional, involuntary spill beyond the NMFS BiOp mandated 12-hour gas cap spill typically occurs as river discharge exceeds powerhouse capacity (172 kcfs) during daytime hours. Total river discharge during the juvenile migration period at MCN ranges from 96-335 kcfs based on 1995-2004 10-year average data (Figure 2.1). Refer to the end of Appendix C for a summary hydrograph.

Juvenile fish bypass facilites begin operation April 1 and continue through September 30. Fish collected during the spring are bypassed back to the river either through the main bypass pipe and full flow PIT tag detection system or through the transportation facilities in order to collect fish for transport research, fish condition information, and to obtain PIT tag data.

The preferred operation when not collecting spring fish for research is full flow bypass to the river. Full flow bypass may be alternated with every other day bypass through the transportation facilities to allow sampling of fish under the Smolt Monitoring Program. Transportation operations at McNary Dam for subyearling chinook do not begin until inriver migratory conditions are no longer spring-like (usually not until around June 20). Spring-like conditions are defined as favorable flow and water temperatures (i.e., river flows are at or above the spring flow target of 220 to 260 kcfs), and ambient water temperatures are below 62°F. When transport operations begin, fish are collected and held for transportation with all fish collected being transported.

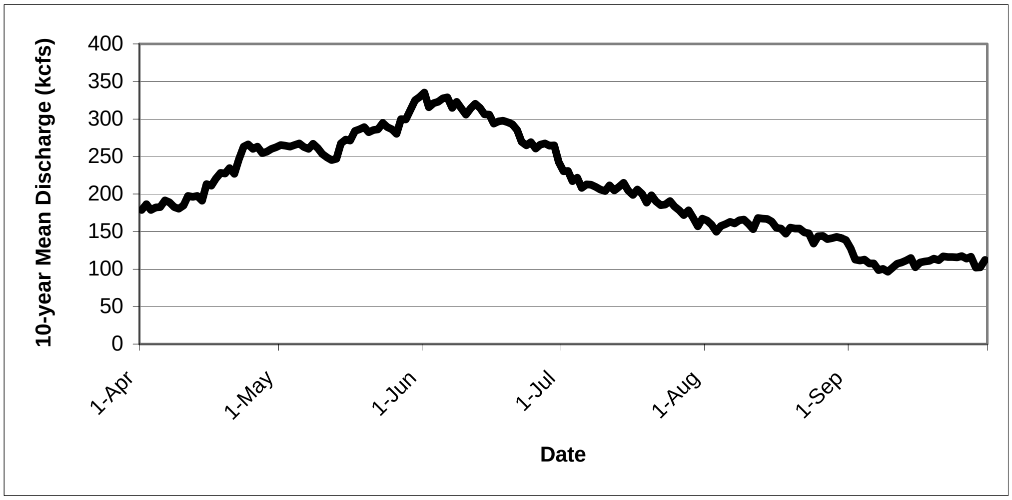


Figure 2.1.— April 1 - September 30 McNary Dam 10-year outflow average (1995-2004).

2.4 Powerhouse Modernization

The powerhouse at McNary Dam began operation in 1954. The 14 turbines, generators, and other power train equipment are 51 years old and reaching the end of their design life.

The USACE and BPA have formed a joint team to evaluate equipment refurbishment options. The team analyzed technical alternatives ranging from turbine refurbishment to replacement of related equipment. The results of the analysis resulted in recommendation to replace all 14 turbines with an increased diameter (280 to 290-inch), minimum-gap diagonal-flow runner. The alternative will result in an increase in the generating capacity, energy production, and hydraulic capacity of the powerhouse.

The recommendation includes biological testing of turbine models and a prototype turbine, as well as fish screens and associated equipment prior to commitment of all 14 units. The biological performance of the prototype turbine will determine the number of runners being replaced. It is currently under evaluation whether 10, 12, or all 14 of the runners will be replaced. Replacement of runners will be completed by 2013.

The following are a summary of key features of the Powerhouse Modenization Program:

- Biological testing of turbine models as well as full size prototype
- Prototype turbine scheduled for installation in 2008-2009
- 1 percent operating limit factored into analysis
- Turbine flows within 1% operating limits: 16.7 – 18.2 kcfs with screens (existing 8.2 to 12.4 kcfs)
- Increase the hydraulic capacity of the powerhouse from 172 to 255 kcfs
- 99 aMW increase in energy production
- Unit capacity increases from 84.7 MVA to 100 MVA each

2.5 Forebay Temperature Study

The USACE is currently investigating the impact of structural and operational changes on the temperature distribution within the fish passages and gatewells at McNary. The primary tool used in the present study is a 3D CFD modeling being performed by IIHR – Hydroscience & Engineering. The purpose is to have the capability of simulating the complex hydrodynamic and thermal conditions in the forebay and turbine intakes. The following is an excerpt from the March 2005 draft report by IIHR – Hydroscience & Engineering:

Several ecological problems are caused by the presence and operation of hydropower plants in a natural environment. High water temperatures due to atmospheric heating and selective withdrawal of water may be lethal or, at the very least, detrimental to fish in rivers and lakes. One such example is McNary Dam located on the Columbia River. During summer months when atmospheric heating is strong and calm wind conditions are present, high water temperatures in the forebay, gatewells, and juvenile fish collection channel are observed to be harmful to fish survival and health. It is speculated that water along the southern end (Oregon shore) of the forebay tends to warm more quickly and to a higher level than water elsewhere in the forebay. The shallow conditions upstream of the southern side of McNary Dam influence the approach flow and thermal conditions at the southern end of the powerhouse. These factors may contribute to warmer water being drawn into the gatewells at this end of the powerhouse (Generating Units 1 through 4). Juvenile salmonids that enter these gatewells may be subject to large changes in water temperature over small distances/times that may prove harmful or fatal to them. In addition to the immediate impact on fish condition and survival, there may be a long-term cumulative impact of reduced fish health, as the stresses that impact fish as they migrate are cumulative.

3.0 Investigation Process with Regional Influence

The following section presents the general approach for development of surface passage at the McNary project. Also included are sections that describe efforts that are attempting to determine how the development of surface passage at McNary relates to the system for safe downstream juvenile fish passage.

3.1 Historical General Approach

The primary goal for surface passage is to provide routes of passage that reduce forebay residence time and improve the survival of juvenile salmonids passing the project. Secondary goals are that they are easily operated, constructed, maintained, and don’t create deficiencies in the dams primary operations such as flood capacity of the spillway. The typical investigation process for attaining the primary goal is with a design team making decisions that are supported from regional agencies. The design team uses various methods to apply experience and judgment in the decision process. The various types of methods include:

- Develop the surface passage objectives (survival goals) and operational criteria.
- Apply available biological data from the project and other relative information.
- Consider lessons learned from prior prototype testing of similar projects.
- Analysis of hydraulic conditions using physical and analytical models.

- Apply validated, peer-reviewed version of the Numerical Fish Surrogate (NFS) model to compare forecasted relative passage efficiencies for alternatives.
- Evaluate the impacts of configurations to secondary goals of design, design schedule, constructability, and cost.

3.2 Region Surface Passage Team

Development of surface passage at McNary should recognize that the NWD Surface Passage Team is coordinating how surface passage at McNary fits into the scheme of the region. The formation of this team was from the strong regional interest and support for this technology that followed the recent success of certain Surface Passage Technology such as the Lower Granite Removable Spillway Weir and the Bonneville Corner Collector.

The NWD Surface Passage Team is a multi-discipline team made up of representatives from the Portland and Walla Walla Districts and the NWD Fish Office. The goal of the team is to develop a coordinated NWD strategy for planning and implementation of normative fish passage technology on the Corps projects on the Lower Snake and Columbia Rivers. A general overview of these projects and mid-Columbia River projects is summarized in a memorandum from NOAA fisheries that is included in Appendix E. The applicable definition of normative fish passage technology is technology that relies primarily on surface flow fish behavior. This includes such devices as: Removable Spillway Weirs, Behavioral Guidance Structures, Corner Collectors, Ice and Trash Sluiceways, Overflow Stoplogs, and Surface Bypass through Non-Overflow sections of dams. Though the emphasis of this effort is primarily on Surface Passage other technologies such as fish screens, spillways, juvenile bypass facilities, and turbine improvements will be considered during the evaluation and ranking process.

3.3 MSIA

Some of the parameters developed and used in the Major System Improvements Analysis Model (MSIA) may be helpful in development of requirements at McNary. MSIA was developed by the Walla Walla District USACE to assist in the evaluation of the potential survival benefits to migrating salmon and steelhead smolts from alternative structural and operational modifications to the 8 dams on the Snake and Lower Columbia Rivers.

The model can also be used to estimate costs and revenues. This model was an extension of, but differs from, other passage and survival spreadsheet models such as SIMPAS and Fish, Gas, Power Integrated Analysis (FGPIA) in that it incorporated optimization software to provide for simultaneous comparisons of thousands to millions of combinations of alternatives. Uncertainty and sensitivity analyses of individual alternatives are also possible. Separate versions of the model were created for yearling Chinook salmon, subyearling Chinook salmon, and juvenile steelhead to accommodate differences in input parameters. Detailed analyses are currently restricted to the four lower Snake River and McNary dams and only pool and dam survivals are currently used for the three lower Columbia River projects. The model structure is, however, set to accommodate detailed operational and survival information for these Lower Columbia projects. Refer to Appendix D for survival and passage metric estimates used in the MSIA model.

4.0 Biological Information

4.1 – Historical Fish Passage

Figure 4.1 illustrates a recent 5-year average historical passage timing of yearling chinook, juvenile steelhead, juvenile sockeye, and subyearling chinook salmon.

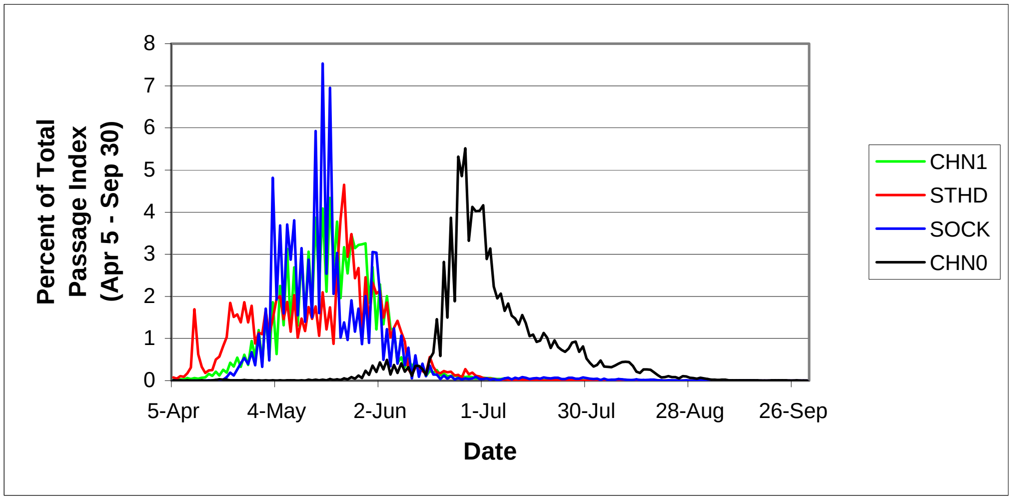


Figure 4.1.— McNary Dam 5-year average (2000-2004) juvenile fish passage index for yearling Chinook (CHN1), juvenile steelhead (STHD), juvenile sockeye (SOCK), and subyearling chinook salmon (CHN0).

4.2 – Juvenile Fish Passage Distribution

Juvenile fish passage metrics have been estimated for yearling chinook at MCN since 2002, and for juvenile steelhead and subyearling chinook in 2004 using radio telemetry techniques (Table 4.1). Estimates of fish passage efficiency (FPE) range from 85.0-96.0% for yearling chinook, 69.0% for juvenile steelhead, and 64.0% for subyearling chinook.

Table 4.1.— Passage metrics for juvenile salmonids at McNary Dam showing proportion of fish passing available routes.

Year	Species	Turbine	Bypass	SPE	FPE	FGE
2002[A]	Yearling Chinook	0.04	0.46	0.47	0.96	0.93
2003[B]	Yearling Chinook[D]	0.05	0.46	0.47	0.95	0.90
	Yearling Chinook[E]	0.04	0.45	0.49	0.96	0.91
2004[C]	Yearling Chinook	0.21	0.28	0.51	0.79	0.57
	Steelhead	0.06	0.21	0.72	0.94	0.77
	Subyearling Chinook	0.58	0.41	0.01	0.42	0.42

A – Axel et al. 2004a
B – Axel et al. 2004b
C – Perry et al. 2005
D – Snake River fish
E – Columbia River fish

The passage distribution of fish tagged with radio transmitters passing through individual routes was estimated in 2004 (Figures 4.2, 4.3, 4.4, 4.5). Figure 4.6 represents the proportion of total flow passing through each individual route (spillbay and turbine) to correspond to passage through each of these routes during the spring and summer study periods.

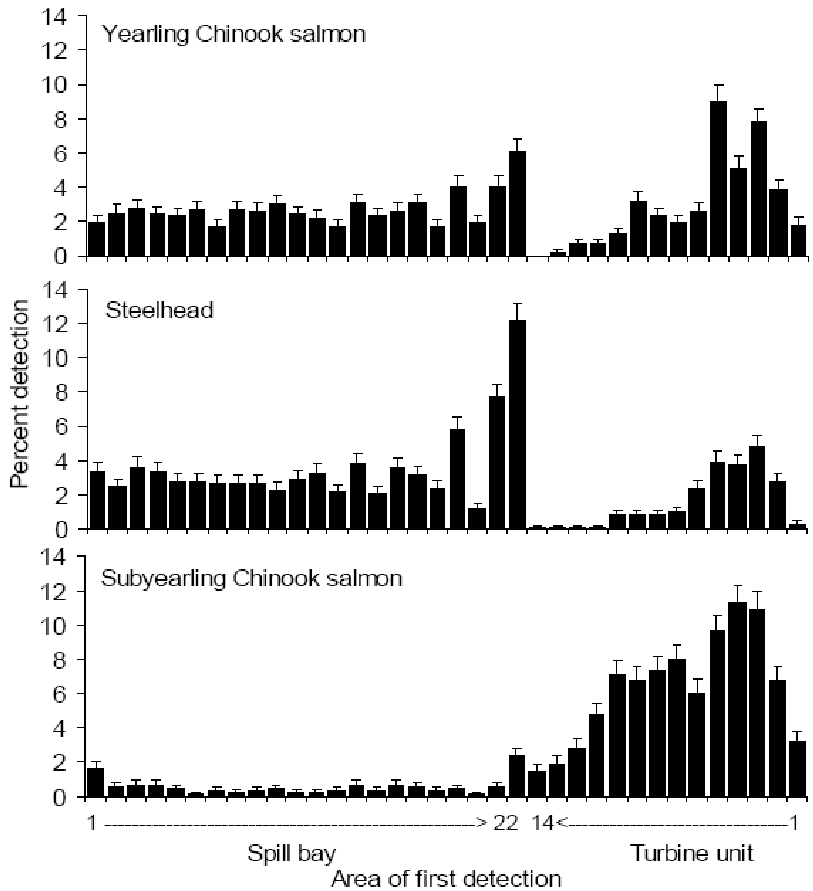


Figure 4.2.— Location of first detection on underwater antennas for yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon by spill bay and turbine unit at McNary Dam in 2004 from Perry et al. 2005. Standard errors represent the standard error of a proportion.

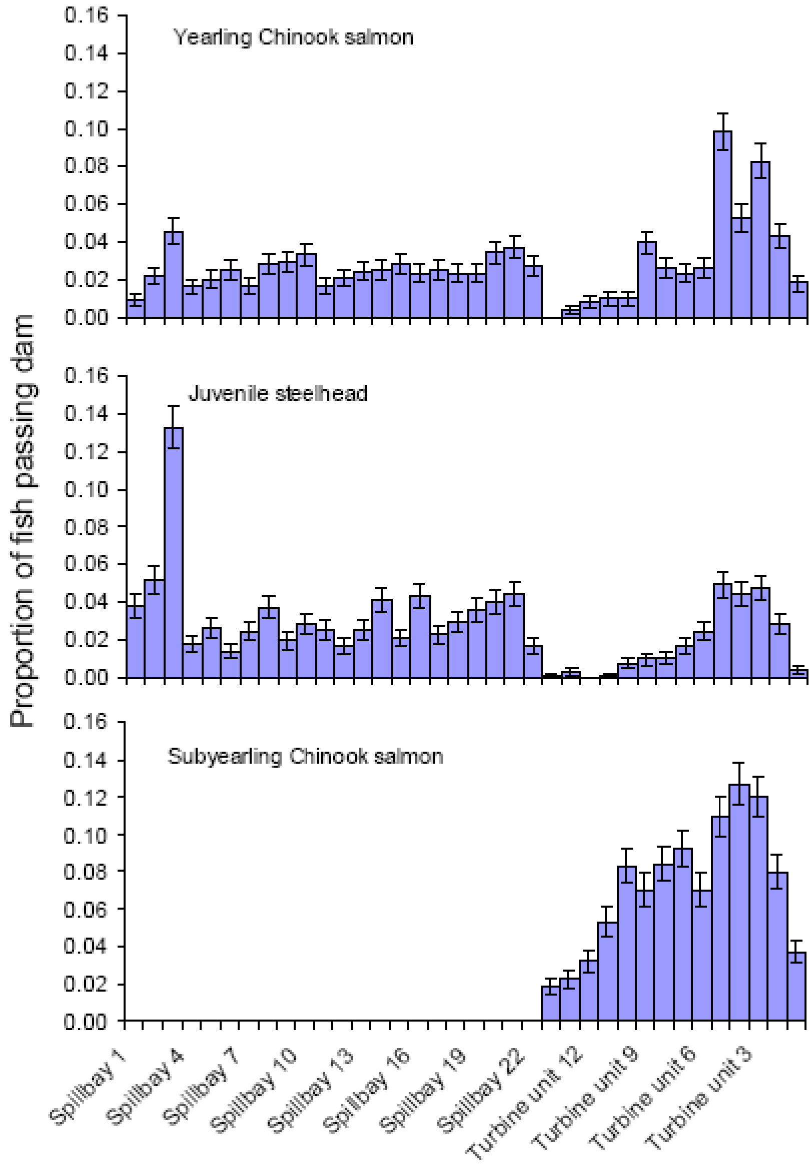


Figure 4.3.— Juvenile fish passage distribution for specific spillbays and turbine units at McNary Dam from Perry et al. 2005. Error bars represent the standard error of a proportion.

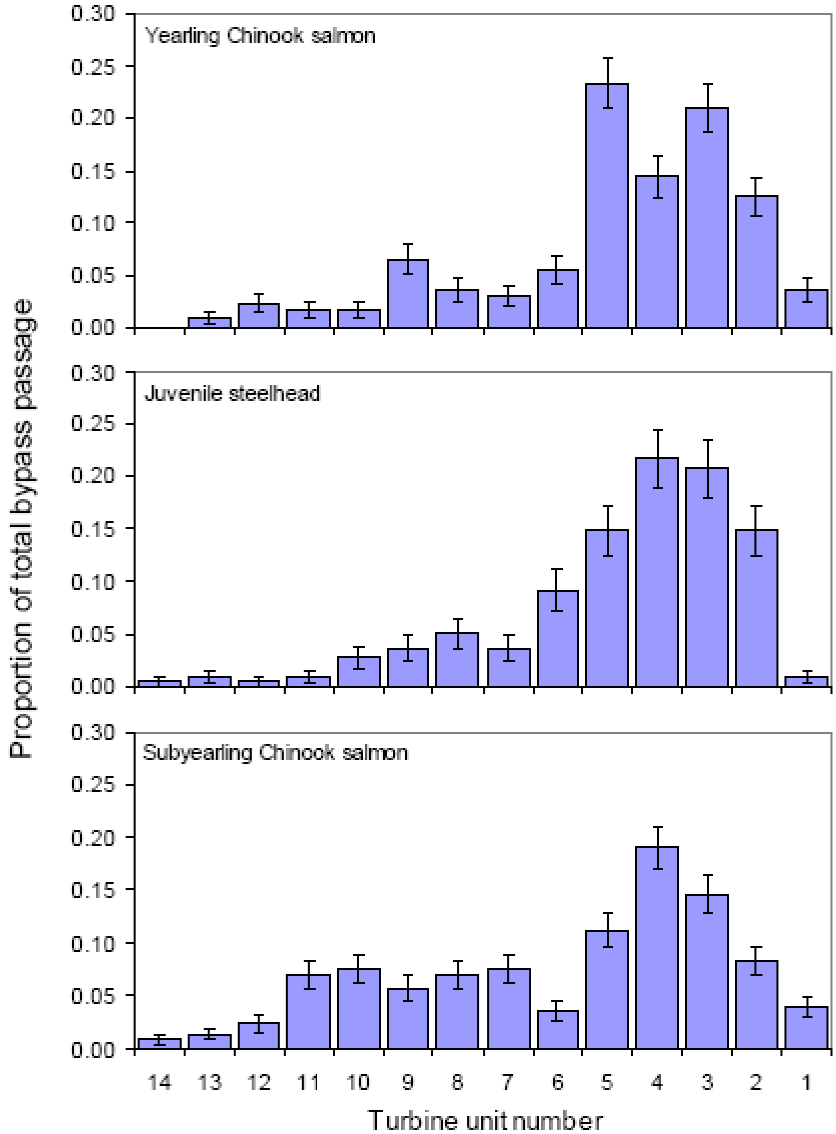


Figure 4.4.— Bypass passage distribution across specific turbine units for juvenile salmonids at McNary Dam from Perry et al. 2005. Error bars represent the standard error of a proportion.

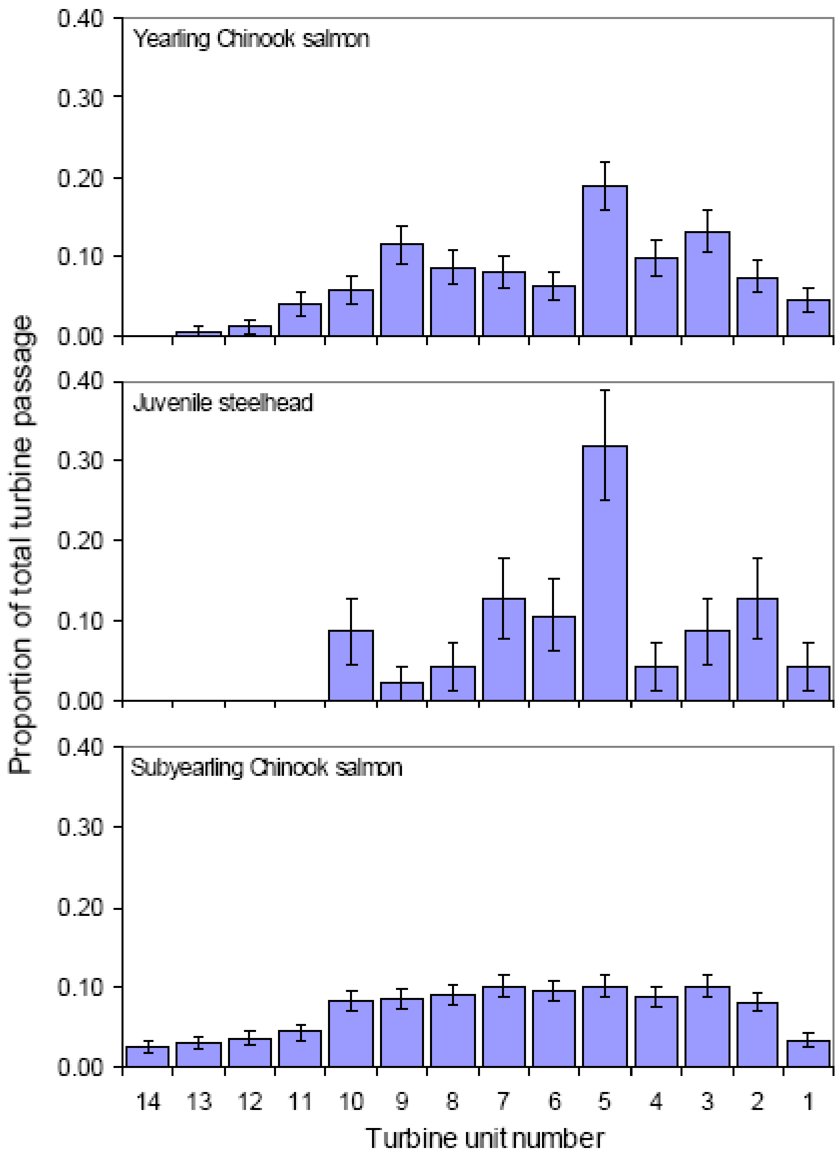


Figure 4.5.— Turbine passage distribution across specific turbine units for juvenile salmonids at McNary Dam from Perry et al. 2005. Error bars represent the standard error of a proportion.

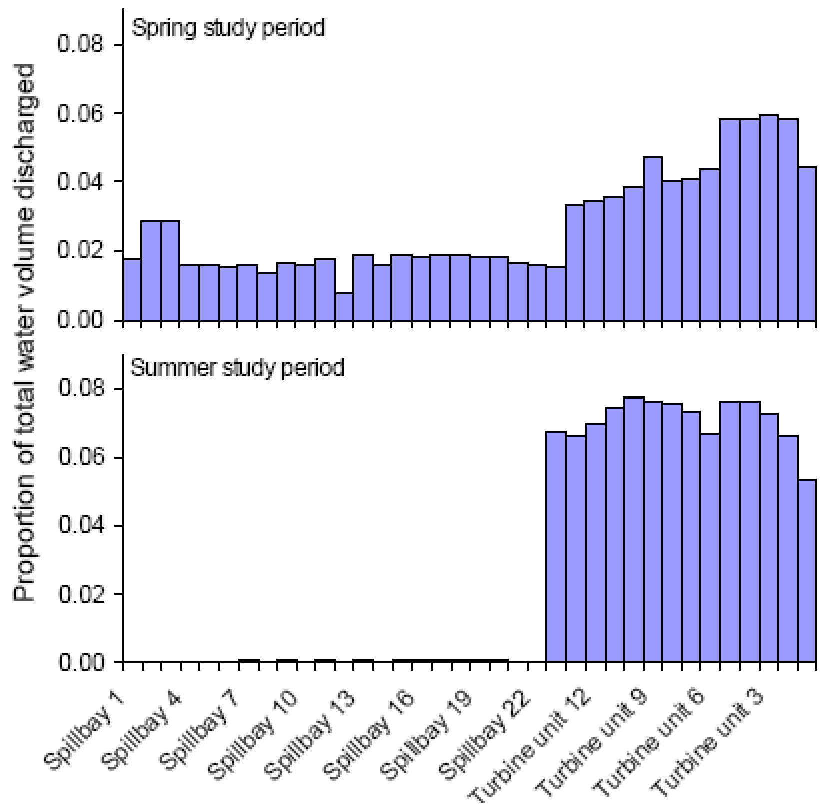


Figure 4.6.— Distribution of percent of total water volume discharged through specific spillbays and turbine units at McNary Dam from Perry et al. 2005.

4.3 – Juvenile Fish Survival

Table 4.2.— Estimates of juvenile fish survival (95% CI).

Year	Species	Spill S	Bypass S	Turbine S	Dam S
2002[A]	Yearling Chinook	0.98 (0.95-1.00)	0.93 (0.89-0.97)	-	0.88 (0.85-0.91)[D]
2003[B]	Yearling Chinook	0.93 (0.87-0.89)	0.87 (0.80-0.93)	-	0.89 (0.85-0.94)[D]
2004[C]	Yearling Chinook	0.97 (0.94-1.00)	0.90 (0.85-0.95)	0.68 (0.61-0.74)	0.88 (0.85-0.91)[E]
2004[C]	Steelhead	1.00 (0.97-1.02)	0.98 (0.92-1.02)	0.70 (0.59-0.85)	0.97 (0.94-1.00) [E]
2004[C]	Subyearling Chinook	0.28 (0.08-0.60)	0.85 (0.80-0.90)	0.73 (0.69-0.78)	0.78 (0.73-0.81) [E]

A – Axel et al. 2004a
B – Axel et al. 2004b
C – Perry et al. 2005
D – Dam includes forebay boat restricted zone downstream to Irrion, OR
E – Dam includes upstream face of dam to tailrace reference group release site at downstream tip of navigation lock wall

5.0 Hydraulic Information

Physical and analytical hydraulic models are being developed for analysis of hydraulic conditions at McNary Dam. There is current hydraulic information that has been developed for other purposes. Portions of this information are shown in Appendix C, Hydraulic Information. The following sections describe the current status of the different models and the specific study objectives.

5.1 1:55 Scale General Model

A 1:55 scale physical general model of the project is located at ERDC. The model reproduces the bathymetry for a distance of approximately 1900 feet upstream and 4200 feet downstream. A model assessment of the tailrace flow conditions is in the process of being completed. The model is under construction to extend the forebay an additional 3000 feet, make flume repairs, model improvements, and calibration of the forebay flow field. The general model is scheduled to be ready to support the decision and design process by late October. The following are the primary objectives planned for the modeling effort:

- Qualitatively assessment of the approach flow to the surface passage entrance to assist in location decision.
- Observe potential tailrace egress differences between alternatives using injected dye to visualize the flow field.
- The model will also be used to assess tailwater differences between the general and sectional model so that the sectional model tailrace levels can be set appropriately.

5.2 1:25 Sectional Model

The scope of work for a 1:25 physical model is being developed and negotiated. The current plan is for a three spillway bays, non-overflow, and an adjacent powerhouse unit. The following are the primary objectives of the modeling effort:

- Develop a design for surface passage that will perform satisfactorily for the design condition of free-overflow for fish passage. Consideration is given to the flow profile and the transition of the profile to the existing spillway ogee or into the tailrace.
- Document the hydrodynamic loadings for use in structural design.
- Assess shapes and configurations to provide improvement in the overall system hydraulics with particular emphasis on the reduction of the standing waves, sudden transitions, and other hydraulic conditions on the downstream portion of the chute and ogee that maybe or perceived to be harmful to fish.

5.3 CFD Forebay Model

A CFD model of the project forebay has been developed by IIHR – Hydroscience & Engineering in support of the temperature study. The CFD model is based upon the FLUENT code. The following are the primary objectives of the modeling effort:

- Utilize the information to calibrate the forebay of the general model at ERDC.

- Investigate the approach flow to the surface passage entrance and to assess the relative zones of influence and approach flow velocity and acceleration fields.
- Couple it with the updated NFS model to assess different alternatives.

5.4 Numerical Fish Surrogate Model

The Numerical Fish Surrogate (NFS) model is a 3-D space-time analysis and simulation decision-support tool (integrating both hydraulic and biological data) that has been developed by John Nestler and Andrew Goodwin at the Corps' Engineering Research and Development Center (ERDC) in Vicksburg, MS. The goal of the NFS, as it relates to improving downstream migration of juvenile salmonids (based on different hypotheses of fish movement behavior), is to provide insights on the effectiveness of various proposed project operations and fish passage structures. The model, which has been used to varying degrees at other projects in the region, is undergoing a model sensitivity and performance validation phase for the Walla Walla District. At the completion of this effort, and with additional regional coordination and input, it is possible that the NFS could be used as part of the surface bypass development effort for McNary.

6.0 Fisheries and Hydraulic Design Guidelines

The development of preliminary fisheries and hydraulic design guidelines will be helpful when evaluating alternatives. Guidelines usually consist of allowable velocities, velocity gradients, depths of flow, flow boundaries, and other factors intended to provide protection for fish passing through a hydraulic structure. The Tables 5.1 and 5.2 list potential fisheries and hydraulic guidelines that have been used on surface passage projects in the region. General project guidelines are also presented in Table 5.3. Some of these will be applicable in developing alternatives of the surface passage at McNary Dam. However, the explicit guidelines for McNary will be developed during the process dependent. They will be based on regional influence and site-specific physical and environmental conditions.

Table 5.1.— Forebay guidelines for surface passage.

Guideline	Title	Description
1	River Flow	Anticipated river flows for operation.
2	Forebay WSEL	The operating range and the normal pool (see Appendix C).
3	Acceleration Field Near the Entrance	No decelerations approaching entrance. Velocity Gradients (NMFS-0.1 fps/ft, Conte Anadromous Fish Research Center-1 fps/ft)
4	Entrance Conditions	Avoid flow instabilities, flow upwelling, shock wave development, flow separation
5	Velocity	Develop Trapping Velocity (Bell, 7 fps for juvenile salmon or steelhead trout)
6	Maintain forebay features	Some projects have hydraulic features that concentrate fish such as eddies, flow concentration in thalweg, etc.
7	Attraction Flow	Lower Granite RSW – 7,000 cfs 1' above MOP Ice Harbor RSW – 7,000 cfs 1' above MOP The Dalles Ice Trash Sluiceway – 4,500 cfs Bonneville B1 Surface Collector – 9,000 cfs Bonneville B2 Corner Collector – 8,500 cfs Wanapum Future Unit Fish Bypass – up to 20,000 cfs Rocky Reach Surface Collector – 6,000 cfs
8	Bypass Flow	Applicable to a dewatering facility
9	Entrance Depth	Depth of 30-50 feet of the water column takes advantage of the typical surface-oriented skew in the vertical distribution.
10	Horizontal Location	Preferred for where project geometry and approach flow patterns concentrate the juveniles.
11	Entrance Width	

Table 5.2.— Tailrace guidelines for surface passage.

Guideline	Title	Description
1	River Flow	Anticipated river flows for operation and structure survivability.
2	Tailwater WSEL	Operating range (see Hydraulic Appendix).
3	Chute Flow	Uniform Depth Minimize shockwave and flow disturbance Avoid areas of low pressures that could cause cavitation or flow separation
4	Stilling Basin Discharge	Avoid skimming with undular or elevated jump (USACE) Avoid unstable and plunging flow with skimming or ramped surface jets (Wanapum)
5	Tailrace Egress	Avoid stilling basin entrainment and shoreline exposure.
6	Powerhouse Entrainment	TDG level increase by the mixing of powerhouse flow with spill. It also potentially draws fish from the powerhouse into the stilling basin where there is a greater exposure to predators and turbulence
7	Juvenile Outfall Impacts	Not to reduce downstream river velocities at juvenile outfall for the fish facility
8	Adult Migration Conditions	Maintain desirable hydraulic conditions at adult fish entrances.
9	Impact Velocity	NMFS criteria of 25 fps

Table 5.3.— General project guidelines.

Guideline	Title	Description
1	Survivability	Anticipated river flows for structure to not suffer damage.
2	Design Life	
3	Collection	Having the ability to collect fish for transport and M&I.
4	Operation Period	Duration for operation (include summer)
5	Project Costs	Regional budgets
6	O&M Costs	

6.0 References

Axel, G.A., M.B. Eppard, E.E. Hockersmith, and B.P. Sanford. 2004a. Migrational behavior and survival of radio-tagged hatchery yearling Chinook salmon at McNary Dam, 2002. Final Report of Research by the National Marine Fisheries Service to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV92844886, Walla Walla, Washington.

Axel, G.A., M.B. Eppard, E.E. Hockersmith, and B.P. Sanford. 2004b. Migrational behavior and survival of radio-tagged hatchery yearling Chinook salmon at McNary Dam, 2003. Final Report of Research by the National Marine Fisheries Service to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV92844886, Walla Walla, Washington.

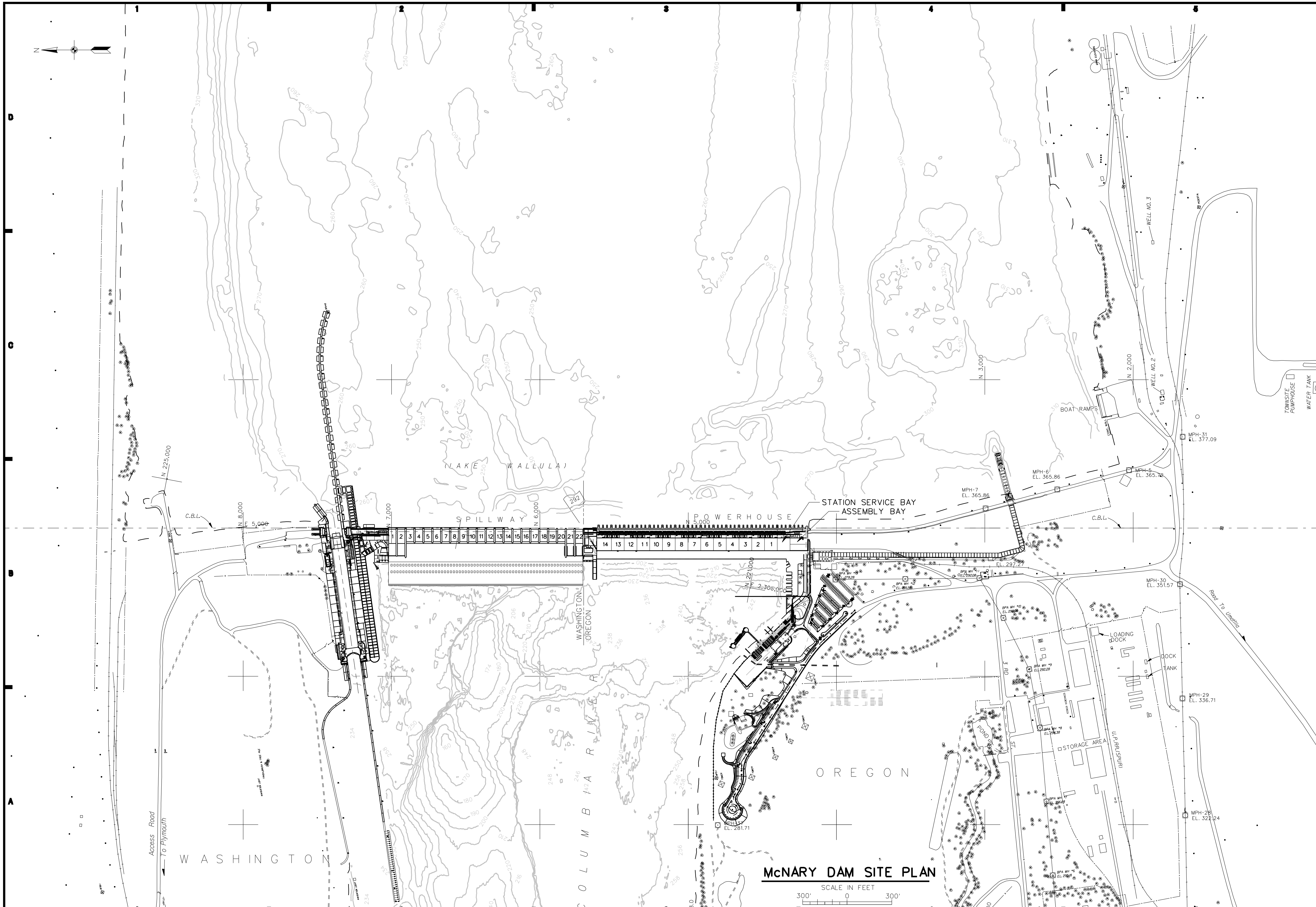
NMFS (National Marine Fisheries Service). 2000. Biological Opinion, Endangered Species Act - Section 7 Consultation. Reinitiation of consultation on operation of the Federal Columbia River Power System, including juvenile fish transportation program and 19 Bureau of Reclamation Projects in the Columbia Basin.

Perry, R. W., A. C. Braatz, S. D. Fielding, J. N. Lucchesi, J. M. Plumb, N. S. Adams, and D. W. Rondorf. 2004. Survival and migration behavior of juvenile salmonids at McNary Dam, 2004. Draft Report of Research by the U. S. Geological Survey to the U.S. Army Corps of Engineers, Walla Walla District, Contract OTS-W-04-1, Walla Walla, Washington.

Appendices

Appendix A

Conceptual Drawings



US Army Corps of Engineers
Walla Walla District

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CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

McNARY DAM
REMOVABLE SPILLWAY WEIR (RSW)

McNARY DAM
GENERAL PLAN

Figure number:
MN-1

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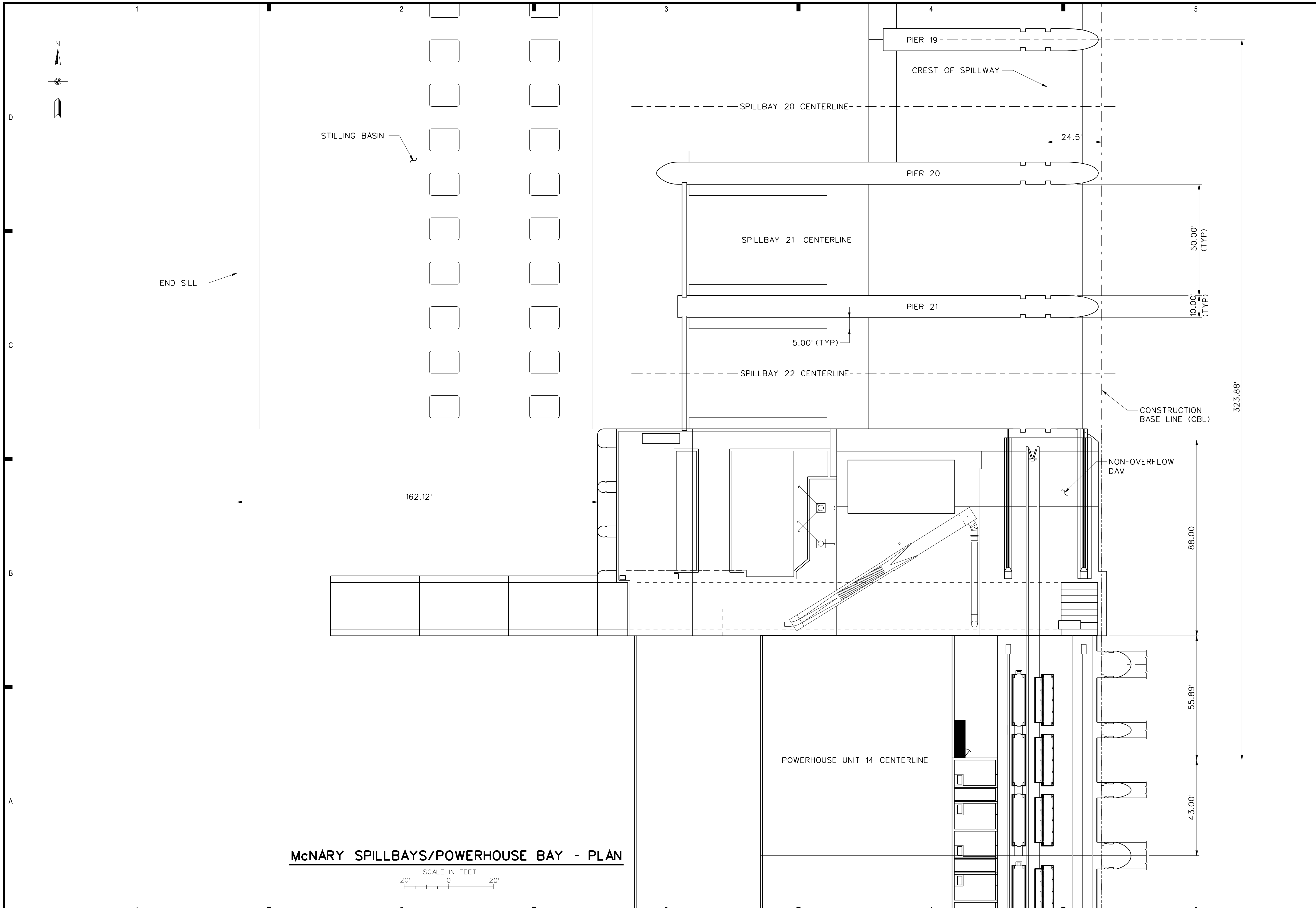

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Walla Walla District

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CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

McNARY DAM
REMOVABLE SPILLWAY WEIR (RSW)

McNARY DAM
SPILLBAY/POWERHOUSE

Figure number:
MN-2

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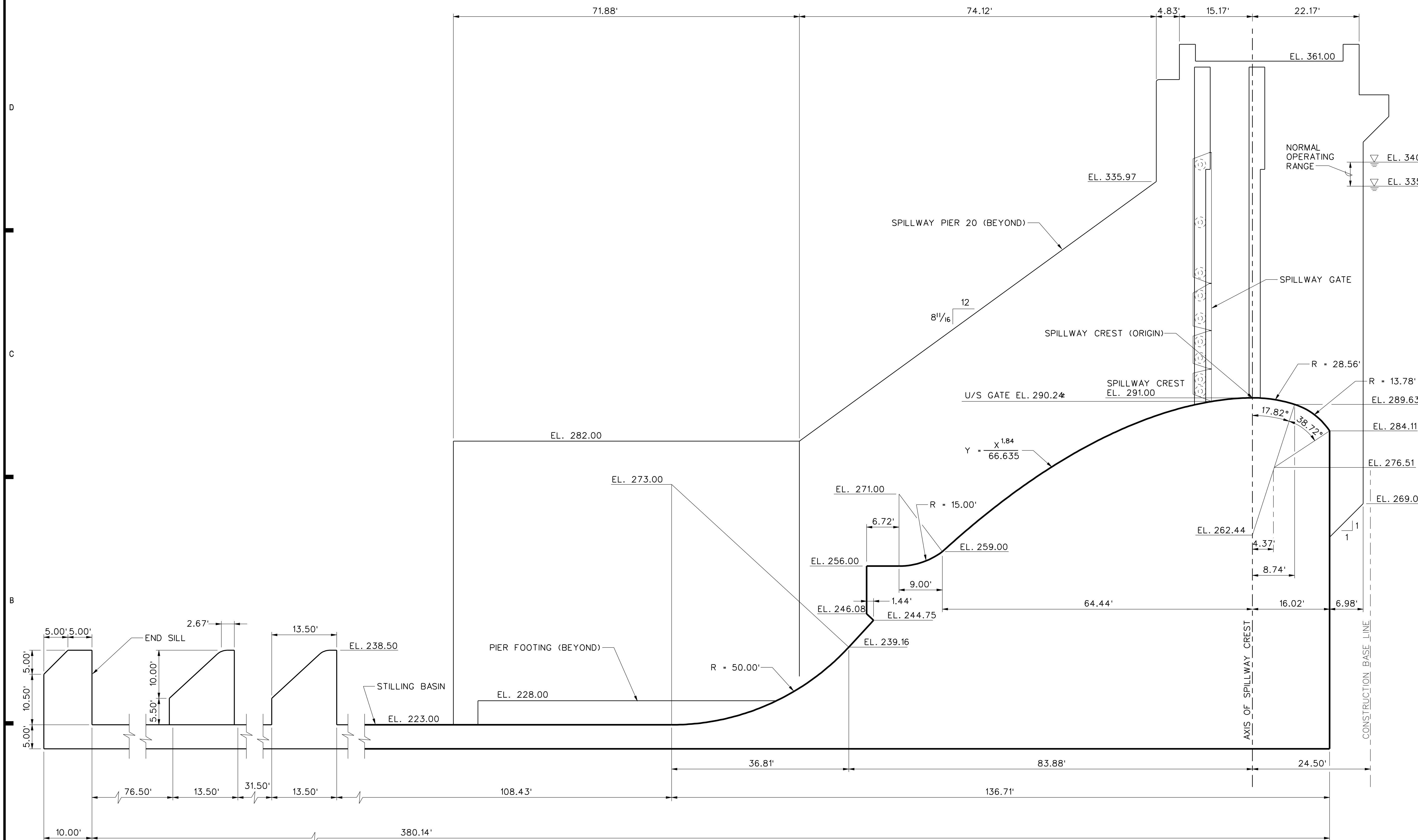

McNARY SPILLWAY BAY 21 - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

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Walla Walla District

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McNARY DAM
REMOVABLE SPILLWAY WEIR (RSW)

McNARY DAM
EXISTING SPILLWAY
TRANSVERSE SECTION

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MN-3

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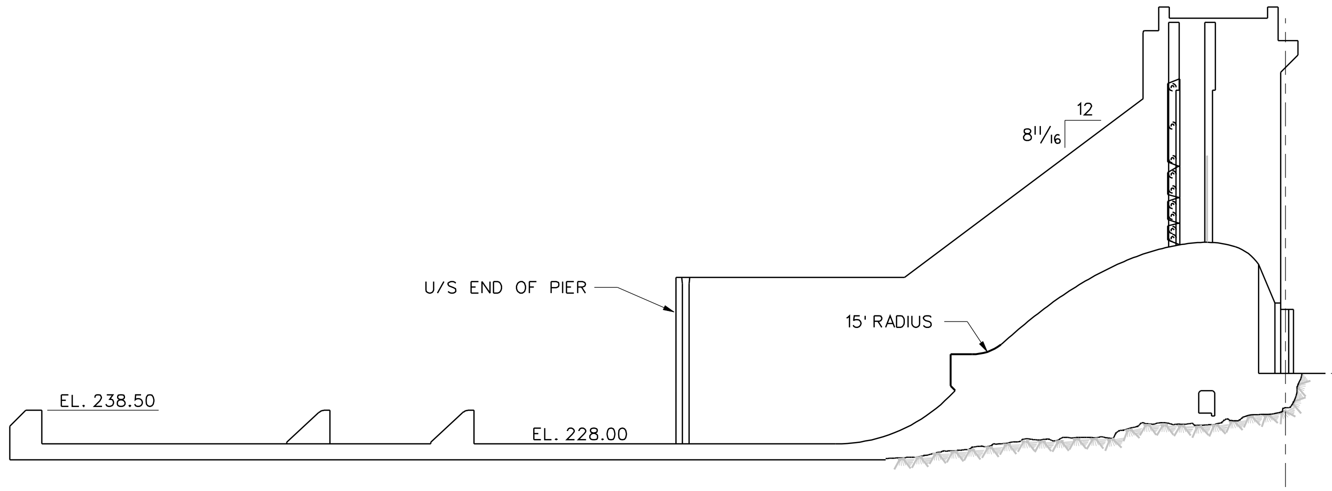
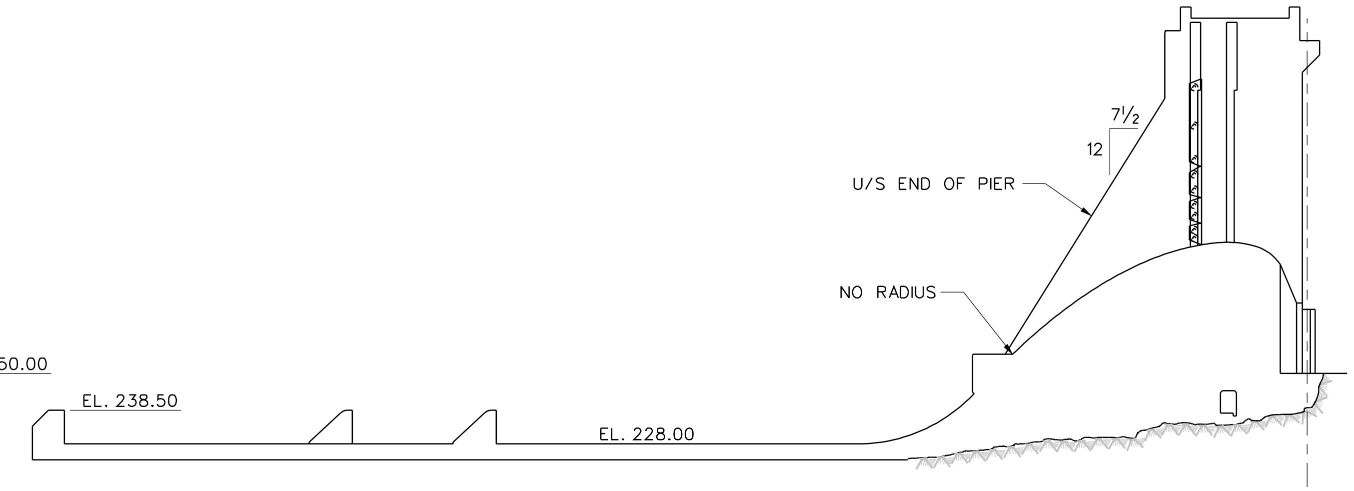


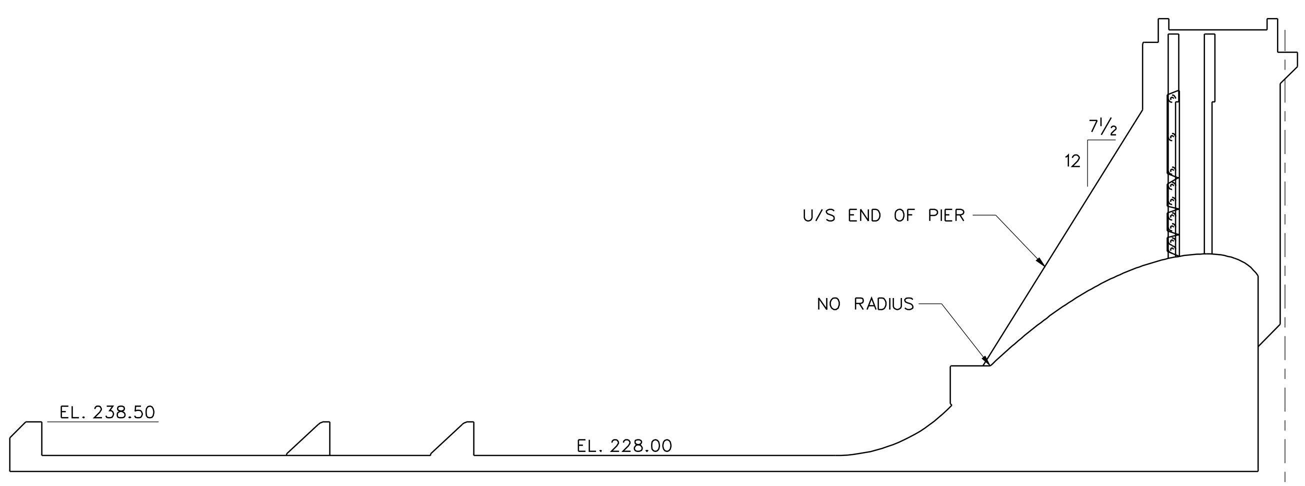
McNARY SPILLWAY BAYS 1 THRU 2 SECTION

SCALE IN FEET
30' 0 30'



McNARY SPILLWAY BAYS 3 THRU 13 SECTION

SCALE IN FEET
30' 0 30'



McNARY SPILLWAY BAYS 14 THRU 19 SECTION

SCALE IN FEET
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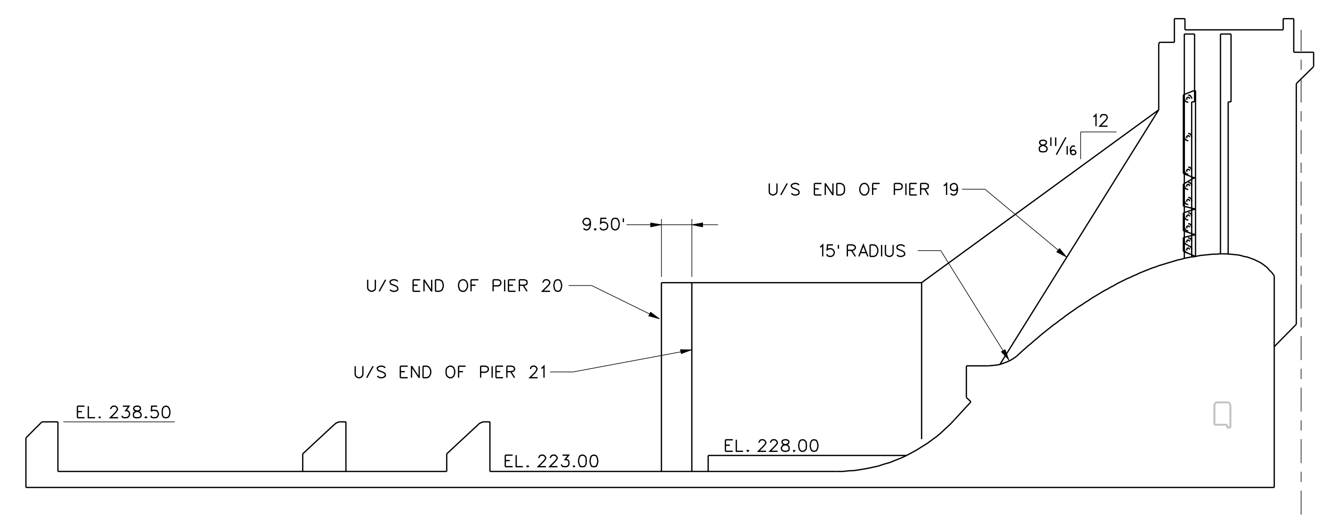


McNARY SPILLWAY BAYS 20 THRU 22 SECTION

SCALE IN FEET
30' 0 30'

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: K. HANSEN
DRAWN BY: JAH
CHECKED BY:
FILE NO.: FN
DATE:
INV. NO. XX-B-XX
CONTRACT NO. ---------

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

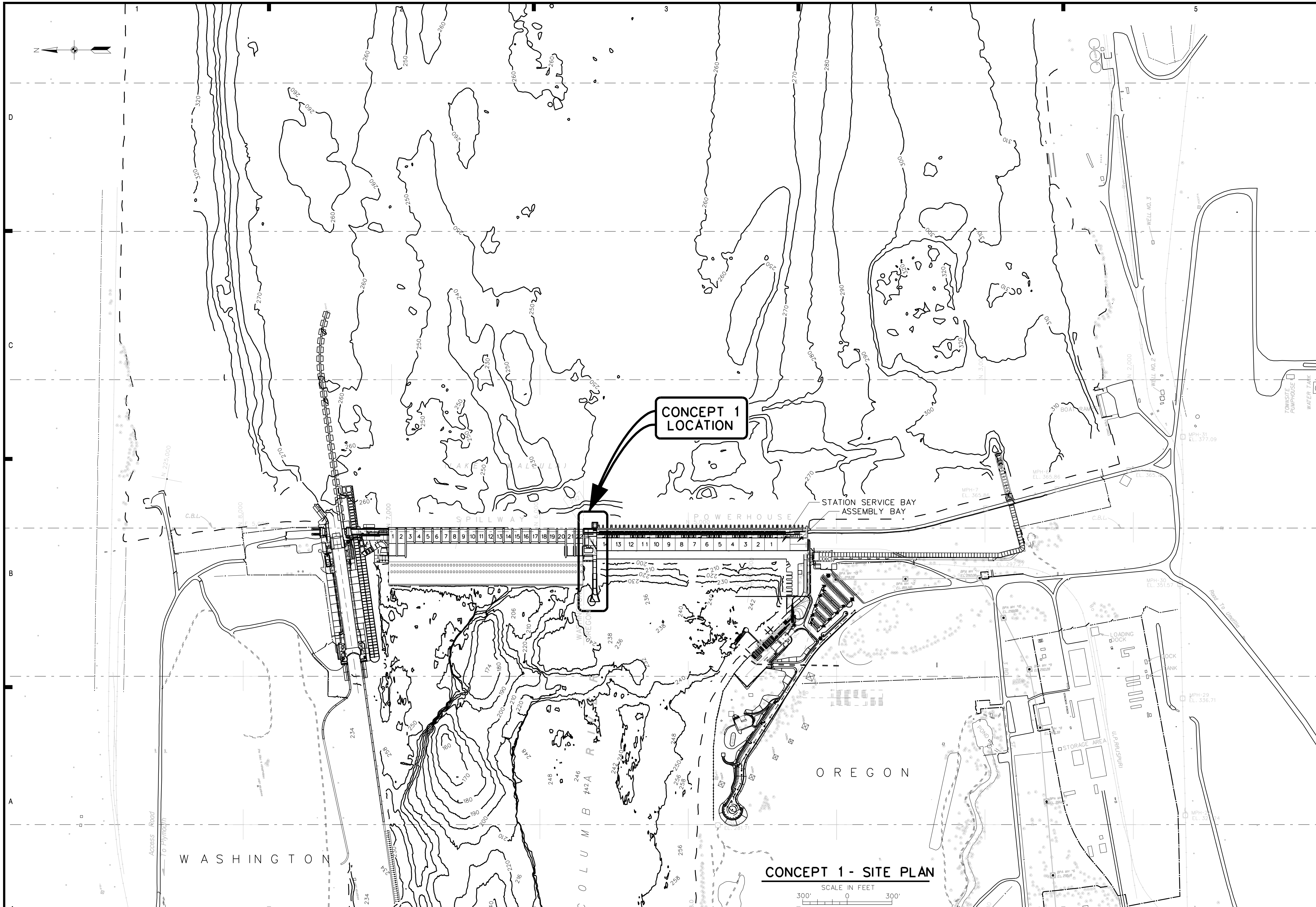
McNARY DAM
REMOVABLE SPILLWAY WEIR (RSW)
McNARY DAM SPILLWAYS DIFFERENCES

Figure number: MN-4

DATE AND TIME PLOTTED: 6/8/2005 3:59:20 PM DESIGN FILE: L:\HYDES\CAD\04RSW\MNA\MNA_RSW_04.DGN
SCALE $SCALE$
USERNAME $USER$

McNary Surface Passage Concept Drawings

Concept #	General Name	Figure	Subject
Concept 1	Center Non-Overflow Weir	C1-1	Site Plan
		C1-2	Plan View
		C1-3	Cross Section
Concept 2	Elevated Center Non-Overflow Weir	C2-1	Site Plan
		C2-2	Plan View
		C2-3	Cross Section
Concept 3	South Non-Overflow Weir	C3-1	Site Plan
		C3-2	Plan View
Concept 4	ITS Bypass	C4-1	Site Plan
		C4-2	Partial Plan and Section
		C4-3	Section thru Channel
Concept 5	ITS Collector	C5-1	Site Plan
		C5-2	Partial Plan and Section
		C5-3	Sections
Concept 6	Powerhouse Bypass	C6-1	Site Plan
		C6-2	Plan View
		C6-3	Cross Section
Concept 7	Powerhouse Collector	C7-1	Site Plan
		C7-2	Plan View
Concept 8	Overflow Fish Gate	C8-1	Site Plan
		C8A-2	Partial Plan
		C8A-3	Transverse Section
		C8B-2	Partial Plan
		C8B-3	Transverse Section
Concept 9	Over and Under Fish Gate	C9-1	Site Plan
		C9A-2	Partial Plan
		C9A-3	Transverse Section
		C9B-2	Partial Plan
		C9B-3	Transverse Section
Concept 10	Bulkhead Weir	C10-1	Site Plan
		C10-2	Partial Plan
		C10-3	Transverse Section
Concept 11	Piernose Bulkhead	C11-1	Site Plan
		C11-2	Partial Plan
		C11-3	Transverse Section
Concept 12	Chevron BGS	C12-1	Site Plan
Concept 13	Diagonal BGS	C13-1	Site Plan
Concept 14	RSW	C14-1	Site Plan
		C14-2	Partial Plan
		C14-3	Transverse Section
Concept 15	Crest w/Stacked Sections	C15-1	Site Plan
		C15-2	Partial Plan
		C15-3	Transverse Section



CONCEPT 1 - SITE PLAN

SCALE IN FEET

300' 0 300'

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

DESIGNED BY: MRV | DATE: 6/29/05
DWN BY: BLP | CHKED BY: N | SOLICITATION NO. XX-B-XXXX
SUBMITTED BY: N | CONTRACT NO.
CHIEF ______ DES. SEC.
FILE NO.: MNA_SPC_C1_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS

CONCEPT 1
SITE PLAN

Sheet number:
C1–1

L:\HYDES\CAD\05-MCNARY-SPC\MNA_SPC_C1_1.DGN

BORDER SIZE IS ANSI D

01:20:10 PM DATE AND TIME PLOTTED:07/07/2005

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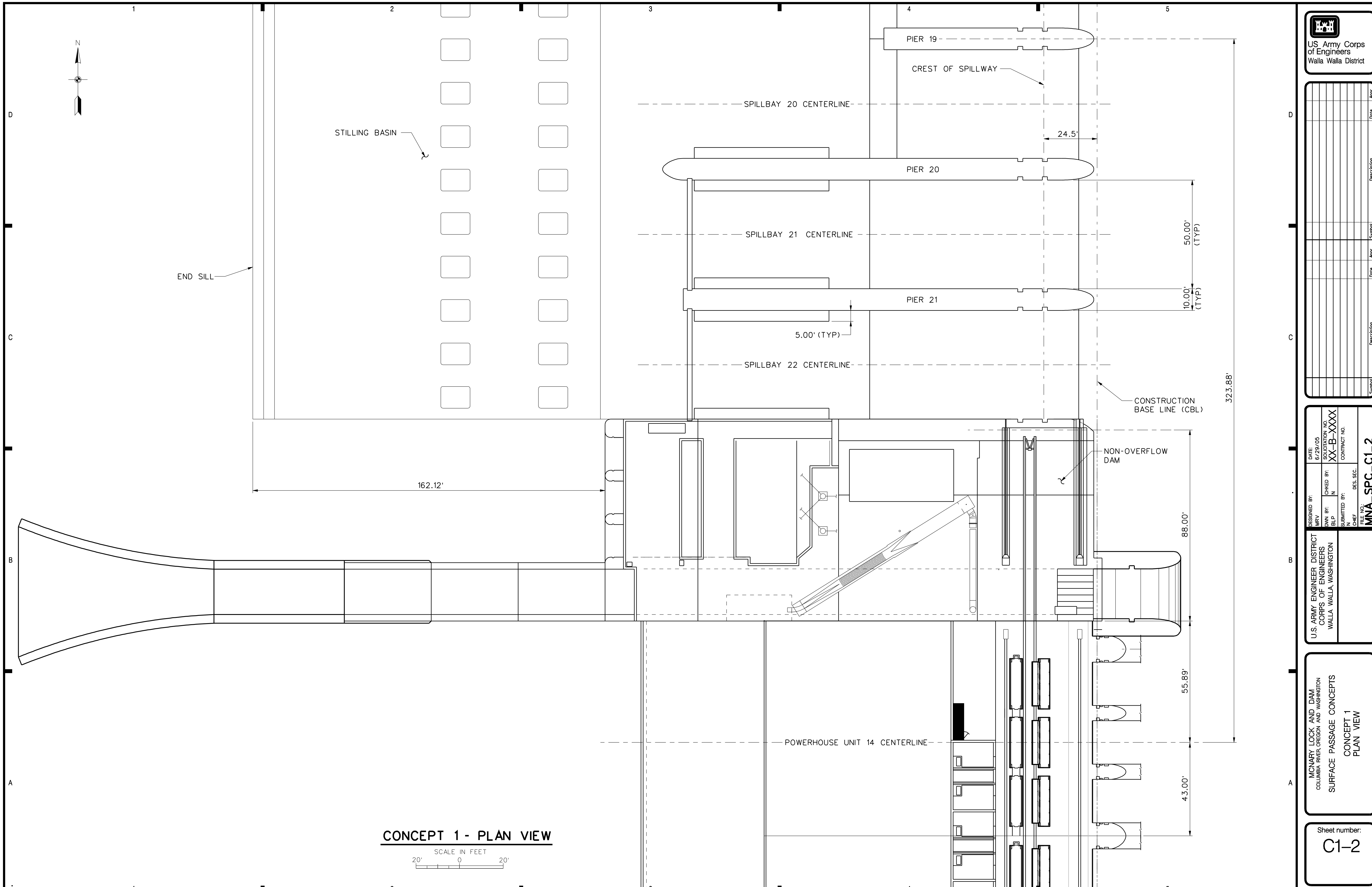

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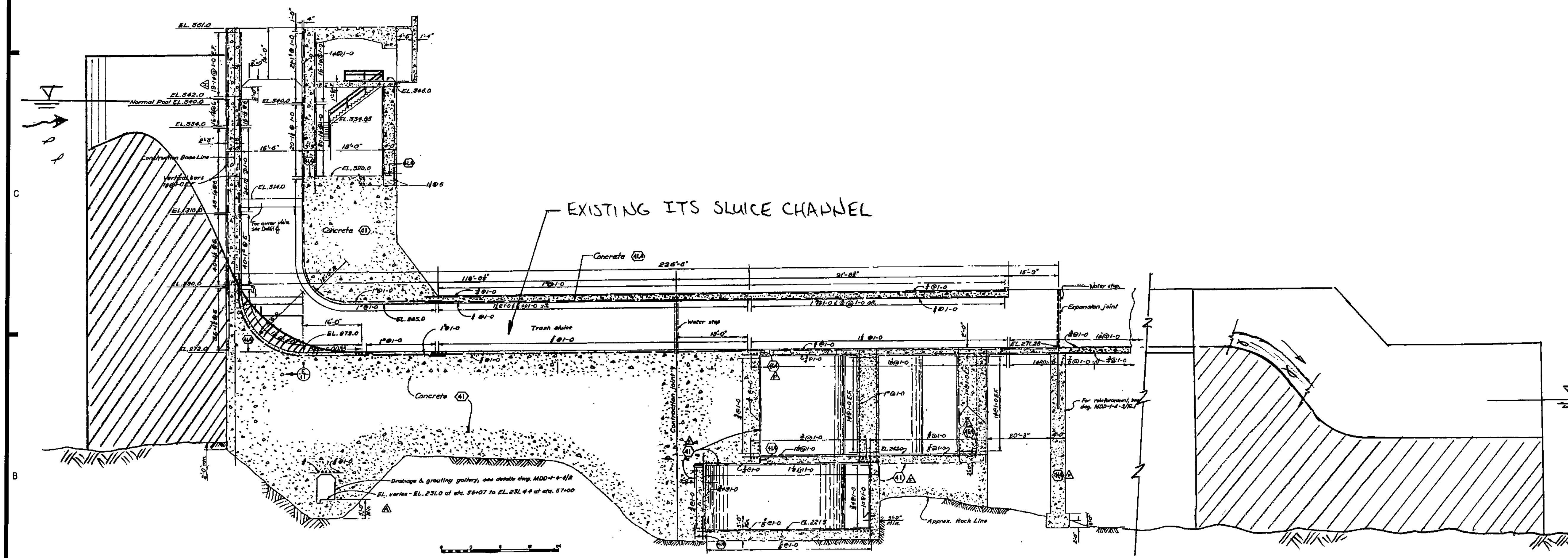


CONCEPT C1 - CROSS SECTION

NOT TO SCALE

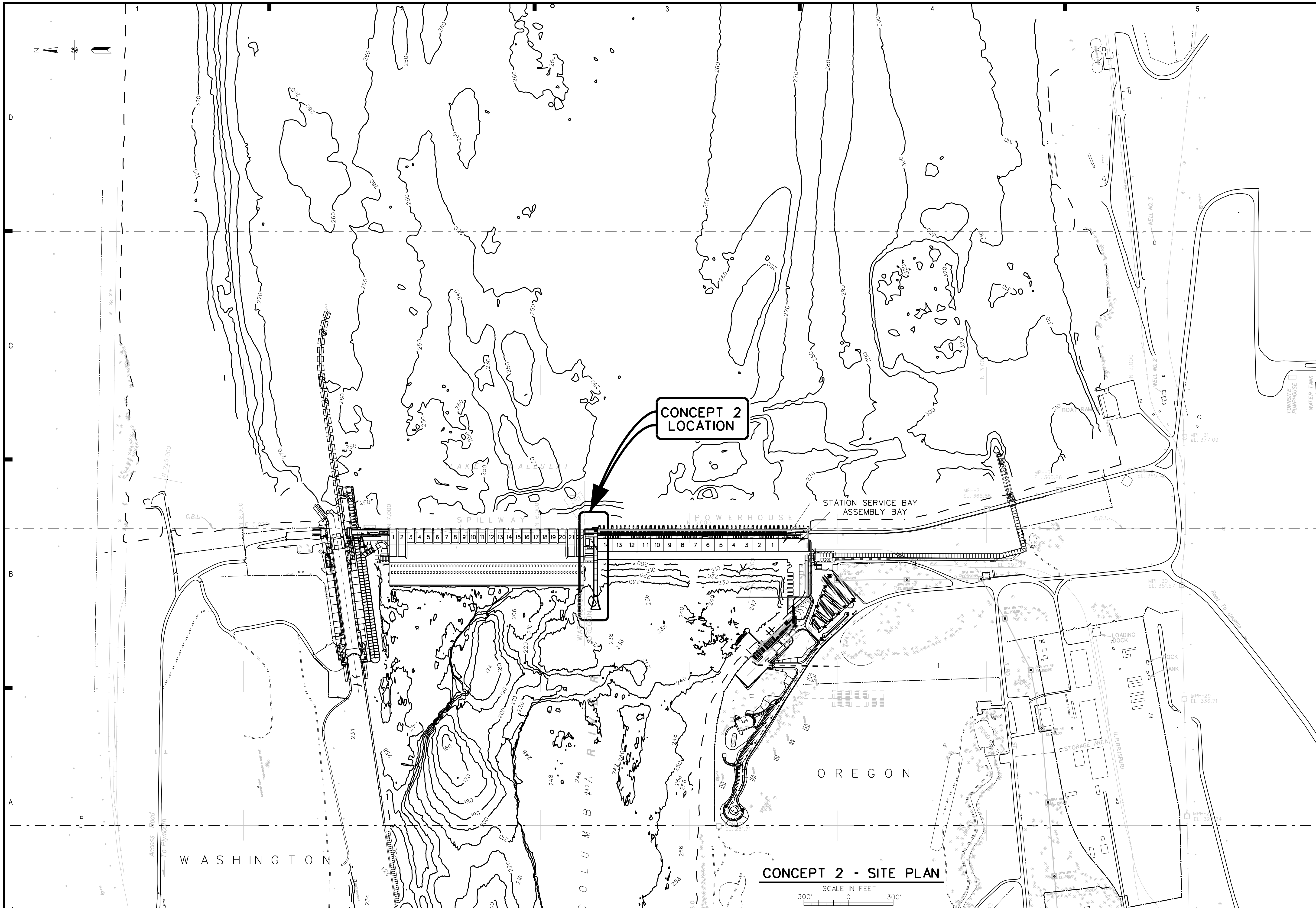
US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: DAP
CHKD BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.: ----
FILE NO.: MNA_SPC_C1-3

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 1
CROSS SECTION

Sheet number: C1-3



CONCEPT 2 - SITE PLAN

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF: DES. SEC.
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: MNA_SPC_C2_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 2
SITE PLAN

Sheet number:
C2-1

BORDER SIZE IS ANSI D

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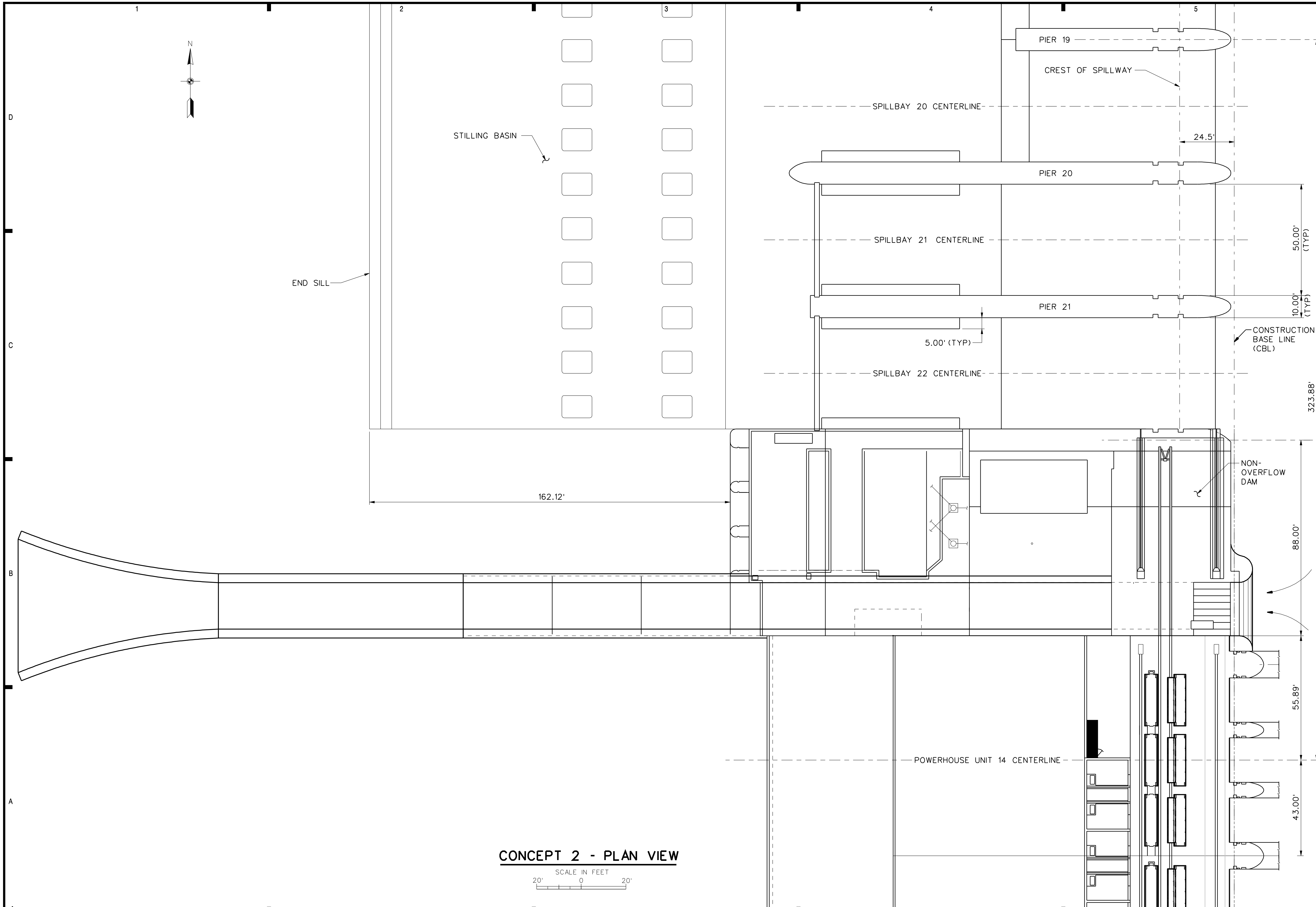

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
CHIEF, DES. SEC.:
FILE NO.: MNA_SPC_C2_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 2
PLAN VIEW

Sheet number:
C2-2

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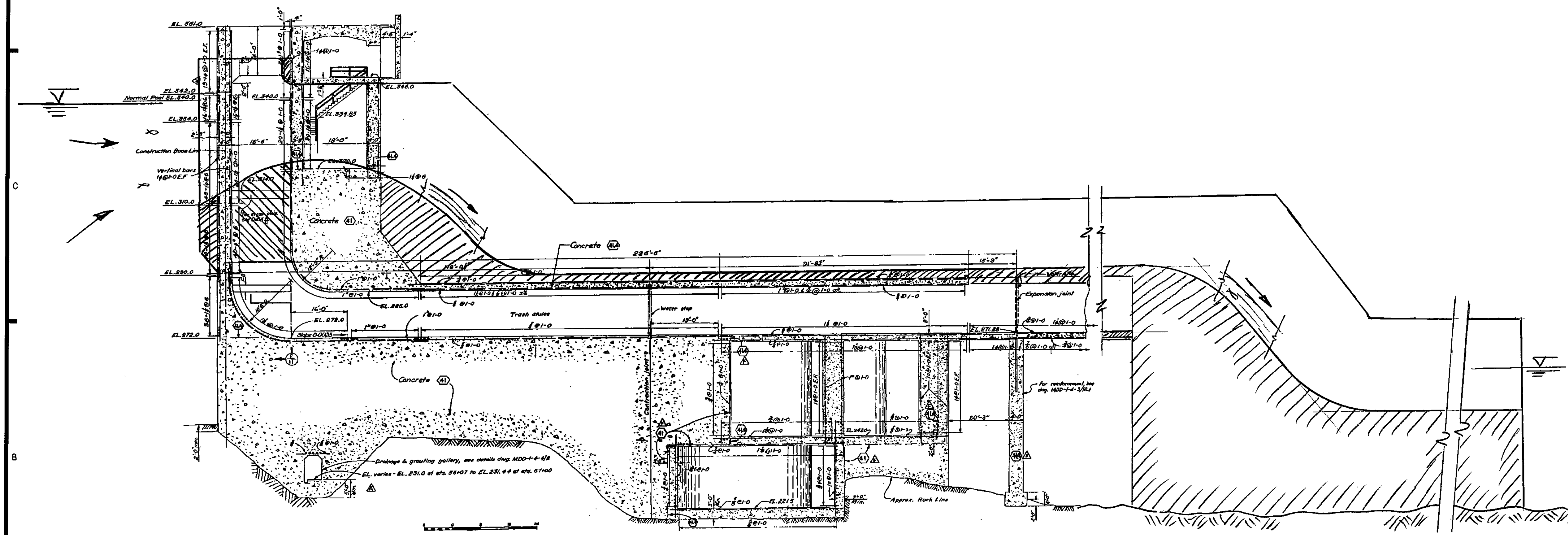


CONCEPT C2 - CROSS SECTION

NOT TO SCALE

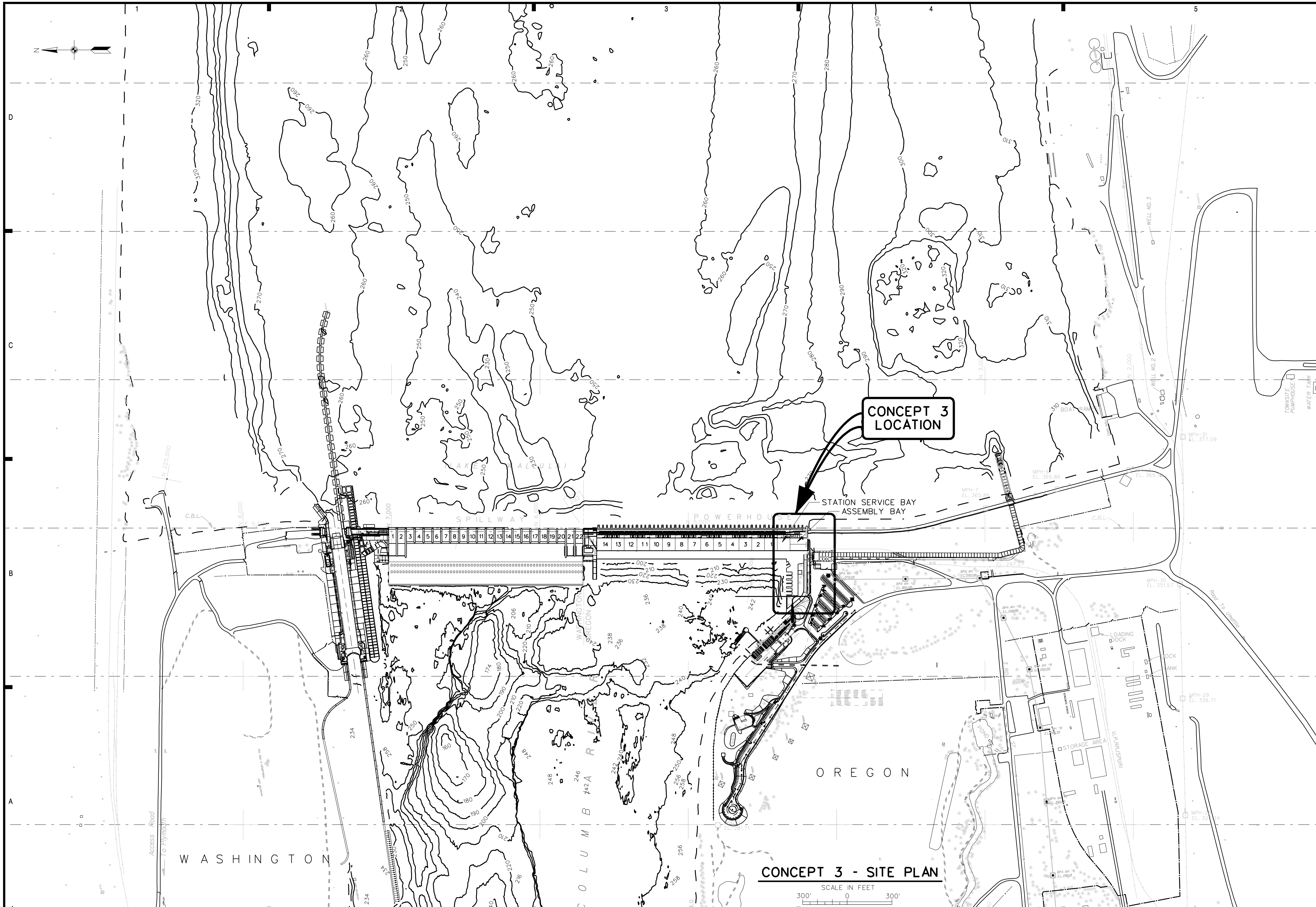
US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV	DATE: 6/29/05
DWN BY: DMP	CHKD BY: N
SUBMITTED BY: N	SOLICITATION NO.: XX-B-XXXX
FILE NO.: MNA_SPC_C2-3	CONTRACT NO.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 2
CROSS SECTION

Sheet number: C2-3



CONCEPT 3 - SITE PLAN

SCALE IN FEET
300' 0 300'

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF ______ DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO. ---------
FILE NO.: MNA_SPC_C3_1

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 3
SITE PLAN

Sheet number:
C3-1

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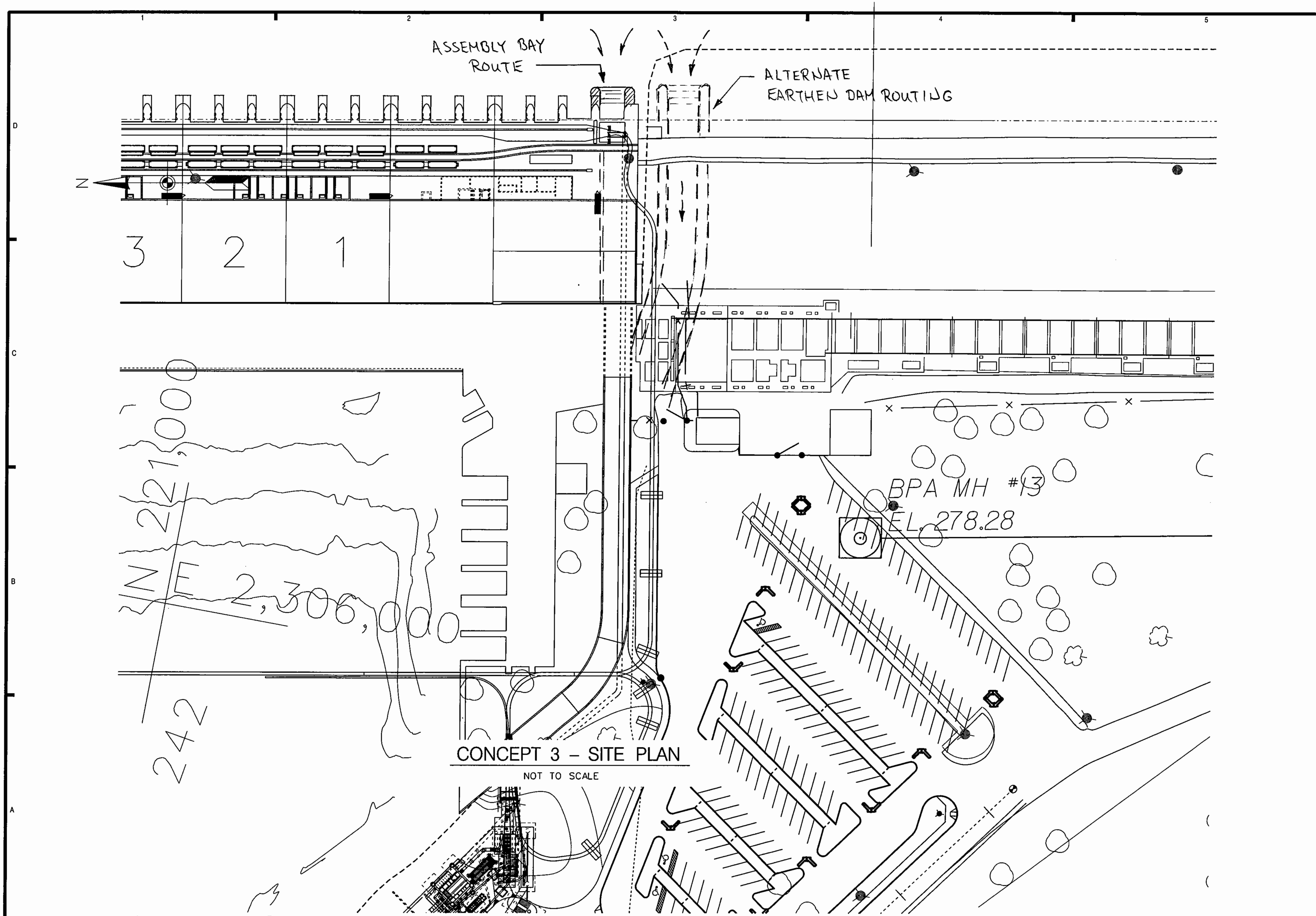

CONCEPT 3 – SITE PLAN

NOT TO SCALE

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
SUBMITTED BY: N
CHIEF ______ DES. SEC.
FILE NO.: MNA_SPC_C3_2

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS

CONCEPT 3
PLAN VIEW

Sheet number:
C3–2

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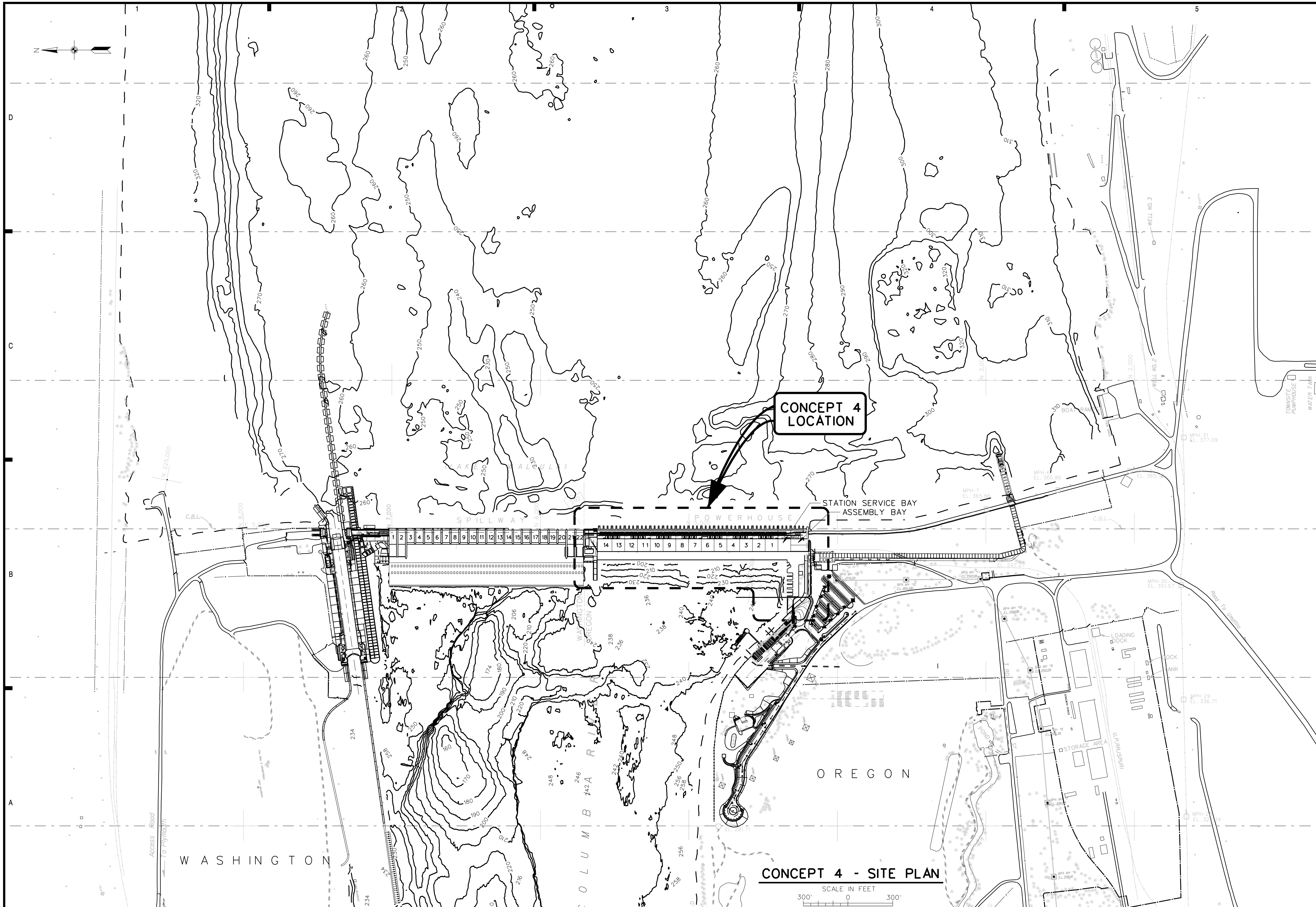

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

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DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO. MNA_SPC_C4_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 4
SITE PLAN

Sheet number:
C4-1

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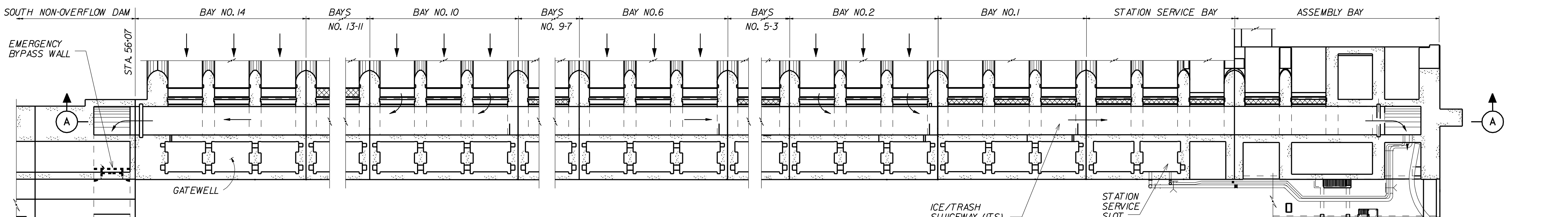
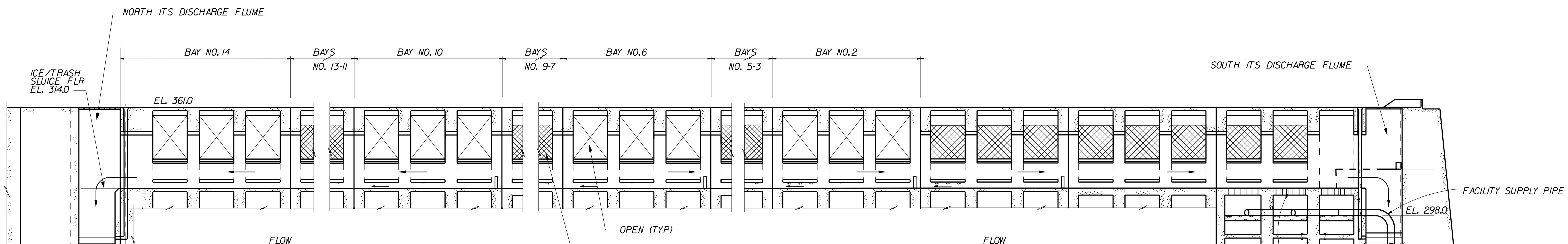


SECTIONAL PLAN AT EL. 333.0

NOT TO SCALE



SECTION A

NOT TO SCALE

CONCEPT C4 - PARTIAL PLAN AND SECTION

NOT TO SCALE

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
CHIEF DES. SEC.:
FILE NO.: MNA_SPC_C4-2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT C4
PARTIAL PLAN AND SECTION

Sheet number:
C4-2

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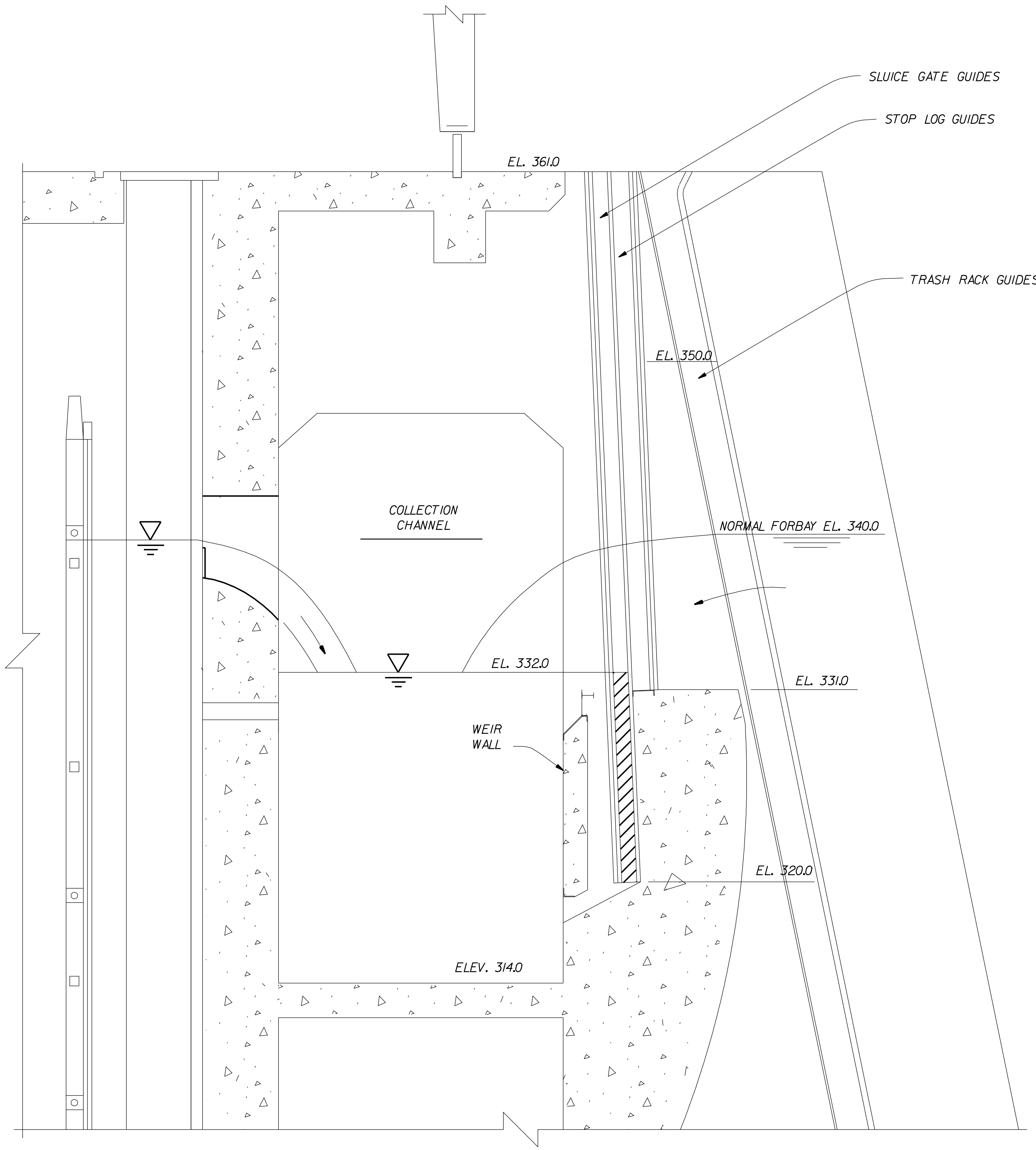

DETAIL A - TRANSVERSE SECTION THRU COLLECTION CHANNEL

SCALE IN FEET
12" 0 5'

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF ______ DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO. --------
FILE NO.: MNA_SPC_C4_3

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 4
SECTION THRU CHANNEL

Sheet number:
C4–3

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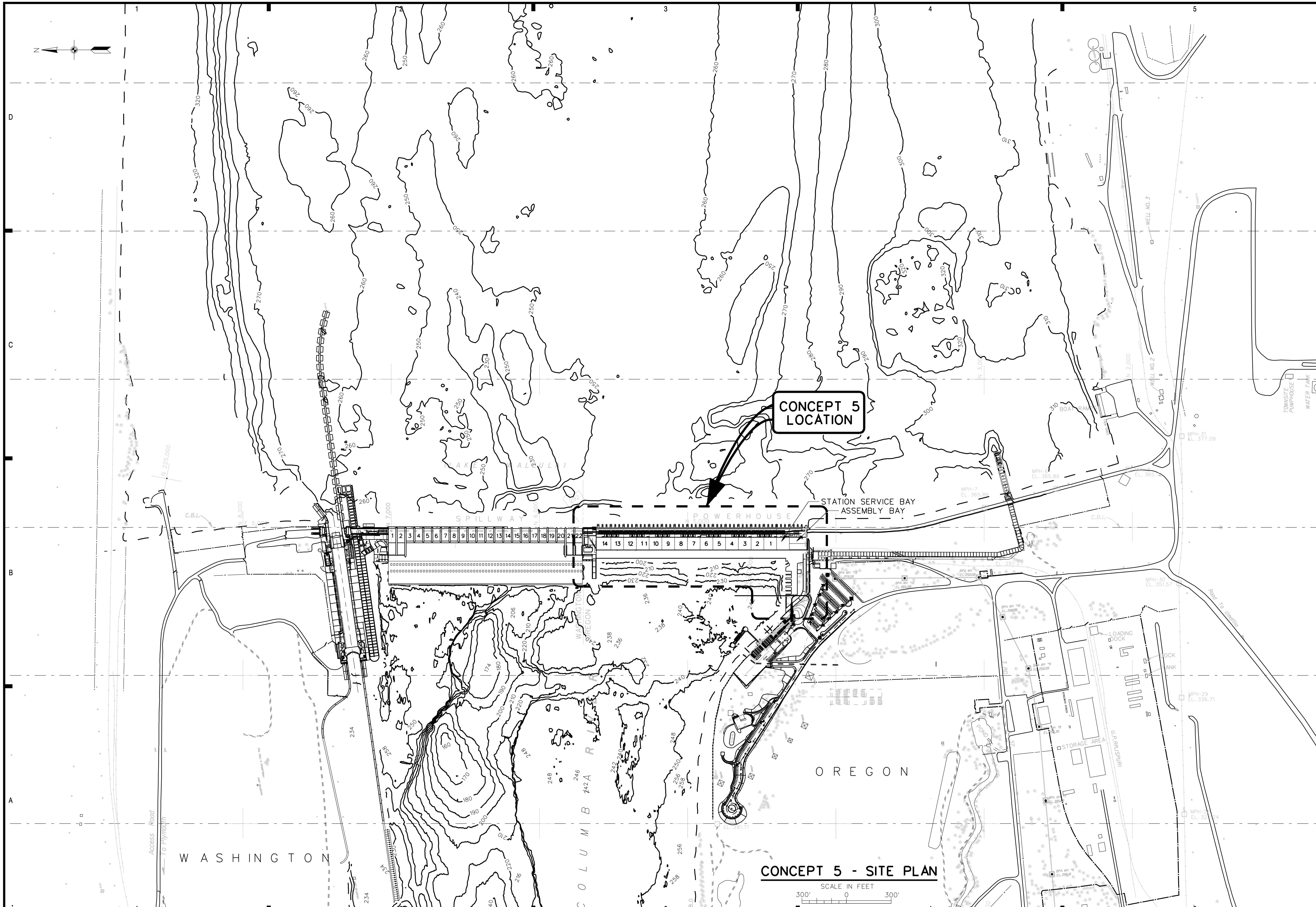

US Army Corps of Engineers Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO.: MNA_SPC_C5_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 5
SITE PLAN

Sheet number: C5-1

BORDER SIZE IS ANSI D

01:21:58 PM DATE AND TIME PLOTTED:07/07/2005

DESIGN FILE: L:\HYDES\CAD\05-MCNARY-SPC\MNA_SPC_C5_1.DGN

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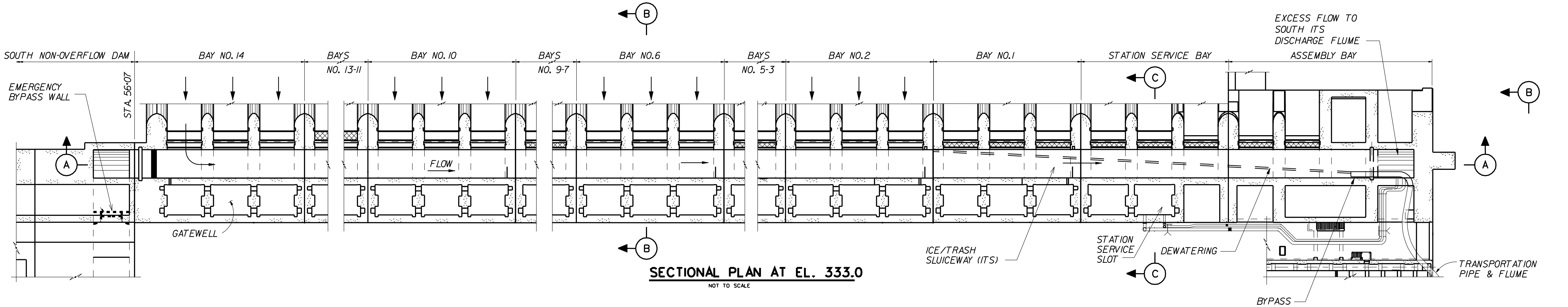
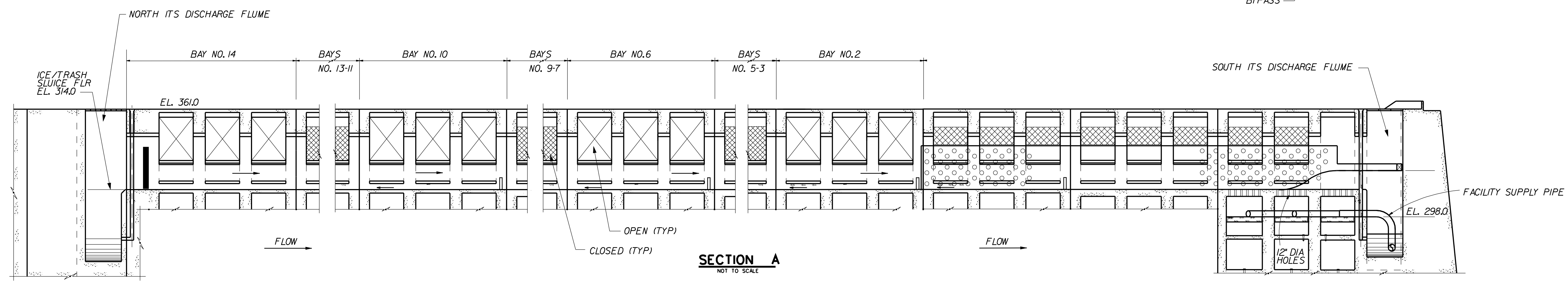


SECTIONAL PLAN AT EL. 333.0

NOT TO SCALE



SECTION A

NOT TO SCALE

CONCEPT C5 - PARTIAL PLAN AND SECTION

NOT TO SCALE

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N CHIEF DES. SEC.
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: MNA_SPC_C5-2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT C5
PARTIAL PLAN AND SECTION

Sheet number: C5–2

BORDER SIZE IS ANSI D

01:22:15 PM DATE AND TIME PLOTTED:07/07/2005

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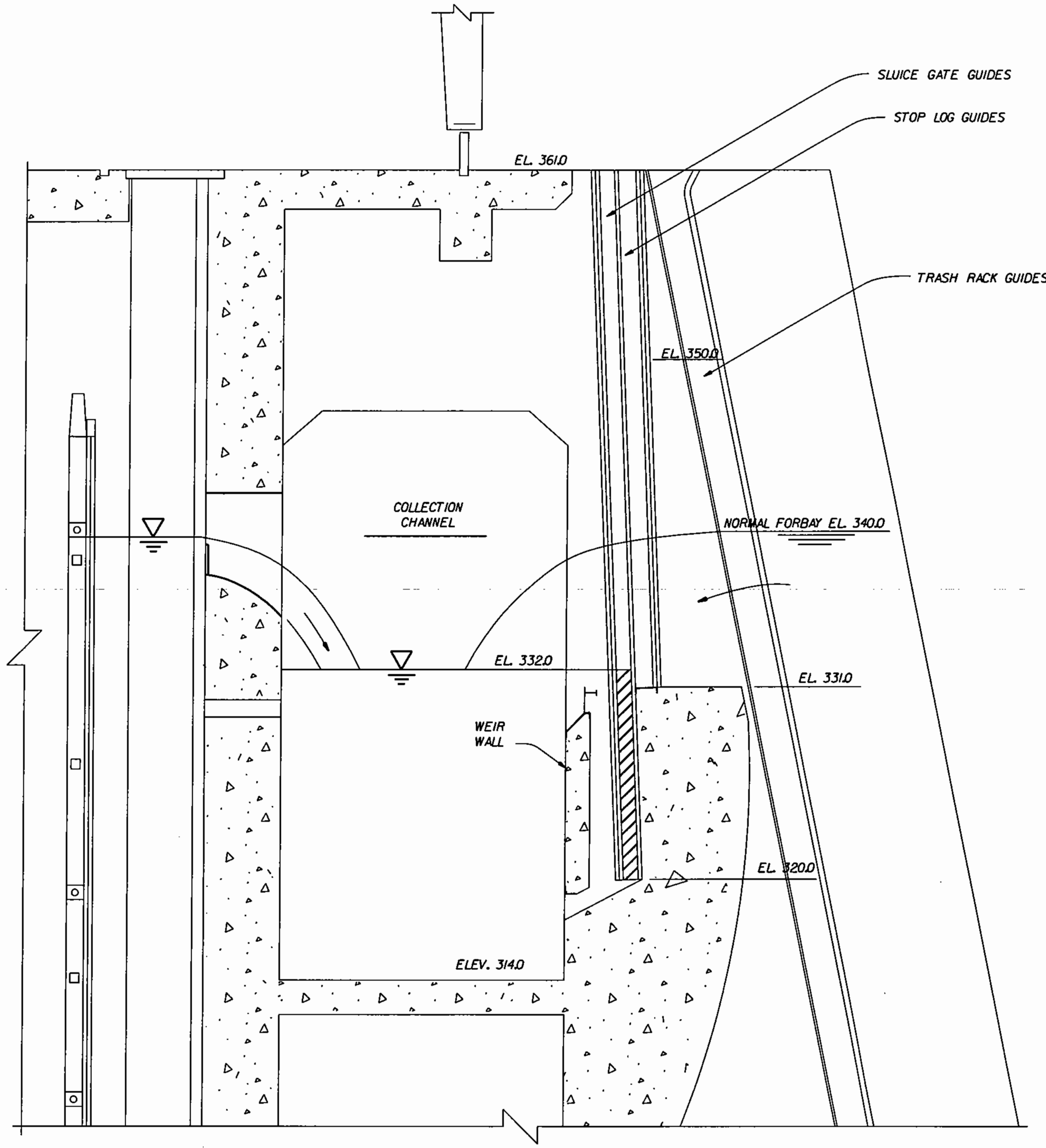

TRANSVERSE SECTION B

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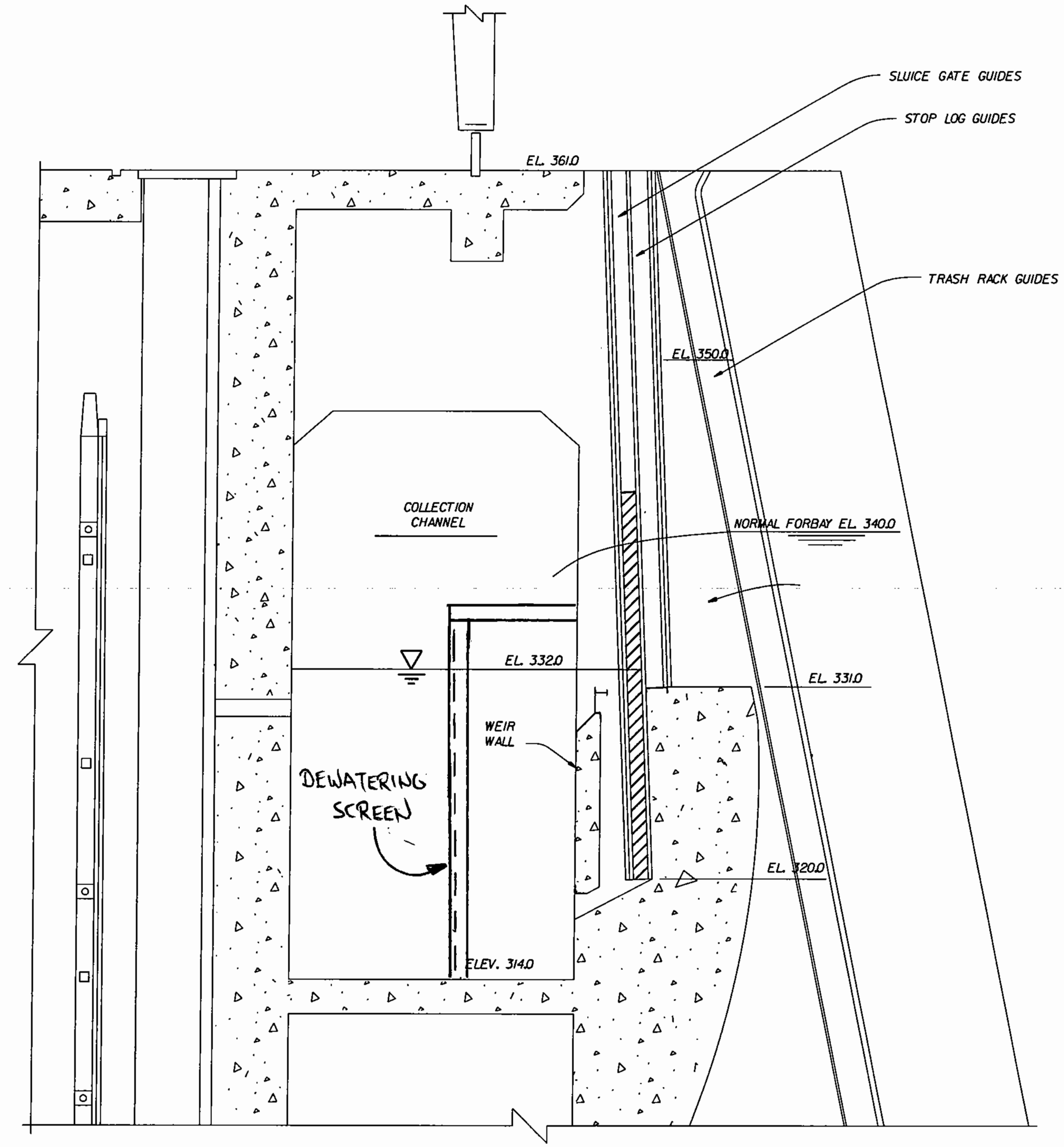


TRANSVERSE SECTION C

NOT TO SCALE

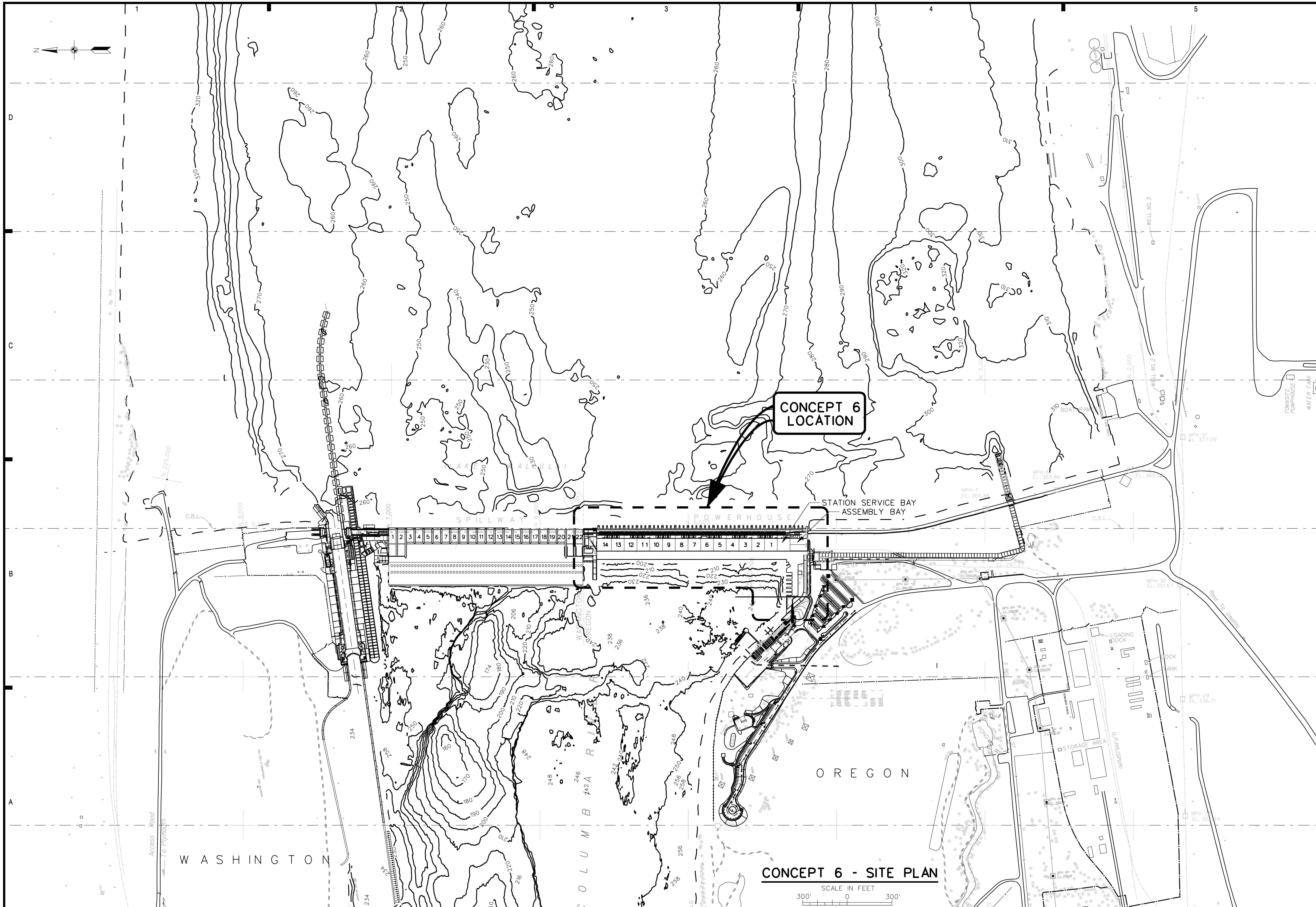
US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N
CHIEF: DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO.: MNA_SPC_C5_3

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 5
SECTIONS THRU CHANNEL

Sheet number: C5-3



US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV	DATE: 6/29/05
DWN BY: BLP	CHKED BY: N
SOLICITATION NO.	XX-B-XXXX
SUBMITTED BY: N	CONTRACT NO.
FILE NO.:	MNA_SPC_C6_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 6
SITE PLAN

Sheet number:
C6-1

BORDER SIZE IS ANSI D

01:22:30 PM DATE AND TIME PLOTTED:07/07/2005

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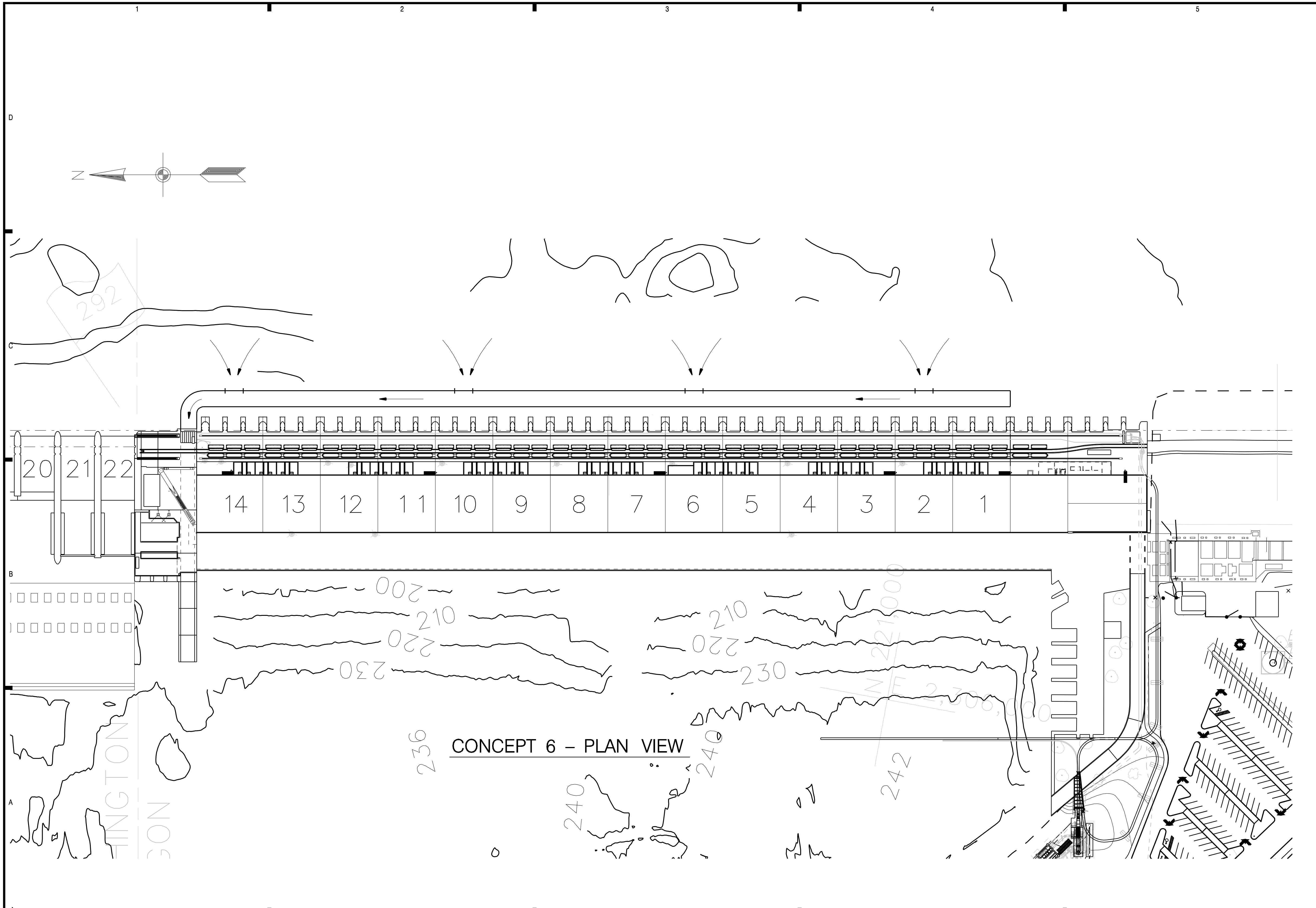

CONCEPT 6 – PLAN VIEW

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N
CHIEF, ______ DES. SEC.
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: MNA_SPC_C6_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 6
PLAN VIEW

Sheet number:
C6–2

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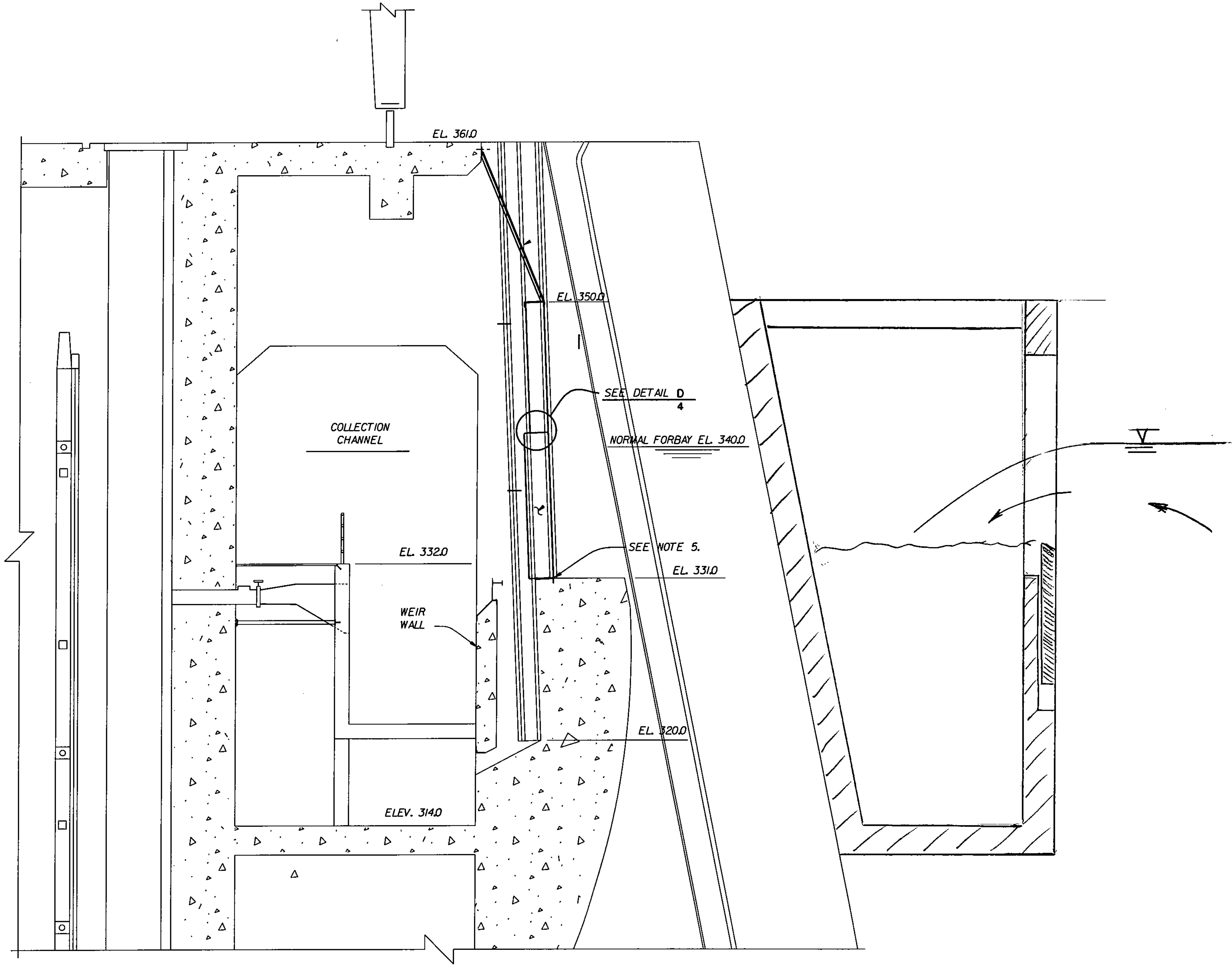

DETAIL A - TRANSVERSE SECTION THRU COLLECTION CHANNEL

SCALE IN FEET
12" 0 5'

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: DAP
CHKD BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
CHIEF, DES. SEC.
FILE NO.: MNA_SPC_C6-3

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT C6
TRANSVERSE SECTION

Sheet number:
C6–3

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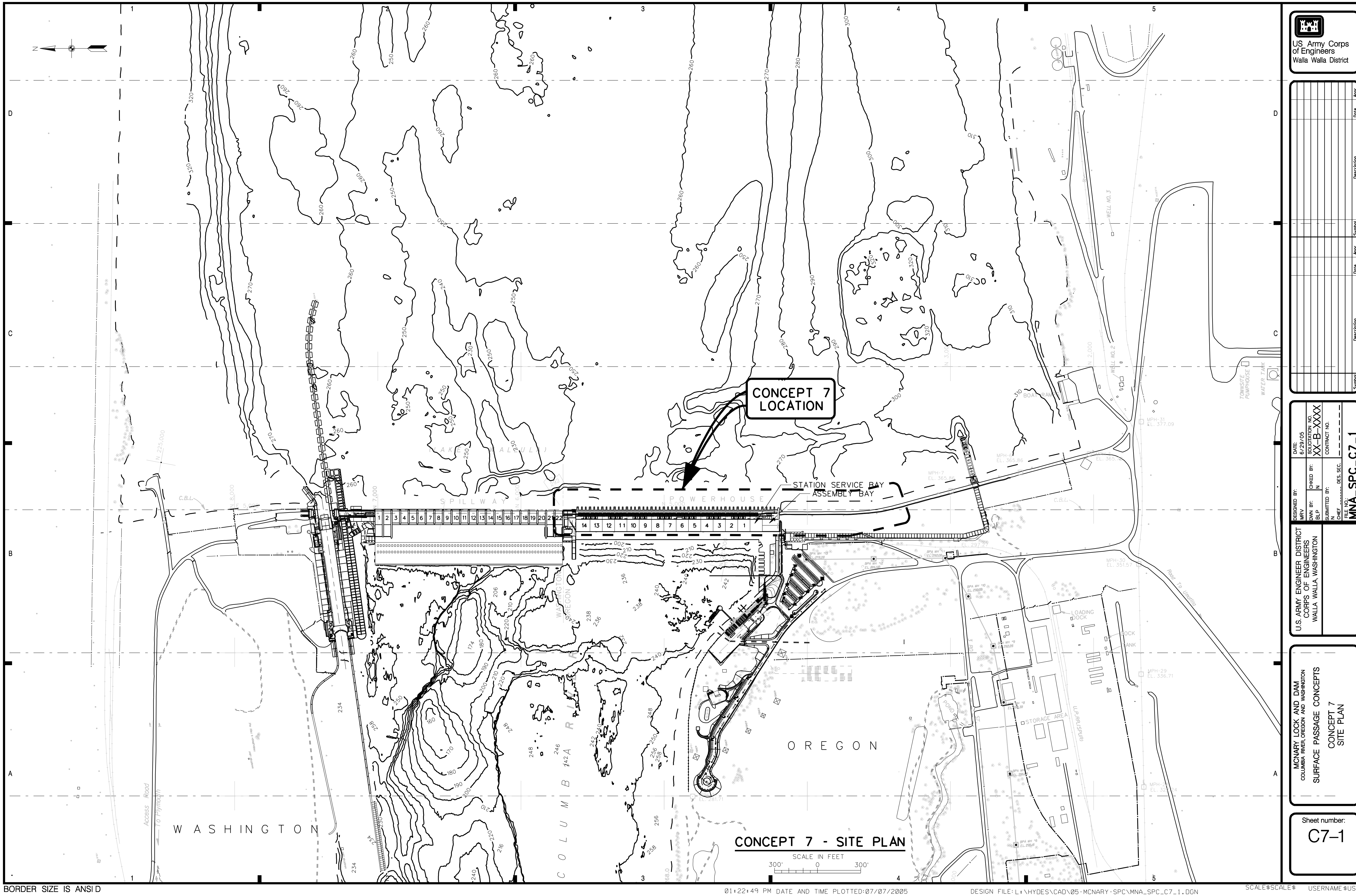

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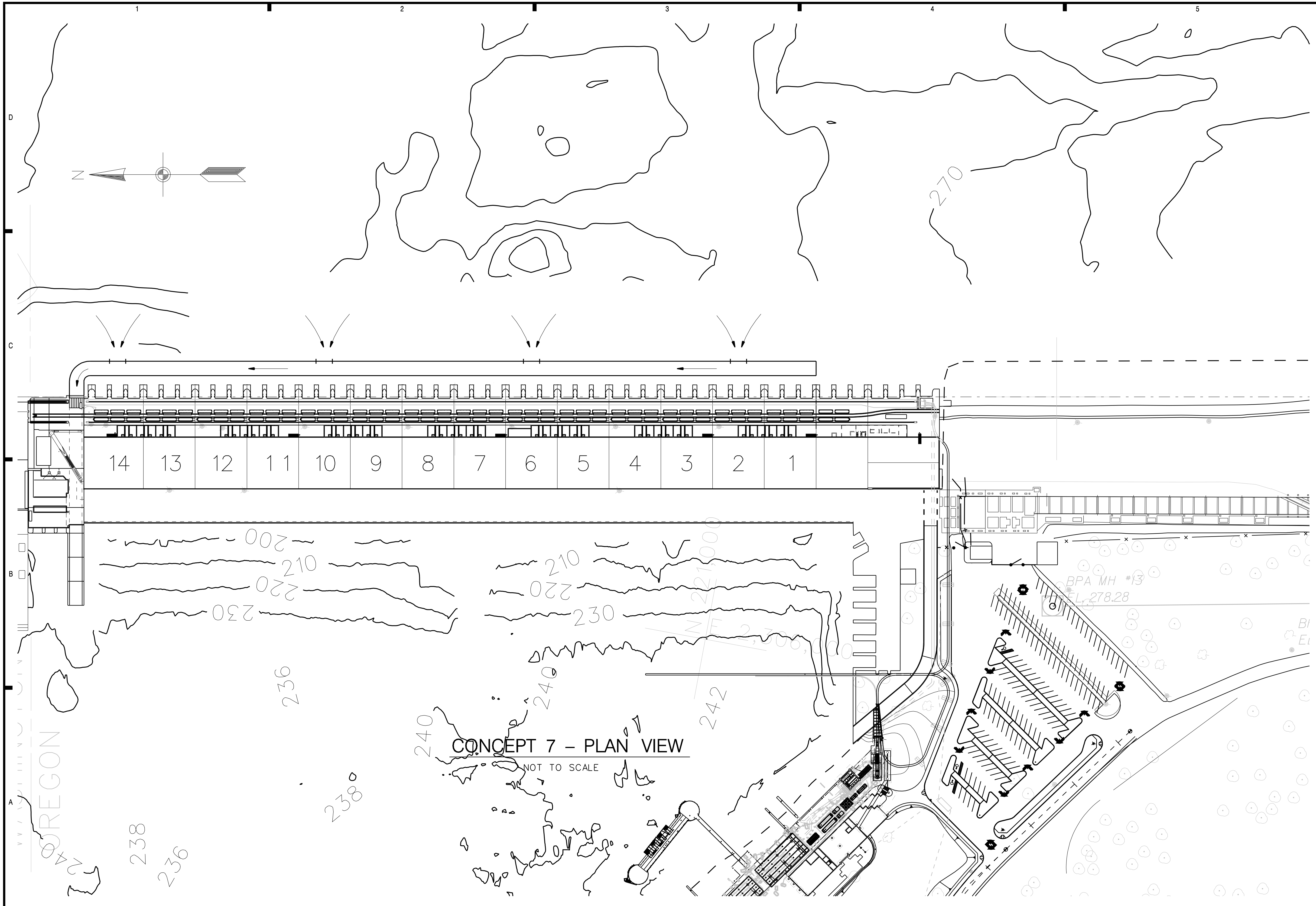

CONCEPT 7 – PLAN VIEW

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DATE: 6/29/05
DWN BY: BLP
CHKD BY: N
SOLICITATION NO.: XX-B-XXXX
SUBMITTED BY: N
CONTRACT NO.:
CHIEF DES. SEC.
FILE NO.: MNA_SPC_C7_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 7
PLAN VIEW

Sheet number:
C7–2

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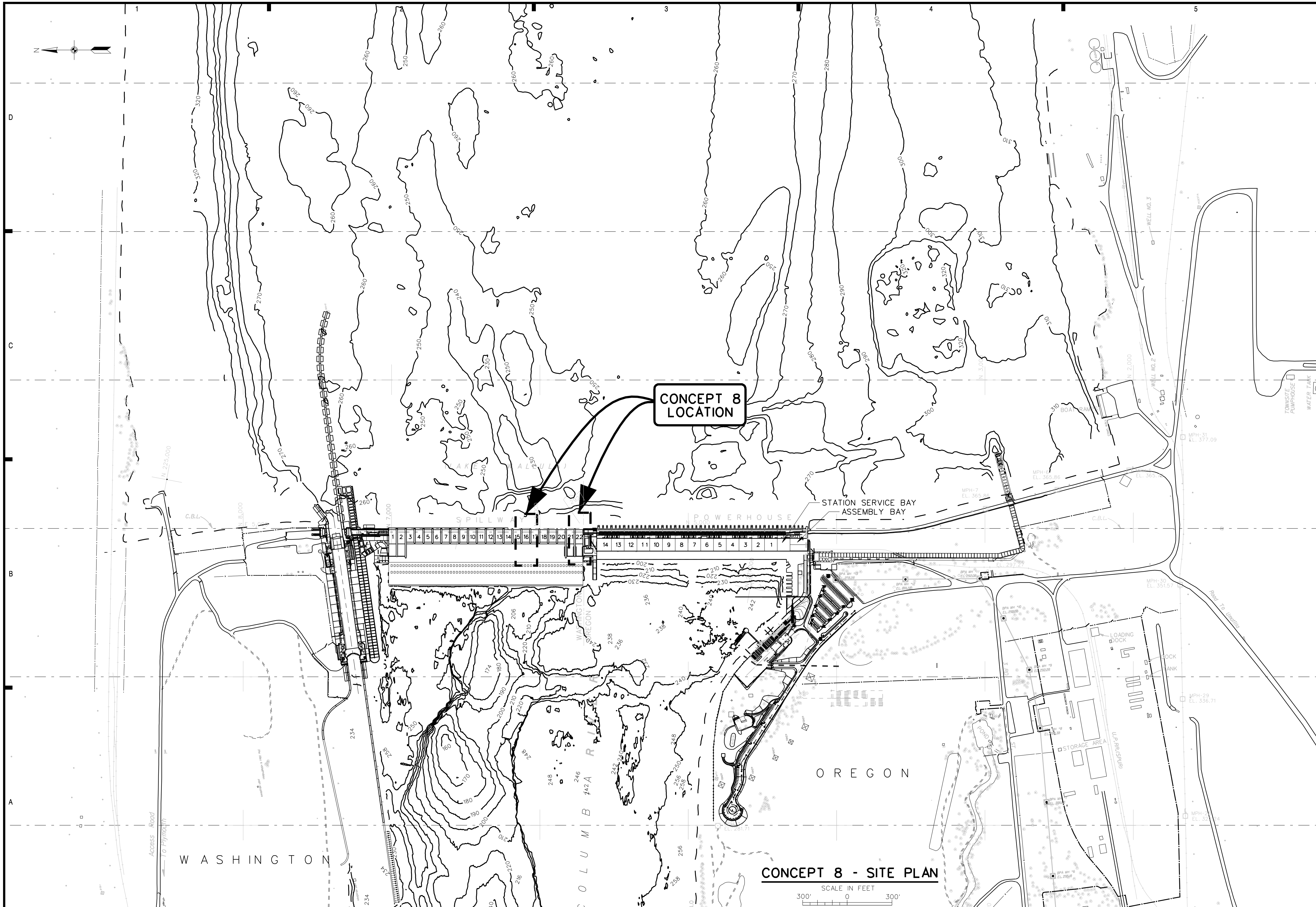


CONCEPT 8 - SITE PLAN

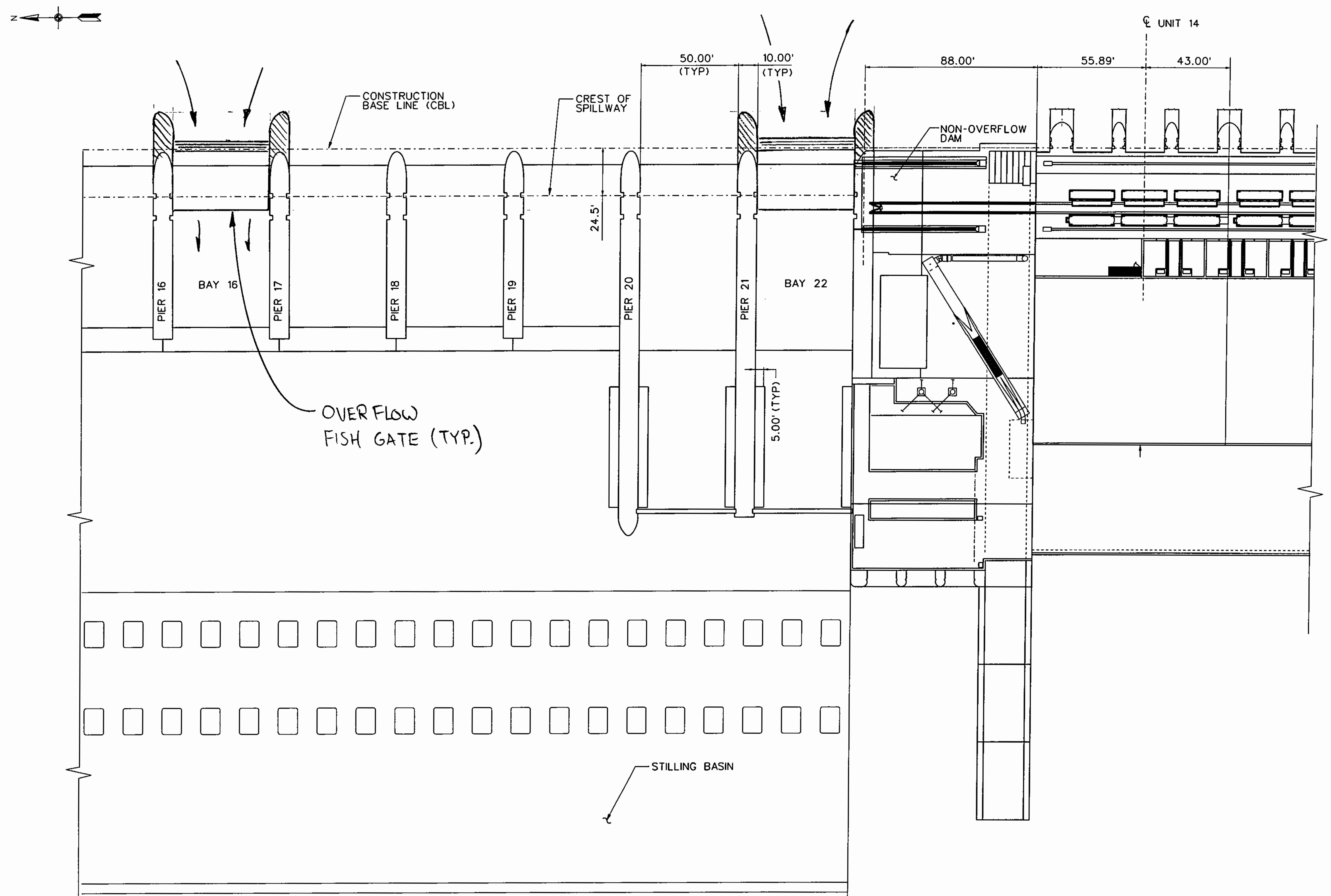
US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO. MNA_SPC_C8_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 8
SITE PLAN

Sheet number:
C8-1



CONCEPT 8A - PARTIAL PLAN

SCALE IN FEET
30' 0 30'

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DATE: 6/29/05
DWN BY: BLP
CKD BY: N
SOLICITATION NO.: XX-B-XXXX
SUBMITTED BY: N
CONTRACT NO.
CHIEF
DES. SEC.
FILE NO.: MNA_SPC_C8A_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 8A
PARTIAL PLAN

Sheet number:
C8A-2

BORDER SIZE IS ANSI D

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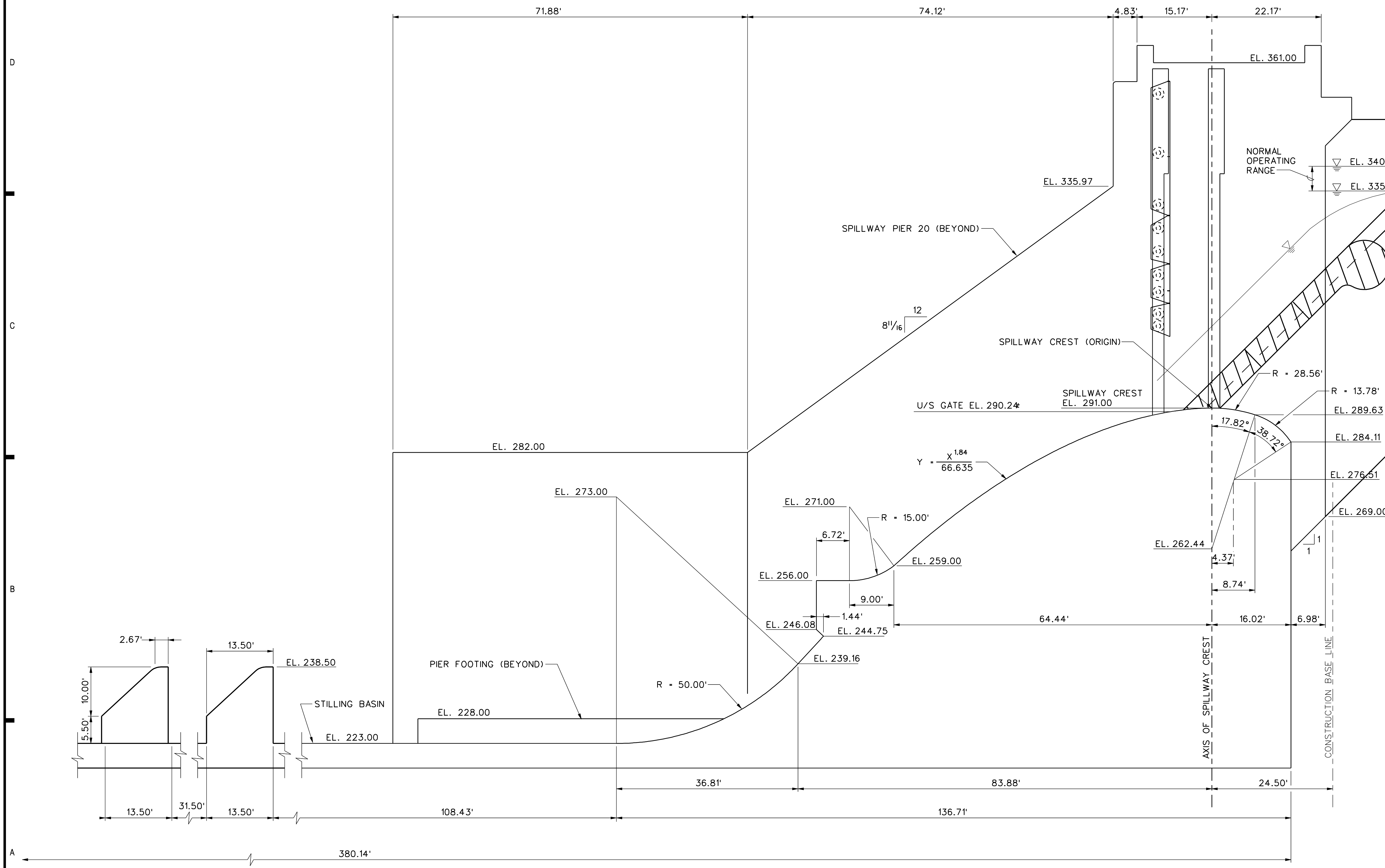

McNARY SPILLWAY BAY 22 - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

DATE:
INV. NO. XX-B-XX
CONTRACT NO.
DESIGNED BY:
DRAWN BY:
CHECKED BY:
FILE NO.:

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

HYDRAULIC STUDY REPORT
REMOVABLE SPILLWAY WEIR (RSW)

Figure number:

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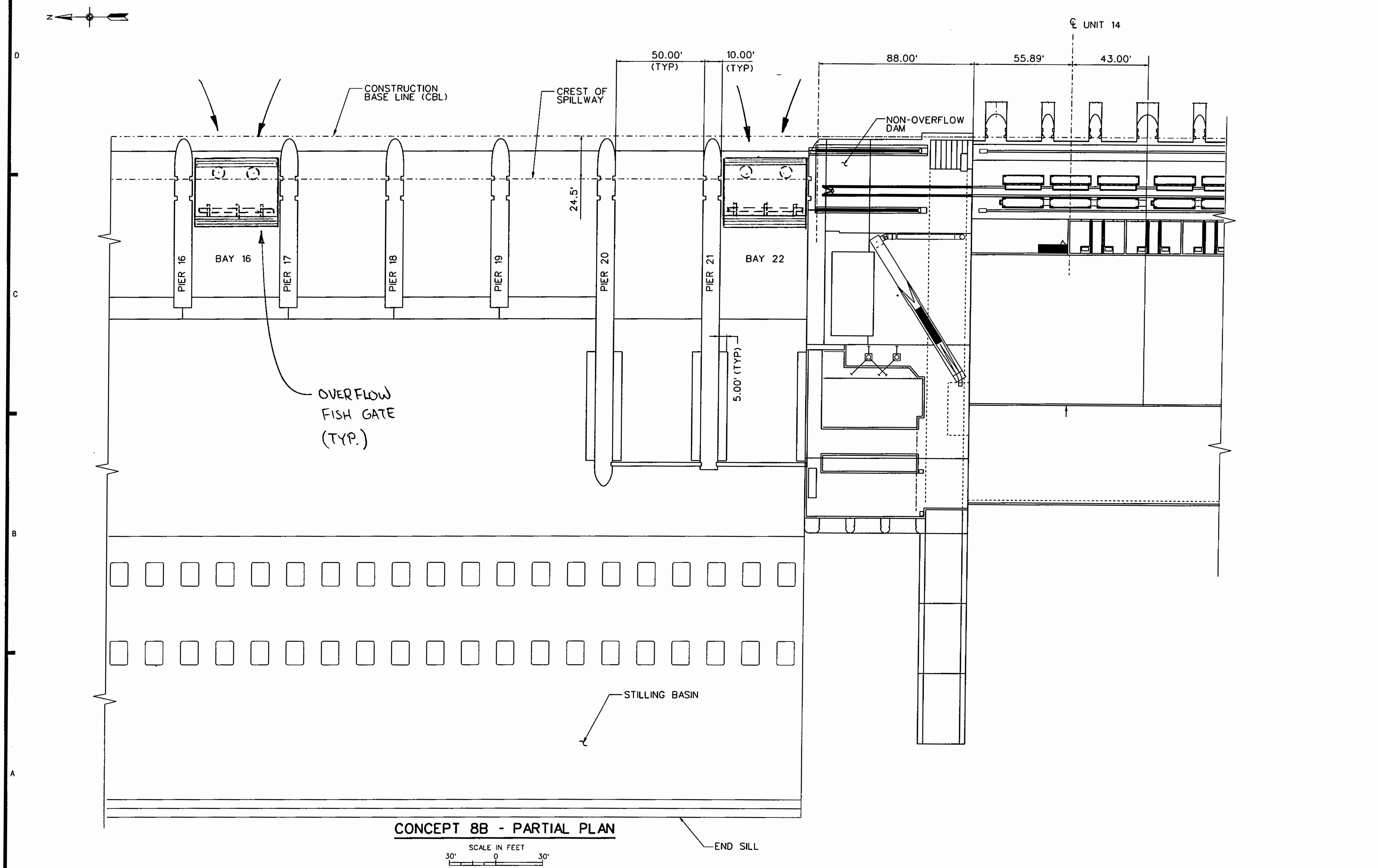

CONCEPT 8B - PARTIAL PLAN

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DATE: 6/29/05
DWN BY: BLP
CKD BY: N
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
SUBMITTED BY: N
CHIEF:
DES. SEC.:
FILE NO.: MNA_SPC_C8B_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 8B
PARTIAL PLAN

Sheet number: C8B-2

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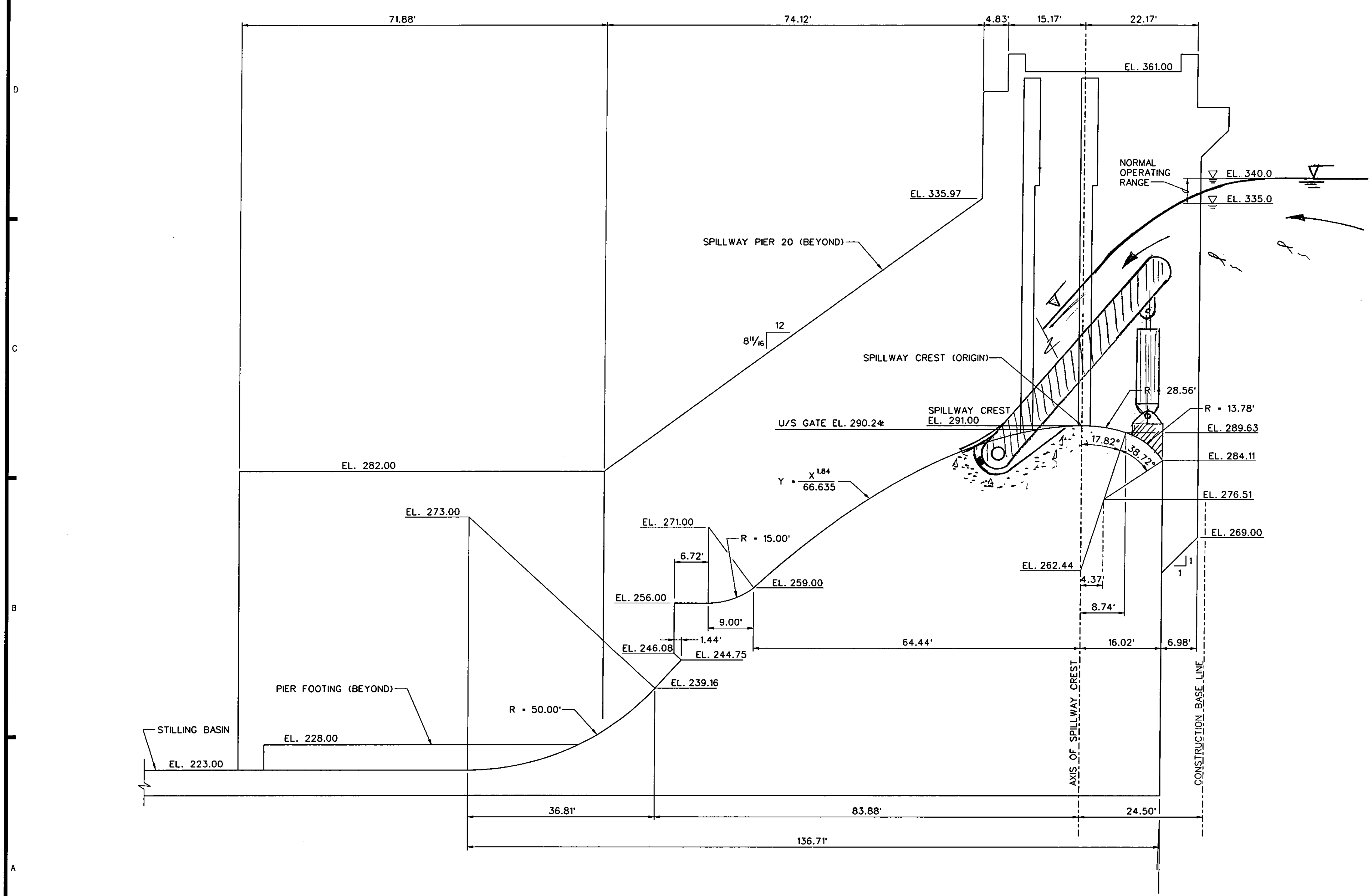

CONCEPT 8B - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N
CHIEF DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO.: MNA_SPC_C8B_3

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 8B
TRANSVERSE SECTION

Sheet number:
C8B-3

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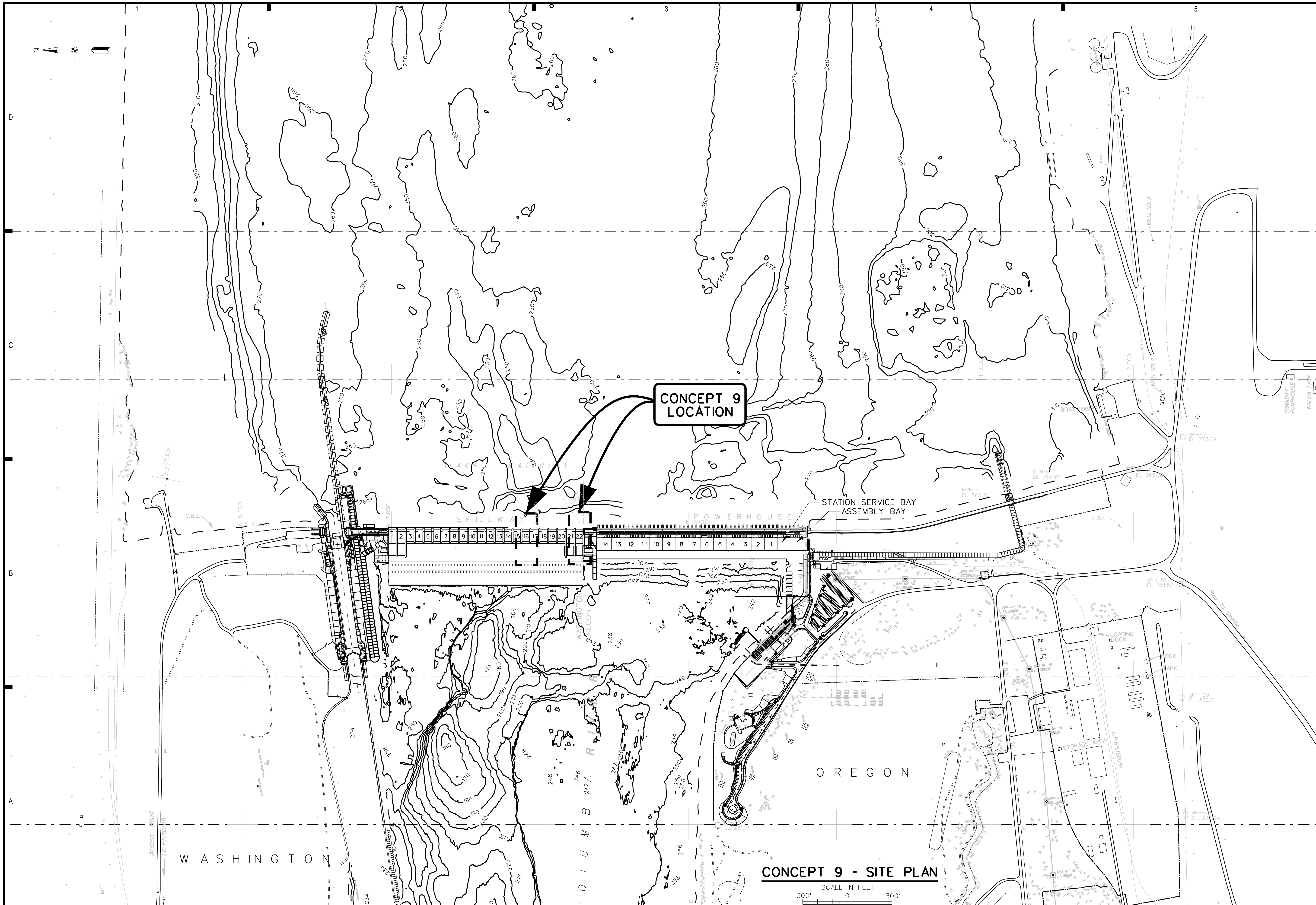

CONCEPT 9 - SITE PLAN

SCALE IN FEET
300' 0 300'

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV	DATE: 6/29/05
DWN BY: BLP	CHKD BY: N
SUBMITTED BY: N	SOLICITATION NO. XX-B-XXXX
CHIEF DES. SEC.	CONTRACT NO.
FILE NO. MNA_SPC_C9_1	

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 9
SITE PLAN

Sheet number:
C9-1

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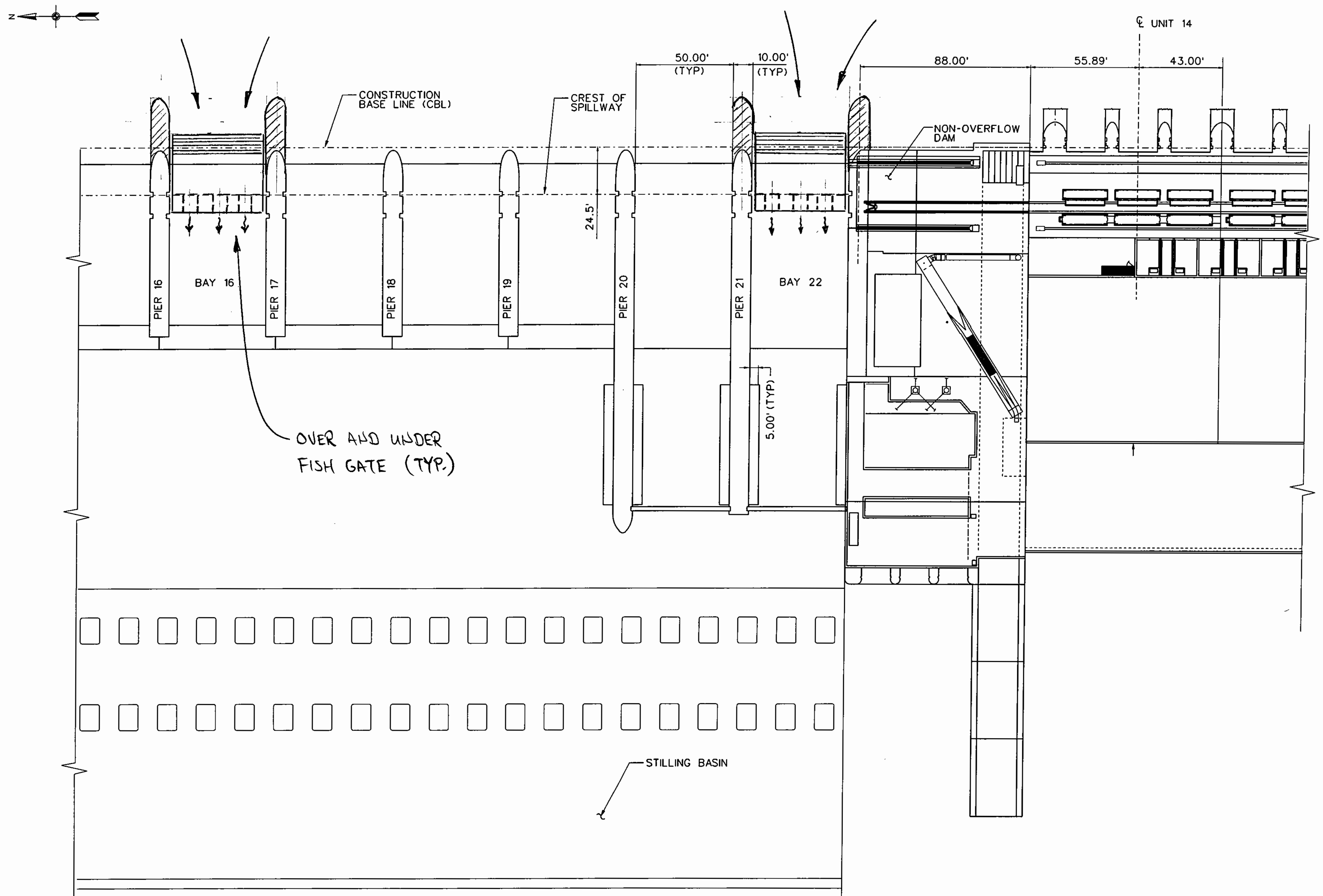

CONCEPT 9A - PARTIAL PLAN

SCALE IN FEET 30' 0 30'

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO.: MNA_SPC_C9A_2

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 9A
PARTIAL PLAN

Sheet number: C9A–2

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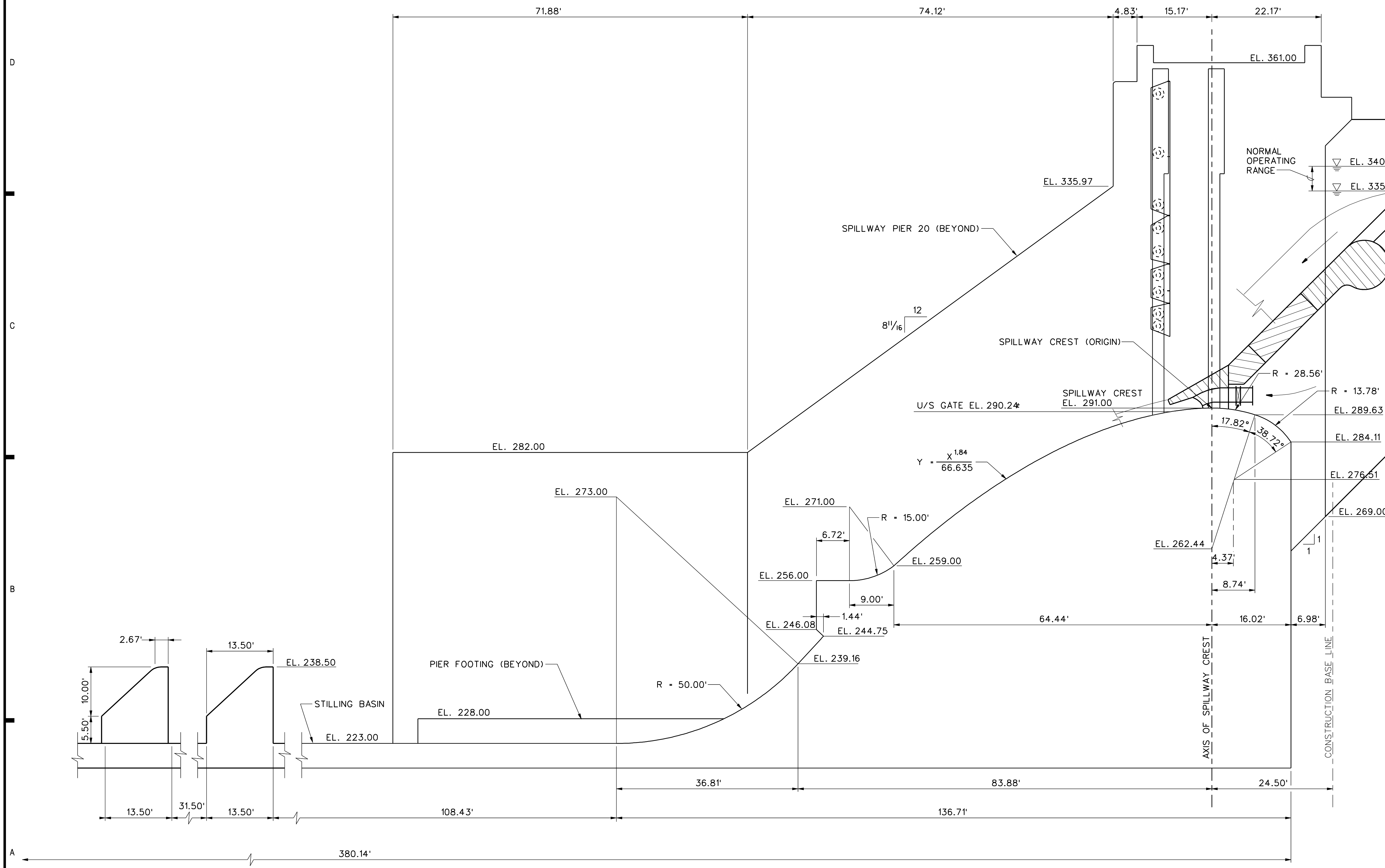

McNARY SPILLWAY BAY 22 - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

Symbol | Description | Date | Appr.

DATE:
DESIGNED BY:
DRAWN BY:
INV. NO. XX-B-XX
CHECKED BY:
CONTRACT NO. ---------
FILE NO.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

HYDRAULIC STUDY REPORT
REMOVABLE SPILLWAY WEIR (RSW)

Figure number:

BORDER SIZE IS ANSI D

DATE AND TIME PLOTTED: 07/07/2005 01:24:01 PM DESIGN FILE: L:\HYDES\CAD\05-MCNARY-SPC\MNA_SPC_C9A-3.DGN
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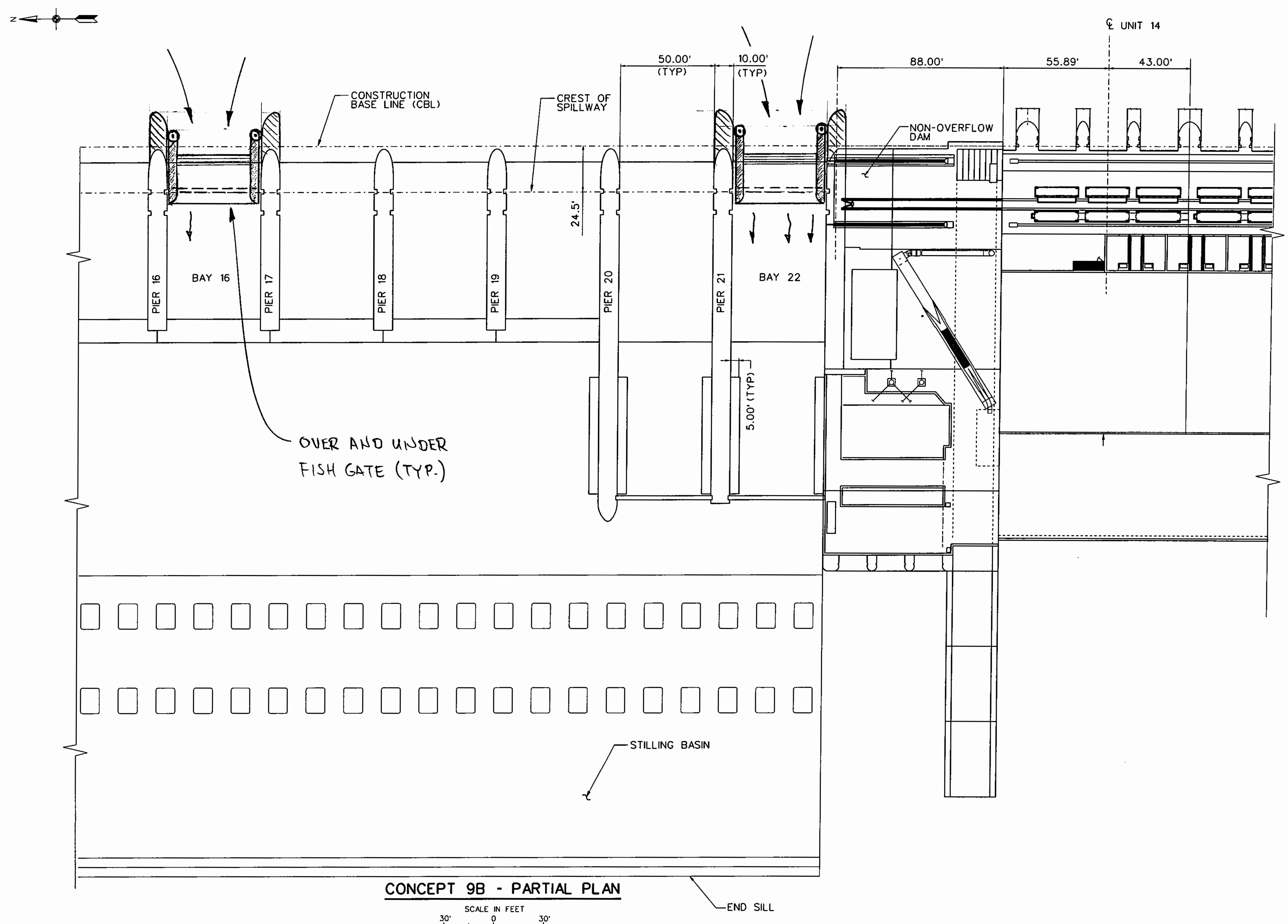

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV | DWN BY: BLP | CHKD BY: N | SUBMITTED BY: | DATE: 6/29/05 | SOLICITATION NO. XX-B-XXXX | CONTRACT NO. | FILE NO.: MNA_SPC_C9B_2

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 9B
PARTIAL PLAN

Sheet number: C9B–2

BORDER SIZE IS ANSI D
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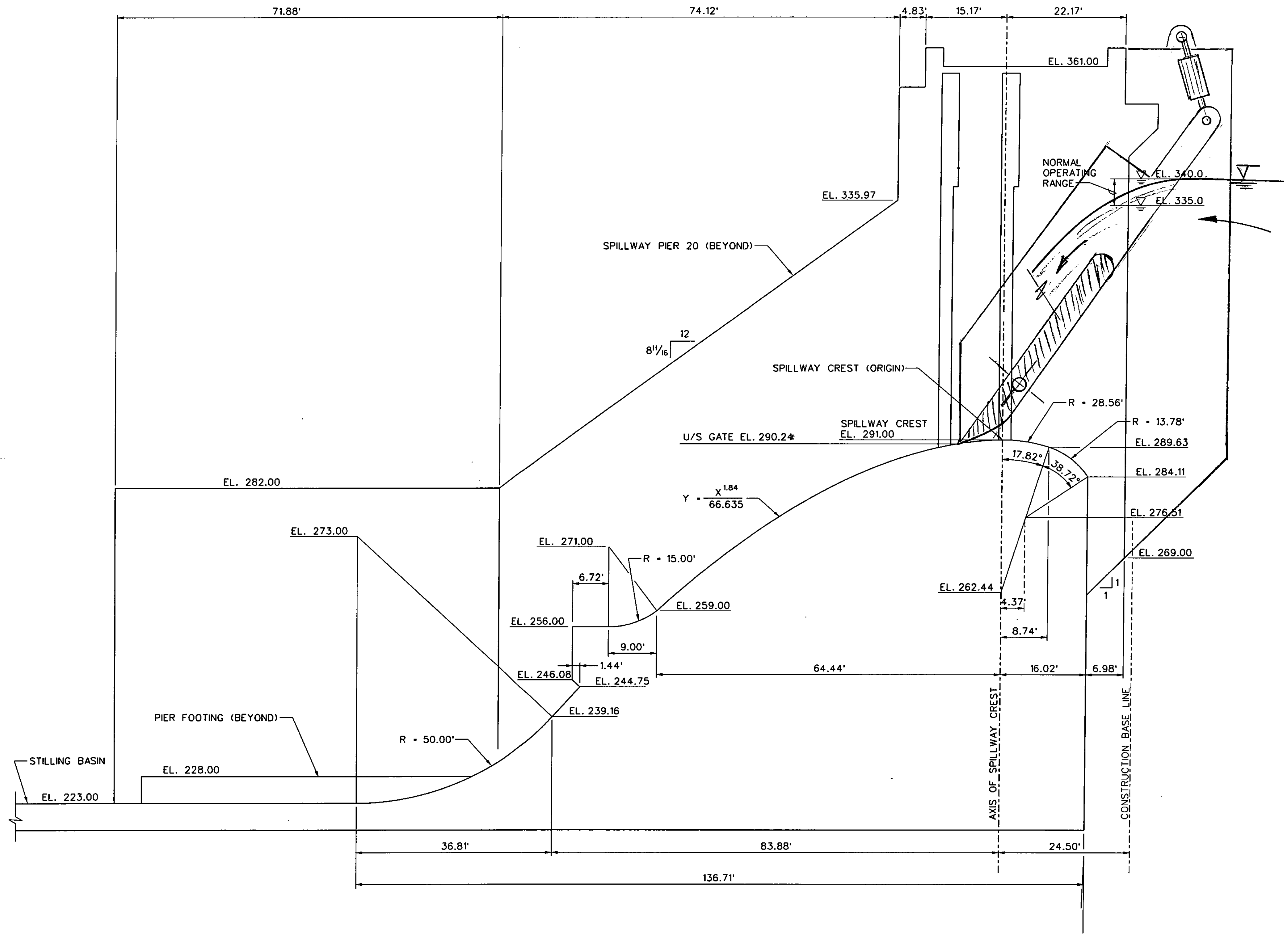

CONCEPT 9B - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: MNA_SPC_C9B_3

MCNARY LOCK AND DAM
COLUMBIA RIVER OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 9B
TRANSVERSE SECTION

Sheet number:
C9B-3

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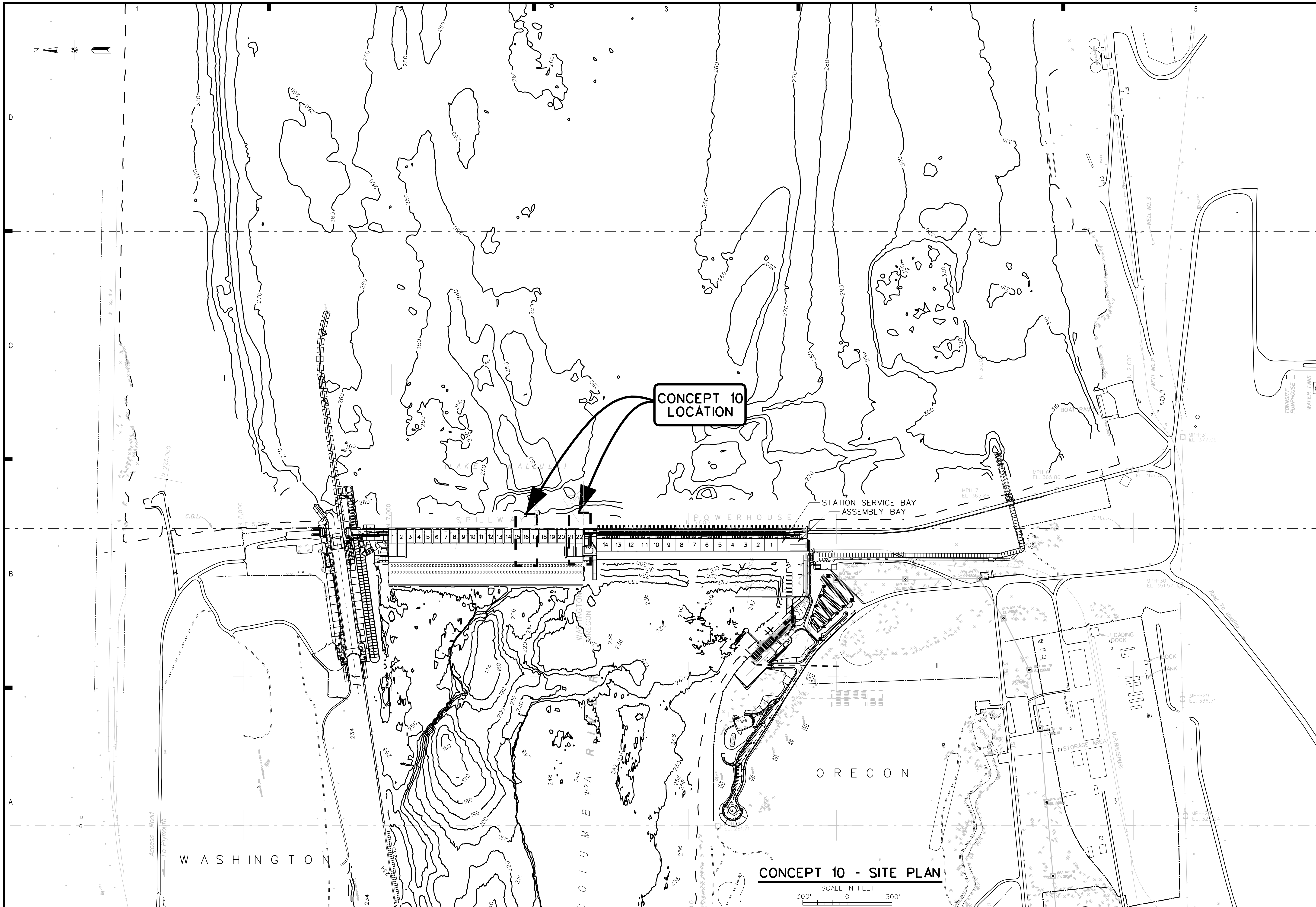

CONCEPT 10 - SITE PLAN

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DATE: 6/29/05
DWN BY: BLP
CHKED BY: N
SOLICITATION NO.: XX-B-XXXX
SUBMITTED BY: N
CONTRACT NO.:
CHIEF DES. SEC.
FILE NO.: MNA_SPC_C10_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 10
SITE PLAN

Sheet number:
C10–1

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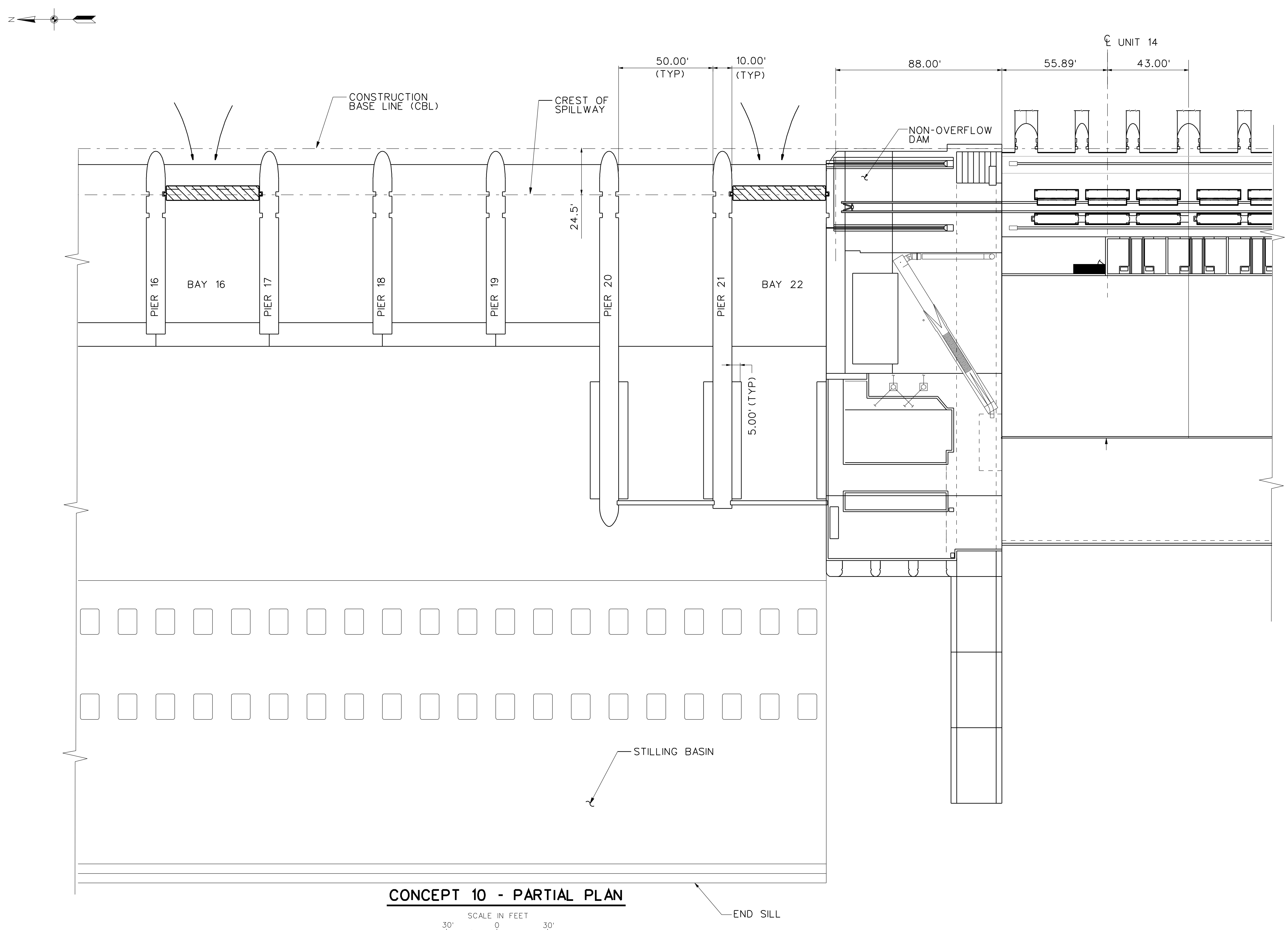

CONCEPT 10 - PARTIAL PLAN

SCALE IN FEET
30' 0 30'

US Army Corps of Engineers
Walla Walla District

DESIGNED BY:	MRV
DWN BY:	BLP
CHKED BY:	N
SUBMITTED BY:	N
DATE:	6/29/05
SOLICITATION NO.	XX-B-XXXX
CONTRACT NO.	
CHIEF, DES. SEC.	
FILE NO.:	MNA_SPC_C10_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 10
PARTIAL PLAN

Sheet number:
C10-2

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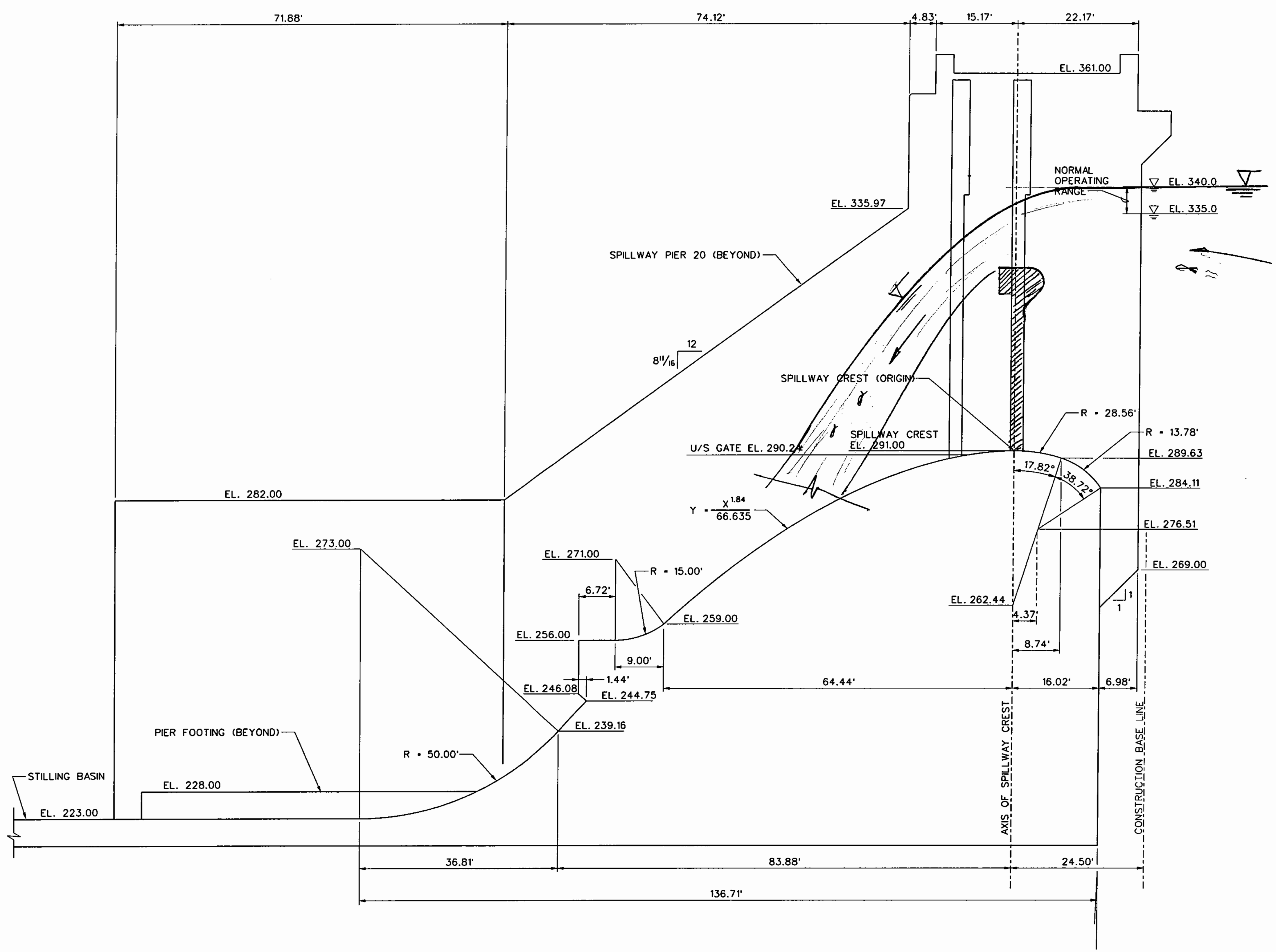

CONCEPT 10 - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: BLP
CHKD BY: N
SUBMITTED BY: N
CHIEF DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO.: MNA_SPC_C10_3

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 10
TRANSVERSE SECTION

Sheet number:
C10-3

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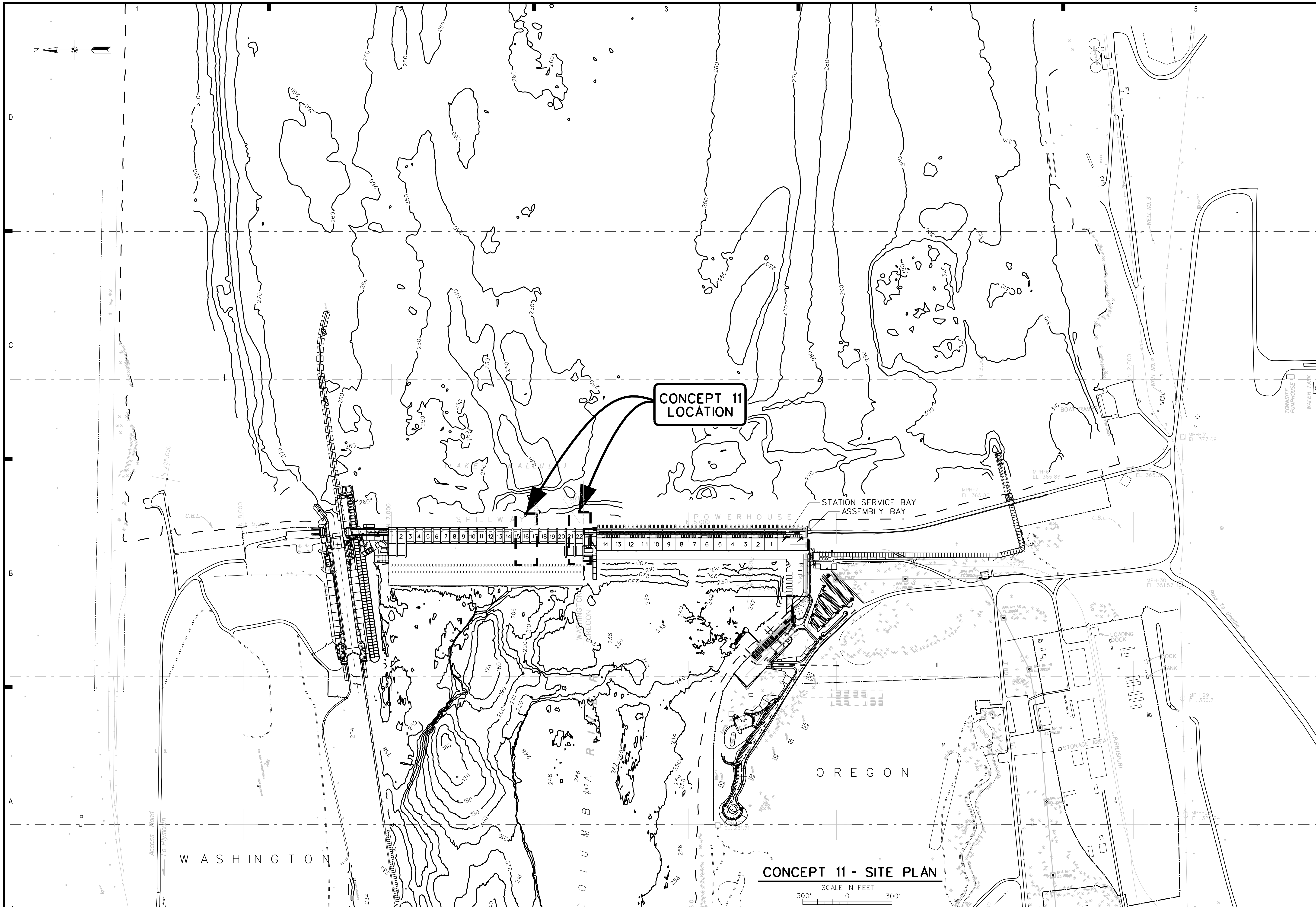

CONCEPT 11 - SITE PLAN

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
DES. SEC.
FILE NO.: MNA_SPC_C11_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 11
SITE PLAN

Sheet number:
C11-1

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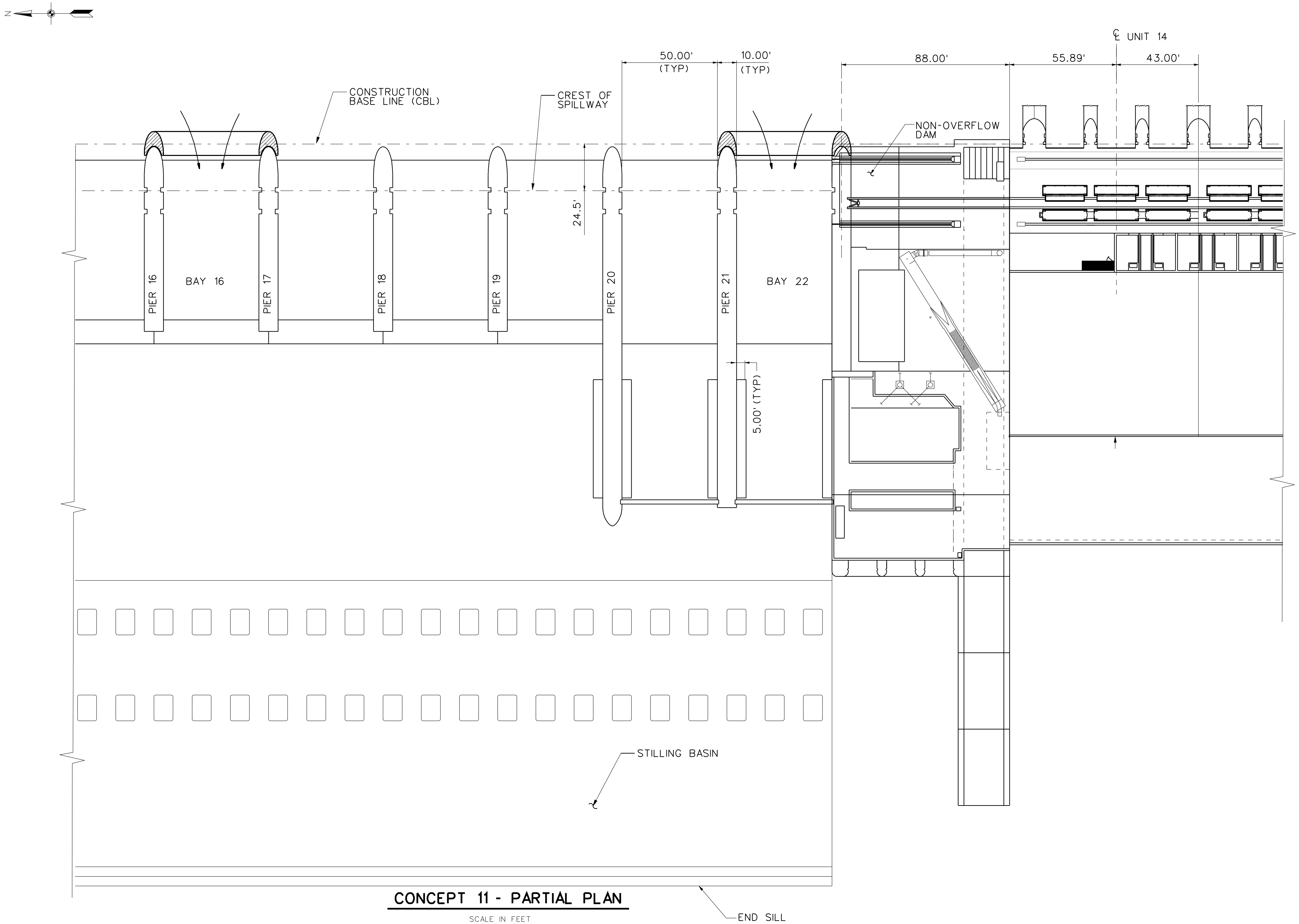

CONCEPT 11 - PARTIAL PLAN

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO.: MNA_SPC_C11_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 11
PARTIAL PLAN

Sheet number:
C11-2

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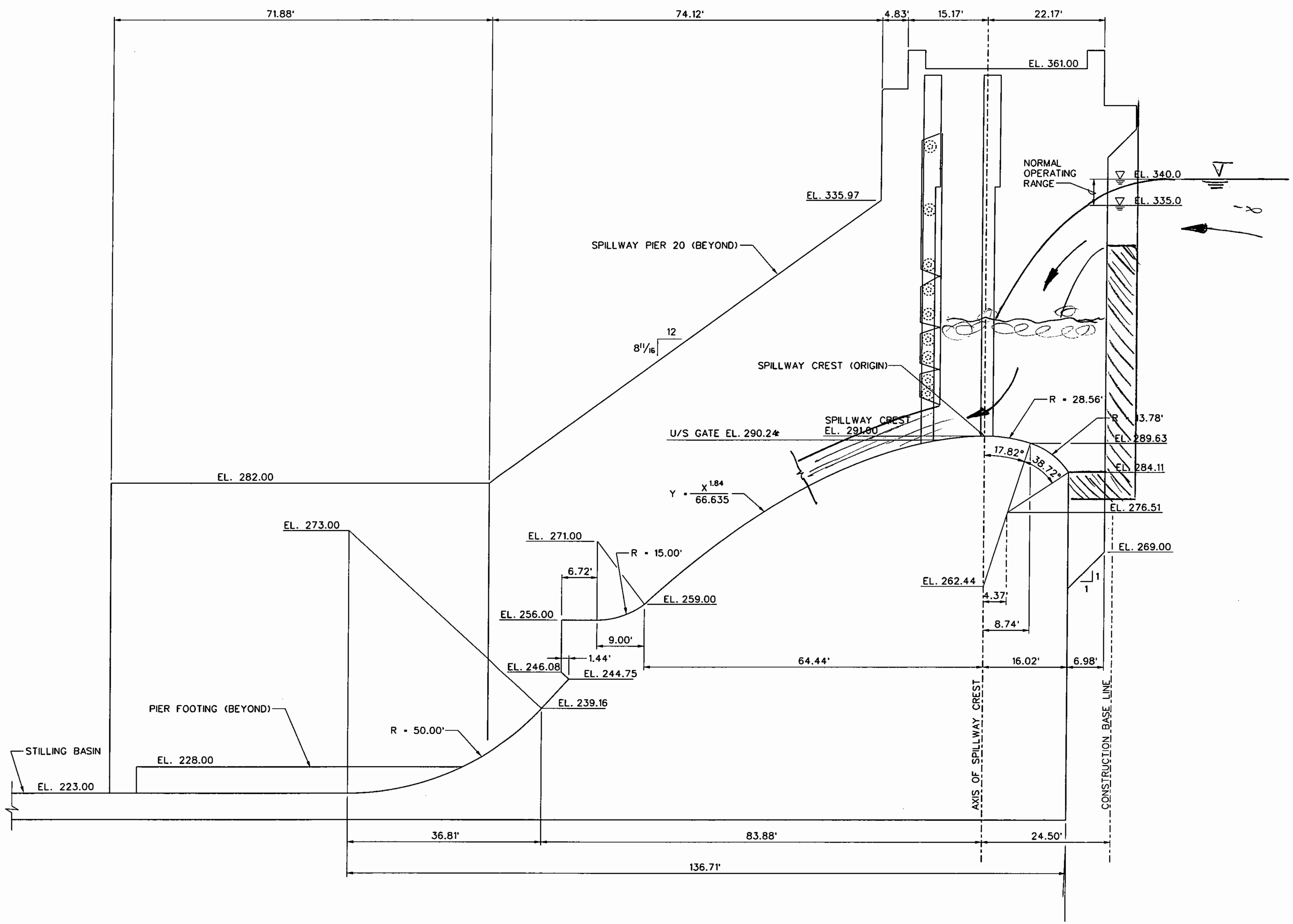

CONCEPT 11 - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DATE: 6/29/05
DWN BY: BLP
CKD BY: N
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.
SUBMITTED BY: N
CHIEF DES. SEC.
FILE NO.: MNA_SPC_C11_3

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 10
TRANSVERSE SECTION

Sheet number:
C11-3

BORDER SIZE IS ANSI D

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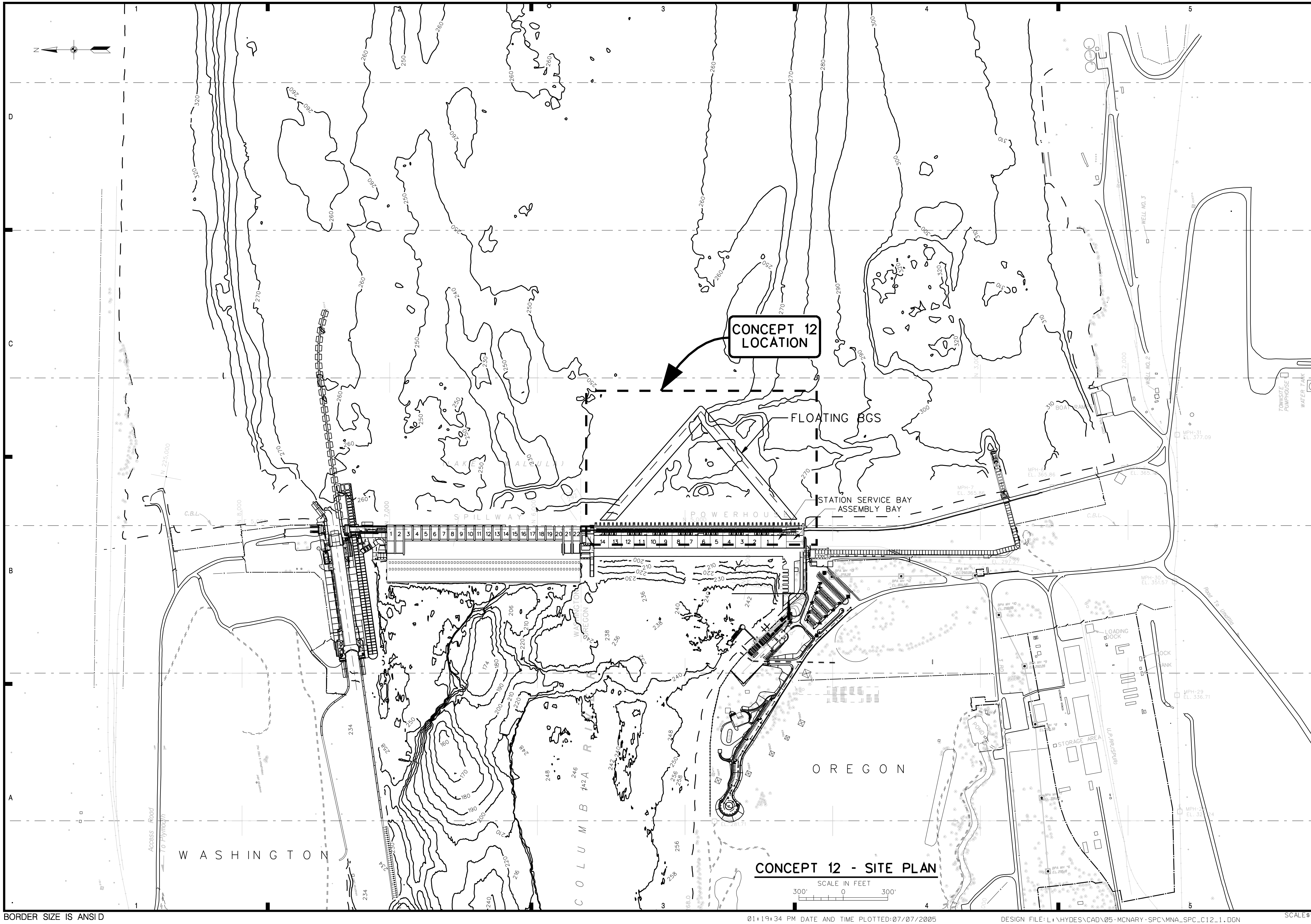

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
CHIEF, DES. SEC.
FILE NO. MNA_SPC_C12_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 12
SITE PLAN

Sheet number:
C12–1

BORDER SIZE IS ANSI D

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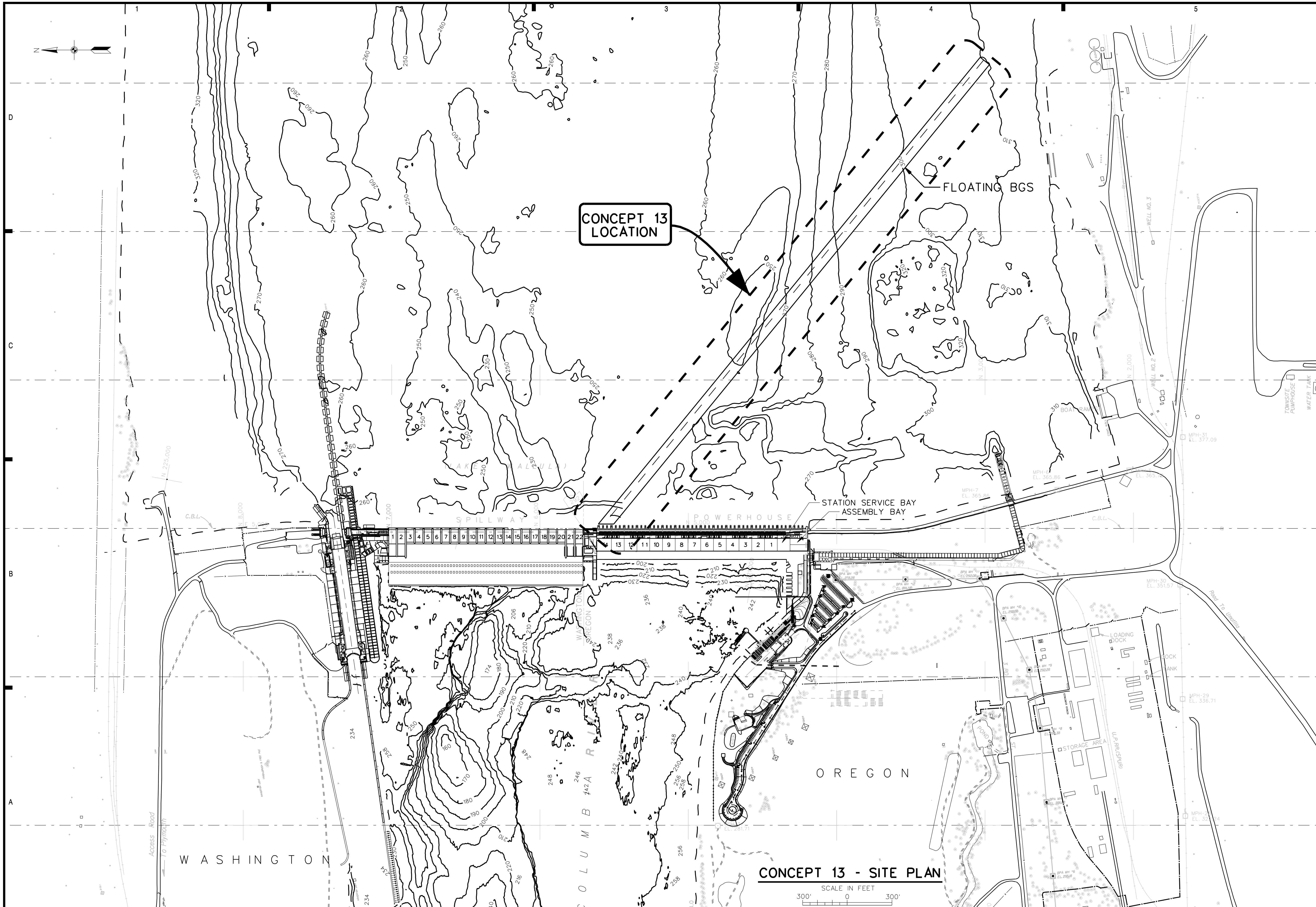

US Army Corps of Engineers
Walla Walla District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF ______ DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO. ________
FILE NO.: MNA_SPC_C13_1

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS

CONCEPT 13
SITE PLAN

Sheet number:
C13-1

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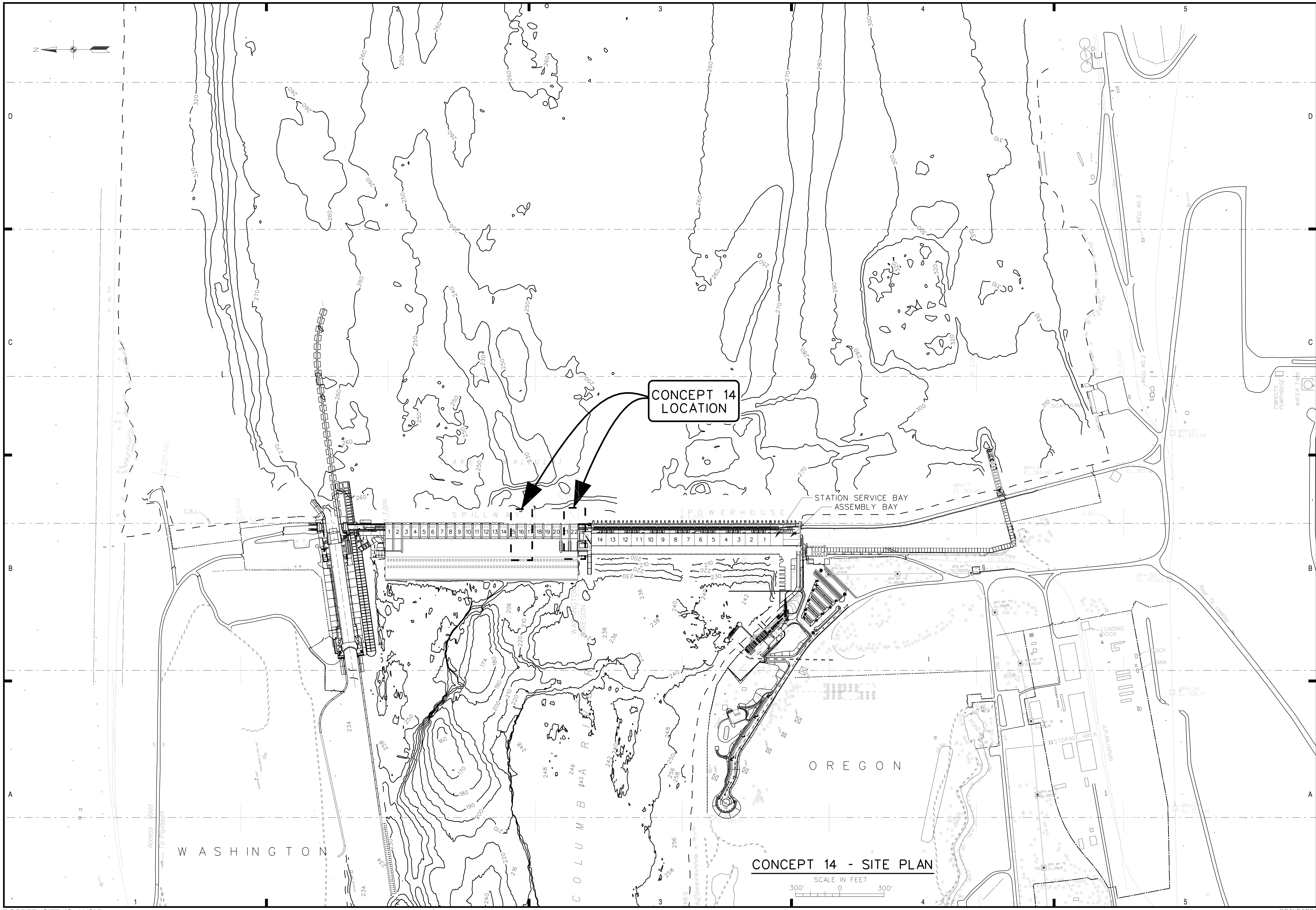

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DATE: 6/29/05
DWN BY: BLP
CHKD BY: N
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
SUBMITTED BY: N
CHIEF, DES. SEC.
FILE NO.: MNA_SPC_C14_1

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS

CONCEPT 14
SITE PLAN

Sheet number:
C14–1

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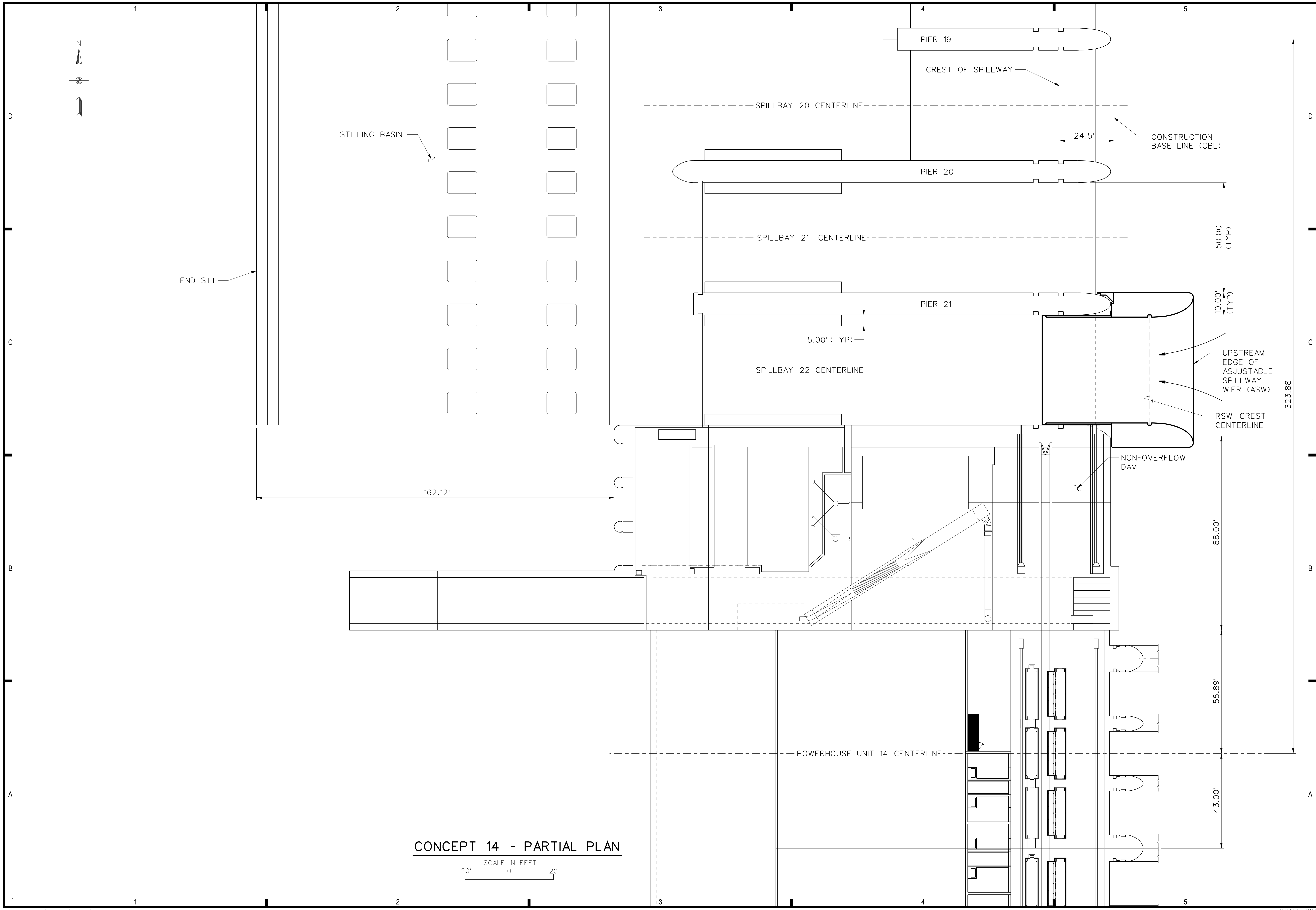

CONCEPT 14 - PARTIAL PLAN

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
CHIEF DES. SEC.
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO. MNA_SPC_C14_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 14
PARTIAL PLAN

Sheet number:
C14-2

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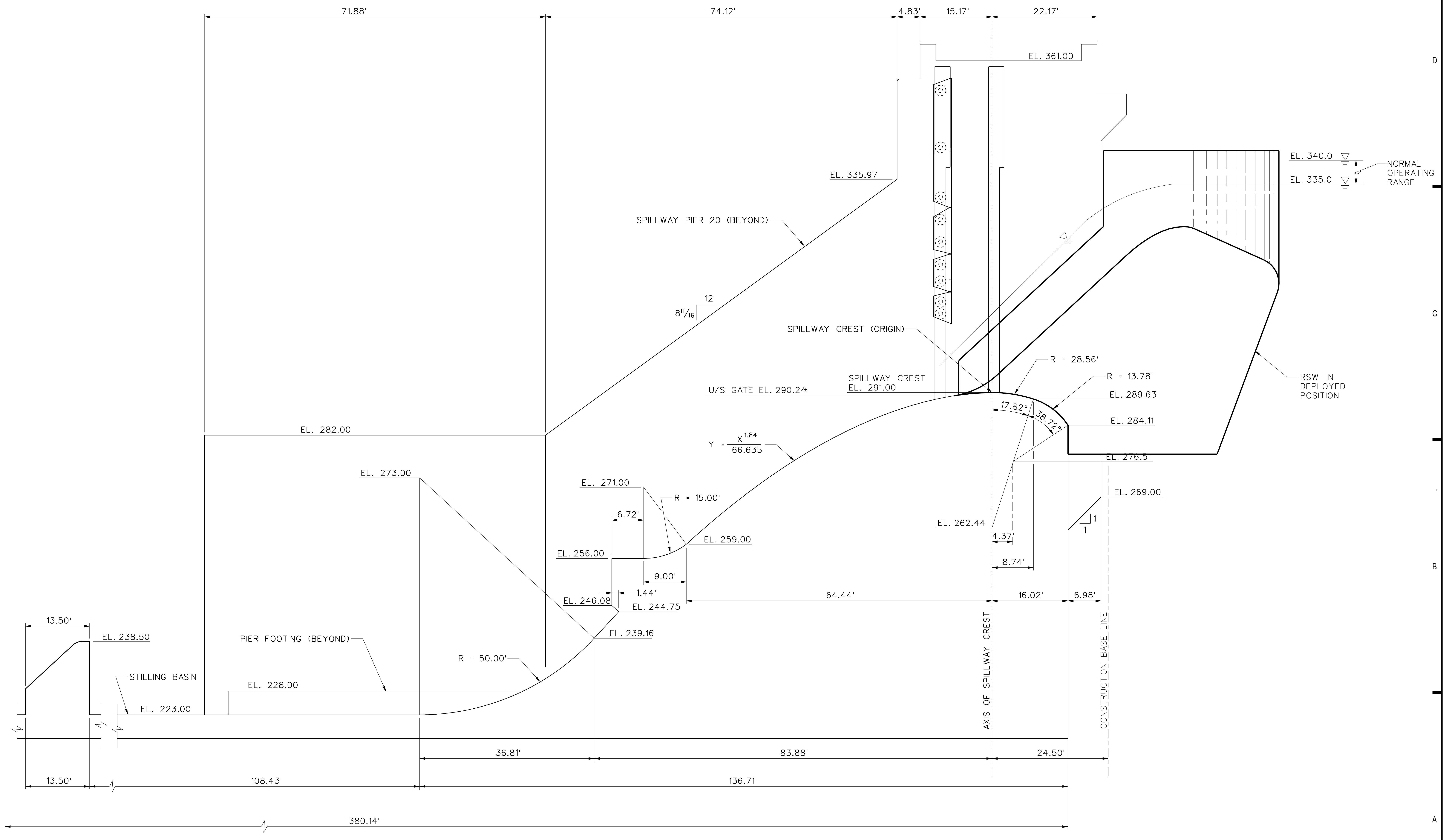

McNARY SPILLWAY BAY 21 - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

Symbol	Description	Date	Appr.

DESIGNED BY: MRV
DATE: 6/29/05
DWN BY: BLP
CHKED BY: N
SOLICITATION NO. XX-B-XXXX
SUBMITTED BY: N
CONTRACT NO.
CHIEF, DES. SEC.
FILE NO. MNA_SPC_C14_3

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 14
TRANSVERSE SECTION

Sheet number:
C14–3

V:\CONSTRUCTION GENERAL\CRFM - MCNARY RSW\ALTERNATIVE BRAINSTORMING WORKSHOP JULY 11, 2005\DRAWINGS\MNA_SPC_C14_3.DGN

BORDER SIZE IS ANSI D

3:20:55 PM DATE AND TIME PLOTTED:7/6/2005

DESIGN FILE:V:\CONSTRUCTION GENERAL\CRFM - MCNARY RSW\ALTERNATIVE BRAINSTORMING WORKSHOP JULY 11, 20

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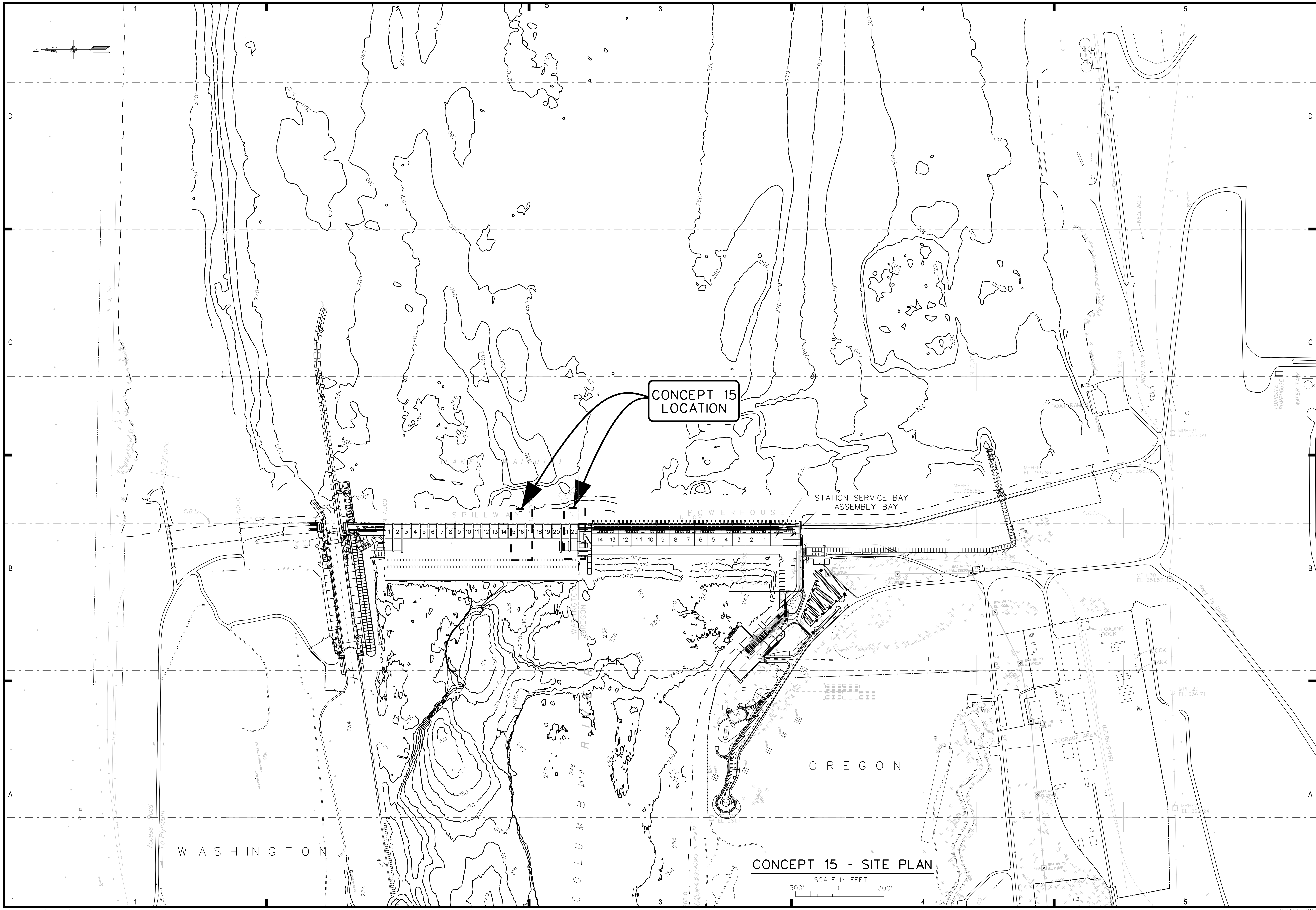

CONCEPT 15 - SITE PLAN

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV	DATE: 6/29/05
DWN BY: BLP	CHKD BY: N
SOLICITATION NO.	XX-B-XXXX
CONTRACT NO.	
SUBMITTED BY:	
FILE NO.	MNA_SPC_C15_1

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS

CONCEPT 15
SITE PLAN

Sheet number:
C15–1

V:\CONSTRUCTION GENERAL\CRFM - MCNARY RSW\ALTERNATIVE BRAINSTORMING WORKSHOP JULY 11, 2005\DRAWINGS\MNA_SPC_C15_1.DGN

BORDER SIZE IS ANSI D

3:22:45 PM DATE AND TIME PLOTTED:7/6/2005

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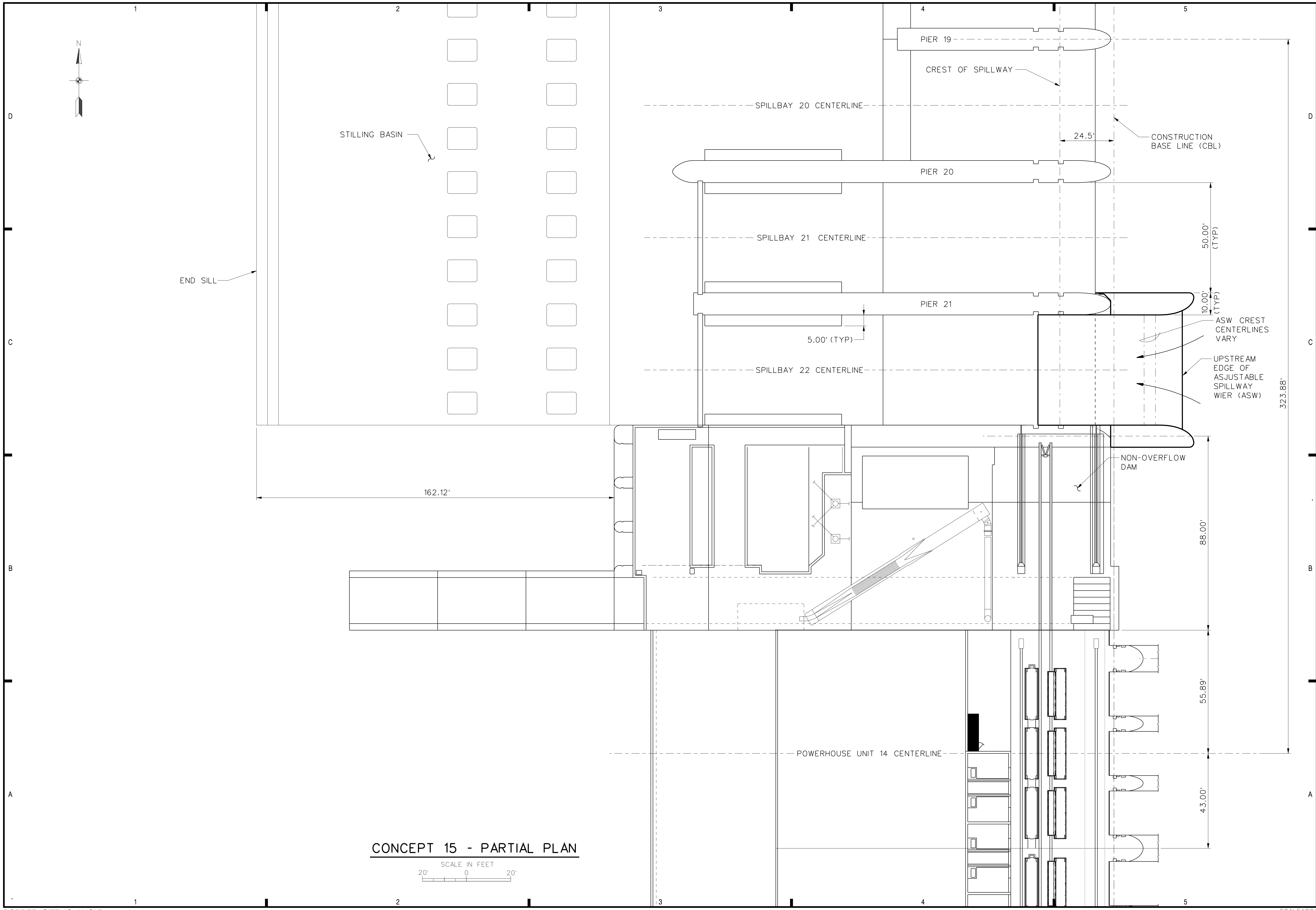


CONCEPT 15 - PARTIAL PLAN

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO.: XX-B-XXXX
CONTRACT NO.:
FILE NO.: MNA_SPC_C15_2

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

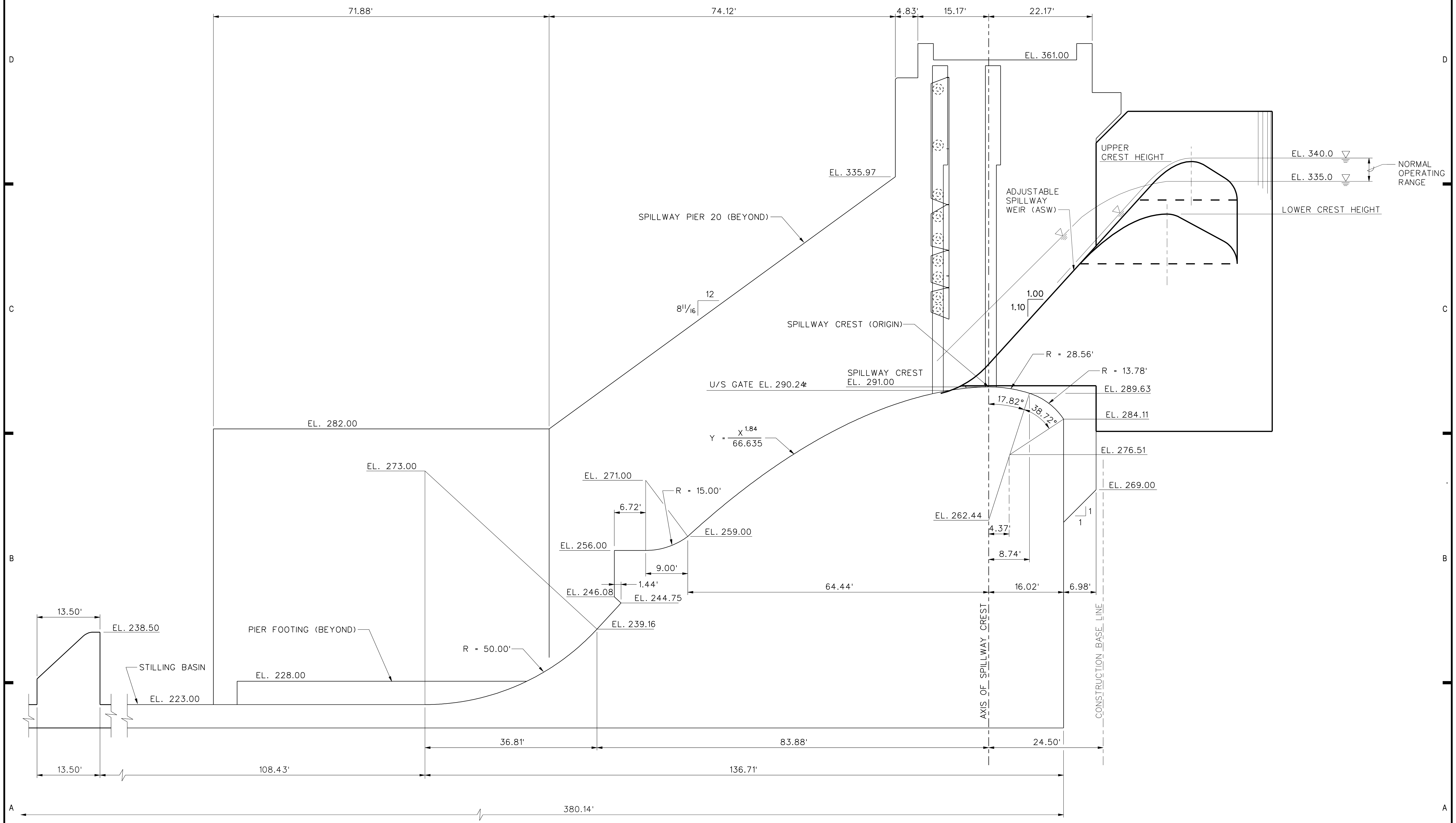
MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 15
PARTIAL PLAN

Sheet number:
C15–2

BORDER SIZE IS ANSI D

3:23:13 PM DATE AND TIME PLOTTED:7/6/2005

DESIGN FILE: V:\CONSTRUCTION GENERAL\CRFM - MCNARY RSW\ALTERNATIVE BRAINSTORMING WORKSHOP - JULY 11, 2005\DRAWINGS\MNA_SPC_C15_2.DGN



McNARY SPILLWAY BAY 21 - TRANSVERSE SECTION

SCALE IN FEET
10' 0 10'

US Army Corps of Engineers
Walla Walla District

DESIGNED BY: MRV
DWN BY: BLP
CHKED BY: N
SUBMITTED BY: N
DATE: 6/29/05
SOLICITATION NO. XX-B-XXXX
CONTRACT NO.
FILE NO. MNA_SPC_C13_3

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
SURFACE PASSAGE CONCEPTS
CONCEPT 15
TRANSVERSE SECTION

Sheet number:
C15–3

BORDER SIZE IS ANSI D

Appendix B
Project Data

McNARY LOCK AND DAM

PERTINENT DATA

1. GENERAL:

Location:
- State.................................... Washington and Oregon
- County............... Benton, Franklin, Walla Walla, and Umatilla
- River... Columbia
- River Mile.. 292.0
- Township.. 5N
- Range.. 28E
- Section... 10
- Latitude.................................... 45° 56′ 09″
- Longitude................................... 119° 17′ 47″

River miles upstream from John Day Dam......................... 76.4
River miles downstream from Ice Harbor Lock and Dam............ 42.7

Owner........... U.S. Army, Corps of Engineers, Walla Walla District

Authorized Purpose.......... Power generation and inland navigation

Other Uses....... Fishery, recreation, irrigation, and water quality

Type of Project.. Run-of-River

Real Estate: Fee acquisition land above pool elevation 340, acres 15,372

2. RESERVOIR:

Name... Lake Wallula 1/

Elevations (feet msl):
- Maximum at dam for spillway design flood.................... 356.5
- Normal operating range.................................. 340-335
- Maximum at dam for standard project flood..................... 340

Length, miles (at normal pool elevation 340).................. 61.6

Length of Shoreline (normal pool, including islands), miles... 242.0
Average width, miles.. 1.0
Maximum width, miles.. 4.6

1/ For the purpose of continuity with existing McNary Lock and Dam documents, the use of the terms "pool" or "reservoir" are used interchangeably. The term "lake" is used to designate a geographical body of water.

2. RESERVOIR (Continued):

Surface area at elevation 340 (low flow, 60,000 cfs), acres.. 38,800

Reservoir Storage for Riverflows, cfs...................... 100,000
Storage below flatpool elevation 340, acre-feet......... 1,350,000
Storage below flatpool elevation 335, acre-feet......... 1,165,000
Storage between elevation 340 and 335, acre-feet.......... 185,000

Drawdown for power, feet.. 5
Height: (normal highpool, elevation 340, to normal tailwater, elevation 265), feet..................... 75

3. LEVEES:

Richland:
Number.. 3
Top width, feet.. 12
Slopes:
Waterside.............................. 1V on 2.5H to 1V on 3H
Landside................................. 1V on 2H to 1V on 3H
Materials.............. Gravel and earth fill with impervious core
Top elevation.................7 to 12 feet above backwater profile for standard project flood

Embankment length, miles.................................. 3.72

Installed pumping capacity, cfs............................. 163

Pasco:
Number.. 6
Top width, feet.. 12
Slopes:
Waterside and landside................................ 1V on 2H
Materials.............. Gravel and earth fill with impervious core
Top elevation................ 8 to 13 feet above backwater profile for standard project flood

Embankment length, miles.................................. 5.38

Installed pumping capacity, cfs............................. 135

Kennewick:
Number.. 8
Top width, feet.. 12
Slopes:
Waterside and landside................................ 1V on 2H
Materials........... Gravel and earth fill with impervious core

3. LEVEES (Continued):

Top elevation............... 6 to 12 feet above backwater profile for standard project flood

Embankment length, miles.................................... 7.68

Installed pumping capacity, cfs............................. 284

4. DAM (GENERAL):

Axis (Lambert).. N10° 33′ 11.8"W
Length and widths (in feet):
Dam total length at crest.................................. 7,365
Spillway overall length.................................... 1,310
Powerhouse overall length.................................. 1,422
Abutments:
North embankment... 1,620
South embankment... 2,495
Nonoverflow areas:
Spillway to powerhouse..................................... 93
Spillway to navigation lock................................ 255
Concrete heights (in feet):
Maximum overall concrete height
(Powerhouse sump deck to deck)............................. 191

Elevations of some features (feet msl):
North and South abutment embankment........................ 365
Intake, spillway bridge, nonoverflow sections.............. 361
Upstream end of navigation lock............................ 348
Downstream end of navigation lock.......................... 342

5. SPILLWAY:

Number of bays... 22
Overall length, feet....................................... 1,310
Deck elevation, feet msl................................... 361
Ogee crest elevation, feet msl............................. 291
Flip lip elevation, feet msl............................... 256

Control gates:
Type................................... Fixed-wheel vertical lift
Remote-controlled gates, number............................ 21
Size (2 split-leaf sections):
Top, feet.................................... 50′W x 27.25′H
Bottom, feet................................. 50′W x 24.55′H
Combined, feet............................... 50′W x 51.80′H

Gantry cranes (joint use with powerhouse):
Number of cranes... 2
Capacity, tons... 200

5. SPILLWAY (Continued):

Stilling Basin:
Stilling basin, type.......................... Horizontal Baffle
Stilling basin length, feet.............................. 248.05
Stilling basin elevation, feet msl........................ 228

Maximum design capacity at elevation 356.5, cfs........... 2,200,000
Maximum spillway capacity at elevation 340, cfs........... 1,368,000

6. POWERHOUSE:

Length overall, feet.................................... 1,422

Spacing, feet:
Units (1 through 14).................................... 86
Erection and service bay................................ 86

Width overall, transverse section, feet..................... 248
Intake deck elevation, feet msl............................. 361
Tailrace deck elevation, feet msl........................... 287
Maximum height (draft tube invert to intake deck), feet......... 191

Turbines:
Type....................... Kaplan, automatic adjustable, 6-blade
Runner diameter, inches..................................... 280
Revolutions per minute..................................... 85.7
Rating horsepower.. 111,300
Distributor centerline elevation.......................... 239.5

Generators:
Rating (nameplates), kilowatts............................ 70,000
Power factor.. 0.95
Kilovolt ampere rating.................................... 73,684
Units installed complete initially.......................... 14
Total units now installed................................... 14
Plant capacity, nameplate rating, megawatts (14 @ 70 MW)........ 980
Overload capacity, megawatts (14 @ 80.5 MW)................... 1,127
Station service units, megawatts (2 @ 3 MW)...................... 6
Hydraulic capacity, cfs................................... 232,000

Crane capacities, tons:
Intake (joint use with spillway)............................ 140
Tailrace gantry, 2 - capacity in tons........................ 30
Bridge crane, 2 - capacity in tons.......................... 350

7. NAVIGATION LOCK AND CHANNELS:

Type.. Single lift
Net clear length, lock chamber, feet......................... 675
Net clear width, lock chamber, feet........................... 86

7. NAVIGATION LOCK AND CHANNELS (Continued):

Upstream gate:
Type.. Miter
Height, feet.. 24

Downstream gate:
Type.. Miter
Height, feet.. 106

Operating water surface elevations in chamber, feet msl..... 257-340
Maximum operating lock lift, feet (forebay elevation 340 and tailwater elevation 257).................................... 83

Length of guidewalls (from face of gate), feet:
Upstream (floating).................................... 1,417
Downstream.. 1,520

Downstream approach channel:
Minimum width, feet.. 250
Moorage dock, feet.................................. 870 X 16.5

Downstream sill:
Sill elevation, feet msl.................................... 236
Depth over sill at tailwater elevation 265, feet............... 29
Depth over sill at tailwater elevation 257, feet............... 21

Upstream sill:
Sill elevation, feet msl.................................... 320
Depth over sill at forebay elevation 340, feet................. 20
Depth over sill at forebay elevation 335, feet................. 15

8. LEFT ABUTMENT:

Material.......................... Impervious core with rock shells
Length (not including upstream blanket), feet................. 2,495
Height of maximum section.................................... 103
Embankment elevation, feet msl................................ 365
Embankment top width, feet...................... Variable, 30 to 50
Slope, upstream.. 1V on 1.5H
Slope, downstream............... Variable, 1V on 1.3H to 1V on 1.5H
Freeboard over maximum pool (elevation 356.5), feet............. 8.5
Freeboard over normal pool (elevation 340), feet................ 25

9. RIGHT ABUTMENT:

Material.......................... Impervious core with rock shells
Length, feet.. 1,620
Height of maximum section.................................... 110
Embankment elevation, feet msl................................ 365
Slope, upstream.. 1V on 1.5H
Slope, downstream.. 1V on 2H

9. RIGHT ABUTMENT (Continued):

Freeboard over maximum pool (elevation 356.5), feet............. 8.5
Freeboard over normal pool (elevation 340), feet................. 25

10. FISH FACILITIES:

Upstream Migrants - Adult Fish Ladder:
Number of fish ladders.. 2
Slope.. 1V on 20H
Ladder clear width, feet.. 30
North shore ladder design capacity, cfs..................... 180
South shore ladder design capacity, cfs..................... 210

Operating elevations (Washington & Oregon):
Design range:
Pool elevations, feet msl......................... 335 to 340
Tailwater elevations, feet msl................... 257 to 275
Riverflow, cfs............................ 12,500 to 510,000

Maximum operating range:
Pool elevations, feet msl......................... 334 to 341
Tailwater elevations, feet msl.................. 257 to 279 ±
Riverflow, cfs............................ 12,500 to 800,000

Fishway system attraction water:
Powerhouse collection system, pumps....................... 3
South shore.................... Gravity & Diffusion Chambers
North shore.................... Gravity & Diffusion Chambers

Downstream Migrant - Juvenile Bypass System:
Design pool range, feet msl.......................... 340 to 335
Design capacity, cfs.................................. 200 to 250
Submersible traveling fish screens.......................... 42
Vertical barrier fish screens............................... 42
Gatewell orifices from bulkhead:
Number... 84
Size (diameter in inches)................................. 12
Juvenile collection channel................................. 1
Juvenile transportation pipe................................ 1

Juvenile Holdling and Sampling Facility........................ 1
Water supply pipe.. 1

Juvenile transportation facilities:
Truck loading facility....................................... 1
Barge loading facility....................................... 1

II. <u>HYDROLOGIC DATA</u> (based on streamflow data for McNary Reservoir inflow):

Drainage area, square miles.................................. 214,000
Period of record (14 years).................... Oct 1973 - Sep 1986
Average annual regulated inflow volume, acre-feet.......128,100,000

Discharges in cubic feet per second:
Mean daily maximum of record, 21 June 1974, cfs.......... 580,400*
Average annual flow, cfs................................. 176,800*
Average annual maximum mean daily flow, cfs.............. 361,000*
Average annual minimum mean daily flow, cfs............... 68,400*

Note: * Reflects regulation by Libby, Dworshak, and other existing projects since 1973.

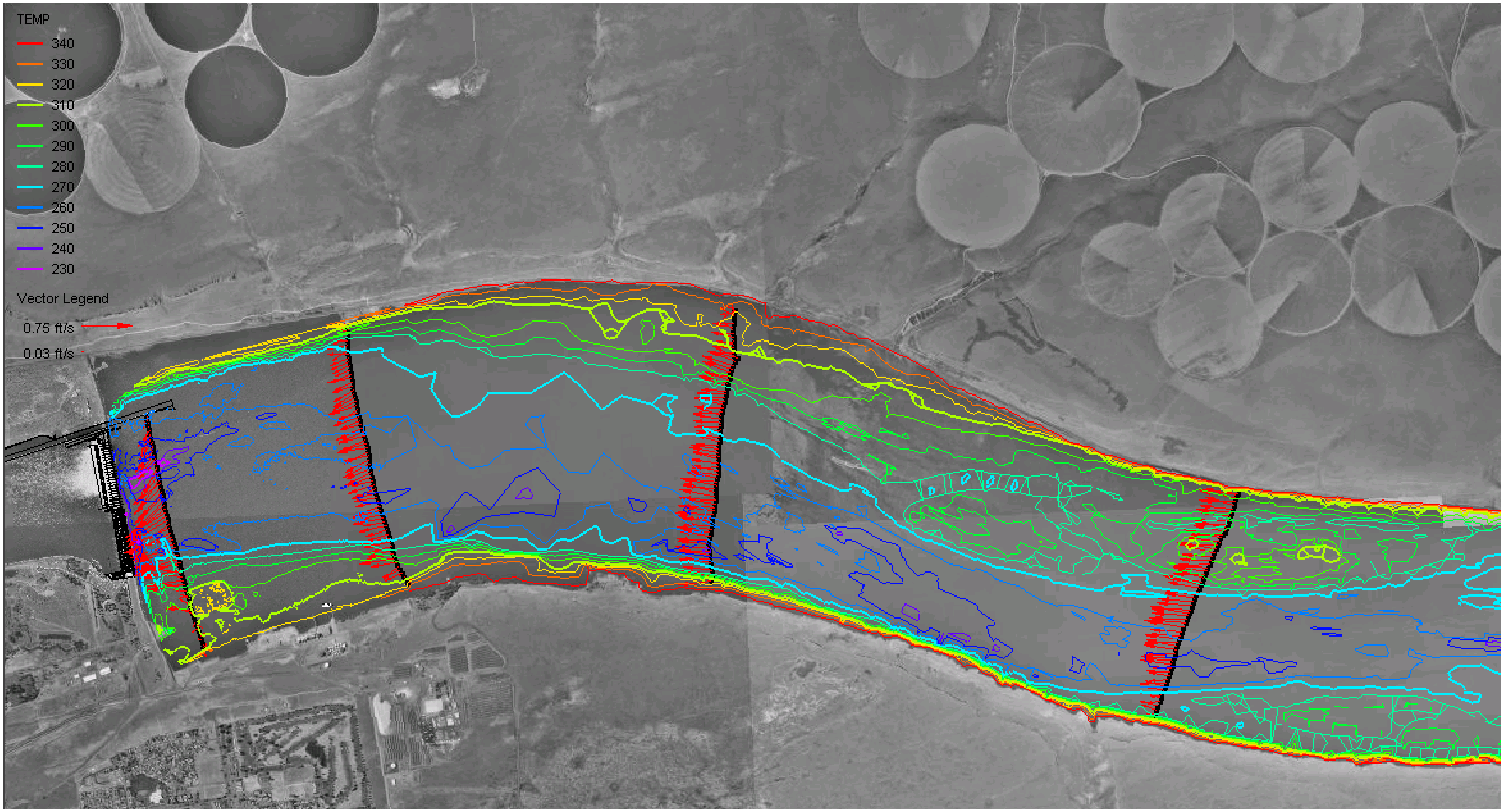
Extreme outside period of record:
Flood of June 1894 (Columbia R. at The Dalles), cfs.... 1,240,000
Flood of June 1894,
controlled by existing projects, cfs................... 668,000

Probable maximum flood (1969 computation regulated by existing system at The Dalles).................................. 2,060,000
Standard project flood (controlled by existing projects):
Columbia River below Priest Rapids, cfs.................. 540,000
Columbia River above Snake River, cfs.................... 570,000
Columbia River at McNary Dam, cfs........................ ~~810,000~~ 831,000 ←

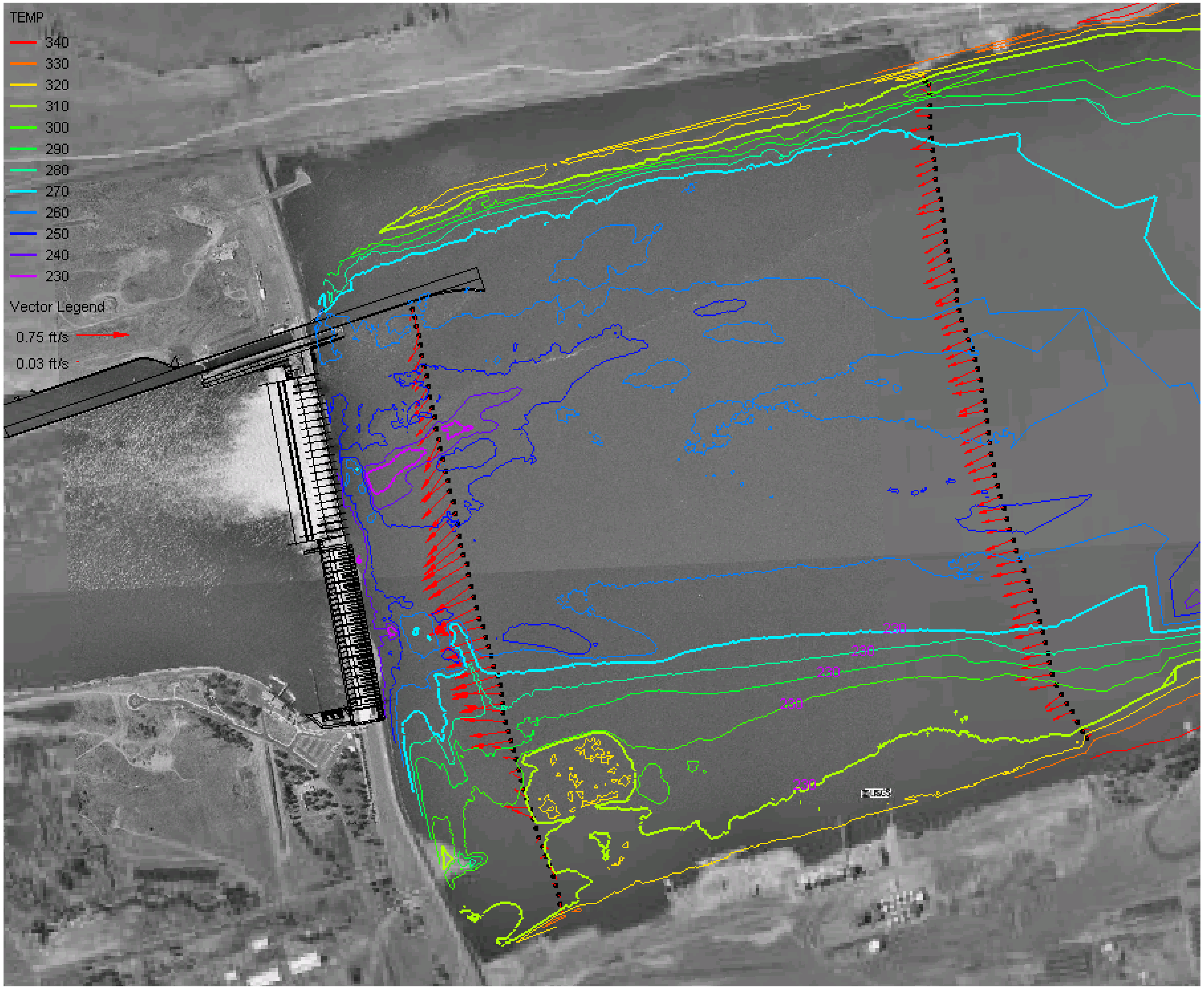
Spillway design flood, cfs............................. 2,200,000

Major Reservoir Tributaries:
Walla Walla River (mouth at RM)............................ 313.9
Snake River (mouth at RM).................................. 324.2
Yakima River (mouth at RM)................................. 335.2

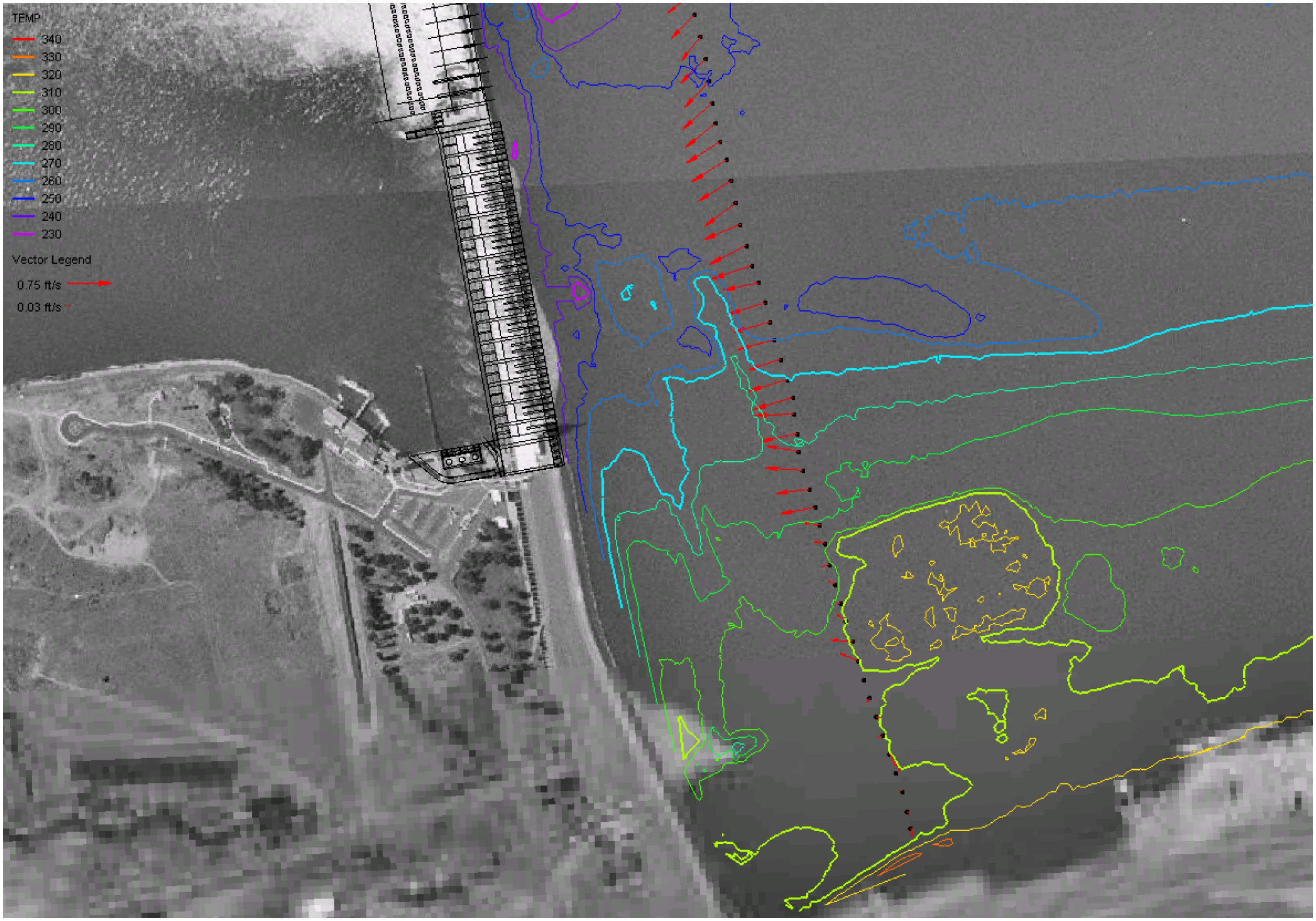
Appendix C
Hydraulic Information



Depth Averaged Velocities in the Columbia River upstream of McNary Dam



Depth Averaged Velocities in the Columbia River upstream of McNary Dam



Depth Averaged Velocities in the Columbia River upstream of McNary Dam

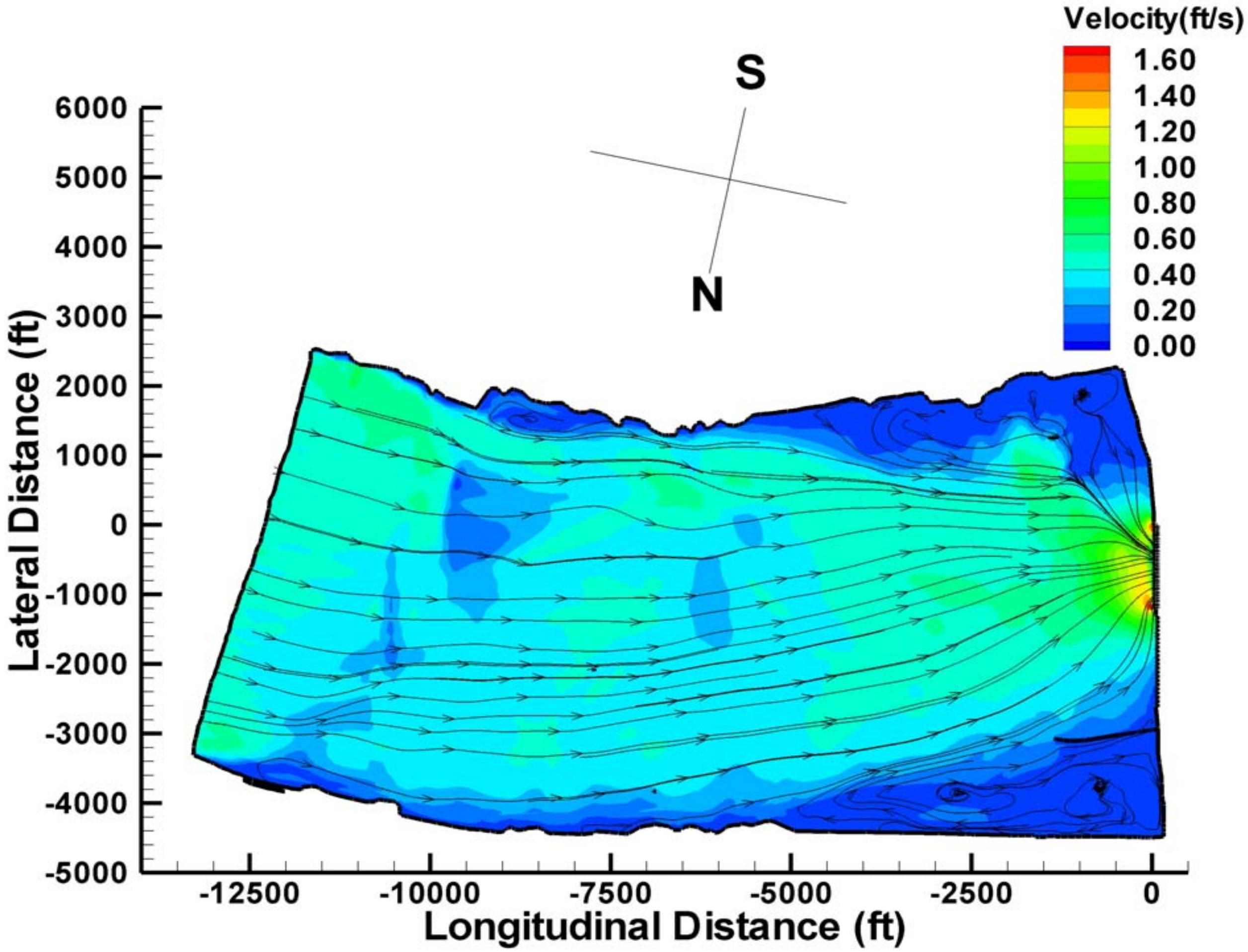


Figure 35: Contours of the predicted in plane velocity magnitudes and streamlines in a plane situated at z=100.4 ft (Case_1: with no spill) *(Insert by USCOE -155 kcfs total river with approximately 11 kcfs in each of the 14 units and z of 100.4 represents water surface)*

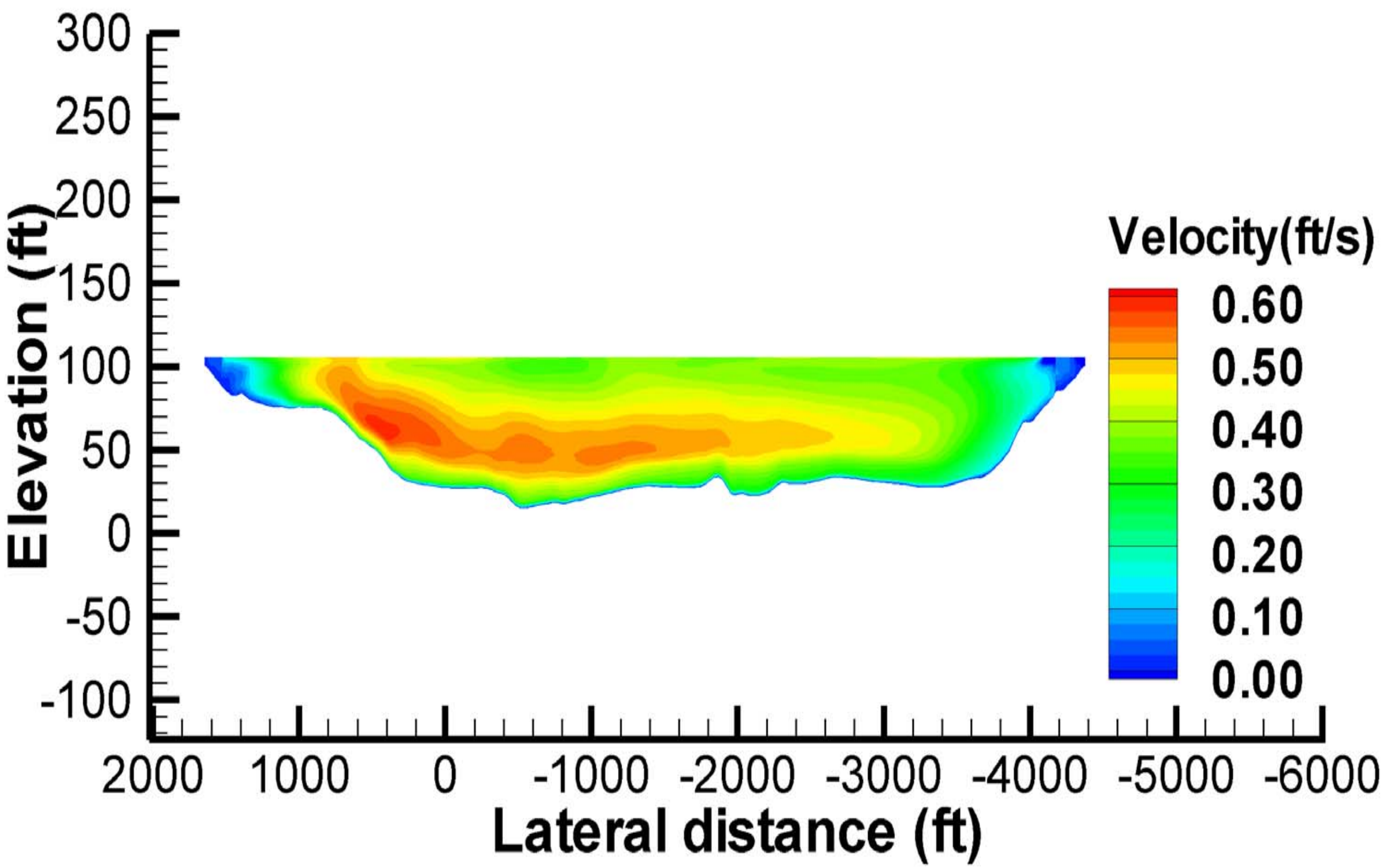


Figure 35-A: X-section at 5000 ft upstream of the Dam in the forebay showing the normal velocity contours for validation Case 1 (Total River Q=155 kcfs, no spill condition).

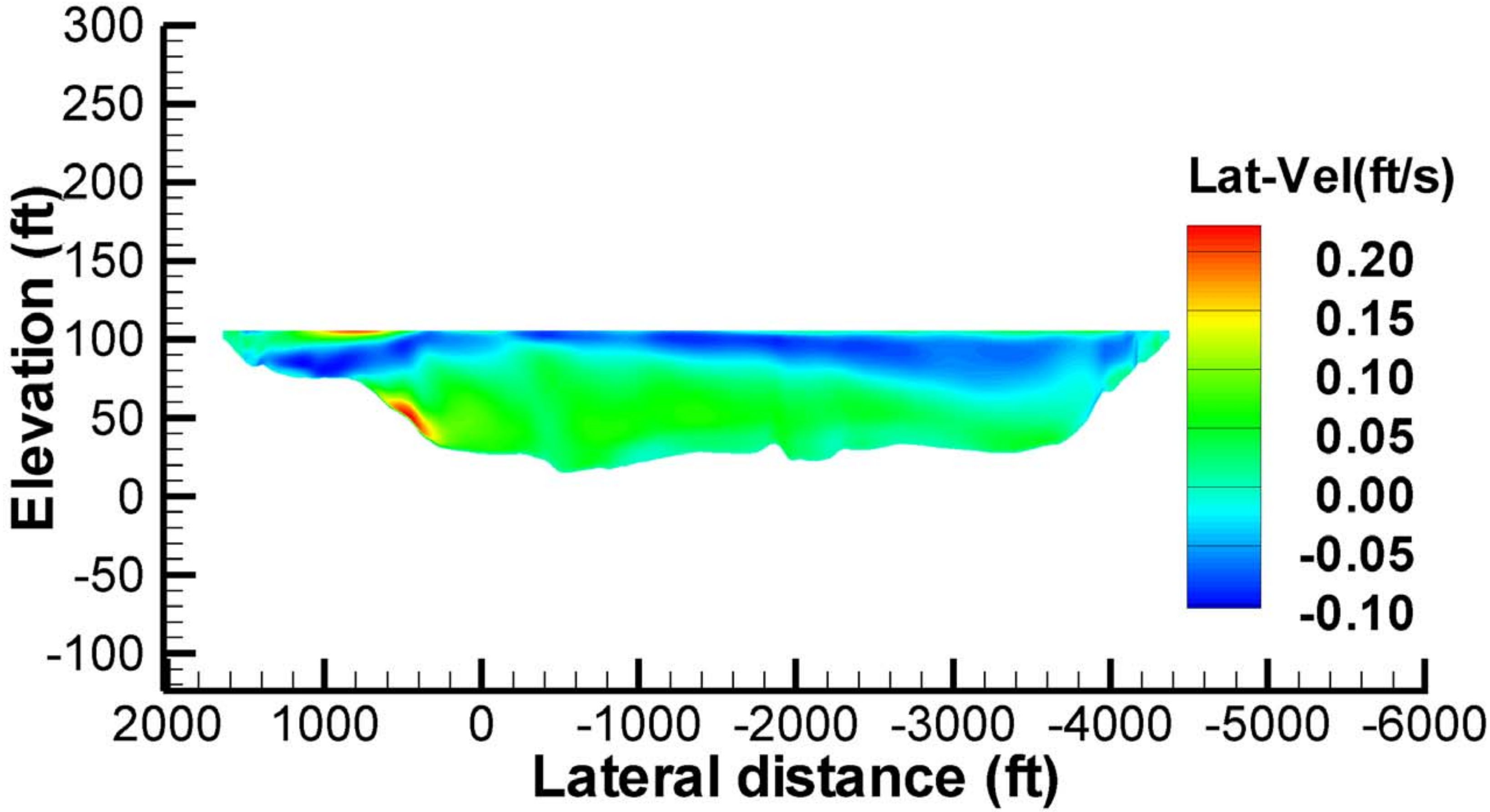


Figure 35-B: X-section at 5000 ft upstream of the Dam in the forebay showing the lateral velocity contours for validation Case 1 (Total River Q=155 kcfs, no spill condition).

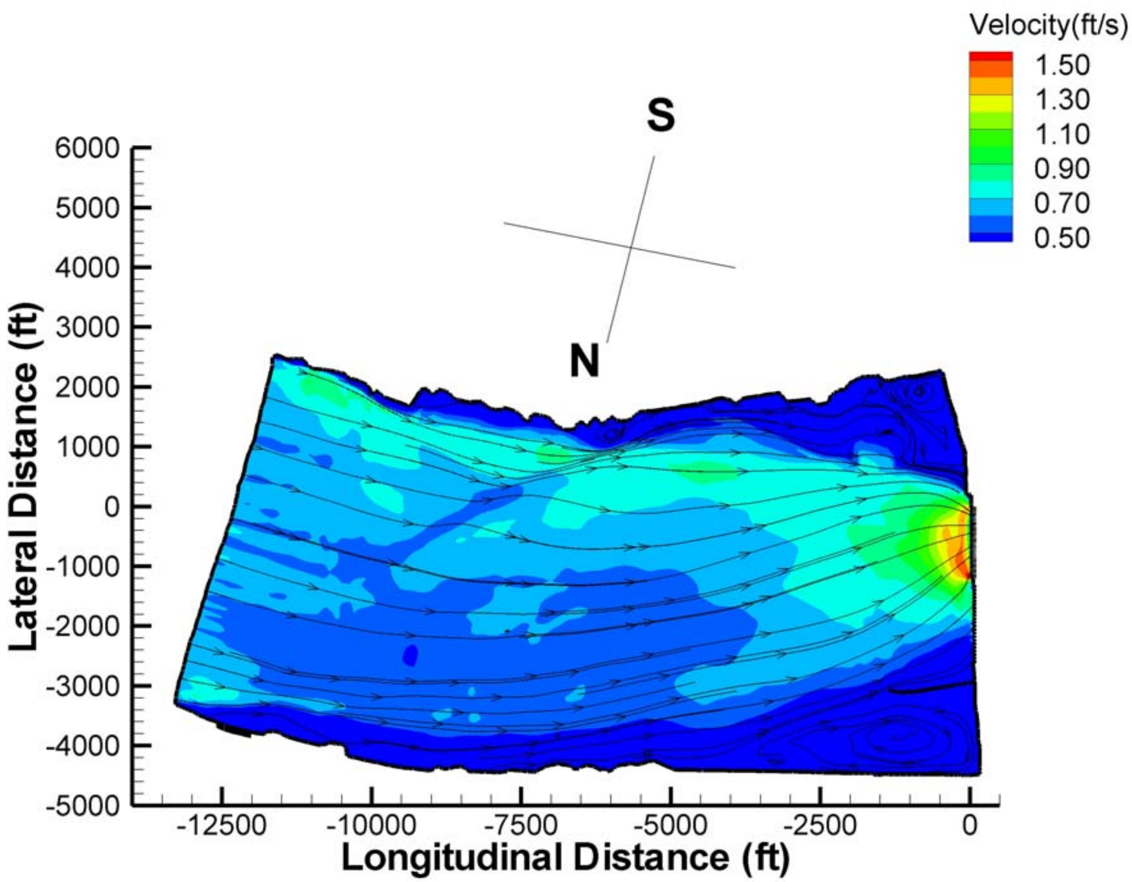


Figure 47: Contours of the predicted in plane velocity magnitudes and streamlines in a plane situated at z=100.4 ft (Case_2: with spill, June 30, 2004) *(Insert by USCOE –217.3 kcfs total river with approximately 12 kcfs in each of the 14 units for 167.5 PH flow and 49.8 kcfs spillway with bay 5@2 kcfs and bays 7, 9, 11, and 13-21 @ approximately 4 kcfs each and z of 100.4 represents water surface)*

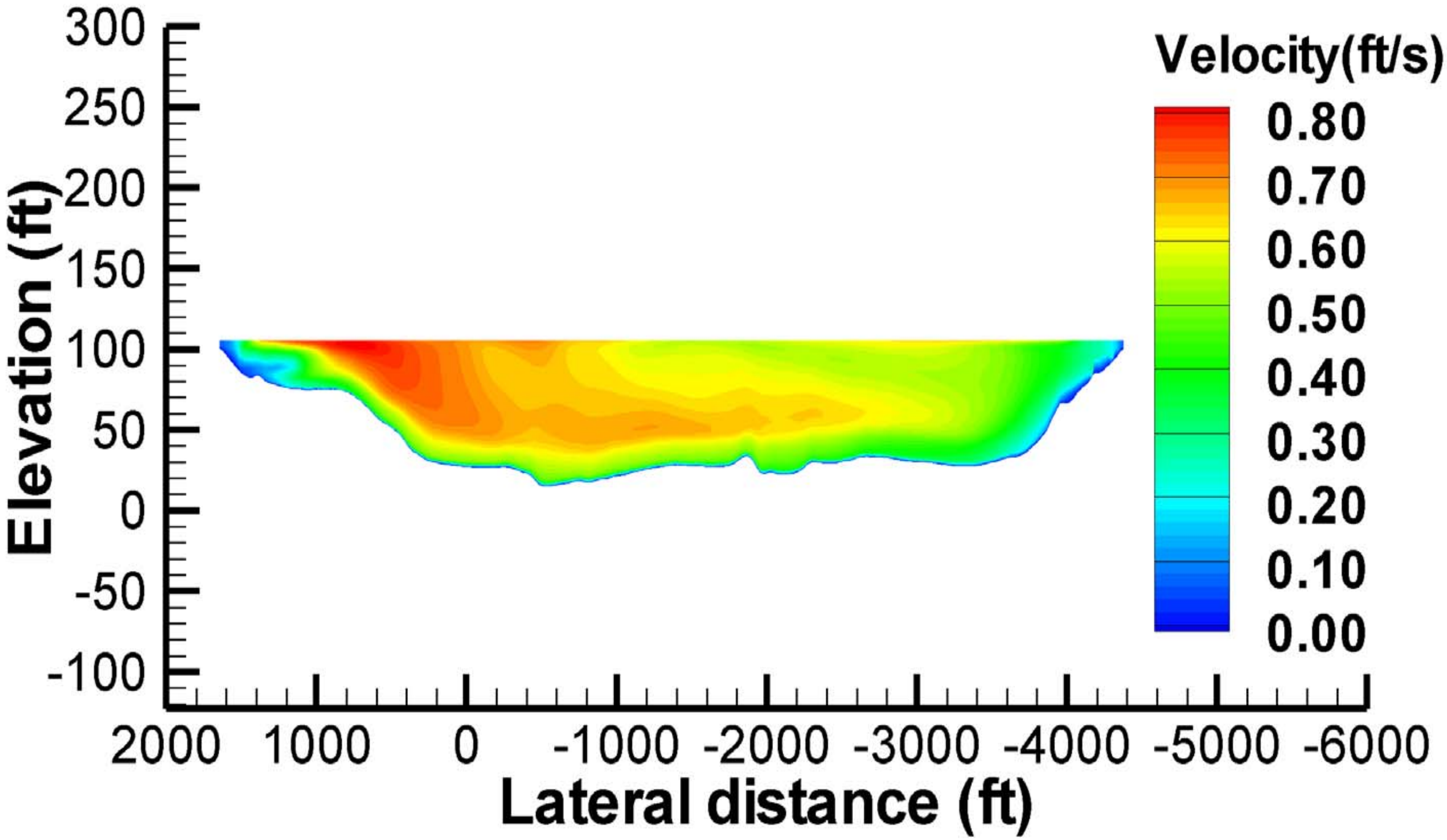


Figure 47-A: X-section at 5000 ft upstream of the Dam in the forebay showing the normal velocity contours for validation Case 2 (Total River Q=217.3 kcfs, with spill condition).

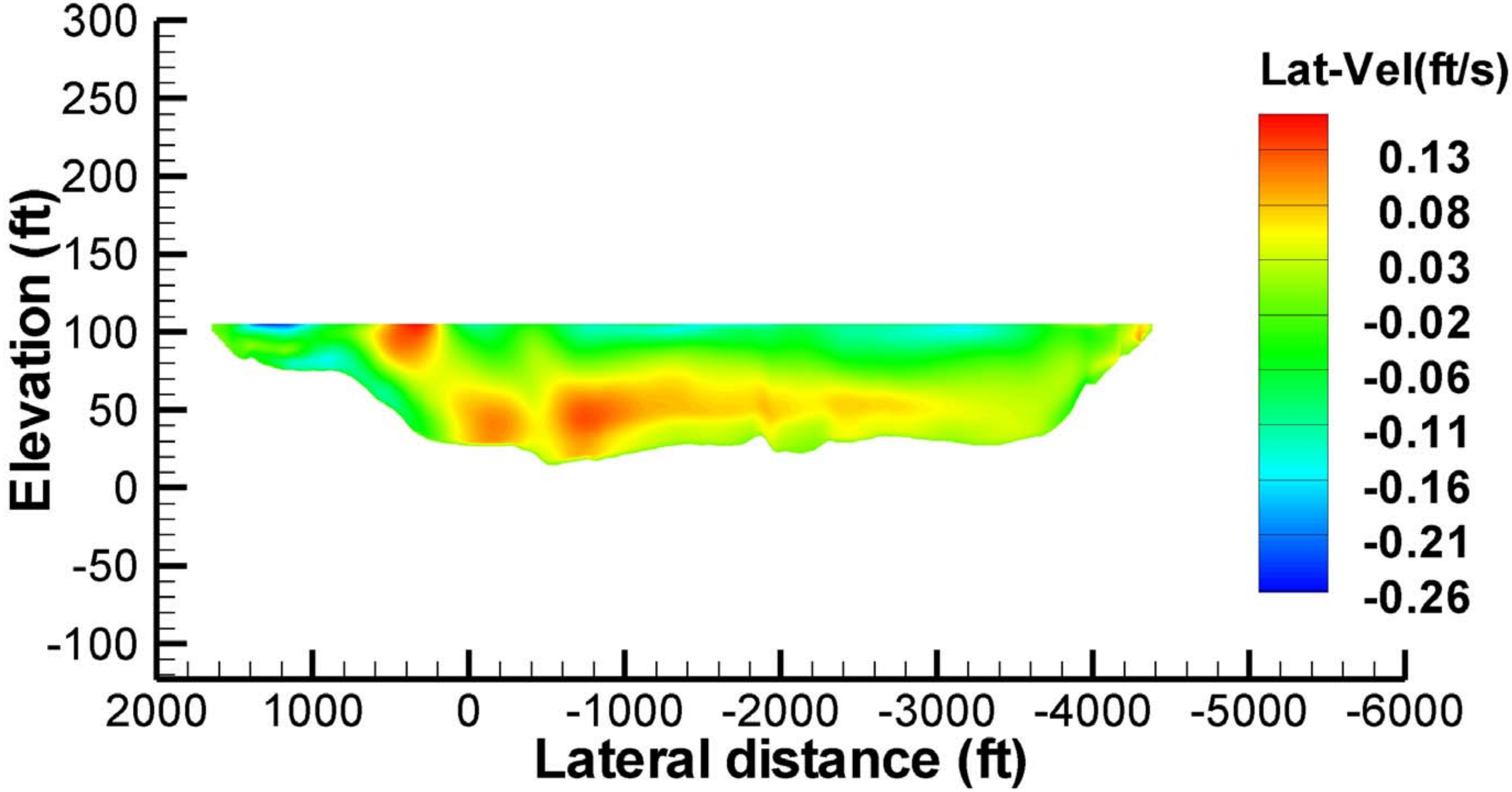


Figure 47-B: X-section at 5000 ft upstream of the Dam in the forebay showing the lateral velocity contours for validation Case 2 (Total River Q=217.3 kcfs, with spill condition).

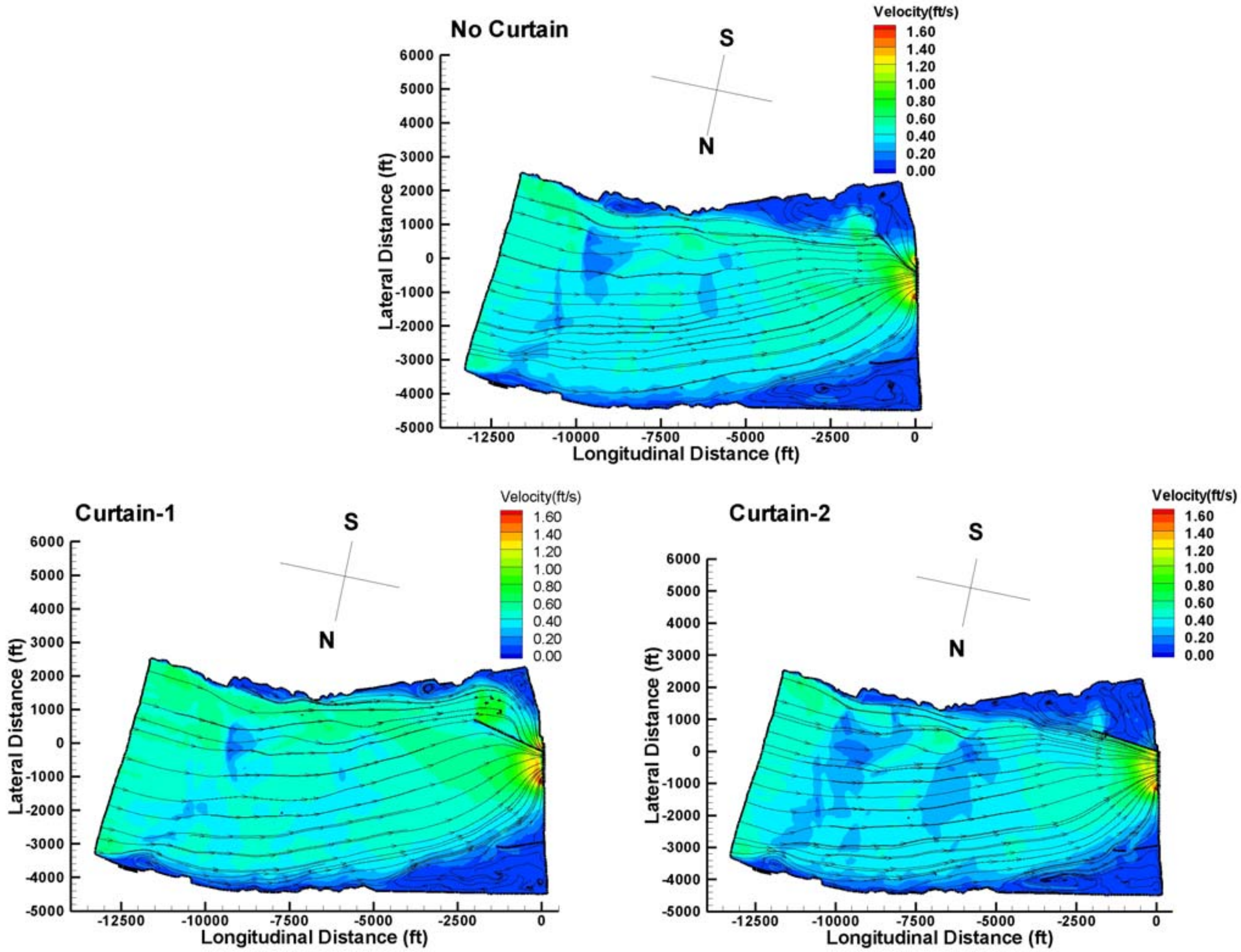
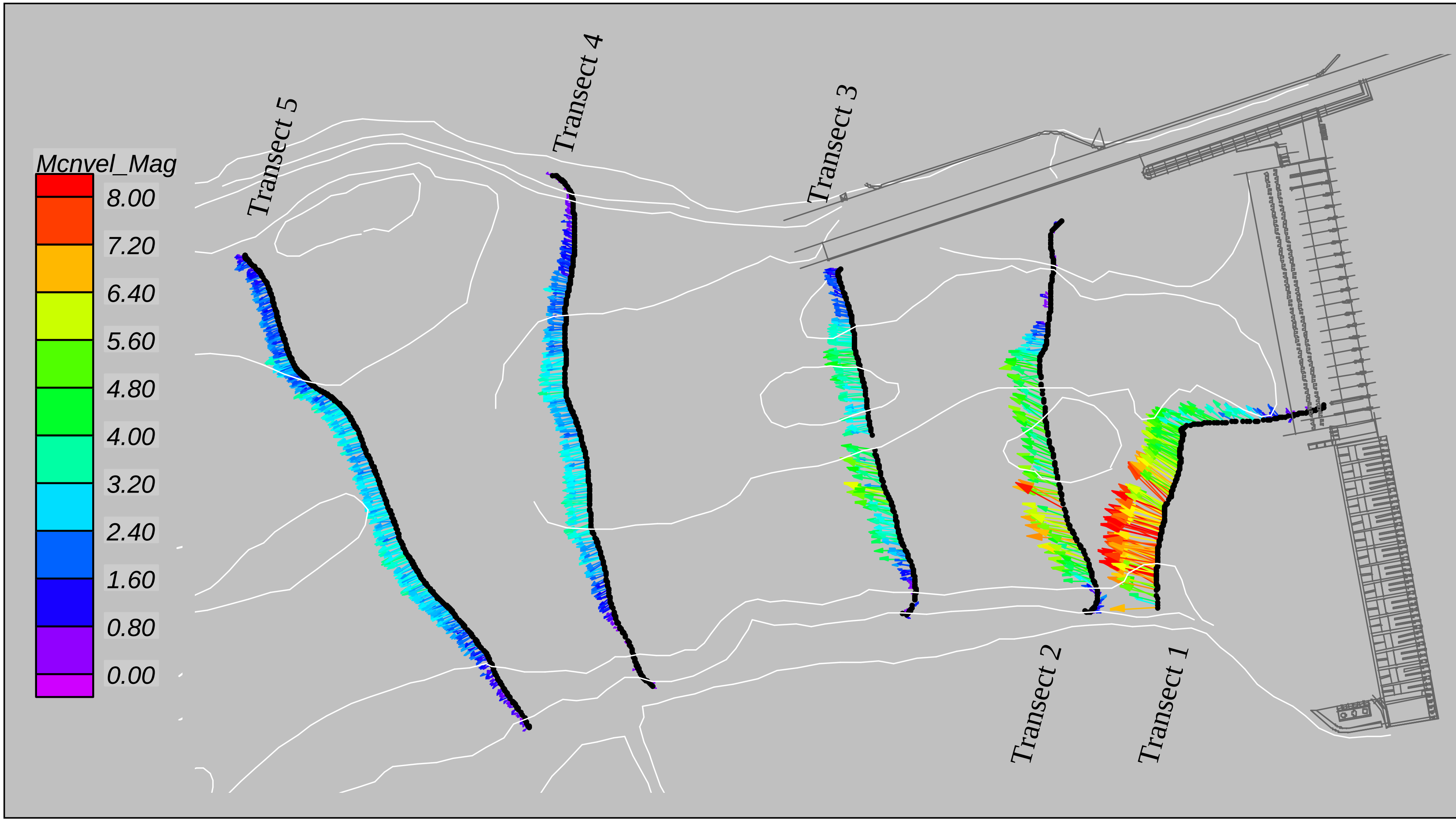


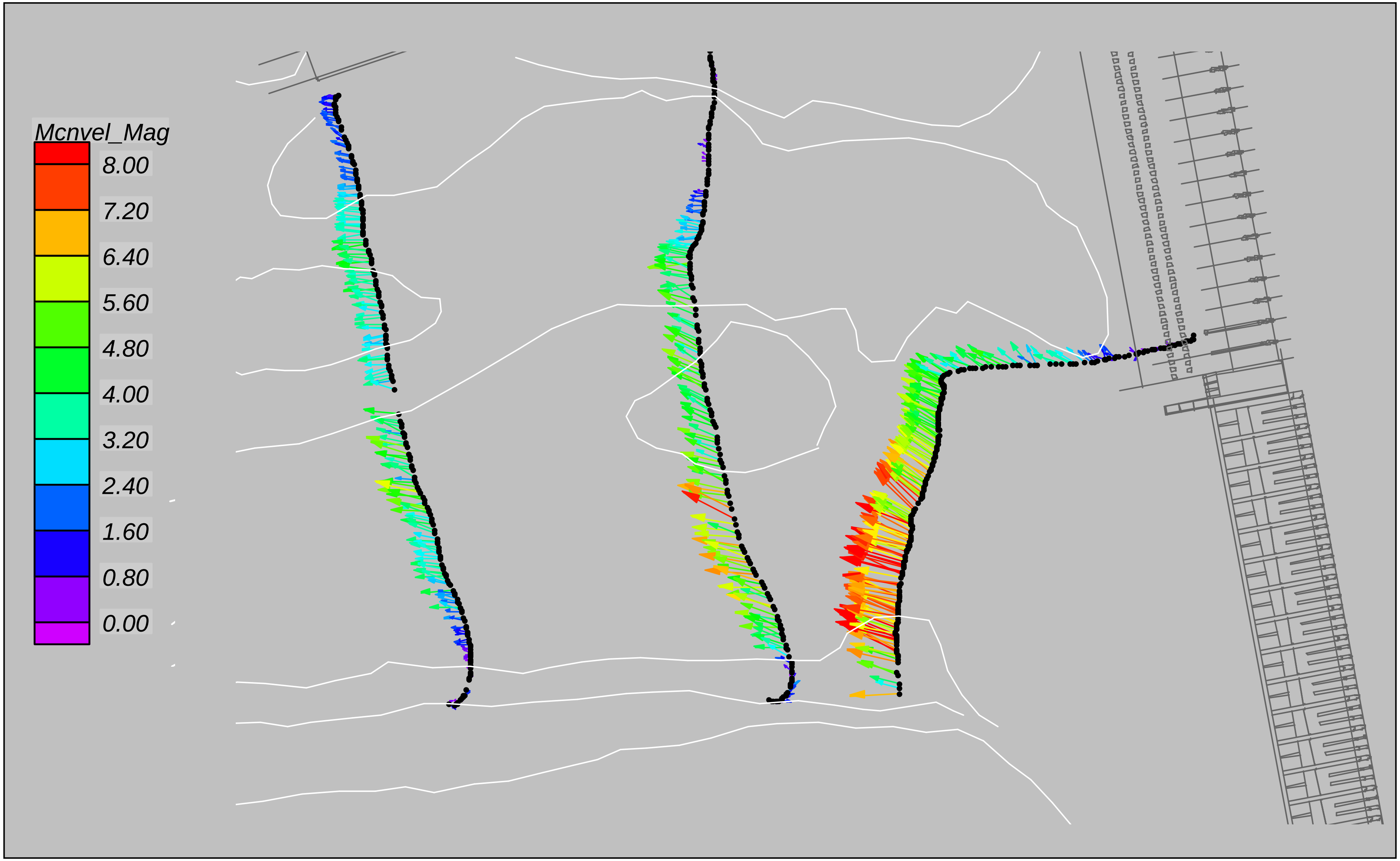
Figure 76: Predicted flow velocity contours and streamlines shown in a plane situated at Z=100.4 ft for all three forebay conditions (no curtain, curtain_1, and curtain_2)



Depth-Averaged ADCP Velocities below McNary Dam, 1300 hrs April 2, 2000

(Q_{ph}=154 kcfs, Q_{sp}=0, TWE=265.8 ft)

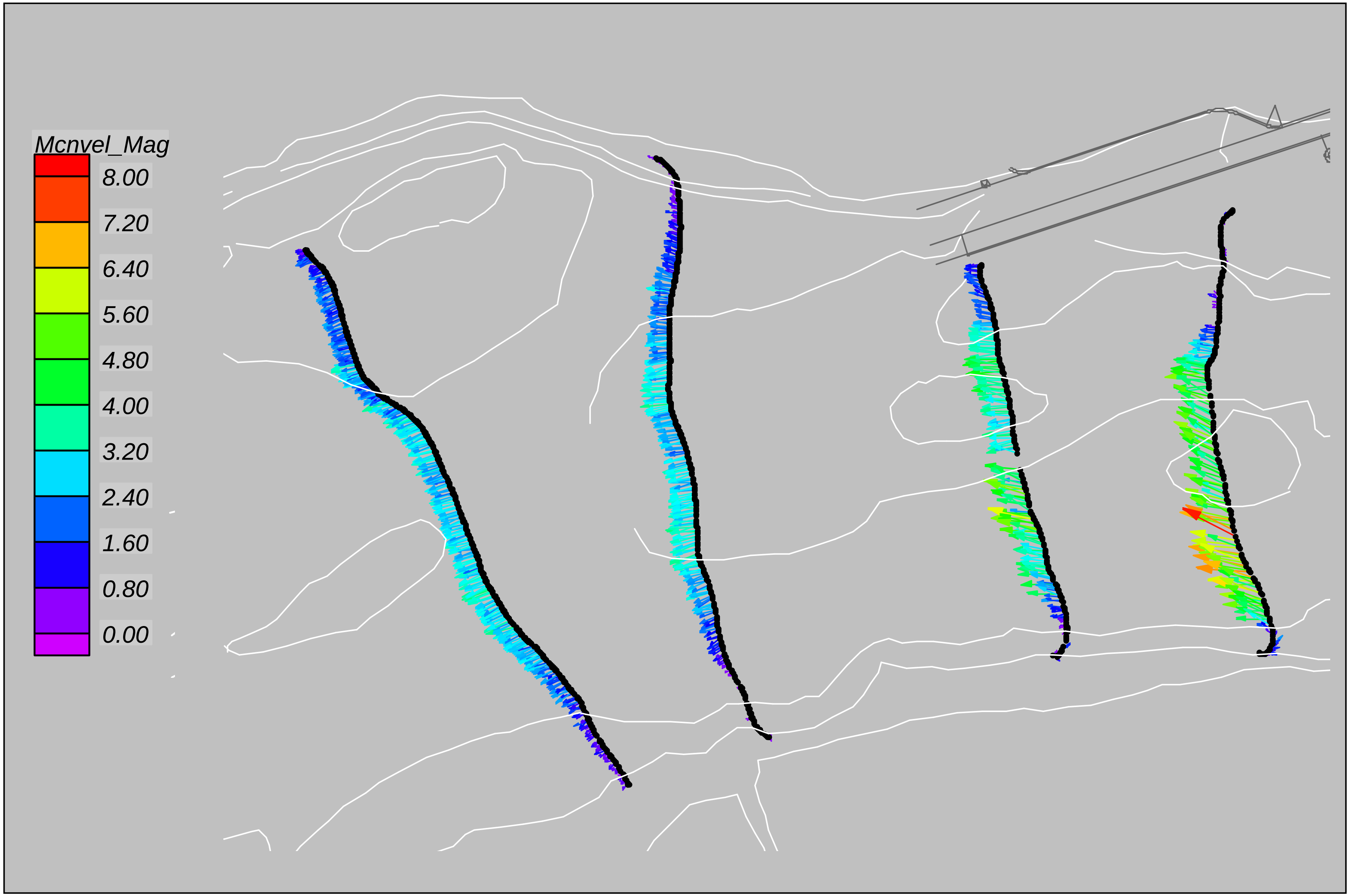
(Data Aggregation by Ensemble Number with No Filter)



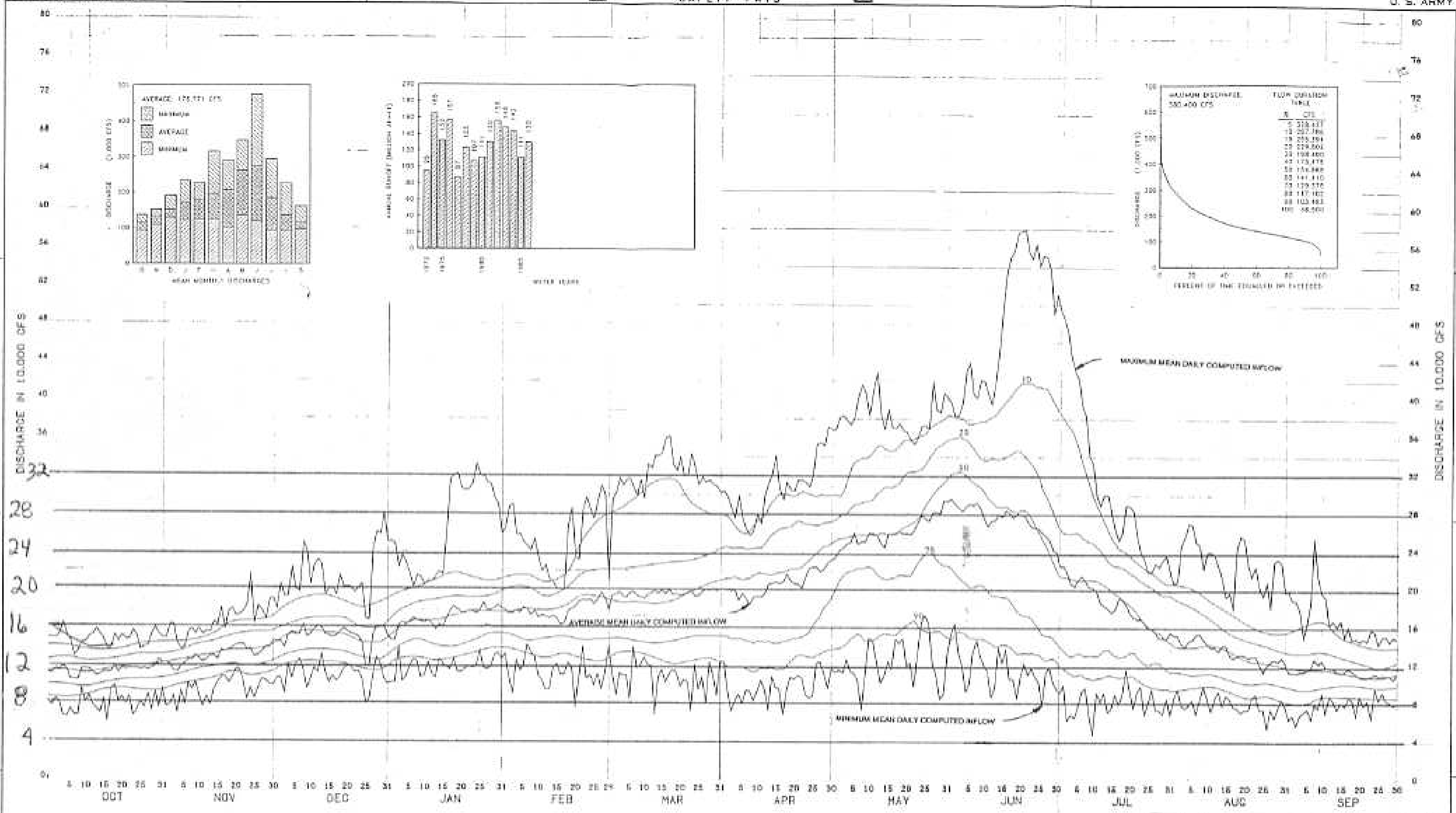
Depth-Averaged ADCP Velocities below McNary Dam, April 2, 2000

(Q_{ph}=154 kcfs, Q_{sp}=0, TWE=265.8 ft)

(Data Aggregation by Ensemble Number with No Filter)



Depth-Averaged ADCP Velocities below McNary Dam, April 2, 2000
(Data Aggregation by Ensemble Number with No Filter)



NOTES

1. RECORDS USED:
   WATER YEARS 1973-1986: OBSERVED DISCHARGES FOR COLUMBIA RIVER AT McNARY DAM, OREGON AND WASHINGTON. DISCHARGE RECORDS USED ARE FROM DATA PUBLISHED BY U.S.G.S.
2. DRAINAGE AREA IS 214,000 SQUARE MILES.
3. DISCHARGES USED REFLECT THE EFFECTS OF IRRIGATION AND RESERVOIR STORAGE DEVELOPMENTS.
4. CURVES OF PERCENT CHANCE OF OCCURRENCE REPRESENT THE AVERAGE FLOW FOR THAT DAY. A POINT ON AN EXCEEDENCE CURVE REPRESENTS THE AVERAGE DAILY DISCHARGE FOR A SPECIFIC DAY WHICH HAS BEEN EXCEEDED THE GIVEN PERCENTAGE OF TIME.

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS	WATER YEAR	DATE	CFS
1973	DEC 12	237,600			
1974	JUN 21	580,400			
1975	JUN 04	451,200			
1976	MAY 17	428,800			
1977	MAR 27	166,200			
1978	JUN 08	348,500			
1979	MAY 24	292,800			
1980	JUN 11	324,300			
1981	JUN 09	421,800			
1982	JUN 23	441,900			
1983	MAY 30	407,400			
1984	MAY 31	402,600			
1985	MAY 16	376,400			
1986	JUN 01	382,200			

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

McNARY LOCK AND DAM

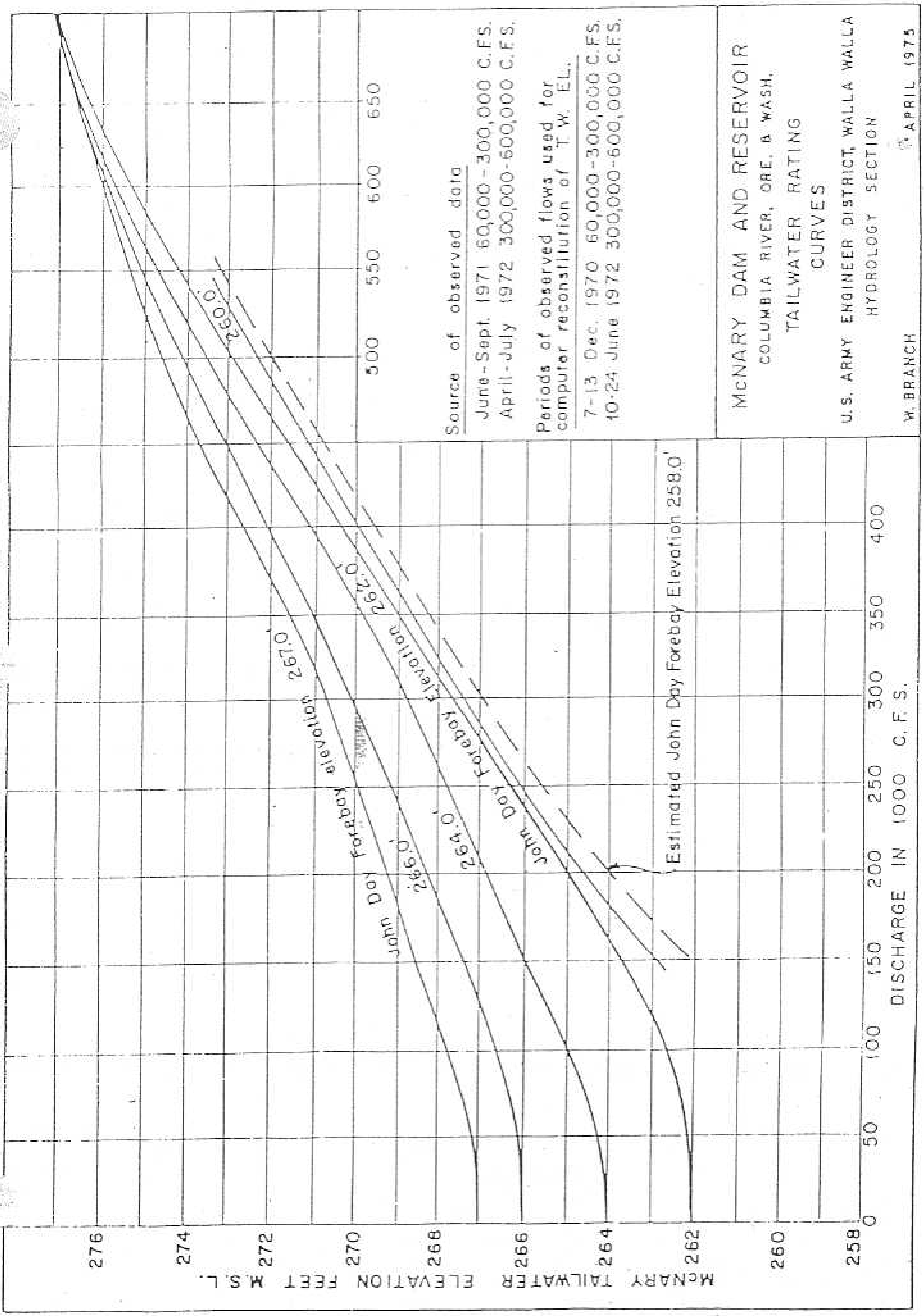
COLUMBIA RIVER, OREGON AND WASHINGTON

SUMMARY HYDROGRAPHS

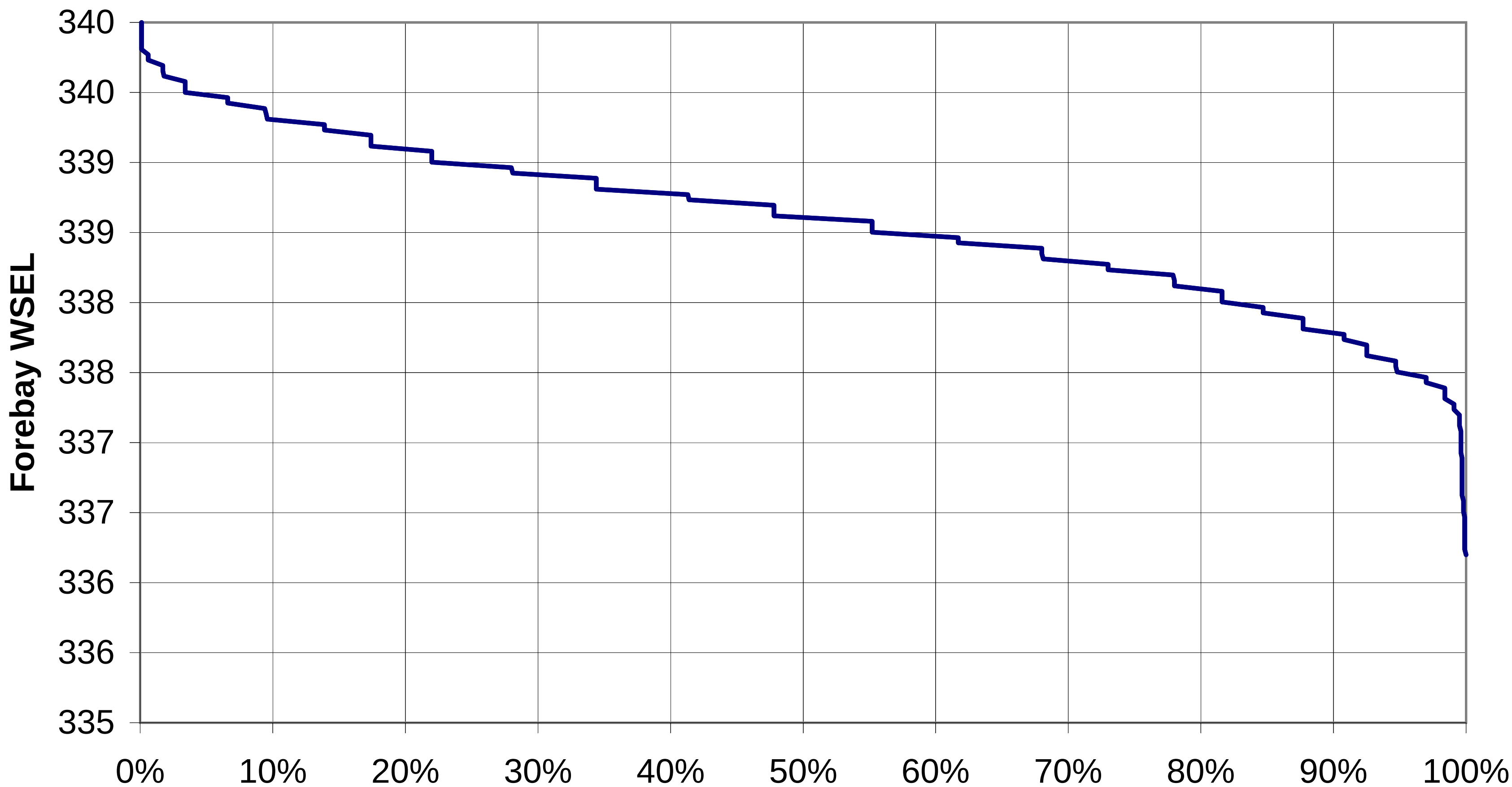
COLUMBIA RIVER AT McNARY DAM, ORE. & WASH.

COMPUTED REGULATED INFLOW

SCALE AS SHOWN


McNARY DAM AND RESERVOIR
COLUMBIA RIVER, ORE. & WASH.
TAILWATER RATING CURVES
U.S. ARMY ENGINEER DISTRICT, WALLA WALLA
HYDROLOGY SECTION
W. BRANCH
APRIL 1975
Source of observed data
June-Sept. 1971 60,000-300,000 C.F.S.
April-July 1972 300,000-600,000 C.F.S.
Periods of observed flows used for computer reconstitution of T.W. EL.
7-13 Dec. 1970 60,000-300,000 C.F.S.
10-24 June 1972 300,000-600,000 C.F.S.
John Day Forebay elevation 267.0
266.0
John Day Forebay Elevation 262.0
264.0
260.0'
Estimated John Day Forebay Elevation 258.0'
McNARY TAILWATER ELEVATION FEET M.S.L.
276
274
272
270
268
266
264
262
260
258
0
50
100
150
200
250
300
350
400
500
550
600
650
DISCHARGE IN 1000 C.F.S.

McNary Forebay
Water Surface Elevation Exceedance
Based on Daily Data April 1st to September 30th 1994-2003



Appendix D

MSIA Information

Ranges for base data: June, 2004

System Passage Analysis Tool
Walla Walla District COE

Steelhead

MCN

Survival Values	Best Est	Low	High
Reservoir	0.907	0.890	0.970
Turbines	0.870	0.860	0.900
Intake Screens to Facility	0.995	0.920	0.980
Surface Collector to Facility (SBC)	0.990	0.980	0.999
Spillway Normal Bays	0.980	0.950	0.990
Training Spill	0.980	0.950	0.990
Bulk Spill	0.980	0.960	1.000
Spillway RSW	0.980	0.960	1.000
Barge Survival	0.985	0.980	1.000
Facility Release to River	0.935	0.935	1.000
BON to Estuary			
Extra Mortality Value (as Survival)			
Delayed Mortality (as Survival)	0.411		
Juveniles: Dam Survival for JDA/TDA/BON			

Effectiveness Values			
RSW Effectiveness	3.5	3.5	7.0
SBC Effectiveness	7.0		
BGS Effectiveness	0.78	0.4	0.9
Training Spill Effectiveness	0.3		
Normal Bay Effectiveness			
FGE	0.87	0.83	0.91

PINK= changes needed for sensitivity analysis

Flows (kcfs)			
Snake River			
High			
Average			
Low			
Columbia River			
High			
Average			
Low			
Per Project			
Normal Bay Night (BiOp) (120% gas cap)	160		
Normal Bay Day (BiOp)			
Normal Bay Night (BiOp) (110% gas cap)	40		
Normal Bay Day (BiOp)			
Maximum Transport	26		
RSW	14.0		
Training Flow	24.0		
SBC	6.0		
Maximum Powerhouse	174		
Minimum Powerhouse	50		

Fish Passage Diel %	0.5		

Purple= 2000 Biop (see Biop citation worksheet)
Red= Numbers from citations in Williams et al. December 2003 Passage of Adult and Juv Salmon through FCRPS (see ranges citation worksheet)
Lt Green= Regional Agreement on values and ranges (citations to follow in appendix)
Low and high estimates of model inputs were COE source (BPJ) except where highlighted.
D' value for McNary used lowest value for Snake River rather than one provided by NMFS due to sample size.
D value used for projects came from NOAA Fisheries Tech Effects Memo- July, 2004 (hatchery steelhead)
Intake Screens to Facility and Facility Release to River are combined to equal Bypass mortality Numbers in NOAA Fisheries 2000 Biop.
Biop Condition at IHR is an RSW 19k spill 24 hours a day.

System Passage Analysis Tool
Walla Walla District COE

Ranges for base data:

Spring/Yearling Fish

MCN

Survival Values	Best Est	Low	High
Reservoir	0.977	0.879	0.977
Turbines (direct and indirect)	0.870	0.860	0.900
Intake Screens to Facility	0.995	0.920	0.980
Surface Collector to Facility	0.990	0.980	0.999
Spillway Normal Bays	0.980	0.950	0.990
Training Spill	0.980	0.950	0.990
Bulk Spill	0.98	0.96	1.00
Spillway RSW	0.980	0.960	1.000
Barge Survival	0.985	0.985	1.000
Facility Release to River	0.935	0.935	1.000
BON to Estuary			
Extra Mortality Value (as Survival)			
Delayed Mortality (as Survival)	0.502		
Juveniles: Dam Survival for JDA/TDA/BON			

Effectiveness Values	Best Est	Low	High
RSW Effectiveness	3.5	3.5	7.0
SBC Effectiveness	7.0		
BGS Effectiveness	0.78		
Training Spill Effectiveness	0.3		
Normal Bay Effectiveness			
FGE	0.87	0.83	0.91

Flows (kcfs)	Best Est	Low	High
Snake River			
High			
Average			
Low			
Columbia River			
High			
Average			
Low			
Per Project			
Normal Bay Night (BiOp) (120% gas cap)	160		
Normal Bay Day (BiOp)			
Normal Bay Night (BiOp) (110% gas cap)	40		
Normal Bay Day (BiOp)			
Maximum Transport	26		
RSW	14.0		
Training Flow	24.0		
SBC	6.0		
Maximum Powerhouse	174		
Minimum Powerhouse	50		
Fish Passage Diel %	0.5	0.45	0.55

Purple= 2000 Biop (see Biop citation worksheet)
Red= Numbers from citations in Williams et al. 2003 Passage of Adult and Juv Salmon through FCRPS. (see ranges citation worksheet)
Lt Green= Regional Agreement on values and ranges (citations to follow in appendix)
Low and high estimates of model inputs were COE source (BPJ) except where highlighted.
D' value for McNary used lowest value for Snake River rather than one provided by NMFS due to inadequate sample size.
D value used for projects came from NOAA Fisheries Tech Effects Memo- July, 2004 (hatchery sp/summer chinook)
Intake Screens to Facility and Facility Release to River are combined to equal Bypass mortality Numbers in NOAA Fisheries 2000 Biop.
Biop Condition at IHR is an RSW 19k spill 24 hours a day.

Ranges for base data:

System Passage Analysis Tool
Walla Walla District COE

Spring/Yearling Fish

MCN

Survival Values	Best Est	Low	High
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Training Spill	0.980	0.950	0.990
Bulk Spill	0.98	0.96	1.00
Spillway RSW	0.980	0.960	1.000
Barge Survival	0.985	0.985	1.000
Facility Release to River	0.935	0.935	1.000
BON to Estuary			
Extra Mortality Value (as Survival)			
Delayed Mortality (as Survival)	0.502		
Juveniles: Dam Survival for JDA/TDA/BON			

Effectiveness Values			
RSW Effectiveness	3.5	3.5	7.0
SBC Effectiveness	7.0		
BGS Effectiveness	0.78		
Training Spill Effectiveness	0.3		
Normal Bay Effectiveness			
FGE	0.87	0.83	0.91

Flows (kcfs)			
Snake River			
High			
Average			
Low			
Columbia River			
High			
Average			
Low			
Per Project			
Normal Bay Night (BiOp) (120% gas cap)	160		
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Normal Bay Day (BiOp)			
Maximum Transport	26		
RSW	14.0		
Training Flow	24.0		
SBC	6.0		
Maximum Powerhouse	174		
Minimum Powerhouse	50		
Fish Passage Diel %	0.5	0.45	0.55

Purple= 2000 Biop (see Biop citation worksheet)
Red= Numbers from citations in Williams et al. 2003 Passage of Adult and Juv Salmon through FCRPS. (see ranges citation worksheet)
Lt Green= Regional Agreement on values and ranges (citations to follow in appendix)
Low and high estimates of model inputs were COE source (BPJ) except where highlighted.
D' value for McNary used lowest value for Snake River rather than one provided by NMFS due to inadequate sample size.
D value used for projects came from NOAA Fisheries Tech Effects Memo- July, 2004 (hatchery sp/summer chinook)
Intake Screens to Facility and Facility Release to River are combined to equal Bypass mortality Numbers in NOAA Fisheries 2000 Biop.
Biop Condition at IHR is an RSW 19k spill 24 hours a day.

Appendix E

Regional Background
(Excerpt from NOAA Technical Memo)

Passage of Adult and Juvenile Salmon Through Federal Columbia River Power System Dams

John W. Ferguson, Gene M. Matthews, R. Lynn McComas, Randall F. Absolon,
Dean A. Brege, Michael H. Gessel, and Lyle G. Gilbreath

NOAA Technical Memorandum

Fish Ecology Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U. S. Department of Commerce

June 2004

Ice Harbor Dam

Three years of hydroacoustic investigations at Ice Harbor Dam revealed diel passage patterns similar to other Columbia and Snake River dams (Johnson et al. 1983, Ransom and Ouellette 1988). Most migrants passed the dam at 2300. Sluiceway diel passage rates were highest from 0600 to1300. Turbine passage rates were highest from 2100 to 0600.

During all 3 years of study, hourly passage rates through the spillway were more variable than through the turbine units or sluiceway. Generally, spillway passage rates were low in the early morning and then increased steadily to a peak at 1200. The rate then declined rapidly, reaching a low point at 1700, followed by a secondary peak at 2100 (only slightly lower than the peak at 1200).

In 1999, a radiotelemetry study of yearling chinook salmon passage was conducted at Ice Harbor Dam to determine tailrace egress and routes of passage under varying levels of spill and powerhouse flow (Eppard et al. 2000). At 1800 each day, powerhouse flow was reduced while spill was increased to the maximum level based on dissolved gas levels, until 0600 h the following day. The test fish were released in the tailrace of Lower Monumental Dam each morning (0800) via the bypass outfall. Receivers were positioned 1 km above Ice Harbor Dam and across the powerhouse and spillway, in the juvenile bypass channel, and on each submersible traveling screen. Each individual fish could be timed from the study entrance line through the passage route. Of the 580 fish detected 1 km above the dam, diel passage was fairly evenly distributed. A total of 302 and 278 fish passed the project during the day and night, respectively, although release location may have affected these results. Spilled fish had a lower forebay residence time, and fish first detected after dark had a lower forebay residence time than those first detected during daylight hours.

McNary Dam

No hydroacoustic or radiotelemetry studies have been conducted that provide a robust source of diel passage information at McNary Dam. Studies of orifice passage efficiency (OPE) using an orifice trap provide information on hourly passage from the gatewell(s) sampled. McComas et al. (1997) using an orifice trap found that passage from gatewells into the juvenile bypass channel appeared heaviest within a few hours of dawn and dusk, with the dusk peak having generally larger numbers of fish. Orifice trap data does not provide information on when fish first arrived in the forebay or entered the gatewell.

JUVENILE SALMON PASSAGE THROUGH SURFACE BYPASS SYSTEMS AND SLUICEWAYS

Juvenile yearling salmon generally migrate in the upper portion of the water column and approach FCRPS dams near the surface (Dauble et al. 1999, Johnson et al. 2000). However, most turbine intakes and all spill gate sill elevations are greater than 40 ft below forebay water surfaces. Thus, juvenile migrants have to follow flow lines downward into turbine and spill intakes, a behavior that is counter to their normal, surface orientation. Also, juveniles can accumulate in the immediate forebay during the day at sites where spill is limited or nonexistent, and pass the dam at night. Delay of juvenile migrants in forebays may increase losses to predation (Raymond and Sims, 1980).

Many of the older FCRPS dams were constructed with surface-oriented ice and trash sluiceways to pass ice and debris from the forebay to the tailrace. These include (year completed) Ice Harbor Dam (1962), The Dalles Dam (1957), and Bonneville Dam First Powerhouse (1938). The sluiceways include adjustable weir gates above turbine intakes which pass water from the forebay into a longitudinal channel around the dam to the tailrace. In addition, the Bonneville Dam Second Powerhouse was constructed in 1983 with a surface outlet located in one corner of the powerhouse to pass ice and debris to the tailrace.

The Ice Harbor Dam sluiceway was evaluated in 1995 prior to installation of a juvenile bypass system in the sluiceway channel. Combinations of wide, surface-overflow entrances (20 ft wide, 6 ft deep, and 7.5 ft s^{-1} entrance velocity) and deeper, slotted entrances (up to 6 ft wide, 40 ft deep, and up to 4 ft s^{-1} entrance velocity) were studied. The wide, surface-overflow entrances had the highest passage rates based on hydroacoustics (Biosonics 1996b) and radiotelemetry, where a total of 57% of the radio-tagged chinook salmon used sluice gate 2B which was a surface skimming flow (Swan et al. 1996).

The Dalles Dam sluiceway is located along the entire length of the 22-turbine-unit powerhouse, which is oriented parallel to the river channel centerline. Surface flow passes through weir-type chain gates into a channel that has a hydraulic capacity of 5,000 cfs. Typically, three gates above turbine unit 1 at the west end of the powerhouse are opened to pass 3,200 cfs through the sluiceway. During periods of no spill, sluiceway passage was estimated at 40 to 55% (Giorgi and Stevenson 1995). However, sluiceway passage is reduced during periods of spill. For example, in 2000, estimated sluiceway passage was 6 and 7% during the spring and summer, respectively, during 40% spill (Moursand et al. 2001c).

The Bonneville Dam First Powerhouse is perpendicular to the river channel centerline. Estimates of sluiceway efficiency have ranged from 83% for steelhead (Willis and Uremovich 1981) to 13% for subyearling chinook salmon (Krcma et al. 1982), and vary highly by species, flow, time of day, estimation method, forebay elevation, the number of turbines operating, and which sluiceway weirs are open. Although the capacity of the northern most sluice gates was reduced in the early 1980s by installation of a juvenile fish bypass system, total sluiceway capacity was not reduced, and remains at approximately 1,000 cfs. In 2002, estimated sluiceway passage was 33% (95% CI, 32-34%) for spring and 29% (95% CI, 28-30%) for summer with gates 7A and 10C operating, under conditions of 24-h spill and the Bonneville Dam Second Powerhouse being operated as the priority powerhouse. Sluiceway passage during both spring and summer was higher during day than night (Ploskey et al. 2003).

Sluiceway survival is a function of direct mortality that occurs during passage through the sluiceway and plunge into the immediate tailrace, and delayed mortality that occurs downstream. Estimated survival through sluiceways varies with life-history type, time of day, and spill conditions. For example, estimated survival through The Dalles Dam sluiceway in 1998 was 0.960 (95% CI, 0.874-1.054) for coho salmon under 30% spill during the daytime, while estimated survival of subyearling chinook salmon was 0.889 (95% CI, 0.806-0.980) during 30% daytime spill. In 2000, estimated survival of yearling chinook salmon was 0.945 (95% CI, 0.895-0.998) during daytime and 0.940 (95% CI, 0.889-0.995) at night during 40% spill. Estimated survival of subyearling chinook salmon was 0.955 (95% CI, 0.849-1.074) during daytime and 0.972 (95% CI, 0.864-1.094) at night during 40% spill (Absolon et al. 2002).

These sluiceway evaluations suggest that downstream migrants use non-turbine, surface-oriented passage routes, especially during daytime and periods of non-spill. Relatively high passage rates resulted in the sluiceways being highly effective, given their low hydraulic capacity relative to total river discharge. However, their low hydraulic capacity also limited further increases in the percentage of fish that could be passed through these routes.

Wells Dam on the upper Columbia River (completed 1967) is configured differently than all other run-of-the-river dams on the Snake and Columbia Rivers. Powerhouse turbine intake ceilings are 70 ft deep, with 11 spillway gates located over and between the ten turbines. Each of the five turbine pairs has one surface bypass entrance 16 ft wide by 73 ft deep. The surface bypass entrance velocity is approximately 2 fts^{-1}, and each surface bypass slot passes up to 2,200 cfs. Bypassed fish and flow pass through the surface entrances into an afterbay between the entrance and the spill gate, and are discharged to tailwater through the spillway gates, which control bypass entrance flow and velocity. Surface bypass flow is 5 to 7% of the hydraulic capacity of each pair of turbines (Johnson 1996). Evaluations of a surface bypass system at Wells Dam demonstrated that surface-oriented fish will pass in large numbers through the surface route with a relatively small flow. Surface bypass entrance efficiency (ratio of fish passing into the bypass relative to fish passing both the bypass entrance and turbine pair) is approximately 90% (Johnson et al. 1992), and ranges from 84.3 to 95.0% for spring migrants and 76.5 to 97.0% for summer migrants (Skalski et al. 1996).

Prototype Surface Bypass Systems

Based on the successful performance of the Wells Dam surface bypass system, prototype surface bypass systems have been tested at a number of locations in the Pacific Northwest to determine whether fish behavior principles observed at Wells Dam could be applied to dams with appreciably different and more typical powerhouse and spillway configurations, but with similar fish passage performance results. Evaluations of prototype surface bypass systems commenced in 1995 at Wanapum and Rocky Reach Dams, at Lower Granite Dam in 1996, at the Bonneville Dam Second Powerhouse in 1997, and the Bonneville Dam First Powerhouse in 1998. Prior to the 1998 evaluation, the Lower Granite surface bypass collector prototype was deepened to simulate the Wells Dam intake, and a behavioral guidance device was installed. A J-block occlusion device was installed at the west turbine units of The Dalles Dam in 2001, and a removable spillway weir was installed at Lower Granite Dam in 2002.

In 1995, a 55-ft deep prototype surface collector was installed upstream of turbine units 7-10 at Wanapum Dam. A single 16 ft wide by 50 ft deep slot entrance with a hydraulic capacity of 1,400 cfs was located directly above turbine unit 8. The structure occluded the upper portion of the turbine intakes. Due to poor performance of the slot entrance, reduced turbine entrainment associated with the turbine intake occlusions, and increased entrainment through turbines without intake occlusions, the prototype collector was extended in 1996 to also occlude turbine units 4-6. Additional collector entrances were not added. Mean collector efficiency (percent of fish entering the prototype collector relative to the total passing into the collector plus the number passing into reference units) was 30% in 1995 relative to turbine unit 8, and averaged 12% relative to turbine units 7-10. Horizontal distribution across the powerhouse was skewed toward turbine units not covered by the occlusion device, when compared to distribution in years before the prototype collector was installed (Ransom et al. 1996). Further, spillway efficiency during surface bypass prototype testing was higher (43%) than in previous years (30%; Kumagai et al. 1996). This suggests the prototype surface collector may have reduced entrainment at the occluded units, and fish passed over the spillway, increasing spillway effectiveness. The prototype collector was again extended in 1997 to occlude turbine units 1-3, and mean collector efficiency relative to turbine unit 8 averaged 15%, and was 0.9% relative to the entire 10-unit powerhouse during the spring (Kumagai et al. 1997).

Rocky Reach Dam has an eleven-unit powerhouse oriented parallel to the river channel centerline, similar to The Dalles Dam. Juvenile salmon accumulate at the downstream half of the powerhouse between the powerhouse and a non-overflow wall connecting the powerhouse to the west shoreline (Dauble et al. 1999). Evaluations of various prototype surface collection configurations occurred from 1995 through 2002. In 2003, a permanent surface bypass facility was constructed consisting of a single, 40 ft wide by 50 ft deep entrance located immediately downstream from turbine unit 1 with a hydraulic capacity of 6,000 cfs. Most of this flow is screened and pumped back to the forebay. Fish from the surface collector and screened juvenile fish bypass system in turbine units 1 and 2 are routed across the downstream face of the powerhouse and spillway to monitoring facilities and an outfall located on the east shore. Estimated fish passage efficiency (proportion of fish passing through non-turbine routes including the surface bypass, intake screen bypass, and spillway) was 66, 68, 31, and 42% for yearling chinook salmon, steelhead, sockeye salmon, and subyearling chinook salmon (Mosey 2003).

Lower Granite Dam has a six-unit powerhouse located immediately to the south of eight spill bays. In 1996, a prototype surface bypass collector was installed immediately upstream from turbine units 4-6, consisting of a 20 ft wide by 60 ft deep channel, the bottom of which was at the same elevation as the turbine intake ceiling. Attraction flow passed through various entrance configurations and was conveyed through a longitudinal channel to an adjacent spillbay. Maximum discharge through the collector was 3,500 cfs, and flow control was provided by the spill bay gate.

From 1996 through 2000, 11 different entrance configurations were tested at the Lower Granite Dam surface bypass collector to evaluate the effects of entrance characteristics such as discharge, shape, orientation, area, velocity, and change in rate of accelerations (Anglea et al. 2002). In 1998, based on hydraulic model studies, a 15-ft extension was installed on turbine units 4-6 to emulate hydraulic conditions observed at Wells Dam. The upper 17% of the turbine intakes was occluded which decreased the magnitude of downward velocities at mid-depths in the forebay upstream of the collector (Johnson et al. In review). Also in 1998, a 330 m long floating curtain was installed to affect the horizontal distribution of juvenile salmon in the forebay and divert them from turbine units 1-3 to units 4-6 and the collector. The height of the curtain varied from 17 to 24 m. Hydroacoustic evaluations were used to evaluate passage for the general population and compare collector to non-collector passage routes. Radiotelemetry was used to evaluate the responses of yearling chinook salmon, hatchery and wild steelhead, and subyearling chinook salmon to the various configurations tested.

In 1997, 12% of fish passing the dam did so through the collector, based on hydroacoustics (Johnson et al. 1998). Similarly, from 6 to 10% of radio-tagged hatchery and wild steelhead and hatchery spring chinook passed through the collector as compared to the total passing the dam, and from 43 to 65% of the radio-tagged fish that passed within 6 m of the entrances passed through the collector (Adams et al. 1998c). In 1998, by installation of the forebay curtain and collector modifications, the objective was to determine whether horizontal and vertical distribution could be modified to increase the number of fish near the entrances and passing through the collector. More fish were observed in front of the collector and fewer fish were entrained into turbine units 4-6. Passage efficiency was from 14 to 34% depending on species, and from 14 to 51% of fish within 10 m of the entrances passed through the collector. A total of 92, 61, and 67% of radio-tagged hatchery steelhead, hatchery spring chinook salmon, and wild steelhead that approached turbine units 1-3 stayed to the north of the forebay curtain (Adams and Rondorf 2001). Additional research was conducted in 1999 and 2000 with similar results.

Research conducted from 1966 to 2000 showed that surface flow bypass is a valid concept for Lower Granite Dam (Johnson et al. In review). Both spillway efficiency and passage of fish through non-turbine routes increased. For example, performance of the surface bypass collector increased spillway fish passage efficiency from 30 to 57% in 1998 (Johnson et al. 1999). It also improved passage through non-turbine routes at the powerhouse. In 1998, an estimated 83% of the downstream migrants were guided into the bypass system relative to total powerhouse passage, and this increased to 90% when passage through the surface bypass collector was included. Also, concentrating inflow in a single surface entrance produced the optimum configuration. Finally, surface bypass efficiency alone was not high enough for it to be a stand-alone bypass system, but when used in combination with spill and the juvenile bypass system, passage past the dam through non-turbine routes exceeded 90% with more than half of these fish using the collector (Johnson et al. In review).

The Bonneville Dam Second Powerhouse sluice chute is located immediately south of turbine unit 11, the southern-most of eight turbines at the powerhouse. The entrance is 15 ft wide by 20 ft deep and discharges approximately 3,000 cfs. Strong lateral flows toward the north and south ends of the powerhouse concentrate juvenile fish at these locations (Monk et al. 1999a). In 1998, with the six southern-most turbine intake extensions removed (over turbine units 11-14), 52% of the radio-tagged steelhead and

36% of the radio-tagged yearling chinook salmon approaching the powerhouse passed through the sluice chute, compared to 21% of the tagged steelhead and 14% of the tagged yearling chinook salmon detected in the juvenile bypass system. When the chute was closed, 50% of the steelhead and 30% of the yearling chinook salmon were detected in the bypass system (Hensleigh et al. 1998). The combined efficiency of the sluice chute and juvenile bypass system relative to passage through the chute and turbine units 11-13 was 90% during both spring and summer periods, based on hydroacoustics. When the chute was closed, guidance into the juvenile fish bypass system was 55 and 30% of the total fish passing turbine units 11-13 during the spring and summer, respectively. For the sluice chute alone, chute efficiency (proportion of fish passing the chute relative to passage through turbine units 11-13 and the chute) was 83 and 81% in spring and summer, respectively. The effectiveness of the sluice chute was high; about five times more fish passed the chute than would be expected based on the proportion of water passing the chute (Ploskey et al. 1999).

The Bonneville Dam First Powerhouse consists of 10 turbines and is separated from the spillway by Bradford Island. A prototype surface collector in front of turbine units 3-6 was installed in 1998 and evaluated to determine whether occluding the upper intake and passing high flows through a deep-slot entrance would successfully attract fish. The bottom of the collector was from 36 to 42 ft below the water surface and flow through the entrances was routed into the turbine intake. Both 5- and 20-ft wide entrances were tested, which passed approximately 1,000 and 3,000 cfs, respectively.

Ploskey et al. (1999) estimated that collector entrance efficiency was approximately 90% for both spring and summer migrants for both entrance configurations, based on hydroacoustics targets that passed into and under the prototype collector. However, while 45% of the radio-tagged steelhead and 40% of the radio-tagged yearling chinook salmon detected upstream from the first powerhouse passed near the prototype collector, 67% of these fish did not enter the collector and instead moved south along the face of the structure, and initially held upstream from turbine units 1 and 2 (Hensleigh et al. 1998).

In 2000, the prototype collector was expanded southward through turbine unit 1 to attempt to collect fish moving laterally (as observed in 1998). Estimated collection efficiency (the number entering the collector relative to the total number passing turbine units 1-6) was 83, 78, and 81% for radio-tagged steelhead, yearling spring chinook salmon, and subyearling spring chinook salmon, respectively. Also, 71 and 59% of the radio-tagged steelhead and yearling chinook salmon approached more than one entrance before passing (Evans et al. 2001a). Multi-beam hydroacoustic evaluations conducted to evaluate behavior in front of the collector found extensive milling of fish within 5 m of the entrances (Johnson et al. 2001).

In 2002, the upper 45 ft of the turbine intake trashracks at The Dalles Dam were occluded to increase sluiceway passage efficiency. This was based on reduced entrainment of juvenile salmon into turbines at Wanapum and Lower Granite Dams after installation of structures that occluded the upper portion of the turbine intakes at these dams, and strong lateral flows toward the west end of the powerhouse and spillway, and the open sluiceway entrances at the west end of the powerhouse at The Dalles Dam. The "J" shaped occlusions were installed in intakes of two fish attraction flow and four main turbine units at the west end of the powerhouse. The long stem of the "J" blocked the intake, and the nearly horizontal leg extended 20 ft upstream and then upwards 10 ft at a 90-degree angle. In 2002, there was no difference in turbine entrainment with the occlusions installed or removed during the spring; however, turbine entrainment was higher during periods with the "J" device installed during the summer (Johnson et al. 2003). Turbine priorities were different in 2002 compared to previous years, which resulted every other turbine unit being operated. In 2002, spill passage efficiency dropped to 45 and 38% during the spring and summer, respectively, which was lower than in previous years and may have been affected by the turbine operations that year. For example, in 2000, spill efficiency was 86 and 74% during the spring and summer, respectively (Moursand et al. 2001c). The turbine operations in 2002 may have influenced turbine entrainment and the performance of the occlusions.

In 2001, a removable spillway weir (R.W.) was installed in the southern-most spillbay at Lower Granite Dam. The R.W. is nearly 50 ft wide and has a 19.5 ft long ramp extending upstream. The approach ramp was incorporated into the design based on Haro et al. (1998), where juvenile Atlantic salmon passed more readily over weirs with gradual velocity increases upstream of the crest as compared to sharp-crested weirs. The R.W. weir crest is from 11 to 15 ft below normal water surface elevations and transitions to the existing ogee of the spillbay. Discharge through the weir is 7,000 cfs at minimum operating pool. The weir is designed to rotate 90 degrees in the upstream direction to a lowered position to not reduce spill capacity during high river discharge.

In November 2001, a preliminary study using balloon-tagged hatchery yearling chinook salmon found no significant differences in survival or injury rates between fish released into the R.W. and into an adjacent spillbay that was partially-opened and outfitted with a deflector. Estimated 1- and 48-h survival probabilities for fish passing through the R.W. were 0.992 (90% CI, 0.983-1.000) and 0.981 (90% CI, 0.966-0.995), respectively. Estimated 1- and 48-h survival probabilities for fish passing through the adjacent spillbay were 1.00 and 1.00, respectively, and the survival probabilities between the two routes were not significantly different (*P* >0.05; Normandeau Associates et al. 2002).

In 2002, the R.W. was evaluated by comparing bypass efficiency (ratio of fish passing the R.W. and adjacent training spill to total passage) to spill passage efficiency (ratio of fish passing spillway to total passage). During the R.W. tests, spill of 7,000 cfs was provided through the R.W., spill through adjacent bays was provided to establish satisfactory tailrace egress conditions, and total spill was 15,000 cfs and 23,000 cfs. During spill-to-the gas-cap tests, spill of approximately 45,000 cfs was provided though seven spillbays 12 h at night. Surface bypass collector components remained in turbine units 4-6, the floating curtain was attached to the southern end of the surface collector, and surface collector components north of the powerhouse that had routed collector flow to the spillway were removed.

In 2002, the bypass efficiency of the R.W. (the ratio of fish passing the R.W. to fish passing through all routes) was 56, 62, and 61% for radio-tagged hatchery yearling chinook salmon, hatchery steelhead, and wild steelhead, respectively. The bypass efficiency of the R.W. and the adjacent training spill was 78, 73, and 78% for radio-tagged hatchery yearling chinook salmon, hatchery steelhead, and wild steelhead, respectively. In comparison, spill passage efficiency during the spill-to-gas-cap tests was 62, 66, and 54% for radio-tagged hatchery yearling chinook salmon, hatchery steelhead, and wild steelhead, respectively. While training spill adjacent to the R.W. was greater than 50,000 cfs for part of the evaluation period because of high river flow, the combined bypass efficiency of the R.W. and training spill during these periods was similar to the combined bypass efficiency observed when adjacent training spill was 8,000 and 16,000 cfs (Plumb et al. 2003a).

In 2003, the surface bypass collector was removed which eliminated the intake occlusions in turbine units 4-6, and the floating curtain in the forebay was stored well upstream from the dam and had no influence on fish behavior and distributions. Flow through the R.W. was again 7,000 cfs and training spill through adjacent spillbays totaled 12,000 cfs. Due to a more stable hydrograph, flow through spillbays adjacent to the R.W. was more consistent than in 2002. The bypass efficiency of the R.W. (the ratio of fish passing the R.W. to fish passing through all routes) was 58, 69, and 67% for radio-tagged hatchery yearling chinook salmon, hatchery steelhead, and wild steelhead, respectively. The bypass efficiency of the R.W. and the adjacent training spill was 66, 74, and 71% for radio-tagged hatchery yearling chinook salmon, hatchery steelhead, and wild steelhead, respectively. In comparison, spill passage efficiency during the spill-to-gas-cap tests was 52, 59, and 54% for radio-tagged hatchery yearling chinook salmon, hatchery steelhead, and wild steelhead, respectively. Passage through the R.W. was greatest during daylight hours. Median forebay passage times during R.W. tests were 1.92, 1.72, and 2.28 h for radio-tagged hatchery and wild steelhead, and hatchery chinook salmon, respectively. For these same test groups, median passage times during spill-to-the-gas-cap tests were 7.37, 4.64, and 4.98 h, respectively. The estimated relative survival of radio-tagged hatchery yearling chinook salmon passing through the R.W. was 0.980 (95% CI, 0.957-1.03), compared to estimated survival through the spillway under spill-to-the-gas-cap spill of 0.931 (95% CI, 0.871-0.991). There were no significant differences between the treatments ($P = 0.1135$; Plumb et al. 2003b).

Locations of acoustically tagged hatchery yearling chinook salmon and hatchery and wild steelhead in three dimensions from 2002 and 2003 were integrated with numerical model depictions of hydraulic flow fields for Lower Granite Dam operations during time of passage of test fish. The goal was to understand fish behavioral responses to hydraulic conditions in the forebay that would help improve the performance of future surface bypass configurations. Tagged fish generally stayed more than 15 ft away from the upstream face of the 80 ft deep forebay curtain, and tagged fish in the upper 15 ft of the water column generally stayed upstream of the 4 ft deep trash shear boom. The common hydraulic condition in which fish appeared to respond is called strain. Another objective of this integration was to determine the percentage of tagged fish that passed through the R.W. having approached form various distances upstream from the R.W. This was based on observations of fish delaying just upstream from deep-slot surface bypass entrances at the Bonneville Dam First Powerhouse, Lower Granite Dam, and Wanapum Dam. In 2002, 80% of the tagged wild steelhead that passed within 70 m, 80% of tagged hatchery steelhead that passed within 40 m, and 80% of the tagged hatchery chinook salmon that passed within 20 m of the R.W. passed through the surface weir (Cash et al. 2003).

Discussion

Surface bypass performance is a function of forebay collection, safe passage through the surface bypass entrance conveyance, and safe and rapid tailrace egress. Testing of prototype surface bypass systems during the past decade focused primarily on measuring how many fish were guided out of the forebay and into the bypass, an issue considered the greatest challenge at most sites. Results indicate that bypass guidance efficiency varied with location, and where successful, no single feature or operation was responsible. Rather, a combination of factors appear to influence both forebay hydraulic conditions and related fish behavioral responses. These include

1. selection of a location where fish accumulate (naturally or artificially through guidance structures),
2. surface-oriented entrance(s) with unimpeded surface drawdown, and open, natural lighting beyond the weir crest,
3. gradual, increasing velocity as flow approaches the weir crest,
4. use of a floating trash boom or guidance curtain may improve forebay collection performance,
5. larger bypass flows increase passage efficiency, but do not overcome other deficiencies or compromises, and
6. increased discharge through turbines and the spillway reduces passage through surface bypass systems.

Deep-slot entrances at Wells Dam were highly effective, passing approximately 90% of yearling and subyearling migrants. Also, surface-oriented entrances with weir-type flow have historically passed a large number of fish with small quantities of flow. Prototype surface bypass facilities that have proven successful are the Bonneville Dam Second Powerhouse sluice chute and the Lower Granite Dam R.W. The weir entrance appears to collect surface-oriented fish, but also some deeper fish move vertically to pass into the entrance (Cash et al. 2003). Furthermore, there are no signs of fish holding for extended periods upstream of the R.W. as compared to observations in front of deep-slot entrances. These observations suggest that volitional passage of juvenile salmonids is more attainable over weirs than through deep-slot entrances. However, fish respond differently to hydraulic conditions in the weir entrance and approach to the weir, and favor gradual rather than sharp velocity increases (Haro et al. 1998).

In contrast, data from most sites suggest that deep-slot entrances do not perform as well as surface oriented weirs. Fish appeared to delay and avoid entering multiple, deep-slot entrances with lower velocities from 1 to 4 fts^{-1} at Lower Granite Dam and the Bonneville Dam First Powerhouse, and many radio-tagged fish moved back upstream. Multi-beam hydroacoustic studies also identified fish holding immediately upstream from the deep-slot entrances, suggesting a lack of volitional movement into this type of entrance. Also, many radio-tagged fish moved laterally rather than directly into, or under, the prototype surface collector entrances at turbine units 3-6 at Bonneville Dam First Powerhouse in 1998. Fish behavioral investigations have not been conducted upstream of the surface bypass entrances at Wells Dam, and therefore it is not known whether delay is associated with this type of deep-slot entrance.

Surface bypass system performance is related to the proportion of flow through the system. Johnson et al. (In review) suggest that surface bypass flow needs to be greater than 7% of project flow to establish a large enough flow net in the forebay to be effective, based on studies at Wells Dam. However, the configuration of the Wells Dam surface bypass system is unlike any other dam. Therefore, this criterion should be used as a guide and adjusted to meet unique conditions associated with each potential surface bypass location. Performance also appears related to total project flows. For example, at Lower Granite Dam when average project discharge was 85,000 cfs, approximately 60% of the tagged juvenile fish passed through the R.W. or spillway, and this dropped to 40% when average project discharge was 110,000 cfs.

While the forebay guidance curtain at Lower Granite Dam appeared to influence horizontal distribution of fish at the powerhouse in 1998, the potential benefit appears dependent on total project discharge and project operations, and it remains to be determined as to when and under what conditions guidance curtains perform best. For example, the R.W. performed better with the guidance curtain removed in 2003 than when deployed in 2002, and both shallow (4 ft deep trash shear boom) and deep (80 ft deep curtain) devices have been shown to alter fish behavior.

During the mid and late 1990s, surface bypass designs and implementation decisions were made based on the best possible synthesis of biological and hydraulic observations. Hydraulic observations were largely from physical hydraulic models and fish behavioral information was primarily from hydroacoustic and radiotelemetry studies. Radiotelemetry provided an indication of fish location in two dimensions and to the nearest 10 m. However, the emphasis was placed on developing the ability to track fish in three dimensions at finer spatial scales to gain an improved understanding of fish behavior. Additionally, computational fluid dynamics models (with visualization software) were developed that allowed coarse and fine grid observation of forebay hydraulic conditions. Integrating acoustic tag and hydraulic model outputs was necessary to identify fish behaviors and optimize surface bypass system designs and performance.

Thus, three-dimensional evaluations at Lower Granite Dam using acoustically-tagged fish were conducted to assess fish movement under various operations and forebay hydraulic conditions and identify any previously undetected fish responses to forebay hydraulic conditions (Cash et al. 2003). Fish behaviors near both the guidance curtain and trash shear boom were noted in 2002, where fish appeared to avoid zones immediately upstream of both the 80 ft- deep guidance curtain (first observed in 1998) and the 4 ft- deep trash shear boom. Investigation of hydraulic conditions in the zones immediately upstream of both devices suggests these are areas where strain, as defined as the derivative of the vertical velocity component, can be detected.

The integration of hydraulic flow fields and biological data discussed above allows fish behavior in response to existing configurations under certain operations to be reviewed. Nestler and Goodwin (in prep.) have developed a fish behavior model to analyze potential, future configurations and operations. Preliminary analyses suggest the model can be used at larger scales, such as designing the appropriate length, depth, and location of forebay guidance curtains. The methodology is still developing and currently does not appear appropriate for fine-scale determinations such as entrance configuration or discharge.

A successful surface bypass system also requires safe passage through the structure, at the point where the surface bypass discharge jet enters the tailrace, and during egress through the tailrace. Routing a large surface bypass discharge directly to the tailrace results in high impact velocities and potential losses associated with mechanical effects (shear, strike, abrasion) or predation. Northern pikeminnow (*Ptychocheilus oregonensis*) and gulls (*Larus* spp.) may accumulate at sluiceway or bypass outfalls and shallow areas directly downstream (Hansel et al. 1993, Ward et al. 1995, Jones et al. 1997, and Snelling and Mattson 1998). Also, Northern pikeminnow can respond quickly in tailraces to changes in project operations (Faler et al. 1988), emphasizing the need to design good egress conditions in the immediate tailrace. Surface bypass system outfalls are generally located where bypass flow quickly passes downstream to minimize fish exposure to eddies and stagnation zones. For example, radio-tagged spring chinook migrated past a transect 1.2 km downstream of Lower Granite Dam in 19 to 23 min when passage was through the R.W. with training spill, compared to some fish taking up to five times that long when passing during normal spill conditions (Plumb et al. 2004).

Development of surface bypass systems at collector dams required evaluating the feasibility of dewatering large flow volumes if surface bypassed fish were to be transported. Mechanical screening systems of unprecedented size would be required to achieve uniform through-screen velocity distributions, and reliable debris cleaning and removal capability would have to be included in the design. Therefore, a study of high-flow dewatering and high-flow outfall alternatives was conducted for the Bonneville Dam First Powerhouse (ENSR et al. 1998). Based on the options evaluated, NOAA Fisheries and other salmon management agencies recommended use of high-flow outfalls to convey flow to tailraces, and that further high-flow dewatering investigations be curtailed. However, the high-flow outfall alternative required confirmation that discharges greater than 1,000 cfs and impact velocities greater than 25 fts^{-1} (NMFS criteria) would not result in elevated injury rates. Based on laboratory studies, impact velocities up to 52 fts^{-1} at the point of jet entry produced safe conditions for juvenile salmon. Similarly, field studies at the Bonneville Dam Second Powerhouse sluice chute indicated no mortality and injury rates of 2% associated with tailrace impact velocities of 48 fts^{-1} (Pacific Northwest National Laboratory et al. 2001). These data suggest that surface bypass system outfalls with discharges greater than 1,000 cfs and impact velocities up to 50 fts^{-1} can be safely designed.

Passage through Surface Bypass Systems Conclusions

1. Results from studies of the Lower Granite Dam removable spillway weir and Wells Dam deep-slot surface bypass systems demonstrate that surface bypass is a viable concept that can produce high rates of non-turbine fish passage with a relatively small percentage of project discharge. However, poor or marginal results from other studies indicate that satisfactory results are not always achieved with surface bypass systems, and site conditions may limit performance at some locations. Also, it can take several years of testing various configurations under different flow regimes to determine the best design and project operations.

2. Optimum surface bypass performance is attained when the entrance(s) are at a location(s) known to attract large numbers of fish. Weir entrances have proven more successful at passing juvenile salmon and steelhead migrants than deep-slot entrances. Fish appear to pass weir-type entrances most readily if flow velocity into and through the weir increases gradually. Discharge capacity should be sufficient to create a strong upstream velocity flow-field, but high discharge alone will not overcome a marginal entrance location.

3. Surface bypass systems operated 24 h per day reduce forebay residence times of juvenile salmon and potential exposure to predators relative to the existing program of 12-h spill at night. At Lower Granite Dam, forebay residence times of radio-tagged juvenile salmon were from two to four times lower with a removable spillway weir operating compared to spill-to-gas-cap operations, potentially reducing mortality due to predation in the forebay.

4. A surface bypass entrance by itself may not be enough to achieve high rates of dam passage through non-turbine routes. Additional passage facilities, such as a floating forebay curtain or upper turbine intake occlusion device, have been successful in guiding fish.

5. Successful surface bypass designs need to address guidance into the entrance, passage through the collector, discharge into the tailrace, and egress through the immediate tailrace to achieve passage performance goals of high passage efficiency and survival. Recent data indicate that for discharges greater than 1,000 cfs impact velocities up to 50 fts^{-1} are safe for juvenile salmon.

6. Tracking of fish in three dimensions through use of acoustically-tagged fish and integration of these data with hydraulic conditions from computational fluid dynamics modeling allows for a comprehensive assessment of fish behavior upstream of large hydroelectric dams, and may increase the potential for achieving fish passage objectives.