RECLAMATION

Managing Water in the West

Appraisal Assessment of the Black Rock Alternative Delivery System for Sunnyside Division

A component of
Yakima River Basin Water Storage Feasibility Study, Washington

Technical Series No. TS-YSS-4

Black Rock Valley

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region

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U.S. Department of the Interior

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

Mission of the Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

GLOSSARY AND ACRONYMS

Throughout this document, and unless otherwise noted:

Black Rock powerplant	A proposed powerplant near Roza Canal MP 22.6 at the proposed Black Rock outlet facility
Delivery systems	The proposed canal, pipeline, or tunnel systems that deliver water from the proposed Black Rock outlet facility to the existing downstream Roza and Sunnyside Divisions' canal systems for delivery to project lands
Downstream	In the direction of the water flow or current in Roza Canal
Facilities report	Refers to the *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates, Technical Series No. TS-YSS-4 December 2004* [6] report prepared by Reclamation's Denver Technical Service Center
Hydraulic grade line	The surface or profile of water flowing out of hydraulic gradient. The slope of the hydraulic grade line is under pressure; the hydraulic grade line is the actual level water would rise to in a small vertical tube connected to the pipe.
MP	Mile post – refers to locations on the Roza Canal with MP 0.0 being at Roza Diversion Dam
Outflow conveyance	The system and facilities that release water stored in a proposed Black Rock reservoir and convey it to a downstream Black Rock outlet facility
RM	River mile – refers to locations on either the Yakima River or the Columbia River
Station (Sta.)	Any one of a series of points indicating distance from a point of reference
Stationing	Increases in the direction of the water flow and decreases in the direction opposite of the water flow
Sunnyside Division	An irrigation entity comprised of Sunnyside Valley Irrigation District and eight other irrigation districts, companies, and cities

Sunnyside powerplant	A new powerplant proposed at Sunnyside Canal MP 3.83
Upstream	Toward the source of a stream or river; water in the delivery pipeline would flow upstream
USGS	U.S. Department of the Interior Geological Survey
Value Engineering	An organized team effort directed at analyzing the functions of processes, systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality, and safety.
WIS	Washington Infrastructure Services, Inc. – the contractor Brenton County, Washington, commissioned to study the technical feasibility and approximate cost of a Black Rock alternative.

PREFACE

Congress directed the Secretary of the Interior, acting through the Bureau of Reclamation (Reclamation), to conduct a feasibility study of options for additional water storage for the Yakima River basin. Section 214 of the Act of February 20, 2003, (Public Law 108-7) contains this authorization and includes the provision "… with emphasis on the feasibility of storage of Columbia River water in the potential Black Rock Reservoir and the benefit of additional storage to endangered and threatened fish, irrigated agriculture, and municipal water supply."

Reclamation initiated the *Yakima River Basin Water Storage Feasibility Study* (Storage Study) in May 2003. As guided by the authorization, the purpose of the Storage Study is to identify and examine the viability and acceptability of alternate projects by: (1) diversion of Columbia River water to the potential Black Rock reservoir for further water transfer to irrigation entities in the lower Yakima River basin as an exchange supply, thereby reducing irrigation demand on Yakima River water and improving Yakima Project stored water supplies, and (2) creation of additional storage within the Yakima River basin. In considering the benefits to be achieved, study objectives will be to modify Yakima Project flow management operations to most closely mimic the historic flow regime of a Yakima River system for fisheries, provide a more reliable supply for existing proratable water users, and provide additional supplies for future municipal demands.

State support for the Storage Study was provided in the 2003 Legislative session. The capital budget included a $4 million appropriation for the Department of Ecology (Ecology) with the provision the funds "… are provided solely for expenditure under a contract between the department of ecology and the United States bureau of reclamation for the development of plans, engineering, and financing reports and other preconstruction activities associated with the development of water storage projects in the Yakima river basin, consistent with the Yakima river basin water enhancement project, P.L. 103-434. The initial water storage feasibility study shall be for the Black Rock reservoir project."

Reclamation's Upper Columbia Area Office in Yakima, Washington, is managing and directing the Storage Study. Pursuant to the legislative directives, Reclamation has placed initial emphasis on Black Rock alternative study activities. These study activities are collectively referred to as the Black Rock Alternative Assessment (Assessment).

The Assessment has three primary objectives. First, it provides the emphasis directed by Federal and State legislation. Second, it builds upon prior work and studies to provide more information on the configuration and field construction cost of the primary components of a Black Rock alternative. It examines legal and institutional

considerations of water supply and use, and identifies areas where further study is needed. Third, it is a step forward in identifying the viability of a Black Rock alternative.

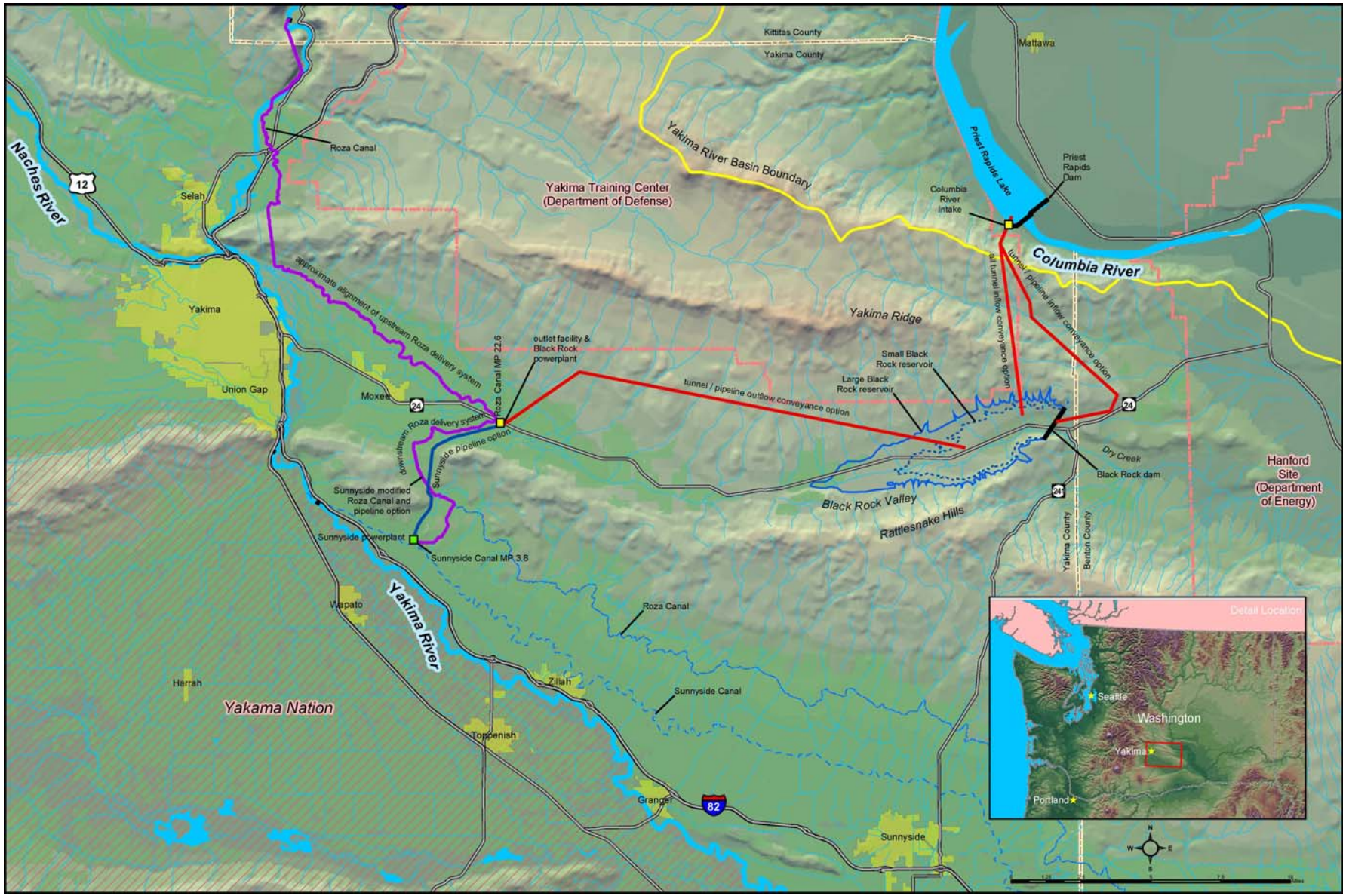
This technical document, prepared by Reclamation's Pacific Northwest Region, Boise, Idaho, is one of a series of documents prepared under the Storage Study. This particular document is a component of the Assessment reporting on preliminary appraisal-level engineering evaluation of designs and cost estimates of a potential Black Rock delivery system for the Sunnyside Division of the Yakima Project. Information and findings of this technical document are included in the Assessment Summary Report.

Further Consultations

The information available at this time is necessarily preliminary, has been developed only to an appraisal level of detail, and is therefore subject to change if this alternative is investigated further in the course of the Yakima River Basin Storage Feasibility Study (Storage Study). Finally, economic, financial, environmental, cultural, and social evaluations of the Black Rock alternative have not yet been conducted.

The policy of the Bureau of Reclamation (Reclamation) requires non-Federal parties to share the costs of financing feasibility studies and the eventual construction of Federal reclamation projects. In light of this policy, the preliminary cost estimates presented in the Assessment Summary Report, and current Federal budgetary constraints, Reclamation is not reaching a decision at this time as to whether the Black Rock alternative will be carried forward into the next phase of the Storage Study or dropped from further consideration. Rather, Reclamation will consult with the State of Washington (which is cost sharing in the Storage Study), the Yakama Nation, the potential water exchange participants, project proponents, and other interested parties before making a decision in this regard. It is anticipated that a decision will be reached by the fall of 2005.

If the Congress provides further funding for the Storage Study, all technically viable alternatives would be compared and an alternative(s) selected for further analyses in the feasibility phase. (Whether the Columbia River-Yakima River water exchange concept in the form of the Black Rock alternative is included will depend upon whether Reclamation, after these additional consultations, decides to carry that alternative forward into the plan formulation phase of the Storage Study.) The selected alternative(s) would then be subject to detailed evaluation in the feasibility phase in terms of engineering, economic, and environmental considerations, and cultural and social acceptability. This feasibility phase would be the last phase of the Storage Study. Preparation of the Feasibility Report/Environmental Impact Statement would be a part of this final phase.



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INTRODUCTION

The two identified Sunnyside Division delivery system plans (Downstream Plan 1 – delivery pipeline [Plan 1] and Downstream Plan 2 – modified Roza Canal and new pipeline [Plan 2]) start at Roza Canal MP 22.6 and end at Sunnyside Canal MP 3.83 as shown on Drawing No. 33-100T-3286 (Appendix A). The peak design flow with Sunnyside Division obtaining all of their water from the Columbia River is 1,262 cfs for both plans. While both plans include a Black Rock powerplant at Roza Canal MP 22.6, the Sunnyside Division receives powerplant discharge flows only under Plan 2. Table 1 summarizes the major features of these two plans.

Table 1. Summary of Black Rock Delivery System for Sunnyside Division

Item	Plan 1 Delivery Pipeline	Plan 2 Modified Roza Canal and New Pipeline
Extent of Columbia River water exchange	100 percent	
Beginning point of delivery	Roza Canal MP 22.6	
Peak capacity delivered	1,262 cfs	
Method of conveyance from Black Rock reservoir outflow conduit to Sunnyside Canal	new buried pipeline	enlarged Roza Canal facilities plus a new pipeline
Downstream point of delivery	Sunnyside Canal MP 3.83	
Delivery method to upstream water users	17 cfs via pressure pipeline	
Delivery method to downstream water users	1,245 cfs via Sunnyside Canal	
Estimated field construction cost at 2004 price levels (excluding Sunnyside powerplant and bypass structure costs)	$210 million	$68 million
Power generation	new Sunnyside powerplant at MP 3.83	

EXISTING WATER DELIVERY SYSTEM

The Sunnyside Division, extending about 60 miles, parallels and serves lands generally north and east of the Yakima River, as well as south of the river in the vicinity of the communities of Mabton, Grandview, and Prosser. Sunnyside Diversion Dam (RM 103.8) diverts Yakima River flows into the 1,320-cfs capacity Sunnyside Canal, the main conveyance facility which transports water to four irrigation districts, two ditch companies, and three cities totaling about 100,000 acres.[1] These entities collectively are referred to as the Sunnyside Division of the Yakima Project (see Figure 1).

The origin of Sunnyside Canal dates back to about 1878 when Konewock Ditch was constructed. Approximately 3,500 acres of the Konewock Ditch Company received their first Yakima River water in 1880. In 1890, the Northern Pacific, Yakima and Kittitas Irrigation Company made plans to enlarge and extend the ditch. The company entered into a contract with Konewock Ditch Company to supply water to its lands in exchange for purchase of the ditch and right-of-way. Purchase took place in 1893, canal enlargement followed, and the name of the ditch changed to Sunnyside Canal.

In 1900, the Washington Irrigation Company acquired the Sunnyside Canal and began selling lands for irrigated agriculture. The Reclamation Service (now Bureau of Reclamation) purchased the Sunnyside Canal in 1905 with the Washington Irrigation Company retaining 9,000 acres. The terms of the purchase required the Reclamation Service to provide water to the 9,000 acres and to honor previously executed water right contracts. The canal capacity at that time was 650 cfs serving about 40,000 acres.

The existing Sunnyside Division is the result of work performed by the Reclamation Service, and subsequently the Bureau of Reclamation (Reclamation) between 1906 and 1923. Reclamation initially operated and maintained the Sunnyside Division's diversion and conveyance facilities. Reclamation entered into contracts in 1945 with each entity establishing a Board of Control with responsibility for operation and maintenance of Sunnyside Canal and some ancillary facilities. The Board of Control is comprised of 12 directors representing entities of the Sunnyside Division. The Board of Control took over operation and maintenance of Sunnyside Diversion Dam in 1959. The Sunnyside Valley Irrigation District, largest of the entities, operates and maintains the Division's joint-use facilities on behalf of the Board of Control.

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[1] These are the Sunnyside Valley Irrigation District, Grandview Irrigation District, Benton Irrigation District, Zillah Irrigation District, Konewock Ditch Company, Piety Flat Ditch Company, city of Grandview, city of Sunnyside, and the city of Prosser.

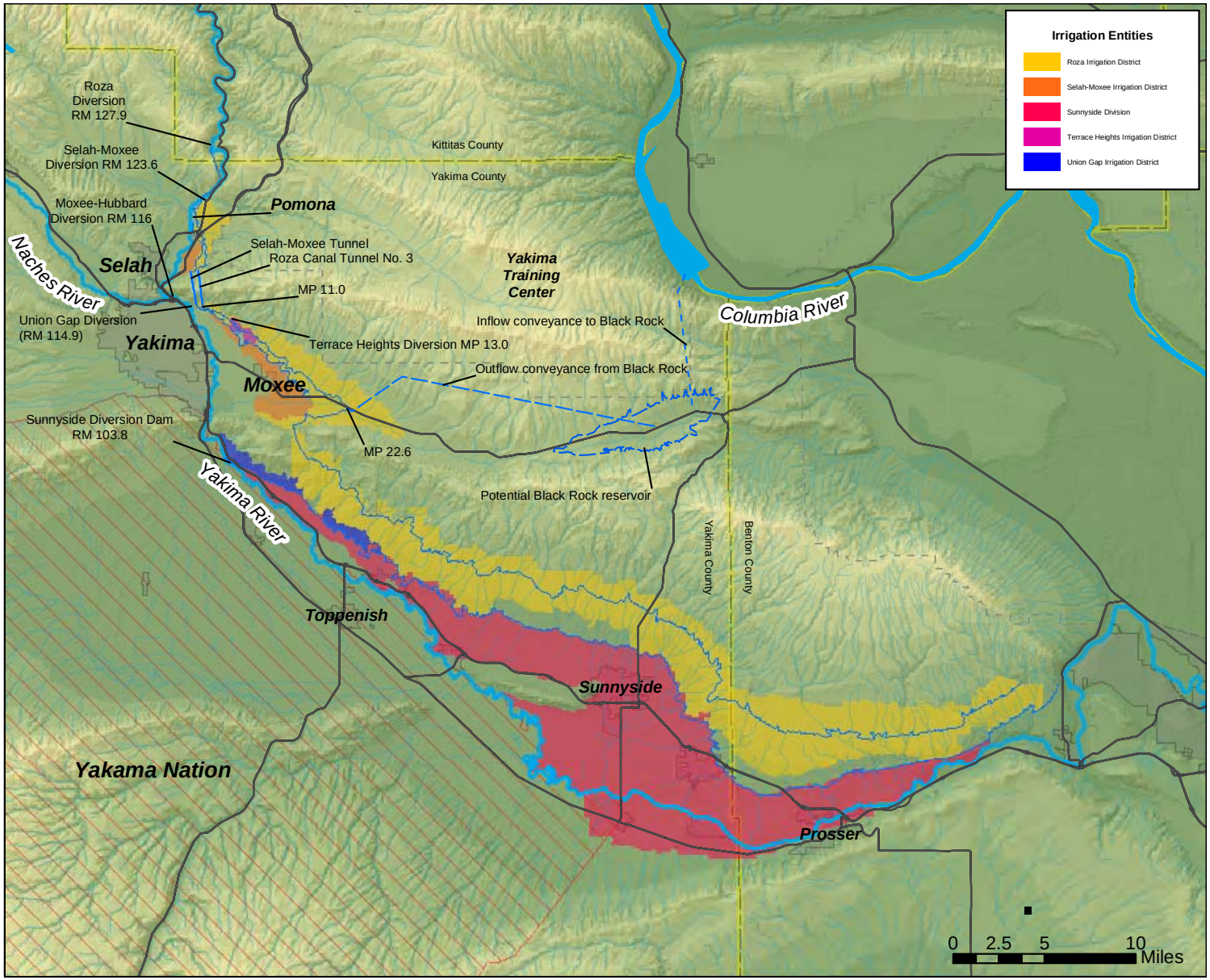


Figure 1. Overview of Sunnyside Division

Yakima River water rights of the Sunnyside Division for the April – October period originally totaled 458,520 acre-feet. However, the 2003 mediated settlement agreement and Conditional Final Order of the Adjudication Court reduced these water rights to 435,422 acre-feet. In addition, the Sunnyside Division can divert up to 12,000 acre-feet of "flood flows" in March when available. The 2003 mediated settlement agreement also provides for a reduction of water rights down to 415,972 acre-feet, and an instantaneous flow (the flow at a particular instant in time) of 1,262 cfs, by the year 2017. A further reduction down to 399,472 acre-feet, and an instantaneous flow of 1,216 cfs, is to occur at some future date. For purposes of preparing conceptual delivery plans for a potential Columbia River water exchange with the Sunnyside Division, the peak delivery requirement is 1,262 cfs.

PLAN 1 – DELIVERY PIPELINE

The 33,600-foot-long steel pipeline originates at a bifurcation structure on the Black Rock reservoir outflow conveyance system directly upstream from a new Black Rock powerplant. Drawing No. 33-100T-3287 (Appendix A) shows a plan view of the pipeline alignment. The alignment runs generally parallel to Roza Canal across orchards to the top of Konowock Pass, and then runs generally parallel to Konowock Pass Road downhill and across open land and orchards to Sunnyside Canal. Drawings Nos. 33-100T-3288, 33-100T-3289, and 33-100T-3290 (Appendix A) show the alignment and pipeline profile. Most of the 93 acres required for a 120-foot-wide construction right-of-way are through orchard land where Reclamation currently has no right-of-way.

Drawing No. 33-100T-3291 (Appendix A) shows a typical pipe trench section having a minimum 5-foot cover. A 6-inch-thick soil-cement slurry provides a gap filler in the haunch area of the pipe, to a height of about 0.25 times the pipe diameter. Compacted select backfill is placed to a height of about 0.7 times the pipe diameter to provide side support. Above that, compacted backfill and topsoil cover the pipeline to finish grade. Pipeline construction work could occur year round.

Pipe Hydraulics

At peak design flow and a minimum Black Rock reservoir water surface elevation of 1500 feet, the hydraulic grade line of the pipeline provides a positive hydraulic head at the highest elevation along the profile and allows water to flow downhill to a Sunnyside powerplant. Excess hydraulic head generates electricity at the powerplant, which has turbines designed for an average 900-cfs flow. Excess flow at the powerplant passes through a bypass structure, pressure reducing valves, and discharges into Sunnyside Canal.

The following Hazen-Williams Formula calculates friction loss for pipeline flow:

$$h_f = \frac{4.72 Q^{1.852} L}{C^{1.852} D^{4.87}}$$

where; h_f = head loss (feet)

Q = discharge (cfs)

L = length of pipe (feet)

C = Hazen-Williams roughness coefficient

D = diameter (feet)

Table B-1 in Appendix B shows the pipeline's hydraulic design calculations. A 12-foot-inside-diameter steel pipe keeps velocities under 12 feet per second**.** A 210-foot static hydraulic head at the start of the pipeline is required to deliver water to Sunnyside Canal. This results in a minimum 438-foot hydraulic head delivered at the new Sunnyside powerplant. The maximum hydraulic head delivered to the powerplant occurs when Black Rock reservoir is at maximum water surface elevation 1778 feet. This results in a maximum 743-foot hydraulic head at Sunnyside powerplant (see table B-2).

Pipe Design

The maximum internal pressure on the pipe controls the required pipe wall thickness. Two conditions are analyzed to determine the maximum pressure: maximum static hydraulic head and maximum transient hydraulic head. The maximum static hydraulic head occurs when Black Rock reservoir is at maximum water surface elevation 1778 feet and there is no flow in the pipe. This condition pressurizes the pipe to the full reservoir water surface elevation. The maximum transient hydraulic head condition is the result of closure of the powerplant valves. The maximum transient elevations used in the design are: elevation 1947 feet at the start of the pipe, elevation 2038 feet at the high point along the pipe, and elevation 2143 feet at Sunnyside Canal powerplant. The *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates, Technical Series No. TS-YSS-2* report identifies the hydraulic transient calculations. For these two conditions, transient elevations control the design.

The steel pipe design is based on guidelines from the American Water Works Association (AWWA) Manual M11. The following formula calculates the wall thickness:

$$t = \frac{p\,d}{2\,s}$$

where; t = wall thickness (in.)

p = pressure (psi)

d = outside diameter of pipe (in.)

s = allowable stress (psi)

The allowable stress is 50 percent of yield stress. ASTM (American Society for Testing and Materials) A572, Grade 60 steel pipe is used.

In addition to the above wall thickness calculation, AWWA M11 specifies a minimum wall thickness for handling based on the following formula:

$$t = \frac{D + 20}{400}$$

where; t = wall thickness (in.)

D = diameter of pipe (in.)

Table B-3 (Appendix B) shows pipe wall thickness calculations.

PLAN 2 – MODIFIED ROZA CANAL AND NEW PIPELINE

Plan 2 includes a modified Roza Canal, wasteway, and a new pipeline to convey water to the Sunnyside Canal and involves the following actions:

- Constructing a new siphon on Roza Canal from Station 1349+00 to Station 1351+95.
- Enlarging the existing Roza Canal from Station 1351+95 to Station 1594+72.
- Constructing a new tunnel from Station 1594+72 to Station 1634+60.

- Enlarging the existing Roza Canal from Station 1634+60 to Station 1689+89.60.
- Enlarging the existing Roza wasteway No. 3 from Station 2+17.72 to Station 95+00.
- Constructing a new pipeline from wasteway No. 3 Station 95+00 to a new Sunnyside Canal powerplant.

Roza Irrigation District has indicated the maximum flow downstream from Roza Canal MP 22.6 is currently about 885 cfs. However, the original design flows of the siphon, Roza Canal, and Wasteway No. 3 will be retained in the modifications and additional capacity of 1,262 cfs will be added to these facilities to convey the Sunnyside Division's Columbia River exchange water.

Construction work for the Roza system modifications likely will occur over two or three nonirrigation seasons, being coordinated so the system can continue to operate during irrigation season. Drawing No. 33-100T-3292 (Appendix A) shows the plan view of the alignment. Modifying Roza Canal and wasteway No. 3 requires acquisition of about 40 acres for additional right-of-way that is equal to the increased canal and wasteway widths and a 120-foot-wide right-of-way for the new pipeline.

New Siphon, Station 1349+00 to Station 1351+95

Black Rock reservoir water releases flow through a new Black Rock powerplant (described in the Black Rock Alternative facilities report) and then discharges into Roza Canal just upstream from a new concrete siphon beginning at Station 1349+00. The new siphon is designed for a flow of 1,300 cfs (Roza) plus 1,262 cfs (Sunnyside), for a total flow of 2,562 cfs. The siphon is similar to an existing concrete siphon at Station 1349+30 as shown on Drawing No. 33-D-1146 (Appendix A), except for a new 24-foot barrel diameter.

Enlarged Canal, Station 1351+95 to Station 1594+72

Enlarging the concrete-lined section of Roza Canal from the new siphon to the inlet of tunnel No. 5 will convey the additional Sunnyside flow (see Drawings Nos. 33-100T-3293 and 33-100T-3294 in Appendix A). Enlargement is possible by excavating the left side of the canal with the exception of the existing pumping plants P4 and P5. Near these two plants, the excavation transitions to the right side of the canal upstream from each plant and then transitions back to the left side downstream from each plant. This maintains the existing 0.00039-foot-per-foot canal slope, but widens the canal bottom width from 12 feet to 35 feet. Canal modifications meet current Reclamation standards that include 20-foot-wide operation and maintenance roads on both sides of the canal, gravel surface

roads, and 1½:1 canal side slopes. Drawing No. 33-100T-3297 (Appendix A) shows a typical modified Roza Canal section.

A new 4-inch-thick reinforced concrete lining and new longitudinal and lateral drains replace the entire existing concrete lining and drains. The modification also includes new cross drainage inlet structures and bridges over the canal. Existing turnout structures are not replaced.

Two new check structures (one at Station 1473+00 and one Station 1594+00) constructed in this canal reach each contain two 26-foot-long Langemann Gates. The check structures maintain a canal water surface similar to that of the original canal for continued service to existing pumping plants and farm turnouts. Checks control the flow depth and limit the velocity in the canal. For a typical maximum 2,147-cfs canal flow (1,262 cfs for Sunnyside and 885 cfs for Roza), the maximum canal velocity is approximately 6 feet per second. For a 2,562-cfs design flow (1,262 cfs for Sunnyside and 1,300 cfs for Roza), the velocity is approximately 7 feet per second.

New Tunnel, Station 1594+72 to Station 1634+60

The design capacity of the existing tunnel No. 5 is 1,250 cfs. To accommodate the additional Sunnyside flow, a second tunnel is excavated and constructed on the left side of and parallel to the existing tunnel. The new tunnel is identical to the existing tunnel (Drawing No. 33-D-1171, Appendix A). Both tunnels would deliver water to users.

Enlarged Canal, Station 1634+60 to Station 1689+89.60

The existing canal from the downstream end of tunnel No. 5 to the wasteway No. 3 check and turnout (see) contains two sections of concrete-lined canal at a 0.00039-feet-per-foot slope and two sections of unlined canal at a 0.00011-feet-per-foot slope. A new reinforced concrete-lined canal with drains stretches throughout this entire reach with a 0.0003-feet-per-foot slope. The bottom width of the existing lined sections increases from 12 feet to 35 feet. The existing unlined canal section maintains its 36-foot bottom width, but has a small change to the canal invert. Modifications to these sections of the canal increases the design flow capacity of 1,262 cfs for delivery to Sunnyside, plus 1,250 cfs which is the original design capacity of this reach of the Roza Canal, for a total design flow capacity of 2,512 cfs.

Enlarged Wasteway No 3, Station 2+17.72 to Station 95+00

Modifying the Roza Canal check and turnout structure and this section of wasteway No. 3 increases the design flow capacity of 1,252 cfs to 2,514 cfs to accommodate the additional Sunnyside delivery flow (see Drawing No. 33-100T-3295, Appendix A). The existing check and turnout structure is shown on Drawing No. 33-D-1717 (Appendix A). The structure is modified by constructing a new turnout parallel to the existing wasteway turnout that contains three 6-foot by 6-foot slide gates as shown on Drawing No. 33-100T-3298 (Appendix A).

The existing 0.004-foot-per-foot wasteway channel slope is maintained, but the bottom width increases from 6 feet to 35 feet. Drawing No. 33-100T-3297 (Appendix A) shows a typical modified wasteway section. A new 4-inch-thick reinforced concrete lining replaces the entire existing concrete lining. New longitudinal and lateral drains beneath the lining replace the old drains.

Five new check/drop structures, constructed at 2,000-foot intervals, are located as shown on Drawing No. 33-100T-3295 (Appendix A). Each structure contains two 26-foot-long Langemann Gates to increase the flow depth and reduce the wasteway velocity. A typical maximum 1,262-cfs Sunnyside delivery wasteway flow has a maximum velocity of approximately 6 feet per second. A maximum 2,514-cfs design flow has a maximum velocity of approximately 9.5 feet per second. Drawing No. 33-100T-3300 (Appendix A) shows a typical check/drop structure.

New Pipeline, Wasteway, Station 95+00 to Sunnyside Canal Powerplant

A turnout structure (Drawing No. 33-100T-3301, Appendix A) constructed on wasteway No. 3 at Station 95+00 diverts Sunnyside flow to a 12-foot-diameter pipeline that extends for about 4,380 feet to Sunnyside Canal powerplant as shown on Drawing No. 33-100T-3296. A Langemann Gate structure constructed in the wasteway at Station 96+50 downstream from the pipeline turnout diverts flow into the pipeline. The pipe details are the same as for Plan 1 - delivery pipeline. Wasteway flows in excess of the 1,262-cfs Sunnyside delivery continue down wasteway No. 3 and into the Yakima River. Waste flows due to powerplant shutdown automatically bypass the powerplant and flow through pressure reducing valves into Sunnyside Canal.

Pipe hydraulic calculations are similar to Plan 1, except that this pipe is unaffected by the Black Rock reservoir water surface elevation. Table C-1 in Appendix C shows the pipe hydraulic calculations for this option. Approximately 222 feet of hydraulic head is delivered to the powerplant. Steel pipe wall thickness calculations for this option (table C-2, Appendix C) are similar to Plan 1. ASTM A36 steel pipe is used.

SUNNYSIDE CANAL MP 3.83 – BOTH PLANS

Both Sunnyside delivery plans include constructing a powerplant, check structure, and a pipeline at Sunnyside Canal MP 3.83. Drawings Nos. 33-100T-3287, 33-100T-3290, 33-100T-3292, 33-100T-3295, and 33-100T-3296 (Appendix A) contain plan views showing the location of these facilities.

Powerplant and Bypass

A powerplant at the delivery point at Sunnyside Canal MP 3.83 recaptures a portion of the energy created from releasing water from Black Rock reservoir and a powerplant bypass provides continued flow to Sunnyside Canal when the powerplant is offline. The potential powerplant would have a turbine design discharge of 900 cfs and output of 29.5 MW for Plan 1 and 15 MW for Plan 2. The *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates, Technical Series No. TS-YSS-2* report addresses the powerplant and bypass structure.

Delivery to Sunnyside Division Lands Upstream from Sunnyside Powerplant

The delivery to Sunnyside Division is at Sunnyside Canal MP 3.83. The majority of the powerplant discharge flows into Sunnyside Canal for delivery to downstream water users. However, a small number of Sunnyside water users are upstream from the powerplant. A check structure in Sunnyside Canal adjacent to the powerplant prevents water from "backing up" the canal. The check structure is similar to the existing Langemann Gate structures on Sunnyside Canal. A small pumping plant at Sunnyside Canal MP 3.83 pumps 17 cfs through a 3.2-mile-long PVC pipe that is buried in the embankment on the right side of Sunnyside Canal. The pump and pipe provide pressure delivery to water users upstream from the check structure. The pipe varies in diameter from 18 inches at MP 3.83 to 6 inches at the upstream end at MP 0.61. Table D-1 in Appendix D shows the pipe hydraulic calculations.

FIELD CONSTRUCTION COST ESTIMATES

Calculating material quantities of each item (based on available data and professional judgment) and applying June 2004 unit prices provides preliminary appraisal-level cost estimates the two downstream plans. Reclamation's field construction costs are the estimated actual in-field contract cost of project construction pay items plus the following:

- Costs for mobilizing contractor personnel and equipment to the project site during initial project startup. *Mobilization* and preparation work is estimated at 5 percent of the total pay-item cost estimate.

- A contingency for *unlisted items* such as those which could be incurred with design changes and "pay items" that have not been itemized. Unlisted items are estimated as 15 percent of the total pay item and mobilization cost. The sum of the pay items, mobilization, and unlisted items is collectively referred to as the construction contract cost.

- *Contingencies* reflect funds to be used after construction starts resulting from overruns on quantities, changed site conditions, changed work orders, and other unforeseen items. Contingencies are estimated as 25 percent of the construction contract cost.

Further, additional noncontract cost will need to be incurred once a proposed Federal water resource project is authorized and Congress provides construction appropriations. These additional costs include such items as preparation of final engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, and construction contract administration and management. Right-of-way acquisition costs for project construction and subsequent project operation must also be included.

Plan 1 – Delivery Pipeline

The excavation quantity for pipeline construction is based on 10-foot-contour-interval topography. Land Development Desktop software calculates the total excavation quantity. Based on geologist's visual observations, rock excavation is estimated to occur between approximately pipeline Station 205+00 and Station 255+00, or about 15 percent of the length of the pipeline. Therefore, 85 percent of the excavation is estimated as common excavation. The cost estimate worksheet on table E-1 (in Appendix E) shows all the individual project items and costs for this option. The total field construction cost is $210 million. These costs do not include a new Sunnyside powerplant and bypass structure.

Plan 2 – Modified Roza Canal and New Pipeline

Quantity estimates for Roza Canal, wasteway, and new pipeline modifications are based on the original construction drawings in Reclamation Specifications (33-D-1042, 33-D-1134, 33-D-1135, and 33-D-1136) for building those facilities. Typical cross sections, ground slopes for the topography, and the original ground surface provide information for calculating excavation and embankment quantities. Figure C-3 and tables C-4 through C-6 in Appendix C show the excavation and embankment quantity calculations for Roza Canal modifications. Figures C-7 and C-9 and tables C-8 and C-10 show the excavation and embankment quantity calculations for wasteway No. 3 modifications. Quantities for estimating the new tunnel came from the original construction drawing for the existing tunnel. The cost estimate worksheet on table E-2 (in Appendix E) shows all the individual project items and costs. The total field construction cost is $68 million. These costs do not include a new Sunnyside powerplant and bypass structure.

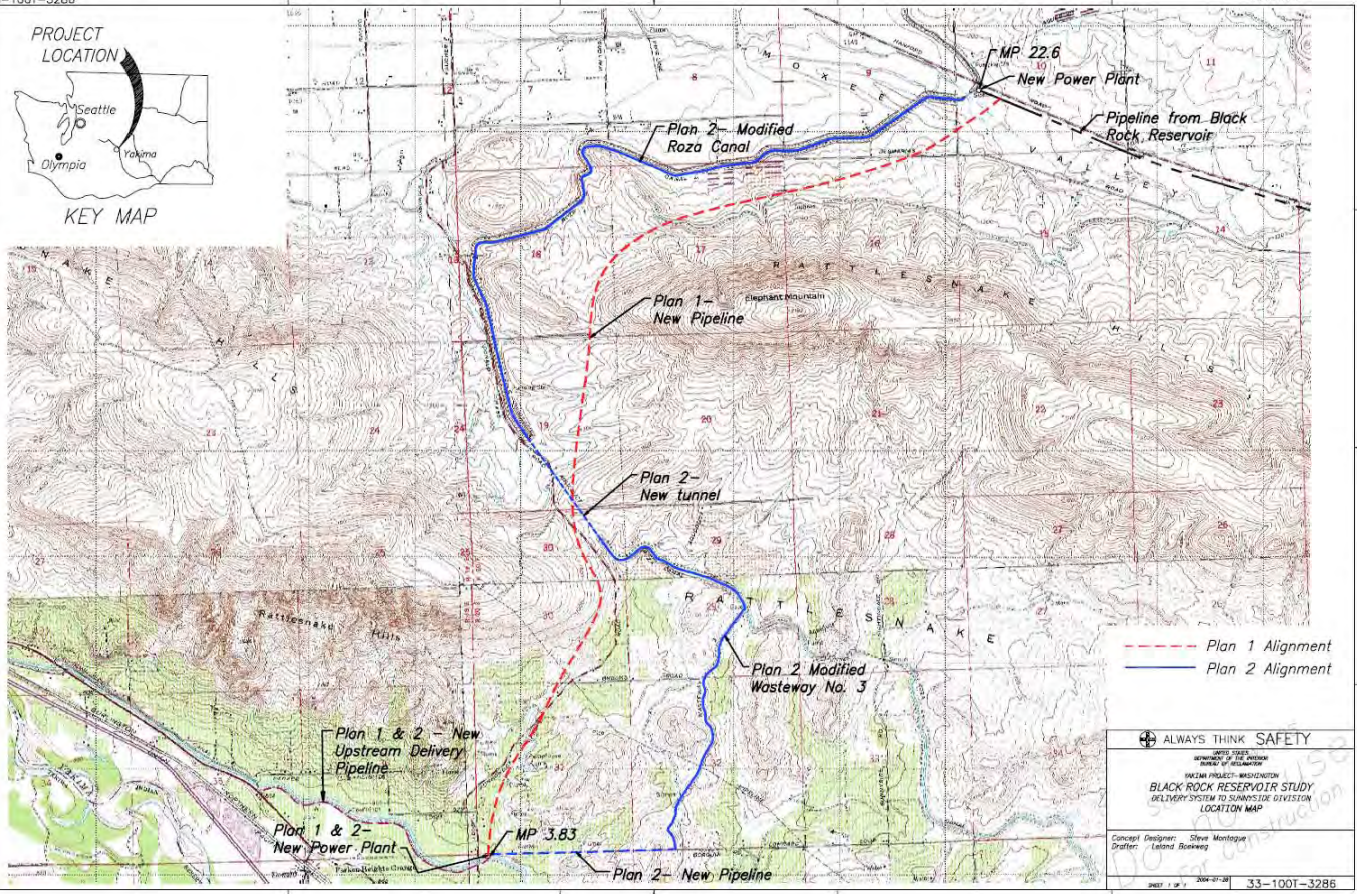
Table 2. Cost Summary of Black Rock Delivery Systems for Sunnyside Division

Item	Plan 1 – Delivery Pipeline	Plan 2 – Modified Roza Canal and New Pipeline
Subtotal of Pay Items	$138,200,000	$44,800,000
Mobilization (5%)	$6,900,000	$2,200,000
Unlisted items (15%)	$19,900,000	$7,000,000
Construction Contract Cost	$165,000,000	$54,000,000
Contingencies (25%)	$45,000,000	$14,000,000
Total Field Construction Cost	$210,000,000	$68,000,000

APPENDIX A – DRAWINGS

33-100T-3286

Sheet 1



33-100T-3287

Sheet 2

NOTE:
Aerial photo's obtained from Yakima County, WA (2002)

ALWAYS THINK SAFETY

YAKIMA PROJECT, WASHINGTON

BLACK ROCK RESERVOIR STUDY

DELIVERY SYSTEM TO SUNNYSIDE DIVISION

PLAN II - PIPELINE

SITEPLAN

Concept Designer: Steve Montague

Drafter: S. Hughes

Not for Use or Construction

33-100T-3287

PLAN – STA. 0+00 TO STA. 125+00

LEGEND

- Plan 1 – Pipeline Plan View
- Plan 1 – Pipeline Invert Profile
- Row

NOTES:

Elevations shown are original ground.

Aerial photos obtained from Yakima County, WA (2002)

PROFILE – STA. 0+00 TO STA. 125+00

500 0 500 1000 1500
SCALE OF FEET

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PROFESSIONAL ENGINEER
STATE OF WASHINGTON
20007 - REGISTERED

YAKIMA PROJECT - WASHINGTON

BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVISION
PLAN 1 - PIPELINE
PLAN & PROFILE - STA. 0+00 TO STA. 125+00

Not for Construction

Concept Designer: Steve Montague
Drafter: D. Hale/JS

CAD FILE NAME: 33-100T-3288
SCALE: 1:500
REVISE TEMPLATE: 12/06/2007
SHEET 1 OF 9
CAD FILENAME: 33-100T-3288

PLAN – STA. 125+00 TO STA. 250+00

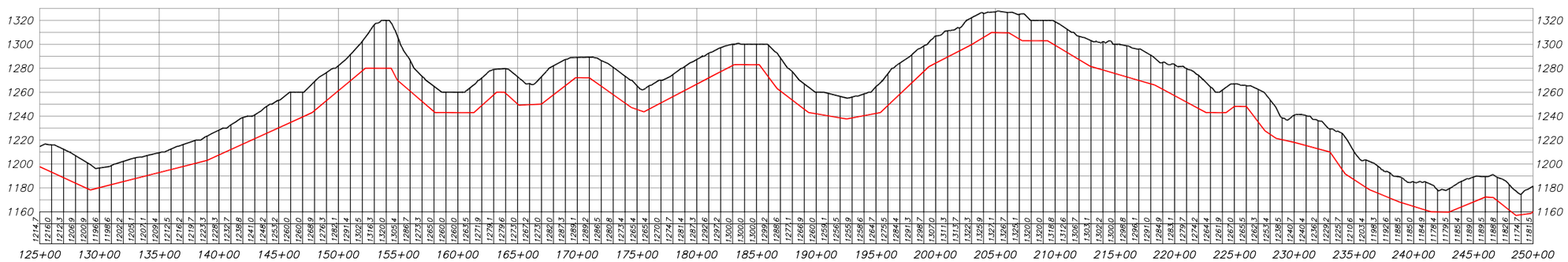
LEGEND

- Plan 1 – Pipeline Plan View
- Plan 1 – Pipeline Invert Profile
- Row

NOTES:

Elevations shown are original ground.

Aerial photos obtained from Yakima County, WA (2002)



PROFILE – STA. 125+00 TO STA. 250+00

500 0 500 1000 1500
SCALE OF FEET

1000 0 1000 2000 3000
SCALE OF FEET

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

YAKIMA PROJECT – WASHINGTON

BLACK ROCK RESERVOIR STUDY

DELIVERY SYSTEM TO SUNNYSIDE DIVISION

PLAN 1 – PIPELINE

PLAN & PROFILE – STA. 125+00 TO STA. 250+00

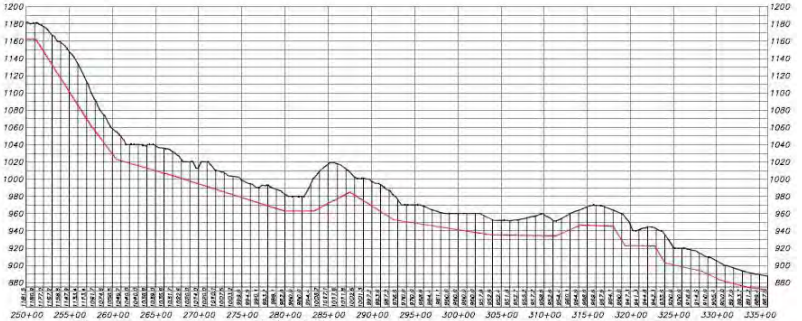
Concept Designer: Steve Montague
Drafter: G. Hope/LB

CAD SYSTEM: AutoCAD Rel. 16.1
BOISE, IDAHO
SHEET 2 OF 4
01DEC2003
CAD FILENAME: 33–100T–3289.DWG
33–100T–3289

Study Working Use
Not for Construction

DATE AND TIME PLOTTED
JANUARY 28, 2005 14:27
PLOTTED BY
CHSUE

PLAN – STA. 250+00 TO STA. 335+92.32



PROFILE – STA. 250+00 TO STA. 335+92.32

LEGEND

- Plan 1 – Pipeline Plan View
- Plan 1 – Pipeline Invert Profile
- Row

NOTES:

Elevations shown are original ground.

Aerial photos obtained from Yakima County, WA (2002)

SCALE OF FEET

SCALE OF FEET

ALWAYS THINK SAFETY

BUREAU OF RECLAMATION
DEPARTMENT OF THE INTERIOR
UNITED STATES

YAKIMA PROJECT, WASHINGTON

BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVERSION
PLAN 1 – PIPELINE
PLAN & PROFILE – STA. 250+00 TO STA. 335+92.32

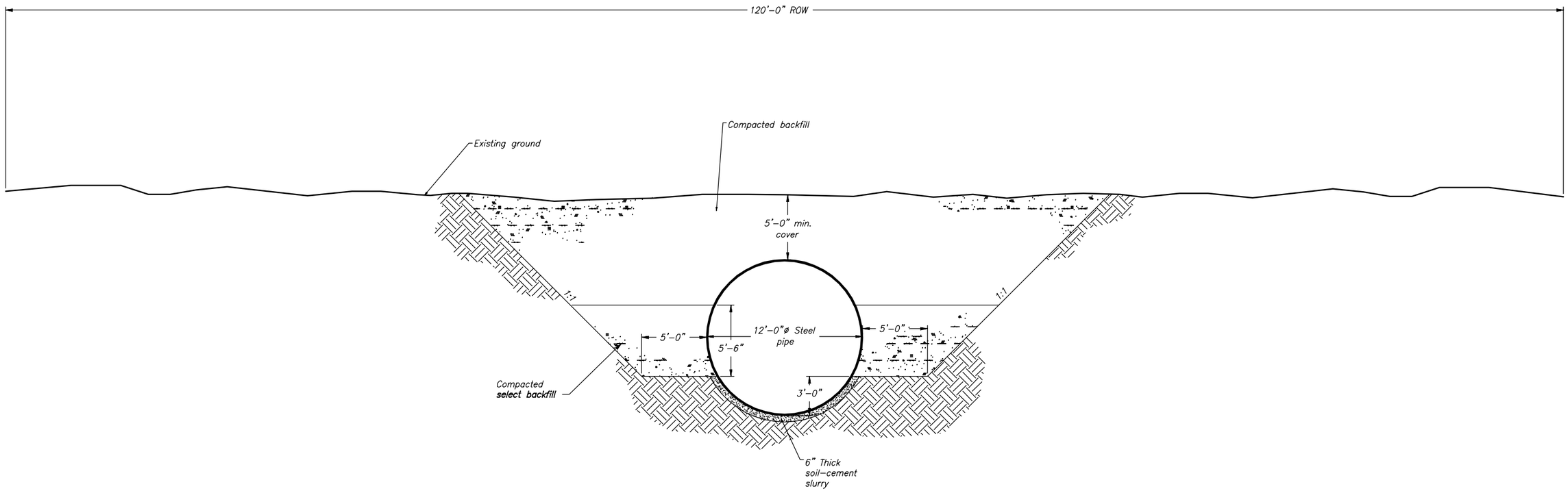
Concept Designer: Steve Montague
Drafter: G. Hoyt/Tal

Not for construction or any other use

CAD FILENAME: 33-100T-3290.DWG

33-100T-3290

DWG AND TAB IN PROJ. DIRECTORY OF CURRENT DATE/TIME



TYPICAL PIPE TRENCH SECTION

1 0 5 10 15
SCALE OF FEET

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

YAKIMA PROJECT – WASHINGTON

BLACK ROCK RESERVOIR STUDY

DELIVERY SYSTEM TO SUNNYSIDE DIVISION

PLAN 1 – PIPELINE

TYPICAL PIPE TRENCH SECTION

Concept Designer: Steve Montague
Drafter: G. Hope/LB

BOISE, IDAHO SHEET 1 OF 1 Feb 6, 2004 33–100T–3291

Study Purposes Only
DO NOT Use for Construction

CAD SYSTEM AutoCAD Rel. 16.0
CAD FILENAME 33-100T-3291.DWG
DATE AND TIME PLOTTED FEBRUARY 9, 2005 10:22
PLOTTED BY GHOPE

33-100T-3292

Sheet 7

NOTES:

1. Roza Canal and Wasteway No. 3 stations shown are existing stations. The new pipeline is new stationing.
2. Aerial photos obtained from Yakima County, WA (2002).

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YAKIMA PROJECT, WASHINGTON

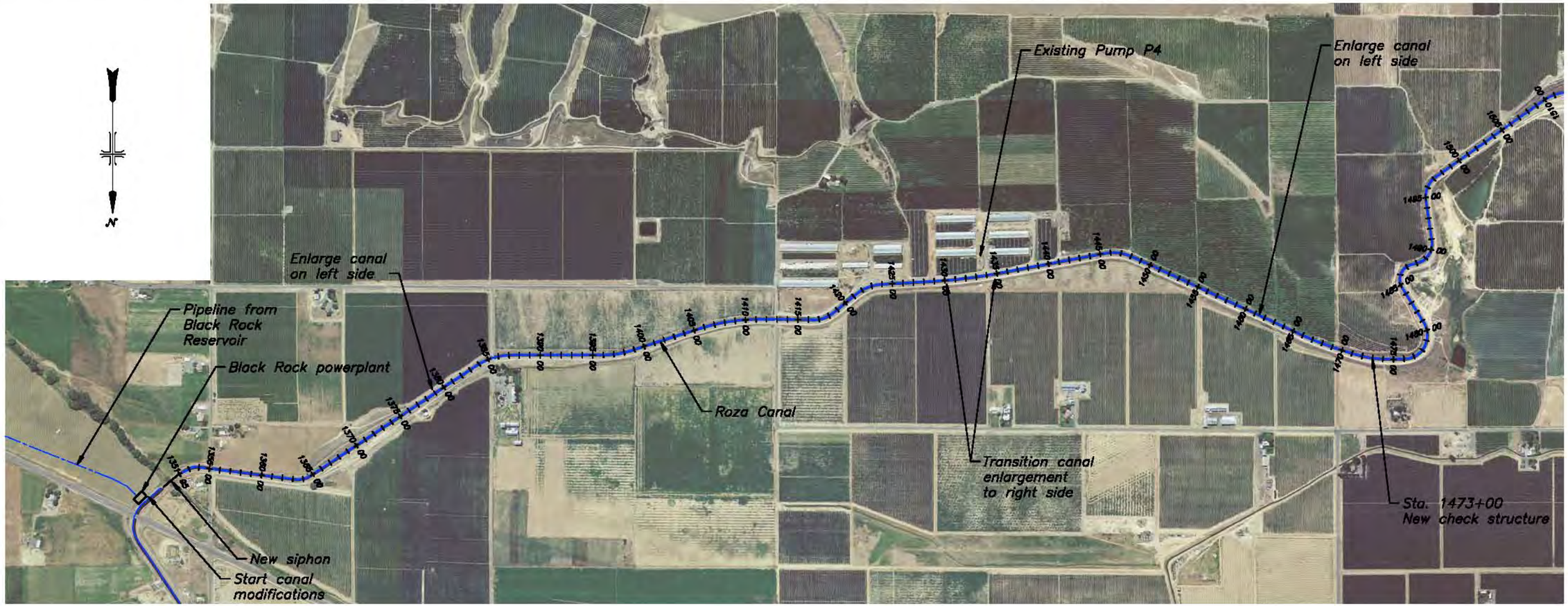
BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVISION
PLAN 2 - CANAL MODIFICATION
SITE PLAN

Concept Designer: Steve Montague
Drafter: G. Jaquin/LB

Do not use for construction

33-100T-3292

33-100T-3293



PLAN – STA. 1349+00 TO STA. 1510+00

NOTES:

1. Stations shown are existing canal stations.
2. Aerial photos obtained from Yakima County, WA (2002)

SCALE OF FEET: 500 0 500 1000 1500

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YAKIMA PROJECT, WASHINGTON

BLACK ROCK RESERVOIR STUDY

DELIVERY SYSTEM TO SUNNYSIDE DIVISION

PLAN 2 – CANAL MODIFICATION

PLAN – STA. 1349+00 TO STA. 1519+00

Concept Designer: Steve Montague
Drafter: G. Hope/LB

Do Not Drawing Use For construction

CAD SYSTEM: BOISE, IDAHO | CAD FILENAME: 33-100T-3293

SHEET 2 OF 8 | 03/07/2003

AutoCAD Rel. 15.1s
33-100T-3293.DWG
DATE AND TIME PLOTTED
MARCH 31, 2003 08:03
PLOTTED BY
CHSUE

PLAN – STA. 1510+00 TO STA. 1689+89.60

NOTES:

1. Stations shown are existing canal stations.
2. Aerial photos obtained from Yakima County, WA (2002)

SCALE OF FEET

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BLACK ROCK RESERVOIR STUDY

DELIVERY SYSTEM TO SUNNYSIDE DIVISION

PLAN 2 - CANAL MODIFICATION

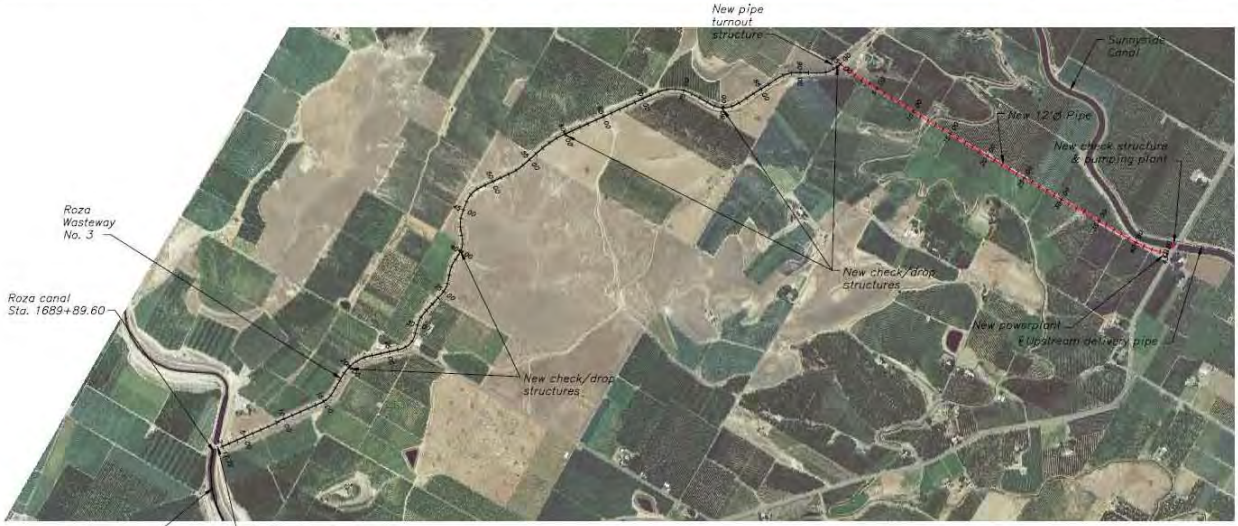
PLAN 2 - STA. 1510+00 TO STA. 1689+89.60

Concept Designer: Steve Montague
Drafter: C. Hage/LB

For Construction

DATE 10/31/03 SHEET 3 OF 9

33-100T-3294



PLAN – WASTEWAY STA. 1+00 TO STA. 95+00
12'ø PIPE STA. 0+00 TO 43+80

NOTES:

1. Wasteway No. 3 stations are existing stations.
2. Aerial photos obtained from Yakima County, WA (2002)

SCALE OF FEET

ALWAYS THINK SAFETY

YAKIMA PROJECT, WASHINGTON

BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVISION
PLAN 2 - CANAL MODIFICATION
PLAN – WASTEWAY & 12'ø PIPE

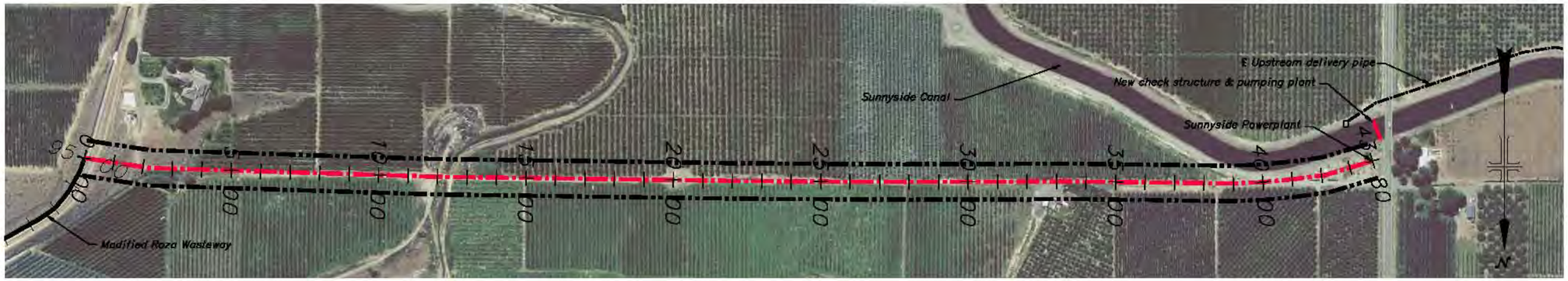
Concept Designer: Steve Montague
Drafter: G. Hope/LB

Not for construction

CAD FILENAME

33-100T-3295

33-100T-3296



LEGEND

- Plan 2 – ℄ Pipeline Plan View
- Plan 2 – Pipeline Invert Profile
- ROW

NOTE:
Aerial photos obtained from Yakima County, WA (2002)

PLAN

200 0 200 400 600
SCALE OF FEET

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YAKIMA PROJECT, WASHINGTON

BLACK ROCK RESERVOIR STUDY

DELIVERY SYSTEM TO SUNNYSIDE DIVISION

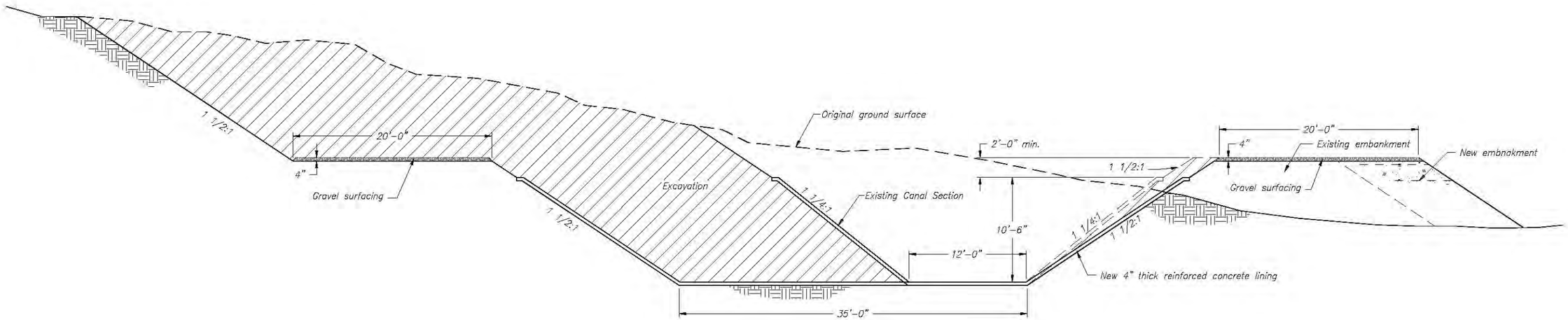
PLAN 2 – 12" PIPE ALIGNMENT
PLAN & PROFILE

Concept Designer: STEVE MONTAGUE
Drafter: G. HOPE/JB

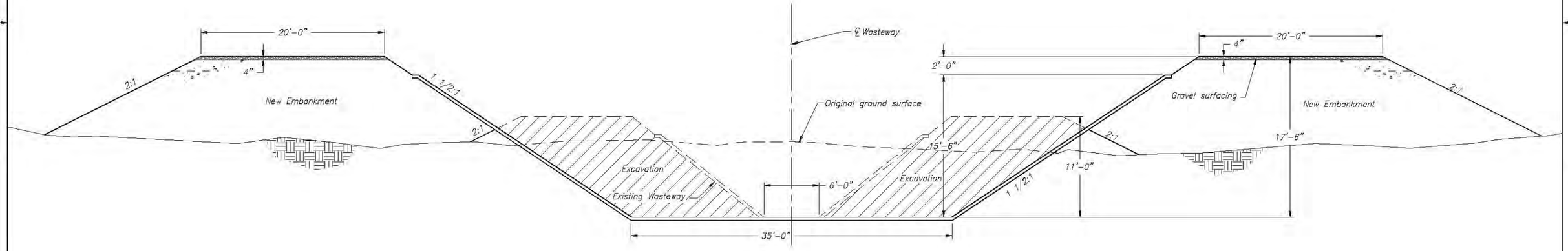
Do Not Use for Construction
Standard Use

CAD SYSTEM	CAD FILENAME
BOISE, IDAHO SHEET 5 OF 8 04DEC2003	33-100T-3296

AutoCAD Rel. 16.0
33-100T-3296.DWG
DATE AND TIME PLOTTED
JANUARY 12, 2005 14:52
PLOTTED BY
LBRENNER



TYPICAL MODIFIED ROZA CANAL SECTION



TYPICAL MODIFIED WASTEWAY NO. 3 SECTION

1 0 5 10 15
SCALE OF FEET

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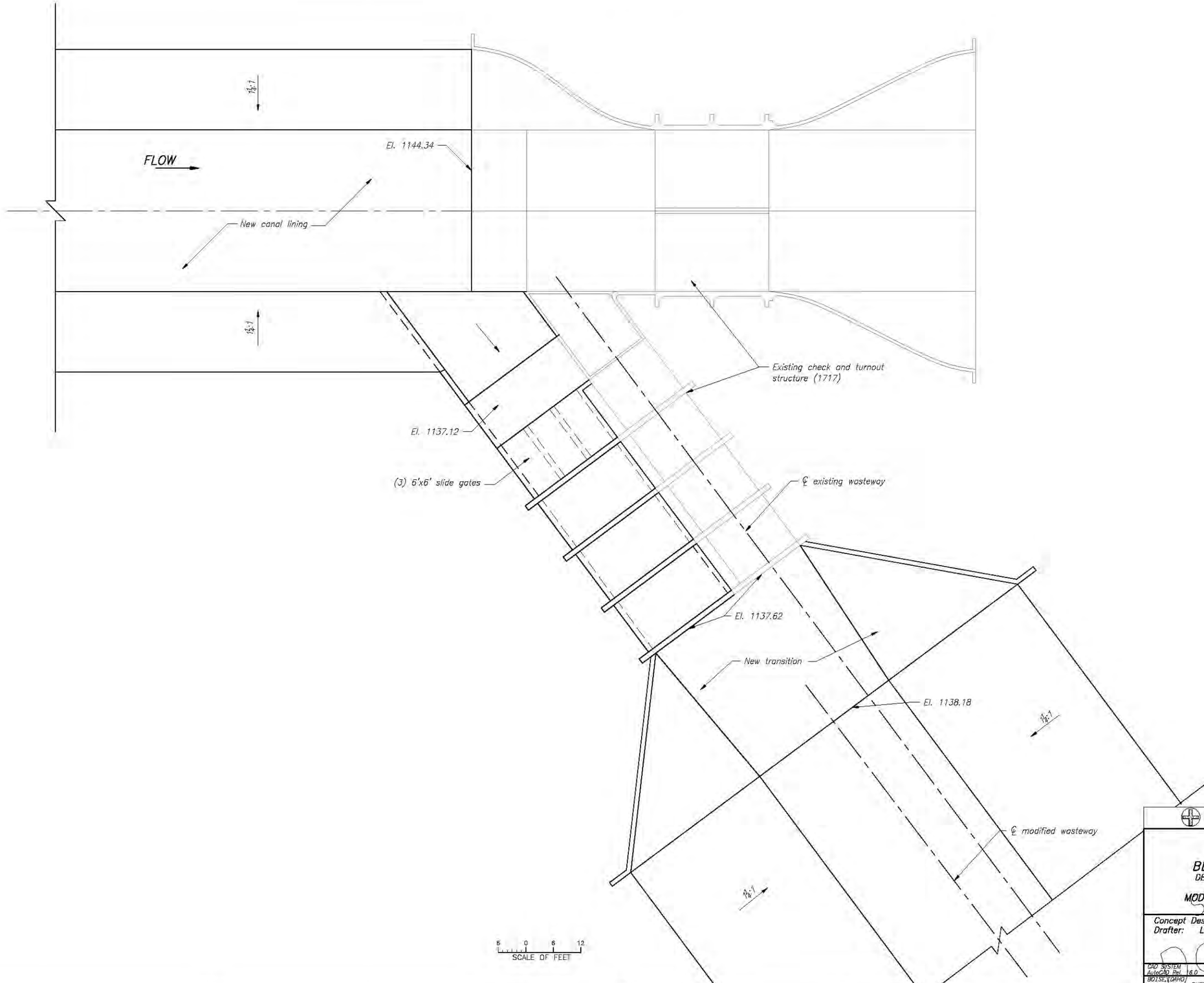
YAKIMA PROJECT–WASHINGTON

BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVISION
OPTION 2–CANAL MODIFICATION
TYPICAL SECTIONS

Concept Designer: Steve Montague
Drafter: Leland Boekweg, EDM

BOISE, IDAHO 2004-02-03 SHEET 1 OF 1 33-100T-3297

CAD SYSTEM AutoCAD Rel. 16.0
CAD FILENAME 33-100T-3297.DWG
DATE AND TIME PLOTTED JANUARY 28, 2015 13:53
PLOTTED BY LBOEKWEG



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YAKIMA PROJECT-WASHINGTON

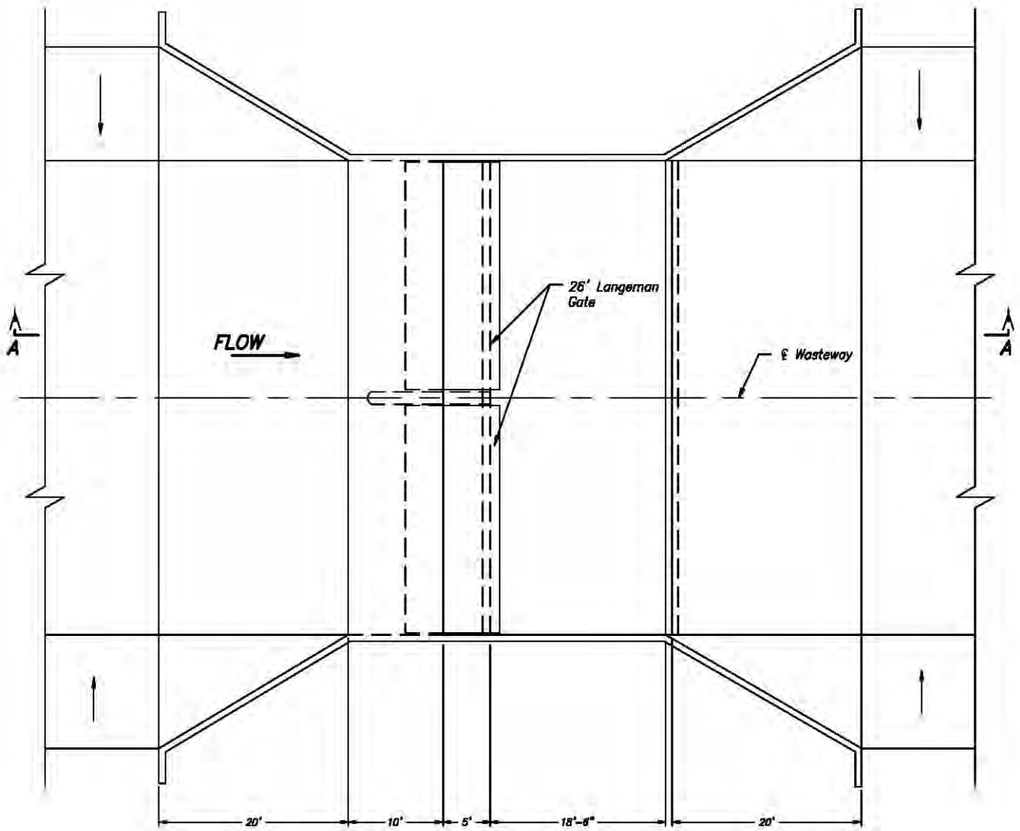
BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVISION
PLAN 2-CANAL MODIFICATION
MODIFIED WASTEWAY TURNOUT STRUCTURE

Concept Designer: Steve Montague
Drafter: Leland Boekweg

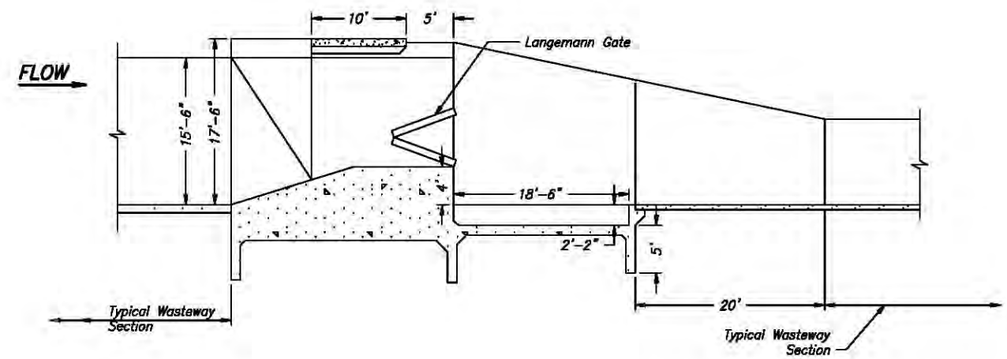
DO NOT USE for construction

CAD SYSTEM AutoCAD Rel. 16.0 BOISE,IDAHO	2004-02-03	CAD FILENAME 33-100T-3298.DWG
SHEET 1 OF 1		33-100T-3298

DATE AND TIME PLOTTED
FEBRUARY 2, 2005 15:55
PLOTTED BY
LBOEKWEG



PLAN–WASTEWAY CHECK STRUCTURE



SECTION A–A

8 0 8 16 24
SCALE OF FEET

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BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVERSION
OPTION 2–CANAL MODIFICATION
WASTEWAY CHECK STRUCTURE
PLAN AND SECTION

Concept Designer: Steve Montague
Drafter: Leland Boekweg, EDM

Not for Construction

BOISE, IDAHO | SHEET 1 OF 1 | 2004-02-02 | 33-100T-3300

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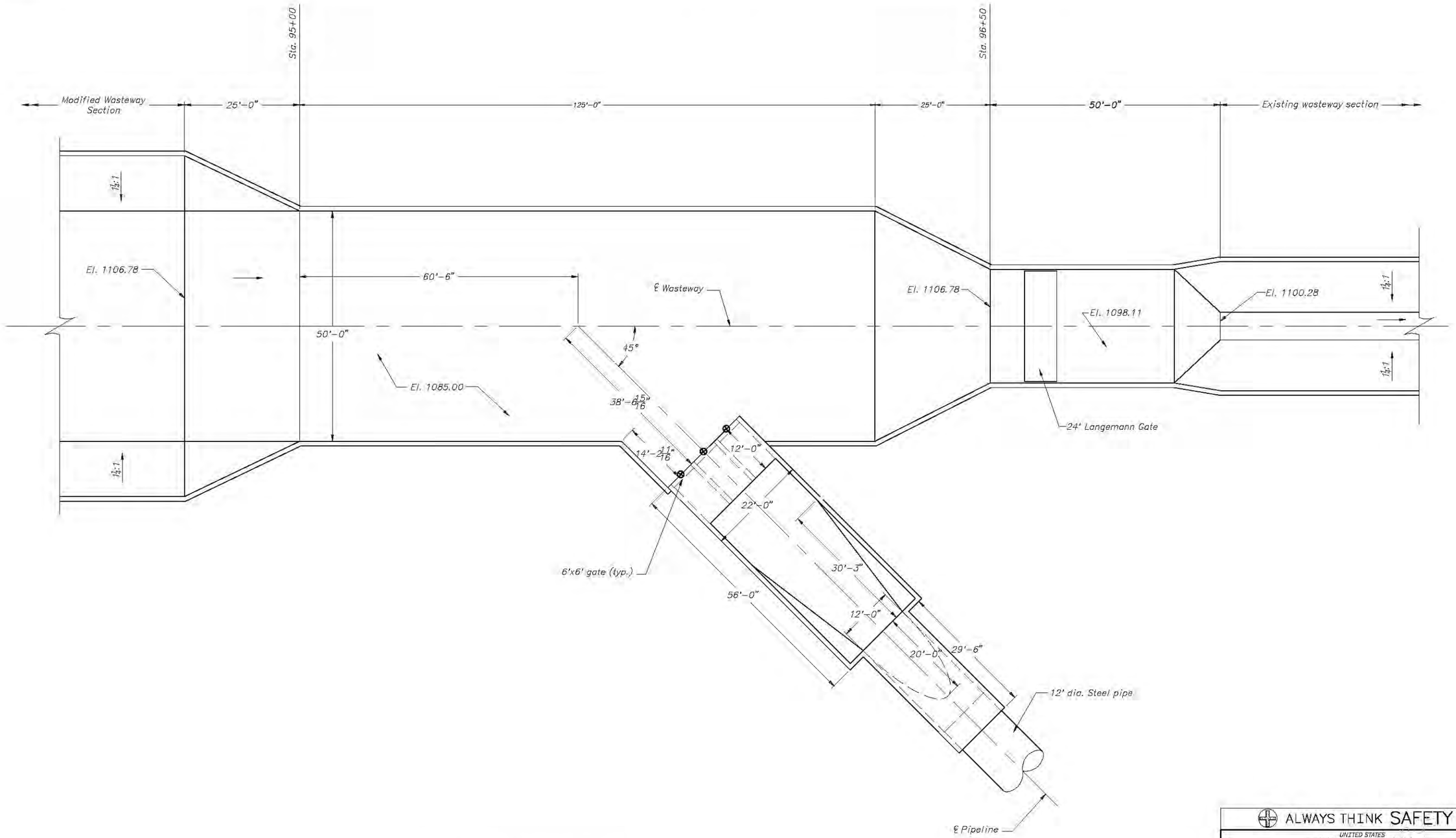
CAD FILENAME 33-100T-3300.DWG
DATE AND TIME PLOTTED FEBRUARY 5, 2026 10:28
PLOTTED BY GNORE



PLAN–PIPELINE TURNOUT STRUCTURE

10 5 10 15 20 25
SCALE OF FEET

ALWAYS THINK SAFETY

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BUREAU OF RECLAMATION
YAKIMA PROJECT – WASHINGTON

BLACK ROCK RESERVOIR STUDY
DELIVERY TO SUNNYSIDE DIVISION
PLAN 2–CANAL MODIFICATION
PIPELINE TURNOUT STRUCTURE

Concept Designer: Steve Montogue
Drafter: Leland Boekweg, EDM

CADD SYSTEM AutoCAD Rel. 16.0	CADD FILENAME 33-100T-3301.DWG
BOISE, IDAHO OCTOBER 2003	33-100T-3301

SPECIFICATION #

FEBRUARY 2, 2005 1:35P
PLOTTED BY LBOEKWEG

SPECIFICATIONS No. 748

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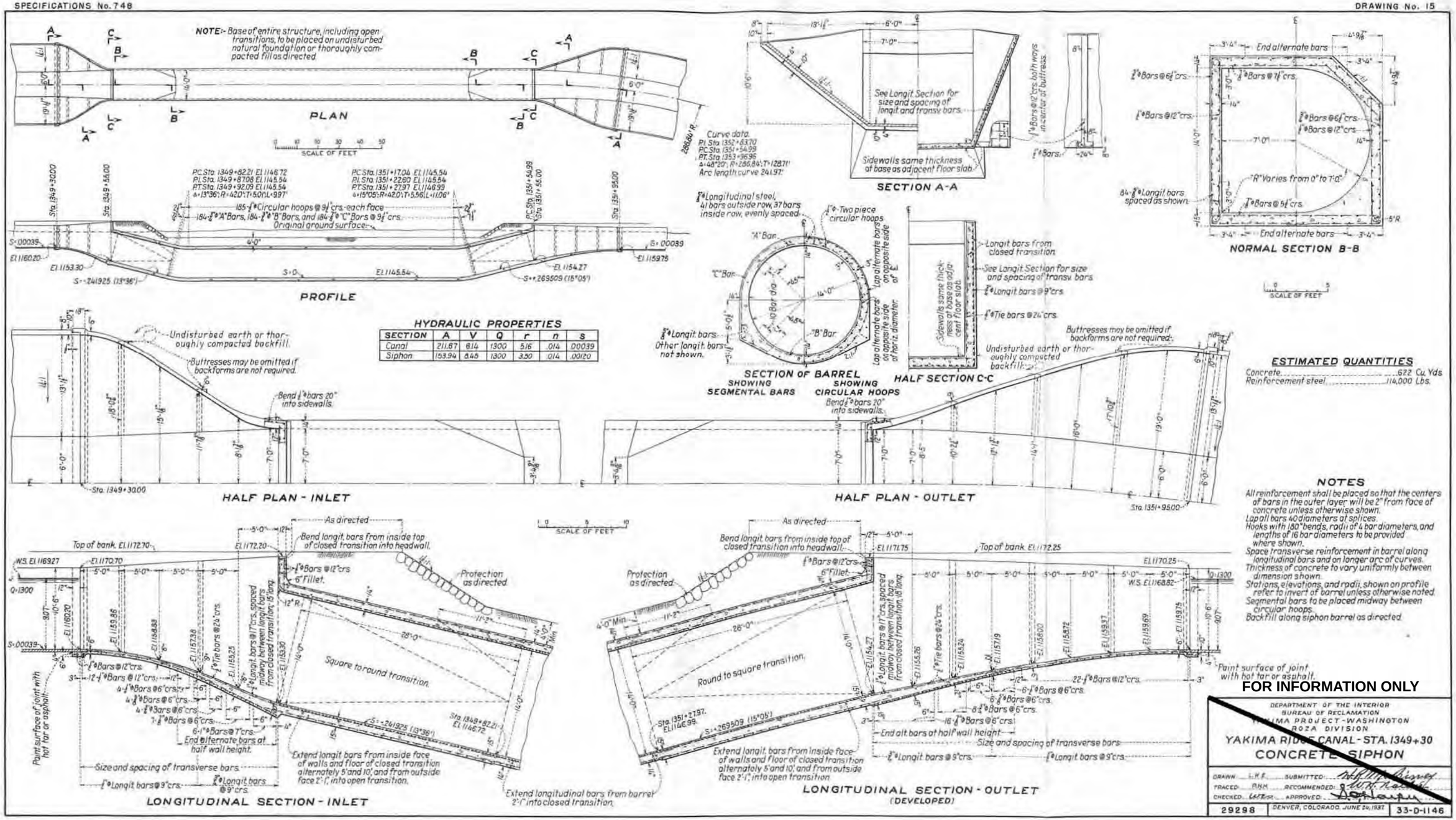


FOR INFORMATION ONLY

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
ROZA DIVISION

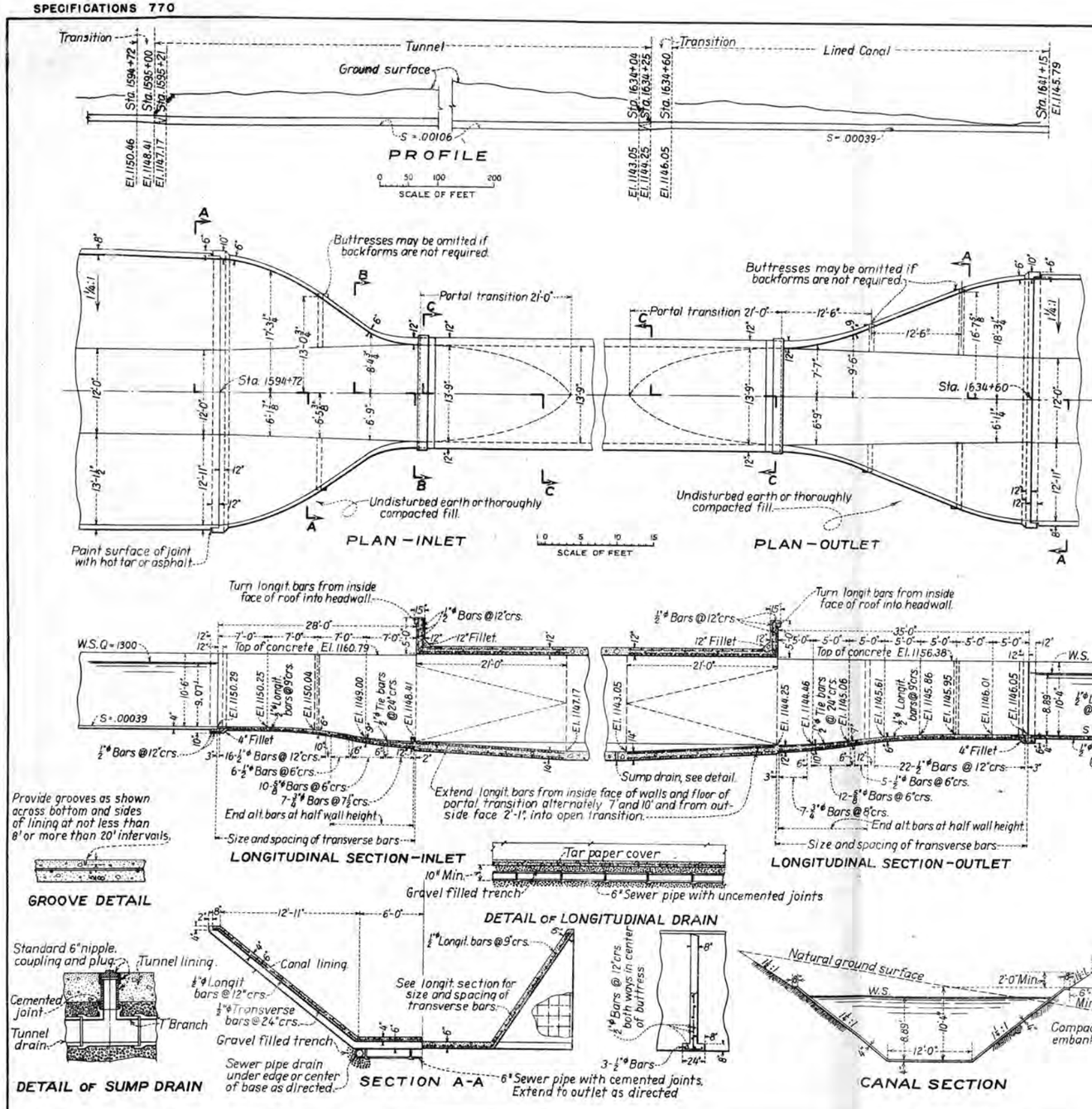
YAKIMA RIDGE CANAL - STA. 1349+30
CONCRETE SIPHON

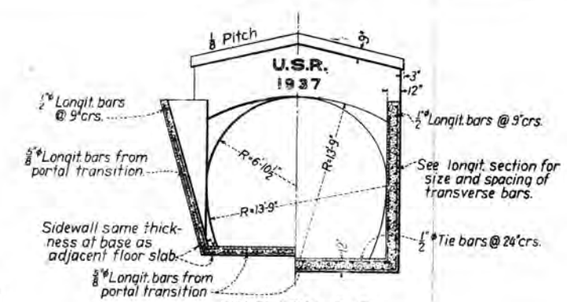
DRAWN L.H.F. SUBMITTED
TRACED RBH RECOMMENDED
CHECKED APPROVED

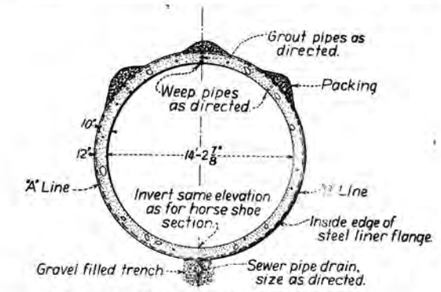
29298 | DENVER, COLORADO, JUNE 24, 1937 | 33-D-1146

SPECIFICATIONS 770

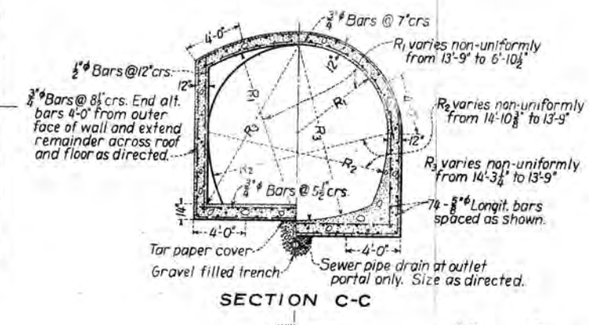
DRAWING No. 2

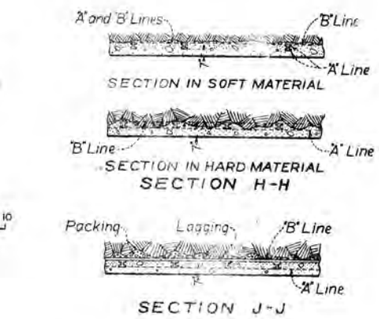


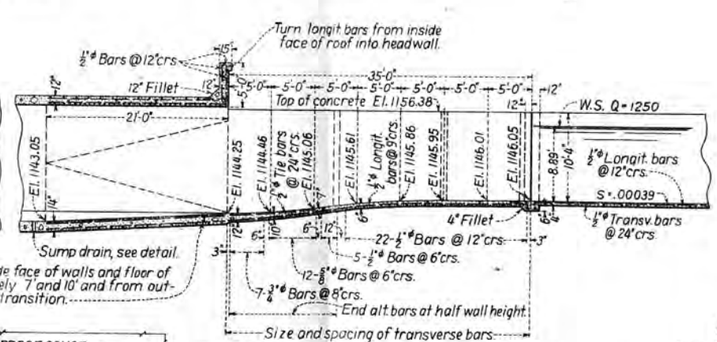


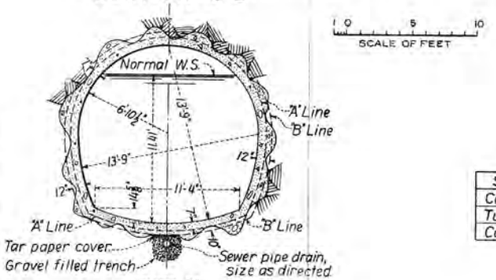


STEEL LINER PLATE DATA					
Inside Dia. Tunnel	Outside Dia. Tunnel	Number Plates	Size Plates	Cover Over Flange	Total thick. Concrete
14'-2 7/8"	16'-2 5/8"	17	36"	10"	12"









HYDRAULIC PROPERTIES

SECTION	A	V	Q	r	n	s
Canal above	211.67	6.14	1300	5.16	.014	.00039
Tunnel	140.06	8.92	1250	4.21	.014	.00106
Canal below	205.47	6.08	1250	5.08	.014	.00039

ESTIMATED QUANTITIES

Concrete reinforced ..... 150 Cu. Yds.
Concrete tunnel lining ..... 7,000 Cu. Yds.
Concrete reinforced canal lining ..... 360 Cu. Yds.
Reinforcement steel ..... 44,500 Lbs.

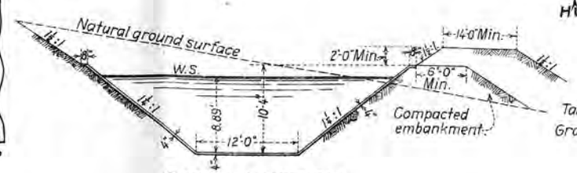
NOTES

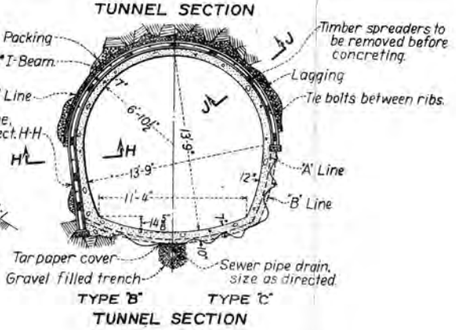
All reinforcement shall be placed so that the centers of bars in the outer layer will be 2" from face of concrete unless otherwise shown.
Lap all bars 40 diameters at splice.
Thickness of concrete to vary uniformly between dimensions shown.

GROOVE DETAIL

DETAIL OF LONGITUDINAL DRAIN

DETAIL OF SUMP DRAIN





FOR INFORMATION ONLY

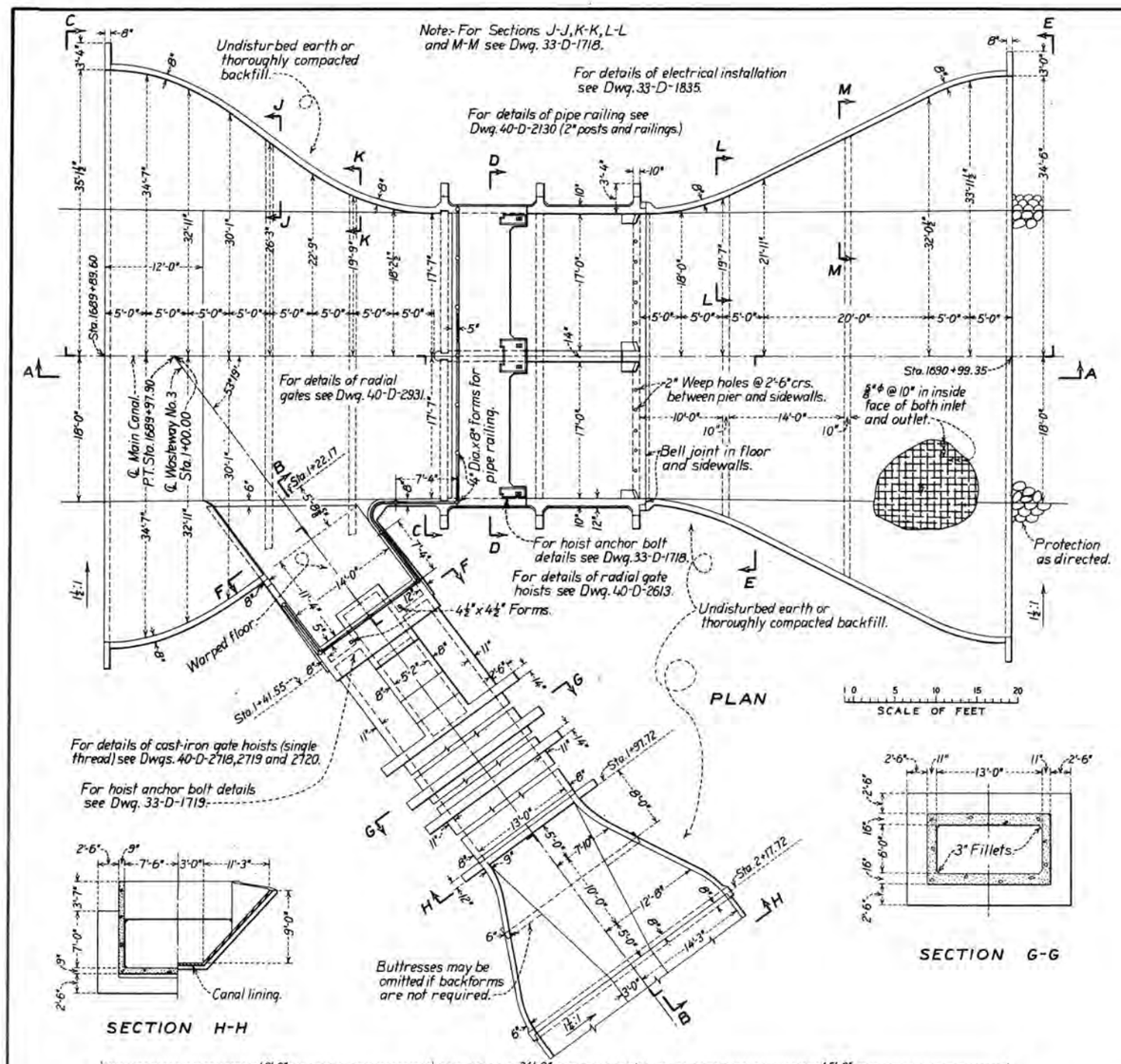
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
ROZA DIVISION

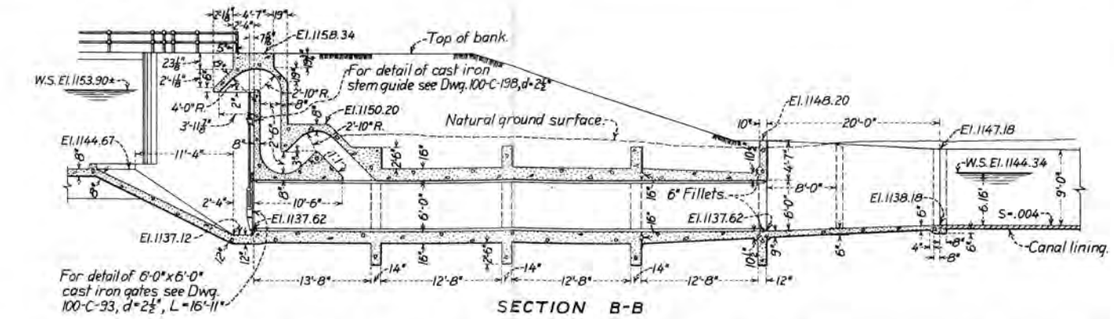
YAKIMA RIDGE CANAL - STA. 1594+72
TUNNEL No. 5

DRAWN L.H.E. SUBMITTED
TRACED W.C.W. RECOMMENDED
CHECKED APPROVED

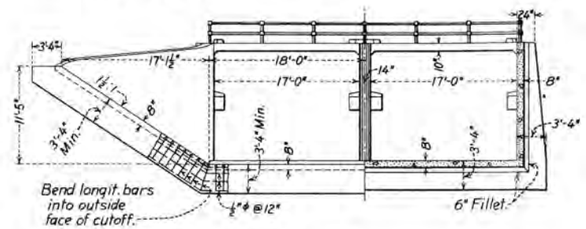
29784 | DENVER, COLORADO. JUNE 19, 1937 | 33-D-1171

DRAWING No. 3

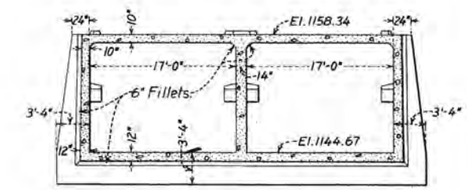




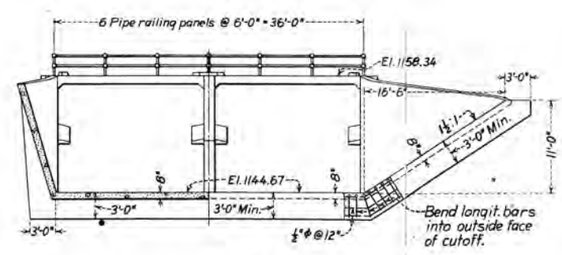
SECTION B-B



SECTION C-C



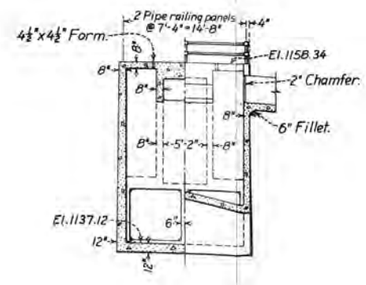
SECTION D-D



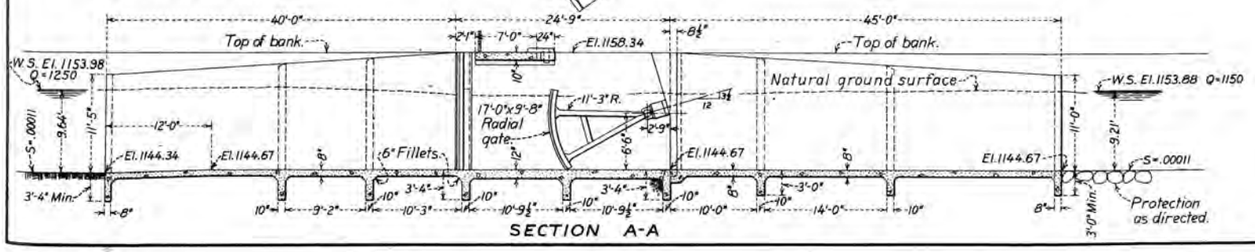
SECTION E-E

SECTION H-H

SECTION G-G



SECTION F-F



SECTION A-A

HYDRAULIC PROPERTIES

SECTION	A	V	Q	r	n	s
Main canal above	486.44	2.57	1250	6.875	.0225	.00011
Main canal below	458.70	2.51	1150	6.63	.0225	.00011
Wasteway	84.39	14.84	1252	3.28	.014	.004
Siphon spillway	12.92	12.38	160			

ESTIMATED QUANTITIES

Concrete ..... 440 Cu. Yds.
Reinforcement steel ..... 48,000 Lbs.

NOTES

All reinforcement shall be placed so that the centers of bars in the outer layers will be 2" from face of concrete unless otherwise shown.
Lap all bars 40 diameters at splices.
Hooks with 180° bends, radii of 4 bar diameters and lengths of 16 bar diameters to be provided where shown.
Thickness of concrete to vary uniformly between dimensions shown.
Base of entire structure to be placed on undisturbed natural foundation or thoroughly compacted fill.
All anchor bolts shall be galvanized.

FOR INFORMATION ONLY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
ROZA DIVISION

YAKIMA RIDGE CANAL STA. 1689+97.9

WASTEWAY No. 3

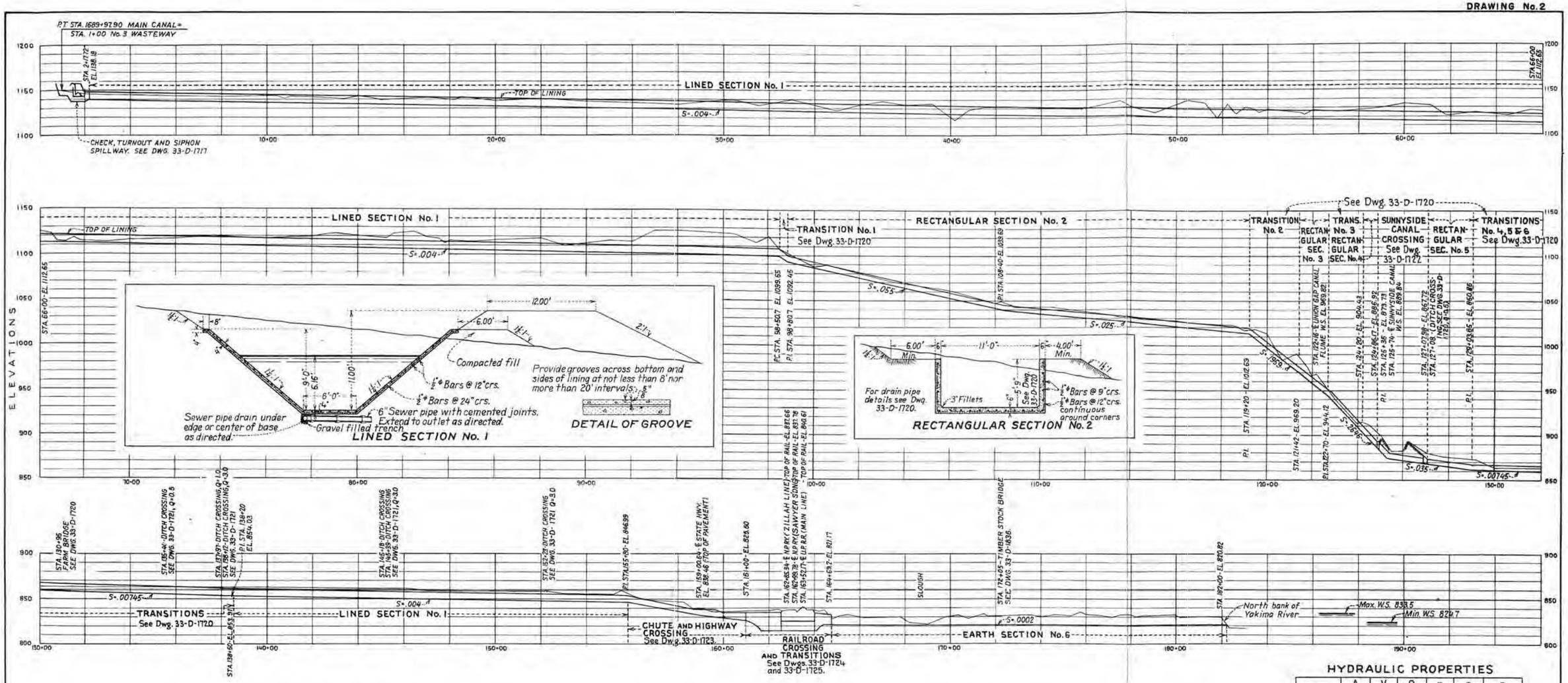
CHECK AND TURNOUT
GENERAL PLAN

DRAWN: H.D.G. SUBMITTED: W. H. Bisney
TRACED: G.E.W. RECOMMENDED: [illegible]
CHECKED: [illegible] APPROVED: [illegible]

DENVER, COLORADO, NOV. 19 1938. SHEET 1 OF 3

33-D-1717

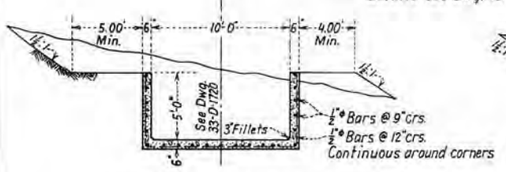
DRAWING No. 2



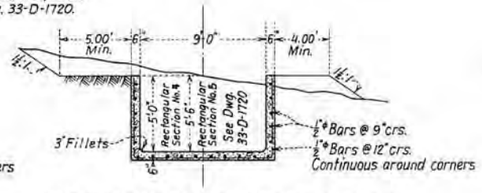
HYDRAULIC PROPERTIES

	A	V	Q	r	n	s
Lined Sec. No. 1	84.39	14.84	1252	3.28	.014	.004
Earth Sec. No. 6	425.39	2.95	1255	6.37	.025	.0002

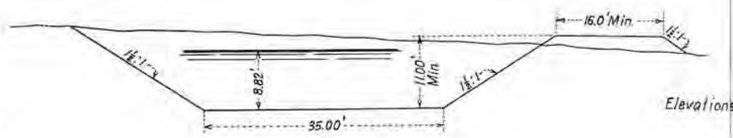
Note: For drain pipe and weep hole details see Dwg. 33-D-1720.



RECTANGULAR SECTION No. 3



RECTANGULAR SECTIONS No's. 4 AND 5



EARTH SECTION No. 6

NOTE
Elevations refer to the grade of the wasteway

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UNITED STATES
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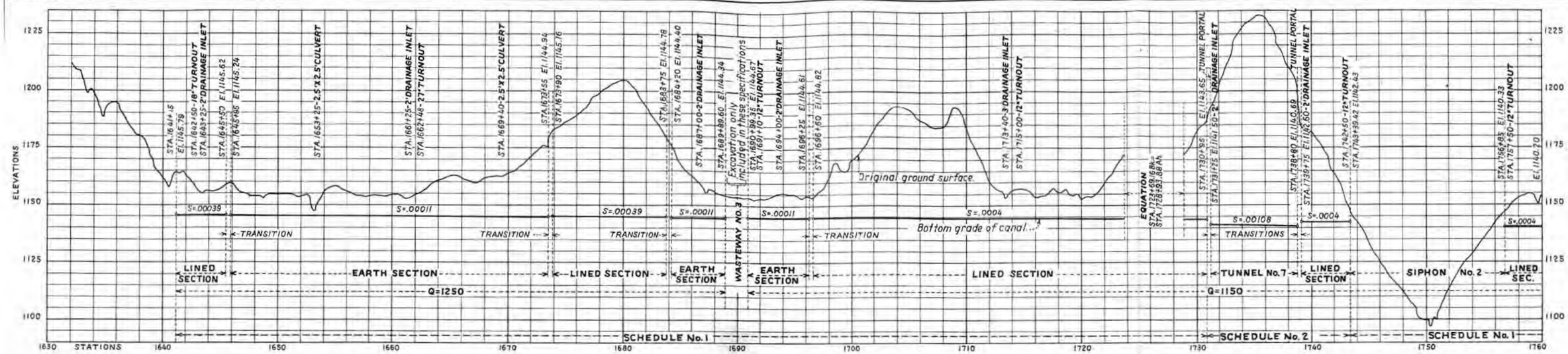
BUREAU OF RECLAMATION
YAKIMA PROJECT-WASHINGTON
ROZA DIVISION
YAKIMA RIDGE CANAL-STA. 1689+97.9
WASTEWAY No. 3
PROFILE AND SECTIONS

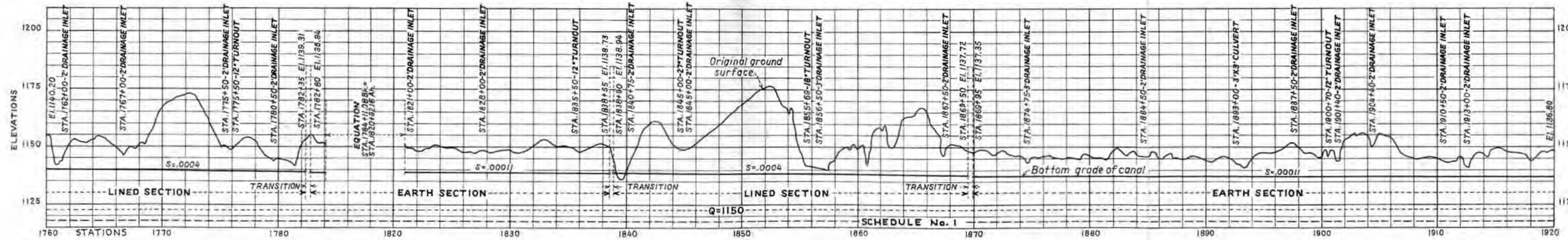
DRAWN: L.K.M. SUBMITTED: W. H. McGinnes
TRACED: S.M.E. RECOMMENDED: W. H. Nalder
CHECKED: H.W.C. APPROVED: A. F. Harper

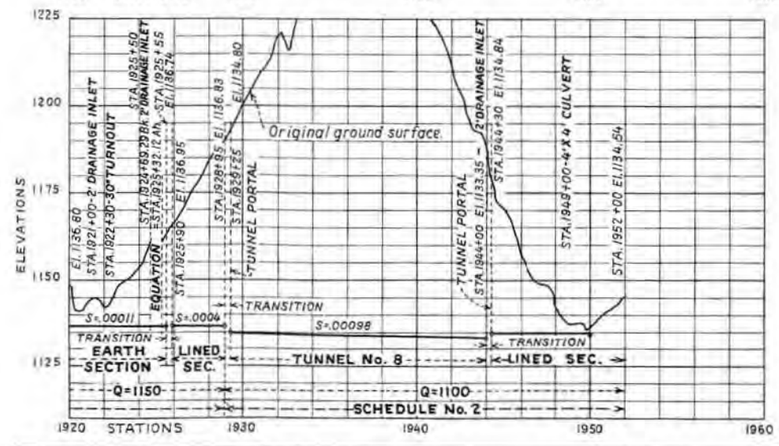
DENVER, COLORADO, NOV. 23, 1938. 33-D-1716

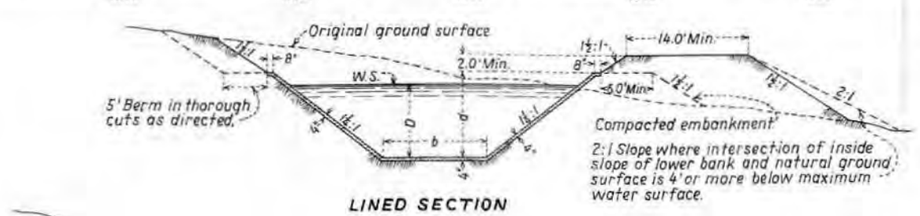
SPECIFICATIONS No. 813

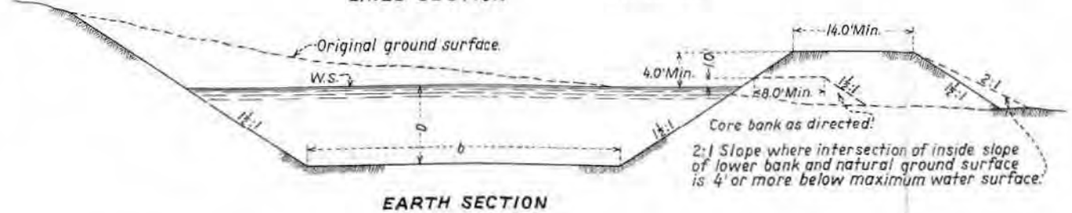
DRAWING No. 2











HYDRAULIC PROPERTIES

SECTION	b	d	D	A	V	Q	r	n	s
Lined	12'-0"	10'-4"	8.89	205.47	6.08	1250	5.08	.014	.00039
Earth	36.0'		9.64	486.44	2.57	1250	6.875	.0225	.00011
Lined	12'-0"	10'-0"	8.48	191.65	6.00	1150	4.90	.014	.0004
Earth	36.0'		9.21	458.80	2.51	1150	6.63	.0225	.00011
Lined	10'-0"	10'-0"	8.82	185.44	5.93	1100	4.85	.014	.000395

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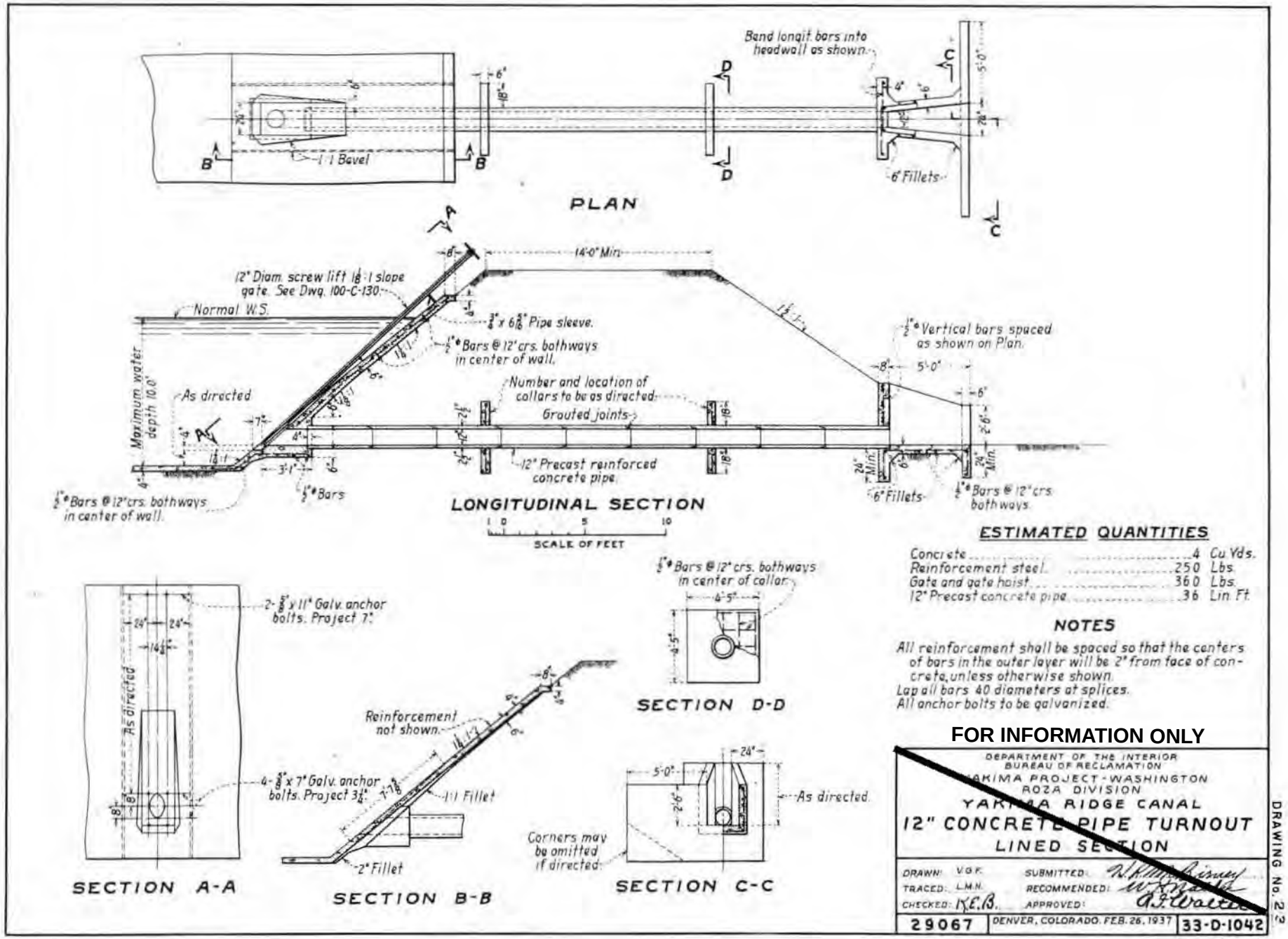
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT-WASHINGTON
ROSA DIVISION

YAKIMA RIDGE CANAL STA. 1641+15 TO 1952+00

PROFILE AND SECTIONS

DRAWN: K.S.E. SUBMITTED:
TRACED: J.A.R. RECOMMENDED:
CHECKED: APPROVED:

DENVER, COLORADO, OCT. 3, 1938 | 33-D-1594



ESTIMATED QUANTITIES

Concrete	4	Cu. Yds.
Reinforcement steel	250	Lbs.
Gate and gate hoist	360	Lbs.
12" Precast concrete pipe	36	Lin. Ft.

NOTES

All reinforcement shall be spaced so that the centers of bars in the outer layer will be 2" from face of concrete, unless otherwise shown.
Lap all bars 40 diameters at splices.
All anchor bolts to be galvanized.

FOR INFORMATION ONLY

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
ROZA DIVISION
YAKIMA RIDGE CANAL
12" CONCRETE PIPE TURNOUT
LINED SECTION

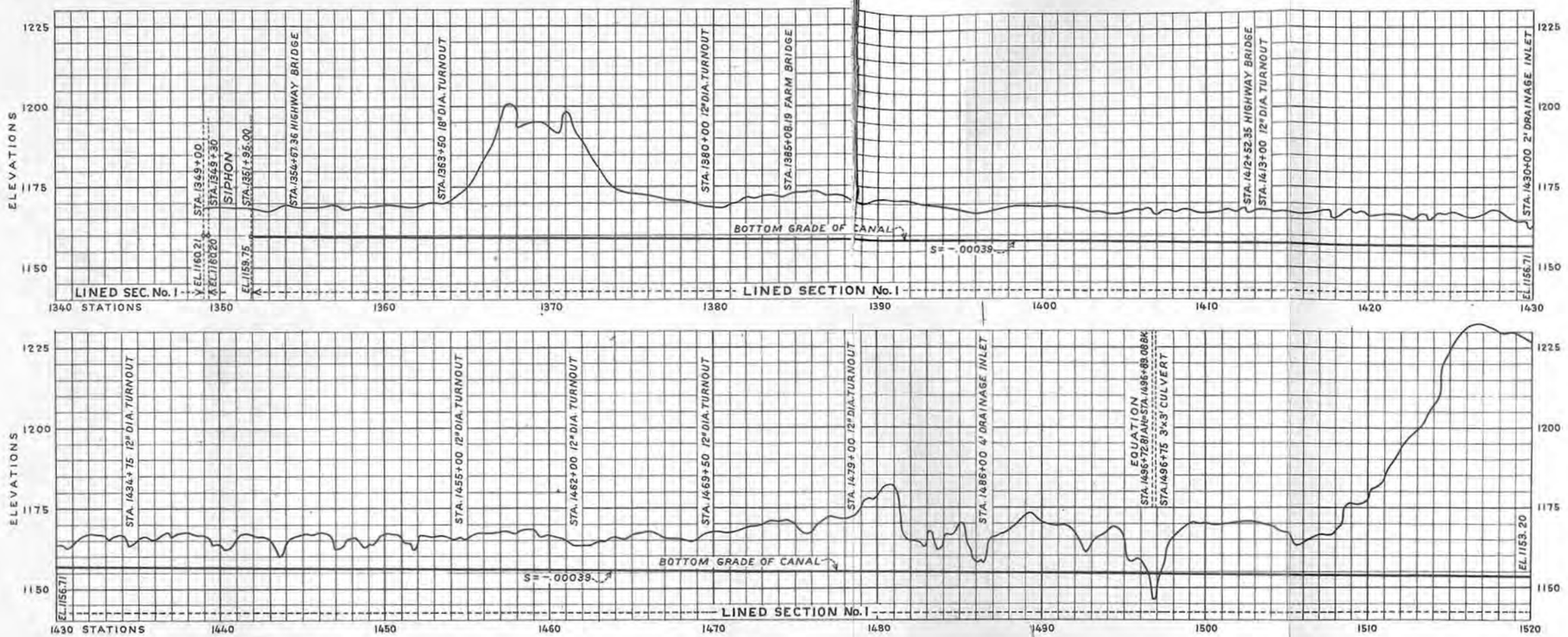
DRAWN: V.G.F. SUBMITTED: W. H. Rinney
TRACED: L.M.N. RECOMMENDED: W. H. Nelson
CHECKED: K.E.B. APPROVED: A. F. Walter

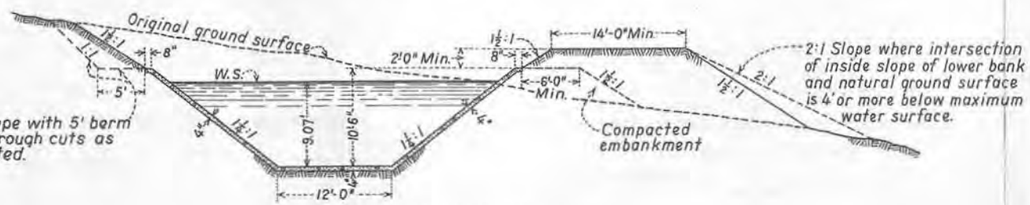
29067 | DENVER, COLORADO, FEB. 26, 1937 | 33-D-1042

DRAWING No. 2 of 2

SPECIFICATIONS No. 748

DRAWING No. 3





LINED SECTION No. 1

HYDRAULIC PROPERTIES

A	V	Q	r	n	s
211.67	6.14	1300	5.16	.014	.00039

FOR INFORMATION ONLY
SCHEDULE NO. 2

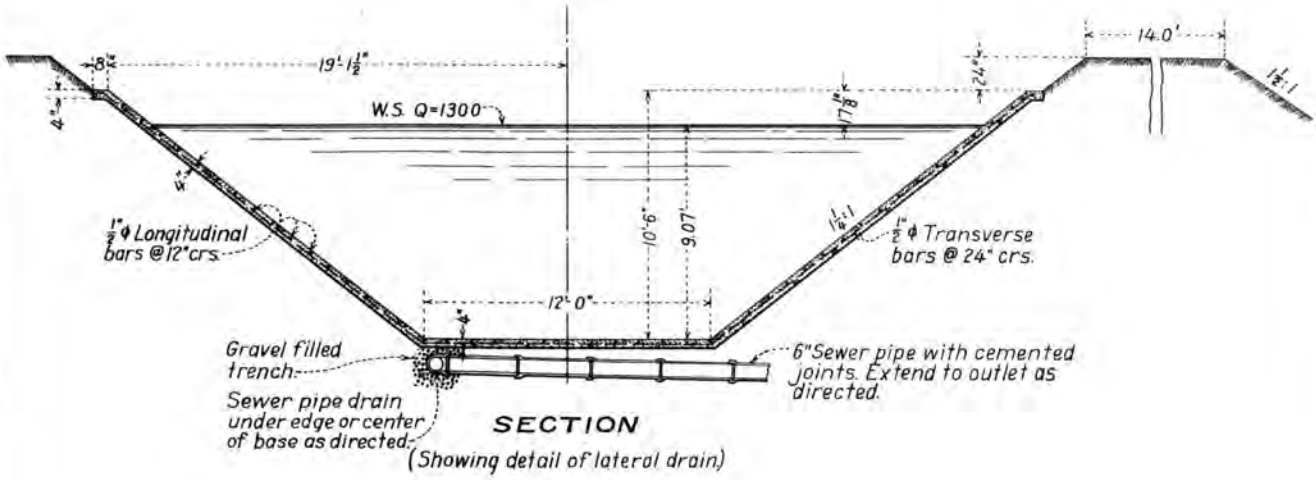
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT-WASHINGTON
ROZA DIVISION

YAKIMA RIDGE CANAL - STA. 1349 TO 1595
PROFILE SECTION

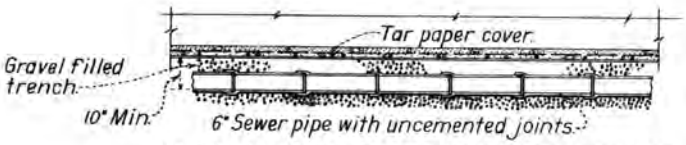
DRAWN H.S.E. SUBMITTED W.R. McGinnis
TRACED C.J.R. RECOMMENDED R.W. Walter
CHECKED V.A.J. APPROVED Hoover

29286 | DENVER, COLORADO JUNE 28, 1937 | 33-D-1134

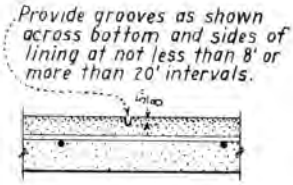
SPECIFICATIONS No. 748 DRAWING No. 4



SECTION
(Showing detail of lateral drain)



DETAIL OF LONGITUDINAL DRAIN



GROOVE DETAIL

NOTES

All reinforcement shall be placed so that the centers of bars in the outer layers will be 1¾" from face of concrete unless otherwise noted.
Lap all bars 40 diameters at splices.
Transitions and canal lining to be placed on undisturbed natural foundation or thoroughly compacted fill.
Longitudinal reinforcement to be continuous thru joints.

HYDRAULIC PROPERTIES

SECTION	A	V	Q	r	n	s
Lined Canal	211.67	6.14	1300	5.16	.014	.00039

ESTIMATED QUANTITIES

Concrete ..... 27,370 Cu. Yds.
Reinforcement Steel ..... 2,289,900 Lbs.

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
ROZA DIVISION

YAKIMA RIDGE CANAL - STA. 1120 TO 1595

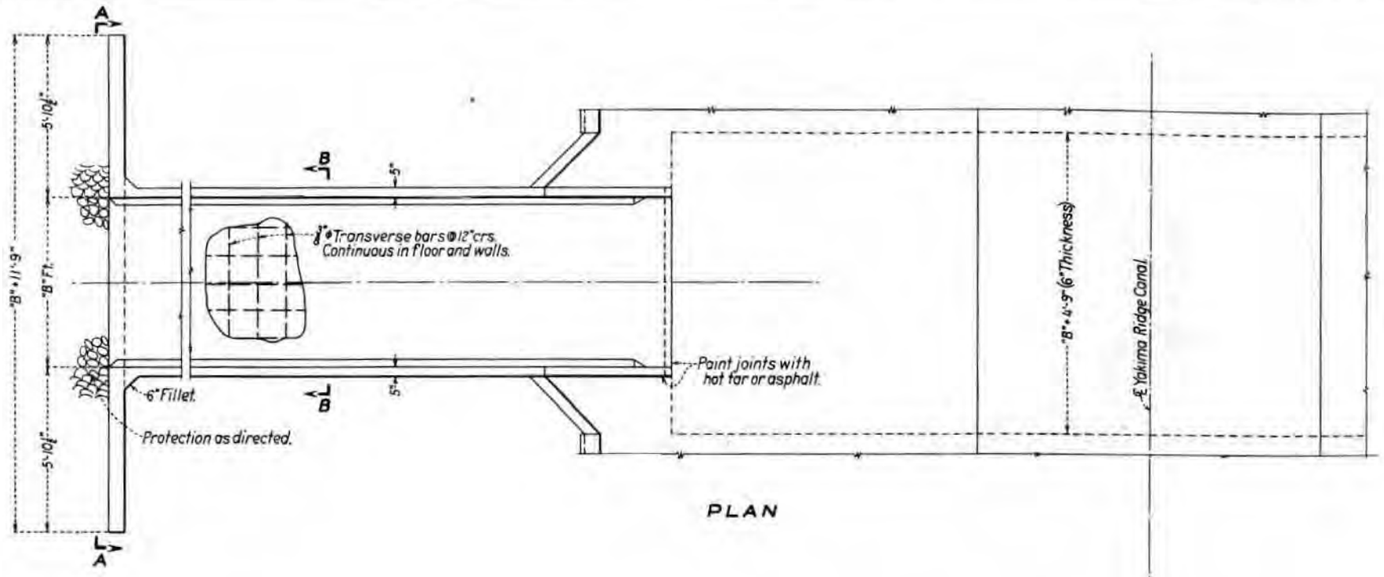
CANAL LINING

DRAWN: R.R.Y. SUBMITTED: [illegible]
TRACED: H. L. E. RECOMMENDED: [illegible]
CHECKED: K. L. E. APPROVED: [illegible]

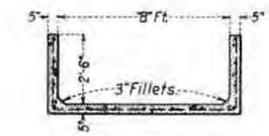
29287 | DENVER, COLO., MARCH, 19, 1937 | 33-D-1135

SPECIFICATIONS No. 748

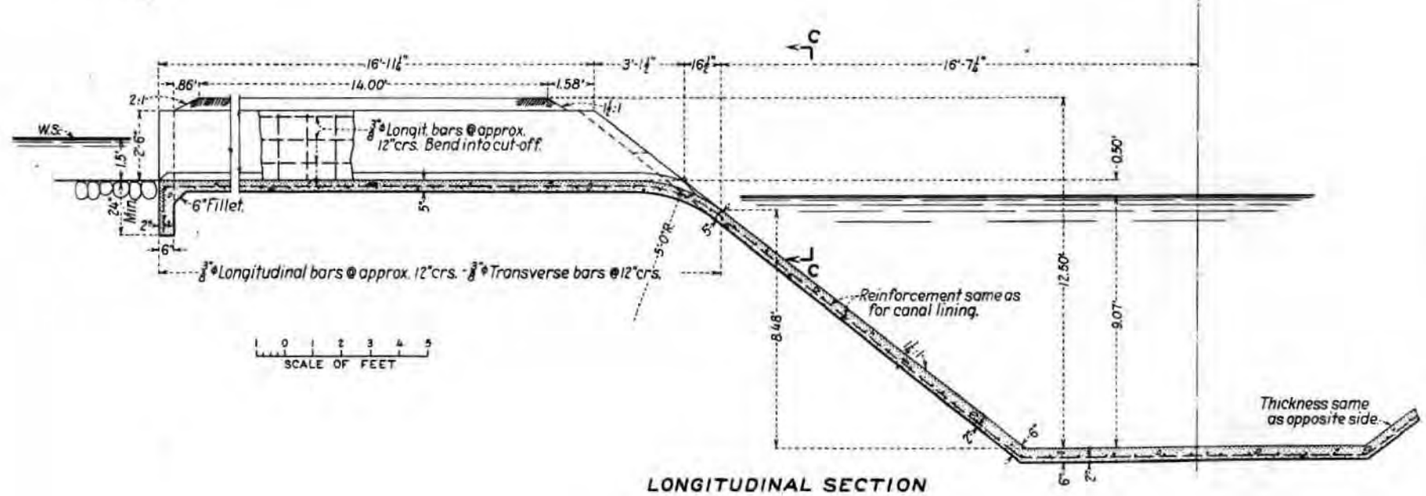
DRAWING No. 5



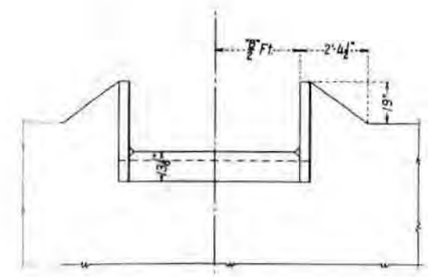
PLAN



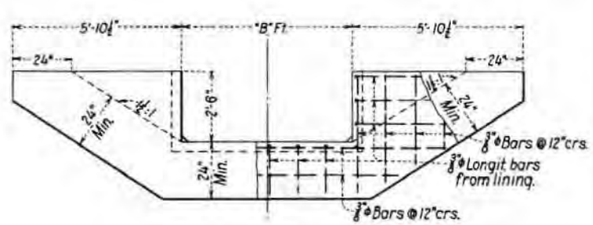
SECTION B-B



LONGITUDINAL SECTION



ELEVATION C-C



ELEVATION A-A

ESTIMATED QUANTITIES
ONE STRUCTURE

Concrete ..... 5.31 + "B" (1.05) Cu Yds.
Reinforcement steel ..... 225 + "B" (320) Lbs.
(Thickened portion of canal lining included)

NOTES

Lap all bars 40 diameters at splices. Stagger splices.
All reinforcement shall be placed in center of slab unless otherwise shown.
Thickness of concrete to vary uniformly between dimensions shown.
"B" = ½ (Ft) 24" Min.

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT - WASHINGTON
ROZA DIVISION

YAKIMA RIDGE CANAL - STA. 1120 TO 1595

DRAINAGE INLETS

DRAWN: R.L.C. SUBMITTED: [illegible]
TRACED: RHH RECOMMENDED: [illegible]
CHECKED: [illegible] APPROVED: [illegible]

29288 | DENVER, COLORADO. JUNE 16, 1932 | 33-D-1136

APPENDIX B – PLAN 1 DATA

Date: 2/1/05

Table B-1

Project: Black Rock Reservoir - Preliminary Design

(Page 1 of 3)

Feature: Water Delivery to Sunnyside Division

Details: Downstream Plan 1 - Pipe Hydraulics (minimum hydraulic head)

Notes: Calculate minimum hydraulic head at powerplant at Sunnyside Canal.

Reservoir Water Surface Elevation =	1500
Pipe diameter (feet) =	12
Peak delivery flow (cfs) =	1262
Hazen-Williams coefficient =	135

Minimum Hydraulic Grade Line

Station	Pipe Invert Elevation	Pipe Slope	Absolute Length (feet)	Friction Loss (feet)	Hydraulic Grade Line Elevation	Pressure Head (feet)
0+00	1155.00				1365	210
1+27	1153.00	-0.015691	127.48	0.21	1365	212
5+41	1153.00	0	413.10	0.68	1364	211
13+09	1163.00	0.013022	768.02	1.26	1363	200
15+19	1173.00	0.047436	211.05	0.35	1363	190
16+00	1183.00	0.123946	81.30	0.13	1362	179
20+30	1183.00	0	429.88	0.71	1362	179
22+58	1163.00	-0.087712	228.90	0.38	1361	198
27+23	1163.00	0	465.02	0.76	1361	198
28+92	1160.65	-0.01394	168.60	0.28	1360	200
33+68	1157.01	-0.007647	476.04	0.78	1359	202
36+69	1157.64	0.00209	301.50	0.50	1359	201
44+78	1163.00	0.006629	808.54	1.33	1358	195
53+74	1175.84	0.014328	896.26	1.47	1356	180
75+26	1222.62	0.021737	2152.65	3.54	1353	130
78+81	1210.83	-0.033198	355.34	0.58	1352	141
89+96	1194.05	-0.015052	1114.95	1.83	1350	156
100+67	1207.74	0.01278	1071.30	1.76	1348	141
103+81	1223.00	0.04856	314.62	0.52	1348	125
106+56	1283.22	0.219101	281.37	0.46	1347	64
110+07	1283.00	-0.000626	351.25	0.58	1347	64
115+00	1213.04	-0.142016	497.56	0.82	1346	133
120+99	1187.58	-0.042506	599.52	0.99	1345	157
122+27	1187.46	-0.00094	127.69	0.21	1345	157
124+89	1195.66	0.031275	262.32	0.43	1344	149
129+24	1178.25	-0.040019	435.39	0.72	1344	165
139+02	1203.00	0.025315	977.98	1.61	1342	139
147+81	1243.00	0.045479	880.44	1.45	1341	98
152+26	1280.00	0.083116	446.69	0.73	1340	60
154+41	1280.00	0	215.00	0.35	1340	60

Table B-1

Preliminary Pipe Profile Data

Station	Pipe Invert Elevation	Pipe Slope	Absolute Length (feet)	Friction Loss (feet)	Static Head Elevation	Pressure Head (feet)
154+94	1270.00	-0.189394	53.74	0.09	1339	69
158+10	1243.00	-0.085492	316.97	0.52	1339	96
161+35	1243.00	0	324.91	0.53	1338	95
163+24	1260.00	0.089952	189.75	0.31	1338	78
163+90	1260.00	0	66.09	0.11	1338	78
165+12	1249.15	-0.089073	122.29	0.20	1338	89
167+00	1250.00	0.004514	188.32	0.31	1337	87
169+85	1272.00	0.077266	285.58	0.47	1337	65
171+00	1272.00	0	115.27	0.19	1337	65
174+54	1247.12	-0.070338	354.59	0.58	1336	89
175+58	1243.60	-0.033697	104.52	0.17	1336	92
183+14	1283.00	0.052158	756.42	1.24	1335	52
185+22	1283.00	0	208.91	0.34	1334	51
186+73	1263.00	-0.133049	151.64	0.25	1334	71
189+36	1243.00	-0.07604	263.78	0.43	1334	91
192+55	1237.61	-0.016906	318.87	0.52	1333	96
195+37	1243.00	0.019076	282.61	0.46	1333	90
199+42	1281.25	0.094603	406.13	0.67	1332	51
204+67	1309.84	0.05445	525.85	0.86	1331	21
206+12	1309.65	-0.001308	145.26	0.24	1331	21
207+25	1303.00	-0.059032	112.85	0.19	1331	28
209+35	1303.00	0	210.89	0.35	1331	28
212+95	1281.57	-0.059536	360.59	0.59	1330	48
218+33	1266.00	-0.028953	538.00	0.88	1329	63
222+64	1243.00	-0.053411	431.23	0.71	1328	85
224+32	1243.00	0	167.85	0.28	1328	85
225+00	1248.12	0.074832	68.61	0.11	1328	80
226+00	1248.12	0	100.00	0.16	1328	80
227+57	1227.57	-0.130659	158.62	0.26	1328	100
228+51	1221.32	-0.066688	93.93	0.15	1327	106
233+00	1210.00	-0.025212	449.14	0.74	1327	117
234+28	1191.60	-0.143302	129.71	0.21	1326	135
236+33	1178.39	-0.0646	204.92	0.34	1326	148
238+86	1168.03	-0.0409	253.51	0.42	1326	158
241+49	1160.00	-0.030578	262.73	0.43	1325	165
242+96	1159.73	-0.001839	146.79	0.24	1325	165
246+00	1172.34	0.041424	304.67	0.50	1324	152
246+67	1171.96	-0.005701	66.65	0.11	1324	152
248+57	1156.98	-0.078536	191.33	0.31	1324	167
249+86	1158.71	0.013437	128.76	0.21	1324	165
251+10	1162.54	0.030922	123.92	0.20	1324	161
260+45	1023.00	-0.149261	945.23	1.55	1322	299
279+91	963.00	-0.030838	1946.58	3.20	1319	356
283+44	963.00	0	353.50	0.58	1318	355
287+44	985.00	0.055004	400.57	0.66	1318	333

Table B-1

Preliminary Pipe Profile Data

Station	Pipe Invert Elevation	Pipe Slope	Absolute Length (feet)	Friction Loss (feet)	Static Head Elevation	Pressure Head (feet)
292+51	953.00	-0.063111	508.05	0.84	1317	364
303+70	935.44	-0.015695	1118.95	1.84	1315	380
311+37	934.28	-0.001512	767.20	1.26	1314	379
314+23	946.96	0.044277	286.66	0.47	1313	366
318+00	945.52	-0.003824	376.57	0.62	1313	367
319+38	923.00	-0.162882	140.08	0.23	1312	389
322+84	922.57	-0.001245	345.47	0.57	1312	389
324+00	903.00	-0.168315	117.91	0.19	1312	409
328+37	893.00	-0.022887	437.03	0.72	1311	418
330+45	883.00	-0.048045	208.38	0.34	1311	428
333+47	875.00	-0.026511	301.87	0.50	1310	435
335+92	871.64	-0.013686	245.52	0.40	1310	438

Total friction loss = 55.34 feet

Date: 2/1/05

Table B-2

Project: Black Rock Reservoir - Preliminary Design

(Page 1 of 3)

Feature: Water Delivery to Sunnyside Division

Details: Downstream Plan 1 - Pipe Hydraulics (maximum hydraulic head)

Notes: Calculate the maximum delivery head at the powerplant at Sunnyside Canal.

Reservoir Water Surface Elevation =	1775
Pipe diameter (feet) =	12
Peak delivery flow (cfs) =	1262
Hazen-Williams coefficient =	135

Maximum Hydraulic Grade Line

Station	Pipe Invert Elevation	Pipe Slope	Absolute Length (feet)	Friction Loss (feet)	Hydraulic Grade Line Elevation	Pressure Head (feet)
0+00	1155.00				1670	515
1+27	1153.00	-0.015691	127.48	0.21	1670	517
5+41	1153.00	0	413.10	0.68	1669	516
13+09	1163.00	0.013022	768.02	1.26	1668	505
15+19	1173.00	0.047436	211.05	0.35	1668	495
16+00	1183.00	0.123946	81.30	0.13	1667	484
20+30	1183.00	0	429.88	0.71	1667	484
22+58	1163.00	-0.087712	228.90	0.38	1666	503
27+23	1163.00	0	465.02	0.76	1666	503
28+92	1160.65	-0.01394	168.60	0.28	1665	505
33+68	1157.01	-0.007647	476.04	0.78	1664	507
36+69	1157.64	0.00209	301.50	0.50	1664	506
44+78	1163.00	0.006629	808.54	1.33	1663	500
53+74	1175.84	0.014328	896.26	1.47	1661	485
75+26	1222.62	0.021737	2152.65	3.54	1658	435
78+81	1210.83	-0.033198	355.34	0.58	1657	446
89+96	1194.05	-0.015052	1114.95	1.83	1655	461
100+67	1207.74	0.01278	1071.30	1.76	1653	446
103+81	1223.00	0.04856	314.62	0.52	1653	430
106+56	1283.22	0.219101	281.37	0.46	1652	369
110+07	1283.00	-0.000626	351.25	0.58	1652	369
115+00	1213.04	-0.142016	497.56	0.82	1651	438
120+99	1187.58	-0.042506	599.52	0.99	1650	462
122+27	1187.46	-0.00094	127.69	0.21	1650	462
124+89	1195.66	0.031275	262.32	0.43	1649	454
129+24	1178.25	-0.040019	435.39	0.72	1649	470
139+02	1203.00	0.025315	977.98	1.61	1647	444
147+81	1243.00	0.045479	880.44	1.45	1646	403
152+26	1280.00	0.083116	446.69	0.73	1645	365
154+41	1280.00	0	215.00	0.35	1645	365

Table B-2

Preliminary Pipe Profile Data

Station	Pipe Invert Elevation	Pipe Slope	Absolute Length (feet)	Friction Loss (feet)	Static Head Elevation	Pressure Head (feet)
154+94	1270.00	-0.189394	53.74	0.09	1644	374
158+10	1243.00	-0.085492	316.97	0.52	1644	401
161+35	1243.00	0	324.91	0.53	1643	400
163+24	1260.00	0.089952	189.75	0.31	1643	383
163+90	1260.00	0	66.09	0.11	1643	383
165+12	1249.15	-0.089073	122.29	0.20	1643	394
167+00	1250.00	0.004514	188.32	0.31	1642	392
169+85	1272.00	0.077266	285.58	0.47	1642	370
171+00	1272.00	0	115.27	0.19	1642	370
174+54	1247.12	-0.070338	354.59	0.58	1641	394
175+58	1243.60	-0.033697	104.52	0.17	1641	397
183+14	1283.00	0.052158	756.42	1.24	1640	357
185+22	1283.00	0	208.91	0.34	1639	356
186+73	1263.00	-0.133049	151.64	0.25	1639	376
189+36	1243.00	-0.07604	263.78	0.43	1639	396
192+55	1237.61	-0.016906	318.87	0.52	1638	401
195+37	1243.00	0.019076	282.61	0.46	1638	395
199+42	1281.25	0.094603	406.13	0.67	1637	356
204+67	1309.84	0.05445	525.85	0.86	1636	326
206+12	1309.65	-0.001308	145.26	0.24	1636	326
207+25	1303.00	-0.059032	112.85	0.19	1636	333
209+35	1303.00	0	210.89	0.35	1636	333
212+95	1281.57	-0.059536	360.59	0.59	1635	353
218+33	1266.00	-0.028953	538.00	0.88	1634	368
222+64	1243.00	-0.053411	431.23	0.71	1633	390
224+32	1243.00	0	167.85	0.28	1633	390
225+00	1248.12	0.074832	68.61	0.11	1633	385
226+00	1248.12	0	100.00	0.16	1633	385
227+57	1227.57	-0.130659	158.62	0.26	1633	405
228+51	1221.32	-0.066688	93.93	0.15	1632	411
233+00	1210.00	-0.025212	449.14	0.74	1632	422
234+28	1191.60	-0.143302	129.71	0.21	1631	440
236+33	1178.39	-0.0646	204.92	0.34	1631	453
238+86	1168.03	-0.0409	253.51	0.42	1631	463
241+49	1160.00	-0.030578	262.73	0.43	1630	470
242+96	1159.73	-0.001839	146.79	0.24	1630	470
246+00	1172.34	0.041424	304.67	0.50	1629	457
246+67	1171.96	-0.005701	66.65	0.11	1629	457
248+57	1156.98	-0.078536	191.33	0.31	1629	472
249+86	1158.71	0.013437	128.76	0.21	1629	470
251+10	1162.54	0.030922	123.92	0.20	1629	466
260+45	1023.00	-0.149261	945.23	1.55	1627	604
279+91	963.00	-0.030838	1946.58	3.20	1624	661
283+44	963.00	0	353.50	0.58	1623	660
287+44	985.00	0.055004	400.57	0.66	1623	638

Table B-2

Preliminary Pipe Profile Data

Station	Pipe Invert Elevation	Pipe Slope	Absolute Length (feet)	Friction Loss (feet)	Static Head Elevation	Pressure Head (feet)
292+51	953.00	-0.063111	508.05	0.84	1622	669
303+70	935.44	-0.015695	1118.95	1.84	1620	685
311+37	934.28	-0.001512	767.20	1.26	1619	684
314+23	946.96	0.044277	286.66	0.47	1618	671
318+00	945.52	-0.003824	376.57	0.62	1618	672
319+38	923.00	-0.162882	140.08	0.23	1617	694
322+84	922.57	-0.001245	345.47	0.57	1617	694
324+00	903.00	-0.168315	117.91	0.19	1617	714
328+37	893.00	-0.022887	437.03	0.72	1616	723
330+45	883.00	-0.048045	208.38	0.34	1616	733
333+47	875.00	-0.026511	301.87	0.50	1615	740
335+92	871.64	-0.013686	245.52	0.40	1615	743

Total friction loss = 55.34 feet

Date: 2/1/05

Table B-3

Project: Black Rock Reservoir - Preliminary Design

Feature: Water Delivery to Sunnyside Division

Details: Downstream Plan 1 - Pipe Hydraulics (pipe wall thickness)

Notes: Static head is based on no pipe flow and maximum reservoir water surface elevation.
Transient head is based on a linear varying water surface elevation between the following points:
Sta. 0+00 = El.1947, Sta. 206+12 = El.2038, Sta. 335+92 = El.2143.
Steel pipe wall thickness by AWWA M11.
ASTM A572 Gr. 60 steel pipe, Fa = 30,000 psi.

Pipe diameter (feet) =	12
Maximum Reservoir Water Surface Elev. =	1775

Maximum Pipe Internal Pressure

Station	Pipe Invert Elevation	Static Head (feet)	Transient Elevation	Transient Head (feet)	Design Pressure (psi)	Required Thick. (in.)	Design Thick. (in.)	Absolute Length (feet)	Steel Weight (tons)
0+00	1155.00	620	1947	792	343	0.82	0.8750		
1+27	1153.00	622	1948	795	344	0.83	0.8750	127	86.30
5+41	1153.00	622	1949	796	345	0.83	0.8750	413	279.67
13+09	1163.00	612	1953	790	342	0.82	0.8750	768	519.95
15+19	1173.00	602	1954	781	338	0.81	0.8125	211	132.64
16+00	1183.00	592	1954	771	334	0.80	0.8125	81	51.10
20+30	1183.00	592	1956	773	335	0.80	0.8125	430	270.18
22+58	1163.00	612	1957	794	344	0.83	0.8750	229	154.96
27+23	1163.00	612	1959	796	345	0.83	0.8750	465	314.82
28+92	1160.65	614	1960	799	346	0.83	0.8750	169	114.14
33+68	1157.01	618	1962	805	349	0.84	0.8750	476	322.28
36+69	1157.64	617	1963	806	349	0.84	0.8750	302	204.12
44+78	1163.00	612	1967	804	348	0.84	0.8750	809	547.38
53+74	1175.84	599	1971	795	344	0.83	0.8750	896	606.77
75+26	1222.62	552	1980	758	328	0.79	0.8750	2153	1457.34
78+81	1210.83	564	1982	771	334	0.80	0.8750	355	240.56
89+96	1194.05	581	1987	793	343	0.82	0.8750	1115	754.82
100+67	1207.74	567	1991	784	340	0.82	0.8750	1071	725.27
103+81	1223.00	552	1993	770	334	0.80	0.8125	315	197.74
106+56	1283.22	492	1994	711	308	0.74	0.8125	281	176.84
110+07	1283.00	492	1996	713	309	0.74	0.8125	351	220.76
115+00	1213.04	562	1998	785	340	0.82	0.8750	498	336.85
120+99	1187.58	587	2000	813	352	0.85	0.8750	600	405.88
122+27	1187.46	588	2001	814	353	0.85	0.8750	128	86.45
124+89	1195.66	579	2002	806	349	0.84	0.8750	262	177.59
129+24	1178.25	597	2004	826	358	0.86	0.8750	435	294.76
139+02	1203.00	572	2008	805	349	0.84	0.8750	978	662.09
147+81	1243.00	532	2012	769	333	0.80	0.8125	880	553.36
152+26	1280.00	495	2014	734	318	0.76	0.8125	447	280.75
154+41	1280.00	495	2015	735	319	0.76	0.8125	215	135.13

Table B-3

Preliminary Pipe Profile Data **(Page 2 of 3)**

Station	Pipe Invert Elevation	Static Head (feet)	Transient Elevation	Transient Head (feet)	Design Pressure (psi)	Required Thick. (in.)	Design Thick. (in.)	Absolute Length (feet)	Steel Weight (tons)
154+94	1270.00	505	2015	745	323	0.78	0.8125	54	33.77
158+10	1243.00	532	2017	774	335	0.80	0.8125	317	199.22
161+35	1243.00	532	2018	775	336	0.81	0.8125	325	204.21
163+24	1260.00	515	2019	759	329	0.79	0.8125	190	119.26
163+90	1260.00	515	2019	759	329	0.79	0.8125	66	41.54
165+12	1249.15	526	2020	771	334	0.80	0.8125	122	76.86
167+00	1250.00	525	2021	771	334	0.80	0.8125	188	118.36
169+85	1272.00	503	2022	750	325	0.78	0.8125	286	179.49
171+00	1272.00	503	2022	750	325	0.78	0.8125	115	72.45
174+54	1247.12	528	2024	777	337	0.81	0.8125	355	222.86
175+58	1243.60	531	2025	781	338	0.81	0.8125	105	65.69
183+14	1283.00	492	2028	745	323	0.77	0.8125	756	475.41
185+22	1283.00	492	2029	746	323	0.78	0.8125	209	131.30
186+73	1263.00	512	2029	766	332	0.80	0.8125	152	95.31
189+36	1243.00	532	2031	788	341	0.82	0.8750	264	178.58
192+55	1237.61	537	2032	794	344	0.83	0.8750	319	215.87
195+37	1243.00	532	2033	790	342	0.82	0.8750	283	191.33
199+42	1281.25	494	2035	754	327	0.78	0.8125	406	255.25
204+67	1309.84	465	2037	728	315	0.76	0.8125	526	330.50
206+12	1309.65	465	2038	728	316	0.76	0.8125	145	91.30
207+25	1303.00	472	2039	736	319	0.77	0.8125	113	70.92
209+35	1303.00	472	2041	738	320	0.77	0.8125	211	132.54
212+95	1281.57	493	2044	762	330	0.79	0.8125	361	226.63
218+33	1266.00	509	2048	782	339	0.81	0.8125	538	338.13
222+64	1243.00	532	2051	808	350	0.84	0.8750	431	291.95
224+32	1243.00	532	2053	810	351	0.84	0.8750	168	113.63
225+00	1248.12	527	2053	805	349	0.84	0.8750	69	46.45
226+00	1248.12	527	2054	806	349	0.84	0.8750	100	67.70
227+57	1227.57	547	2055	828	359	0.86	0.8750	159	107.38
228+51	1221.32	554	2056	835	362	0.87	0.8750	94	63.59
233+00	1210.00	565	2060	850	368	0.88	0.9375	449	325.85
234+28	1191.60	583	2061	869	377	0.90	0.9375	130	94.11
236+33	1178.39	597	2062	884	383	0.92	0.9375	205	148.67
238+86	1168.03	607	2064	896	388	0.93	0.9375	254	183.92
241+49	1160.00	615	2067	907	393	0.94	1.0000	263	1517.15
242+96	1159.73	615	2068	908	393	0.94	1.0000	147	847.64
246+00	1172.34	603	2070	898	389	0.93	1.0000	305	1759.32
246+67	1171.96	603	2071	899	389	0.93	1.0000	67	384.88
248+57	1156.98	618	2072	915	397	0.95	1.0000	191	1104.82
249+86	1158.71	616	2073	915	396	0.95	1.0000	129	743.53
251+10	1162.54	612	2074	912	395	0.95	1.0000	124	715.57
260+45	1023.00	752	2082	1059	459	1.10	1.1875	945	871.03
279+91	963.00	812	2098	1135	492	1.18	1.1875	1947	1793.78
283+44	963.00	812	2101	1138	493	1.18	1.1875	354	325.75
287+44	985.00	790	2104	1119	485	1.16	1.1875	401	369.13

Table B-3

Preliminary Pipe Profile Data

Station	Pipe Invert Elevation	Static Head (feet)	Transient Elevation	Transient Head (feet)	Design Pressure (psi)	Required Thick. (in.)	Design Thick. (in.)	Absolute Length (feet)	Steel Weight (tons)
292+51	953.00	822	2108	1155	500	1.20	1.2500	508	493.06
303+70	935.44	840	2117	1181	512	1.23	1.2500	1119	1085.94
311+37	934.28	841	2123	1189	515	1.24	1.2500	767	744.57
314+23	946.96	828	2125	1178	511	1.23	1.2500	287	278.20
318+00	945.52	829	2129	1183	513	1.23	1.2500	377	365.46
319+38	923.00	852	2130	1207	523	1.25	1.2500	140	135.95
322+84	922.57	852	2132	1210	524	1.26	1.3125	345	352.21
324+00	903.00	872	2133	1230	533	1.28	1.3125	118	120.20
328+37	893.00	882	2137	1244	539	1.29	1.3125	437	445.56
330+45	883.00	892	2139	1256	544	1.31	1.3125	208	212.44
333+47	875.00	900	2141	1266	549	1.32	1.3750	302	322.54
335+92	871.64	903	2143	1271	551	1.32	1.3750	246	262.34

Total Steel Weight (tons) = 31,072

APPENDIX C – PLAN 2 DATA

Date: 2/1/05

Table C-1

Project: Black Rock Reservoir - Preliminary Design
Feature: Water Delivery to Sunnyside Division
Details: Downstream Plan 2 - Pipe Hydraulics (hydraulic head)

Notes: Calculate hydraulic head at powerplant at point of delivery on Sunnyside Canal.
Design Head assumes a 40% transient head increase

Pipe diameter (feet) =	12
Peak delivery flow (cfs) =	1262
Hazen-Williams coefficient =	135

Preliminary Pipe Profile Data

Station	Pipe Invert Elevation	Pipe Slope	Absolute Length (feet)	Friction Loss (feet)	Hydraulic Grade Line Elevation	Pressure Head (feet)	Design Head (feet)
0+00	1085.00				1100	15	21
2+05.33	1073.00	-0.0584	205.68	0.34	1100	27	37
2+36.29	1063.24	-0.3152	32.46	0.05	1100	36	51
3+35.97	1043.00	-0.2031	101.71	0.17	1099	56	79
4+66.59	1023.68	-0.1479	132.04	0.22	1099	76	106
6+67.32	1023.00	-0.0034	200.73	0.33	1099	76	106
9+97.45	983.00	-0.1212	332.54	0.55	1098	115	161
12+11.79	943.00	-0.1866	218.04	0.36	1098	155	217
15+42.53	923.00	-0.0605	331.34	0.54	1097	174	244
19+40.75	905.82	-0.0431	398.59	0.66	1097	191	267
21+11.91	906.68	0.0050	171.16	0.28	1097	190	266
22+42.98	913.00	0.0482	131.22	0.22	1096	183	257
23+90.84	925.00	0.0812	148.35	0.24	1096	171	239
25+00.00	924.79	-0.0019	109.16	0.18	1096	171	240
26+69.49	911.35	-0.0793	170.02	0.28	1096	184	258
28+28.15	910.15	-0.0076	158.66	0.26	1095	185	259
29+31.96	913.81	0.0353	103.87	0.17	1095	181	254
30+55.88	913.37	-0.0036	123.92	0.20	1095	182	254
33+74.72	893.52	-0.0623	319.46	0.53	1094	201	281
35+65.00	888.89	-0.0243	190.34	0.31	1094	205	287
38+94.78	873.00	-0.0482	330.16	0.54	1094	221	309
43+80.25	871.23	-0.0036	485.47	0.80	1093	222	310

Date: 2/1/05 **Table C-2**
Project: Black Rock Reservoir - Preliminary Design
Feature: Water Delivery to Sunnyside Division
Details: Downstream Plan 2 - Steel Pipe Wall Thickness

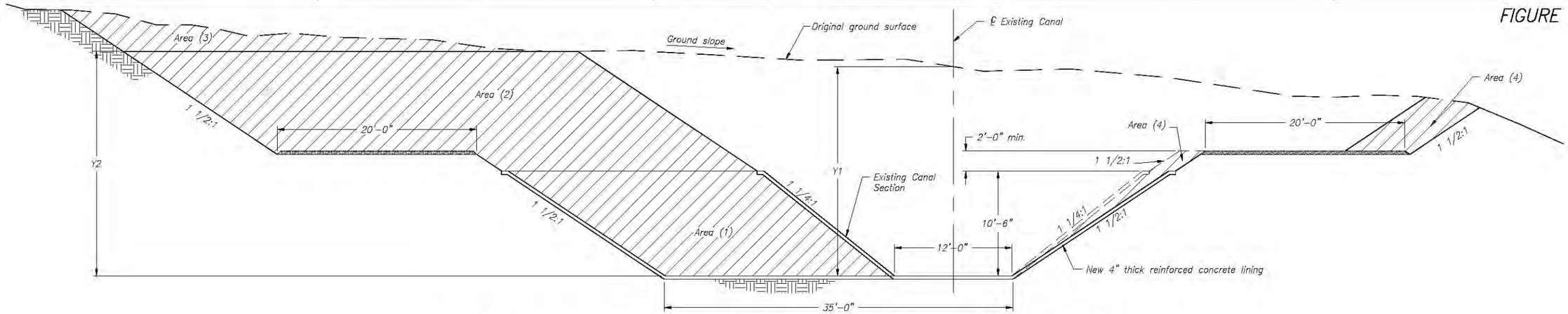
Notes: Steel pipe wall thickness by AWWA M11.
Yield stress, Fy = 36,000 psi; Ultimate stress, Fu = 58,000 psi
Allowable stress, Fa = 18,000 psi

Steel Pipe Quantities

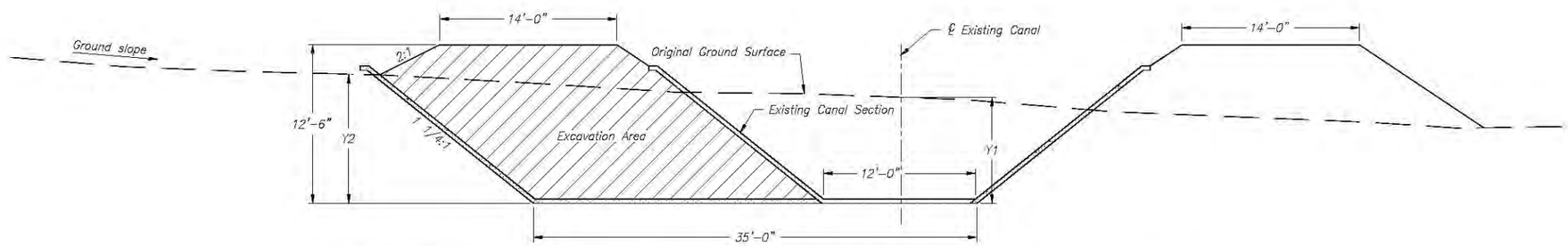
Station	Design Head (feet)	Design Pressure (psi)	Required Thick. (in.)	Design Thick. (in.)	Pipe Length (feet)	Steel Weight (tons)
0+00	21	9	0.41	0.4375		
2+05	37	16	0.41	0.4375	205	69.30
2+36	51	22	0.41	0.4375	32	10.96
3+36	79	34	0.41	0.4375	102	34.33
4+67	106	46	0.41	0.4375	132	44.56
6+67	106	46	0.41	0.4375	201	67.74
9+97	161	70	0.41	0.4375	333	112.23
12+12	217	94	0.41	0.4375	218	73.59
15+43	244	106	0.42	0.4375	331	111.82
19+41	267	116	0.46	0.4375	399	134.52
21+12	266	115	0.46	0.4375	171	57.76
22+43	257	111	0.44	0.4375	131	44.29
23+91	239	104	0.42	0.4375	148	50.06
25+00	240	104	0.42	0.4375	109	36.84
26+69	258	112	0.45	0.4375	170	57.38
28+28	259	112	0.45	0.4375	159	53.55
29+32	254	110	0.44	0.4375	104	35.06
30+56	254	110	0.44	0.4375	124	41.82
33+75	281	122	0.49	0.50	319	123.27
35+65	287	125	0.50	0.50	190	73.44
38+95	309	134	0.54	0.50	330	127.40
43+80	310	134	0.54	0.50	485	187.33

Total Steel Weight = 1,547.24 **tons**

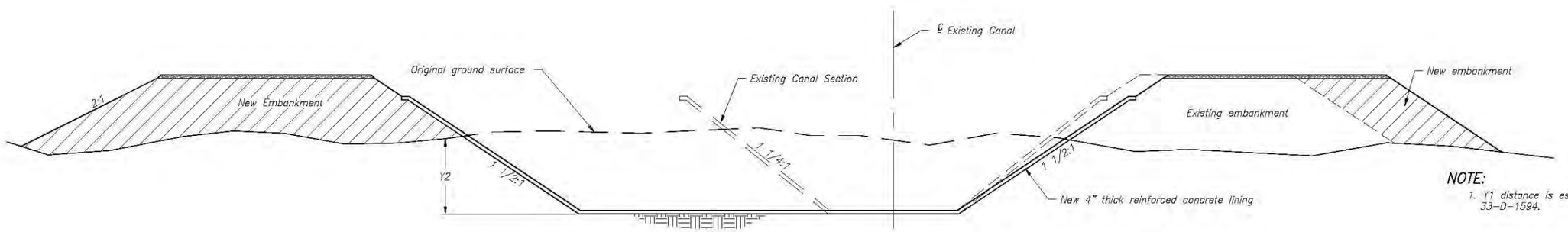
FIGURE C-3



TYPICAL MODIFIED ROZA CANAL SECTION–CASE I EXCAVATION AREA GEOMETRY
Y2 > 10'-6"



TYPICAL MODIFIED ROZA CANAL SECTION–CASE II EXCAVATION AREA GEOMETRY
Y2 < 10'-6"



TYPICAL MODIFIED ROZA CANAL SECTION–EMBANKMENT AREA GEOMETRY

NOTE:
1. Y1 distance is estimated from 33-D-1134 & 33-D-1594.

SCALE OF FEET: 1 0 5 10 15

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT–WASHINGTON

BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVISION
PLAN 2–CANAL MODIFICATION
TYPICAL CANAL AND WASTEWAY SECTIONS
FOR QUANTITY CALCULATIONS

Concept Designer: Steve Montague
Drafter: Leland Boekweg, EDM

BOISE, IDAHO 2004-02-02 SHEET 1 OF 1 FIGURE C-3

CAD SYSTEM AutoCAD Rel. 18.0
CAD FILENAME FIGURE C-3.DWG
DATE AND TIME PLOTTED JANUARY 28, 2005 15:13
PLOTTED BY LBOEKWEG

Table C-4

Date: 02/01/05
Project: Black Rock Reservoir - Preliminary Design
Feature: Water Delivery to Sunnyside Division
Details: Downstream Plan 2 - Expand Roza Canal

Notes: Calculate excavation area at each station to enlarge the existing Roza Canal fromSta. 1238+00 (MP22.54) to Sta. 1689+89.60 (Wasteway No. 3). For Typical Sections see Figure B-3.

Case I - Geometry Calculations

Station	Y1 (feet)	Ground Slope	Y2 (feet)	Area (1) (sq. ft.)	Area (2) (sq. ft.)	Area (3) (sq. ft.)	Area(4) (sq. ft.)	Total Area (s.f.)
1364+40	10.75	0.00	10.75	255.28	6.41	0.00	19.53	281.22
1367+50	42.25	0.00	42.25	255.28	1408.59	0.00	291.00	1954.87
1368+20	34.50	0.00	34.50	255.28	1055.00	0.00	220.28	1530.56
1370+75	35.00	0.00	35.00	255.28	1077.81	0.00	224.84	1557.94
1371+00	40.00	0.00	40.00	255.28	1305.94	0.00	270.47	1831.69
1374+40	15.00	0.00	15.00	255.28	165.31	0.00	42.34	462.94
1390+00	13.00	0.02	13.47	255.28	95.58	21.46	24.09	396.41
1468+70	9.50	0.30	19.11	255.28	353.00	567.72	19.53	1195.53
1474+60	16.00	0.30	30.93	255.28	892.20	567.72	51.47	1766.67
1475+70	11.30	0.30	22.39	255.28	502.32	567.72	19.53	1344.85
1481+00	26.80	0.30	50.57	255.28	1788.11	567.72	150.02	2761.13
1482+00	10.50	0.10	12.75	255.28	62.66	122.45	19.53	459.92
1485+35	11.00	0.05	12.07	255.28	40.34	56.26	19.53	371.41
1487+00	11.00	0.07	12.55	255.28	53.74	81.40	19.53	409.95
1489+25	18.40	0.10	22.04	255.28	486.70	122.45	73.37	937.80
1491+90	13.00	0.10	15.69	255.28	196.85	122.45	24.09	598.67
1494+40	14.20	0.10	17.10	255.28	261.26	122.45	35.04	674.03
1497+80	11.00	0.03	11.62	255.28	28.81	32.70	19.53	336.32
1499+00	16.00	0.10	19.22	255.28	357.88	122.45	51.47	787.07
1504+00	16.00	0.07	18.14	255.28	308.62	81.40	51.47	696.78
1506+20	10.00	0.03	10.58	255.28	1.98	32.70	19.53	309.48
1508+00	13.50	0.07	15.35	255.28	181.18	81.40	28.66	546.52
1514+50	58.50	0.10	69.22	255.28	2639.13	122.45	439.28	3456.14
1515+80	78.00	0.10	92.16	255.28	3685.82	122.45	617.22	4680.77
1517+40	78.00	0.10	92.16	255.28	3685.82	122.45	617.22	4680.77
1520+00	73.00	0.10	86.28	255.28	3417.44	122.45	571.59	4366.76
1527+00	22.00	0.20	32.39	255.28	958.86	297.38	106.22	1617.74
1530+00	12.00	0.10	14.51	255.28	143.17	122.45	19.53	540.43
1533+50	14.00	0.06	15.61	255.28	193.01	68.63	33.22	550.14
1534+00	17.00	0.06	18.90	255.28	343.43	68.63	60.59	727.92
1534+60	17.00	0.05	18.56	255.28	327.77	56.26	60.59	699.91
1537+60	12.50	0.08	14.51	255.28	143.02	94.62	19.53	512.45
1538+00	12.50	0.08	14.51	255.28	143.02	94.62	19.53	512.45
1540+50	11.75	0.12	14.82	255.28	157.24	152.32	19.53	584.37
1594+72	49.20	0.08	56.22	255.28	2045.79	94.62	354.42	2750.11
1641+15	19.80	0.07	22.39	255.28	502.34	81.40	86.14	925.17
1641+75	19.80	0.07	22.39	255.28	502.34	81.40	86.14	925.17
1643+50	9.50	0.07	10.88	255.28	9.70	81.40	19.53	365.91
1645+95	9.50	0.07	10.88	255.28	9.70	81.40	19.53	365.91
1673+55	35.00	0.07	39.37	255.28	1277.20	81.40	224.84	1838.73
1680+25	62.00	0.07	69.54	255.28	2653.60	81.40	471.22	3461.50
1684+20	32.00	0.07	36.02	255.28	1124.27	81.40	197.47	1658.42

2/1/05

Project: Black Rock Reservoir - Preliminary Design
Feature: Water Delivery to Sunnyside Division
Details: Downstream Plan 2 - Expand Roza Canal

Notes: Calculate quantities of material to be excavated to enlarge the existing Roza Canal from Sta. 1351+95 (Siphon) to Sta. 1689+89.60 (Wasteway No. 3). For Typical Sections see Figure B-3.

ROZA CANAL - Reference Drawings 33-D-1133, 33-D-1134, 33-D-1594

Excavation Volume

Station	Y1 (feet)	Ground Slope	Y2 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
<SIPHON>						
1351+95	9.00	0.03	9.53	Case II	287.50	0
1364+40	10.75	0.00	10.75	Case I	281.22	13,112
1367+50	42.25	0.00	42.25	Case I	1954.87	12,837
1368+20	34.50	0.00	34.50	Case I	1530.56	4,518
1370+75	35.00	0.00	35.00	Case I	1557.94	14,585
1371+00	40.00	0.00	40.00	Case I	1831.69	1,569
1374+40	15.00	0.00	15.00	Case I	462.94	14,448
1390+00	13.00	0.02	13.47	Case I	396.41	24,826
1430+00	8.75	0.03	9.27	Case II	287.50	50,660
1468+70	9.50	0.30	19.11	Case I	1195.53	106,284
1474+60	16.00	0.30	30.93	Case I	1766.67	32,365
1475+70	11.30	0.30	22.39	Case I	1344.85	6,338
1481+00	26.80	0.30	50.57	Case I	2761.13	40,299
1482+00	10.50	0.10	12.75	Case I	459.92	5,965
1485+35	11.00	0.05	12.07	Case I	371.41	5,157
1486+00	3.50	0.05	3.97	Case II	287.50	793
1486+55	3.60	0.05	4.07	Case II	287.50	586
1487+00	11.00	0.07	12.55	Case I	409.95	581
1489+25	18.40	0.10	22.04	Case I	937.80	5,616
1491+90	13.00	0.10	15.69	Case I	598.67	7,540
1492+67	6.00	0.10	7.46	Case II	287.50	1,264
1494+40	14.20	0.10	17.10	Case I	674.03	3,080
1496+40	1.00	0.02	1.10	Case II	287.50	3,561
1496+45	0.00	0.02	0.07	Case II	287.50	53
1497+30	0.00	0.02	0.07	Case II	287.50	905
1497+80	11.00	0.03	11.62	Case I	336.32	578
1499+00	16.00	0.10	19.22	Case I	787.07	2,496
1504+00	16.00	0.07	18.14	Case I	696.78	13,739
1506+20	10.00	0.03	10.58	Case I	309.48	4,100
1508+00	13.50	0.07	15.35	Case I	546.52	2,853
1514+50	58.50	0.10	69.22	Case I	3456.14	48,180
1515+80	78.00	0.10	92.16	Case I	4680.77	19,589
1517+40	78.00	0.10	92.16	Case I	4680.77	27,738
1520+00	73.00	0.10	86.28	Case I	4366.76	43,562
1527+00	22.00	0.20	32.39	Case I	1617.74	77,577
1530+00	12.00	0.10	14.51	Case I	540.43	11,990
1533+50	14.00	0.06	15.61	Case I	550.14	7,068

ROZA CANAL - Reference Drawings 33-D-1133, 33-D-1134, 33-D-1594

Station	Y1 (feet)	Ground Slope	Y2 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
1534+00	17.00	0.06	18.90	Case I	727.92	1,183
1534+60	17.00	0.05	18.56	Case I	699.91	1,586
1535+25	0.00	0.03	0.11	Case II	287.50	1,189
1537+60	12.50	0.08	14.51	Case I	512.45	3,481
1538+00	12.50	0.08	14.51	Case I	512.45	759
1538+30	5.00	0.08	5.99	Case II	287.50	444
1540+50	11.75	0.12	14.82	Case I	584.37	3,552
1567+50	8.60	0.03	9.11	Case II	287.50	43,593
1594+72	49.20	0.08	56.22	Case I	2750.11	153,118
<Tunnel No. 5>						
1641+15	19.80	0.07	22.39	Case I	925.17	
1641+75	19.80	0.07	22.39	Case I	925.17	2,056
1643+50	9.50	0.07	10.88	Case I	365.91	4,184
1645+95	9.50	0.07	10.88	Case I	365.91	3,320
<Existing Unlined Section>						
1673+55	35.00	0.07	39.37	Case I	1838.73	
1680+25	62.00	0.07	69.54	Case I	3461.50	65,762
1684+20	32.00	0.07	36.02	Case I	1658.42	37,451
<Existing Unlined Section>						
1689+89.6	<Wasteway No. 3>					

Total Volume = 938,093 cu. yds

Table C-6

Date: 2/1/05
Project: Black Rock Reservoir - Preliminary Design
Feature: Water Delivery to Sunnyside Division
Details: Downsteam Plan 2 - Expand Roza Canal

Notes: Calculate embankment volume to enlarge the existing Roza Canal from Sta.1351+95 (Siphon) to Sta.1689+89.60 (Wasteway No. 3). For Typical Sections see Figure B-3.

ROZA CANAL - Reference Drawings 33-D-1133, 33-D-1134, 33-D-1594

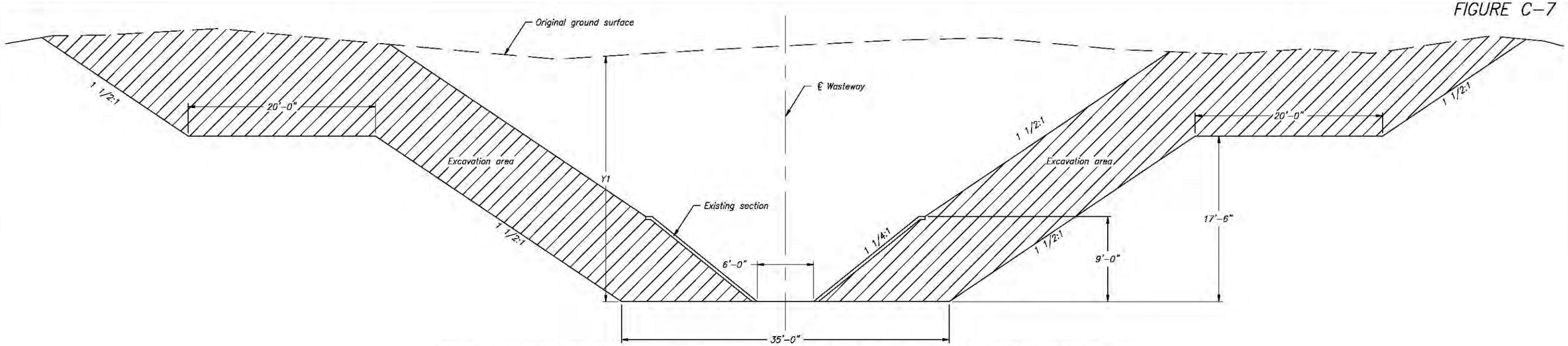
Embankment Volume

Station	Y1 (feet)	Y2 (feet)	Area (sq. ft.)	Volume (cu. yds.)
1351+95	9.00	9.53	104.6	
1364+40	10.75	10.75	55.6	3,692.1
1365+00	12.5	12.5	0.0	61.7
1416+00	12.5	12.5	0.0	0.9
1430+00	8.75	9.27	114.5	2,969.2
1452+00	12.5	12.50	0.0	4,665.9
1485+35	11.00	12.07	22.5	1,388.5
1486+00	3.50	3.97	362.0	462.9
1486+55	3.60	4.07	356.2	731.6
1487+00	12.5	12.50	0.0	296.9
1492+00	12.5	12.50	0.0	0.0
1492+67	6.00	7.46	198.4	246.1
1494+00	12.5	12.50	0.0	488.6
1496+40	1.00	1.10	527.9	2,346.0
1496+45	-8.00	-8.00	1,227.4	162.5
1497+30	-8.00	-8.00	1,227.4	3,864.2
1497+80	11.00	11.62	32.4	1,166.5
1498+50	12.5	12.50	0.0	41.9
1505+00	12.5	12.50	0.0	0.0
1506+20	10.00	10.58	66.8	148.5
1508+00	12.5	12.50	0.0	222.7
1643+00	12.5	12.50	0.0	0.0
1643+50	9.50	10.88	63.8	59.0
1645+95	9.50	10.88	63.8	578.5
1652+50	12.5	12.50	0.0	773.4

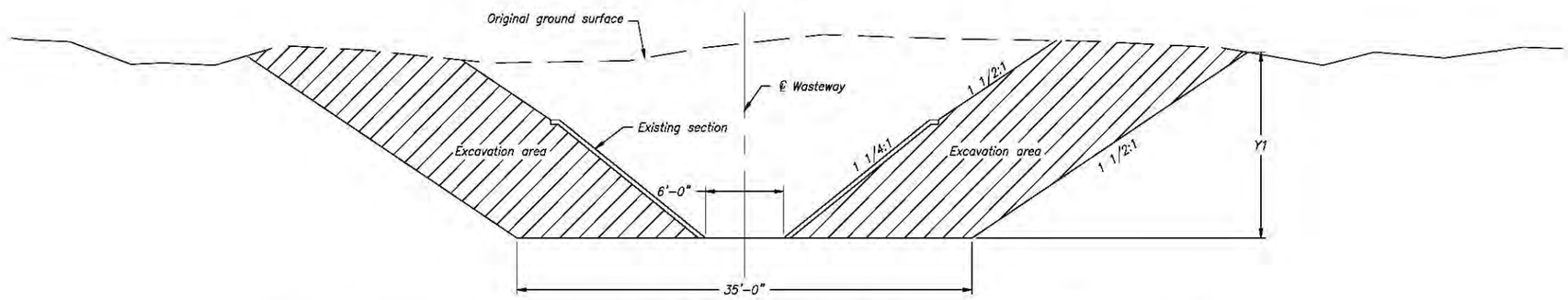
Total Embankment Volume = 24,367.8 cu. yds.

FIGURE C-7

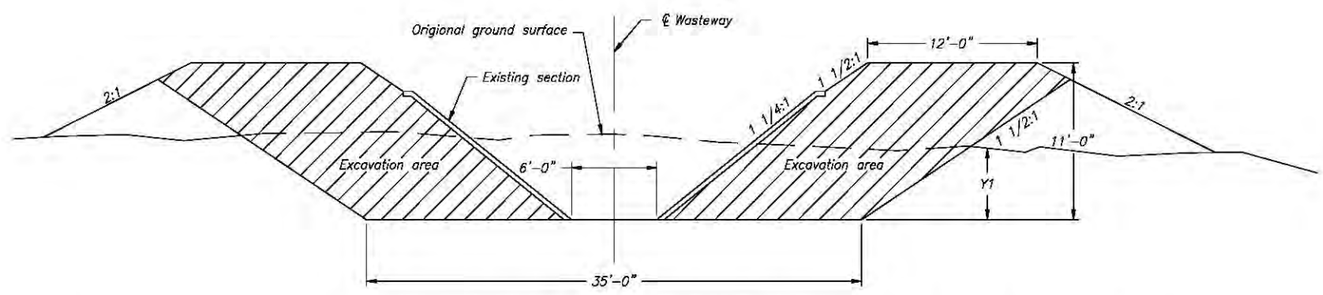
FIGURE C-7



TYPICAL MODIFIED WASTEWAY NO. 3 SECTION–CASE I EXCAVATION AREA GEOMETRY
Y1 > 17'-6"



TYPICAL MODIFIED WASTEWAY NO. 3 SECTION–CASE II EXCAVATION AREA GEOMETRY
11'-0" < Y1 < 17'-6"



TYPICAL MODIFIED WASTEWAY NO. 3 SECTION–CASE III EXCAVATION AREA GEOMETRY
Y1 < 11'-0"

NOTE:
1. Y1 distance is estimated from 33-D-1716.

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BLACK ROCK RESERVOIR STUDY
DELIVERY SYSTEM TO SUNNYSIDE DIVISION
PLAN 2–CANAL MODIFICATION
TYPICAL CANAL AND WASTEWAY SECTIONS
FOR QUANTITY CALCULATIONS

Concept Designer: Steve Montague
Drafter: Leland Boekweg

BOISE, IDAHO | SHEET 1 OF 1 | 2004-07-29 | FIGURE C-7

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CAD SYSTEM
AutoCAD Rel. 16.0
DGN REFERENCE
FIGURE C-7.DWG

Table C-8

2/1/05 **(Page 1 of 3)**

Project: Black Rock Reservoir - Preliminary Design
Feature: Water Delivery to Sunnyside Division
Details: Downstream Plan 2 - Expand Roza Canal

Notes: Calculate quantities of material to be excavated to enlarge the existing Roza Wasteway No. 3 from Sta. 2+17.72 to Sta. 95+00. For Typical Sections see Figure B-7.

Wasteway No. 3 - Reference Drawing 33-D-1716

Excavation Quantities

Station	Y1 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
2+17.72	6.00	Case III	348.25	
8+00	6.00	Case III	348.25	7,510
10+00	8.00	Case III	348.25	2,580
10+70	5.00	Case III	348.25	903
11+00	7.50	Case III	348.25	387
12+00	7.50	Case III	348.25	1,290
13+25	5.50	Case III	348.25	1,612
14+00	9.00	Case III	348.25	967
15+10	5.50	Case III	348.25	1,419
17+05	9.50	Case III	348.25	2,515
18+20	7.00	Case III	348.25	1,483
18+40	9.00	Case III	348.25	258
20+00	6.00	Case III	348.25	2,064
22+00	10.00	Case III	348.25	2,580
28+00	5.00	Case III	348.25	7,739
30+00	11.50	Case II	365.00	2,642
30+50	11.00	Case III	348.25	660
31+55	6.00	Case III	348.25	1,354
33+00	13.00	Case II	415.25	2,050
35+00	2.00	Case III	348.25	2,828
36+15	9.00	Case III	348.25	1,483
37+00	13.00	Case II	415.25	1,202
38+00	10.00	Case III	348.25	1,414
39+20	11.50	Case II	365.00	1,585
40+20	-4.50	Case III	348.25	1,321
40+85	5.50	Case III	348.25	838
41+50	9.00	Case III	348.25	838
45+55	8.50	Case III	348.25	5,224
47+50	17.00	Case II	549.25	3,241
48+00	10.00	Case III	348.25	831
49+00	5.00	Case III	348.25	1,290
50+40	18.00	Case I	602.75	2,466
51+25	16.00	Case II	515.75	1,761
51+75	-1.00	Case III	348.25	800
52+20	14.50	Case II	465.50	678

Wasteway No. 3 - Reference Drawing 33-D-1716

Excavation Quantities

Station	Y1 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
52+55	5.00	Case III	348.25	527
52+90	11.50	Case II	365.00	462
53+30	11.00	Case III	348.25	528
53+60	6.50	Case III	348.25	387
54+00	10.00	Case III	348.25	516
55+45	7.00	Case III	348.25	1,870
55+60	5.50	Case III	348.25	193
56+00	10.00	Case III	348.25	516
57+30	9.50	Case III	348.25	1,677
59+10	14.50	Case II	465.50	2,713
60+00	18.50	Case I	639.50	1,842
61+10	17.00	Case II	549.25	2,422
61+75	6.50	Case III	348.25	1,080
61+99	5.75	Case III	348.25	310
63+10	10.00	Case III	348.25	1,432
64+50	6.75	Case III	348.25	1,806
65+50	14.00	Case II	448.75	1,476
66+00	13.25	Case II	423.63	808
66+50	11.00	Case III	348.25	715
66+80	1.25	Case III	348.25	387
67+15	1.25	Case III	348.25	451
67+50	6.00	Case III	348.25	451
67+80	2.50	Case III	348.25	387
69+00	1.50	Case III	348.25	1,548
70+00	5.00	Case III	348.25	1,290
73+00	10.00	Case III	348.25	3,869
76+00	8.50	Case III	348.25	3,869
78+00	12.00	Case II	381.75	2,704
79+00	16.00	Case II	515.75	1,662
81+35	12.00	Case II	381.75	3,906
81+60	17.00	Case II	549.25	431
82+50	19.50	Case I	713.00	2,104
83+00	13.75	Case II	440.38	1,068
83+55	12.50	Case II	398.50	854
83+85	7.50	Case III	348.25	415

Table C-8
(Page 3 of 3)

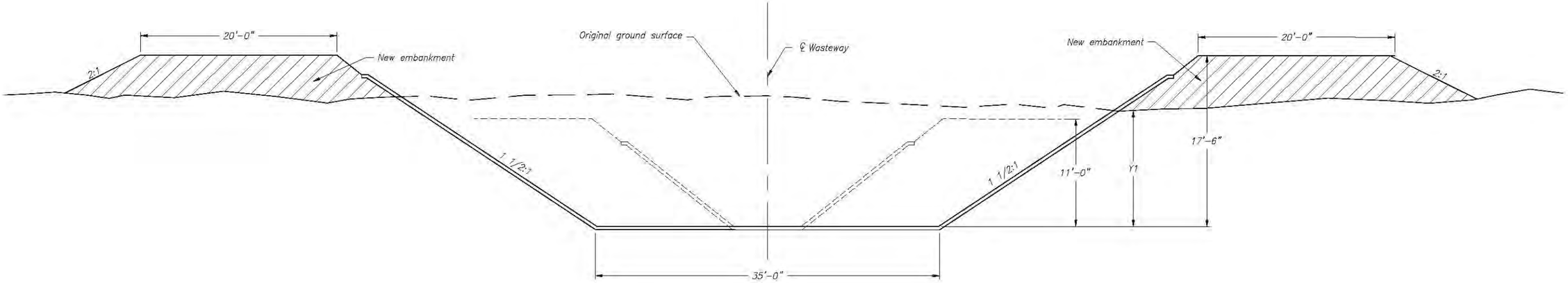
Wasteway No. 3 - Reference Drawing 33-D-1716

Excavation Quantities

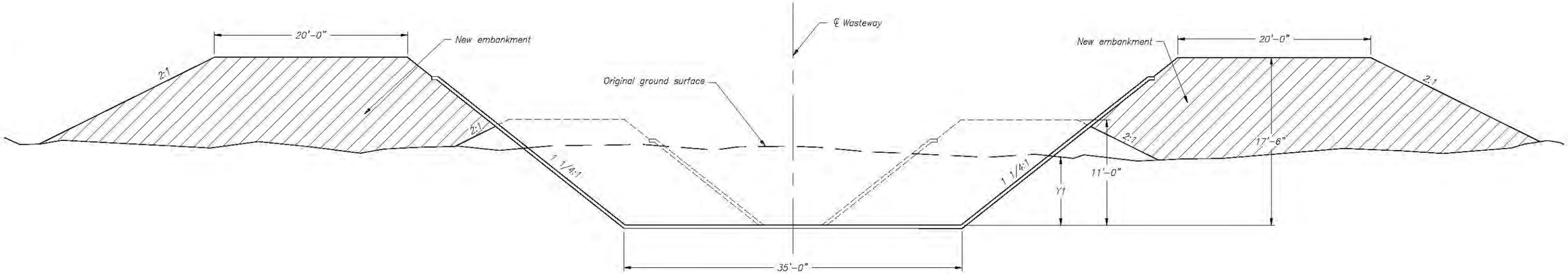
Station	Y1 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
84+10	10.00	Case III	348.25	322
85+00	9.00	Case III	348.25	1,161
88+00	15.00	Case II	482.25	4,614
88+70	9.50	Case III	348.25	1,077
89+70	8.75	Case III	348.25	1,290
90+90	13.50	Case II	432.00	1,734
92+00	13.00	Case II	415.25	1,726
93+00	26.00	Case I	1190.75	2,974
95+00	25.00	Case I	1117.25	8,548

Total Excavation Volume = 137,933 Cubic yards

FIGURE C-9



TYPICAL MODIFIED WASTEWAY NO. 3 SECTION–CASE II EMBANKMENT AREA
11'-0" < Y1 < 17'-6"



TYPICAL MODIFIED WASTEWAY NO. 3 SECTION–CASE III EMBANKMENT AREA
Y1 < 11'-0"

NOTES:

1. Case I–No embankment required.
2. Y1 distance is estimated from 33–D–1716.

1 0 5 10 15
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TYPICAL CANAL AND WASTEWAY SECTIONS
FOR QUANTITY CALCULATIONS

Concept Designer: Steve Montague
Drafter: Leland Boekweg

BOISE, IDAHO | SHEET 1 OF 1 | 2004–07–29 | FIGURE C–9

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CAD SYSTEM
AutoCAD Rel 15.0
CAD FILENAME
FIGURE C-9.DWG

Table C-10
(Page 1 of 3)

Date: 2/1/05
Project: Black Rock Reservoir - Preliminary Design
Feature: Water Delivery to Sunnyside Division
Details: Downstream Plan 2 - Expand Roza Canal

Notes: Calculate embankment quantities required to enlarge the existing Roza Wasteway No. 3 from Sta. 2+17.72 to Sta. 95+00. For Typical Sections see Figure B-9.

Wasteway No. 3 - Reference Drawing 33-D-1716

Embankment Quantities

Station	Y1 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
2+17.72	6.00	Case III	832.88	
8+00	6.00	Case III	832.88	17,962
10+00	8.00	Case III	662.88	5,540
10+70	5.00	Case III	917.88	2,049
11+00	7.50	Case III	705.38	902
12+00	7.50	Case III	705.38	2,613
13+25	5.50	Case III	875.38	3,659
14+00	9.00	Case III	577.88	2,018
15+10	5.50	Case III	875.38	2,960
17+05	9.50	Case III	535.38	5,094
18+20	7.00	Case III	747.88	2,733
18+40	9.00	Case III	577.88	491
20+00	6.00	Case III	832.88	4,180
22+00	10.00	Case III	492.88	4,910
28+00	5.00	Case III	917.88	15,675
30+00	11.50	Case II	366.01	4,755
30+50	11.00	Case III	407.88	717
31+55	6.00	Case III	832.88	2,413
33+00	13.00	Case II	250.88	2,910
35+00	2.00	Case III	1172.88	5,273
36+15	9.00	Case III	577.88	3,728
37+00	13.00	Case II	250.88	1,305
38+00	10.00	Case III	492.88	1,377
39+20	11.50	Case II	366.01	1,909
40+20	-4.50	Case III	1725.38	3,873
40+85	5.50	Case III	875.38	3,131
41+50	9.00	Case III	577.88	1,749
45+55	8.50	Case III	620.38	8,987
47+50	17.00	Case II	20.88	2,316
48+00	10.00	Case III	492.88	476
49+00	5.00	Case III	917.88	2,613
50+40	18.00	Case I	0.00	2,380
51+25	16.00	Case II	67.88	107
51+75	-1.00	Case III	1427.88	1,385
52+20	14.50	Case II	151.51	1,316

Wasteway No. 3 - Reference Drawing 33-D-1716

Embankment Quantities

Station	Y1 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
52+55	5.00	Case III	917.88	693
52+90	11.50	Case II	366.01	832
53+30	11.00	Case III	407.88	573
53+60	6.50	Case III	790.38	666
54+00	10.00	Case III	492.88	951
55+45	7.00	Case III	747.88	3,332
55+60	5.50	Case III	875.38	451
56+00	10.00	Case III	492.88	1,014
57+30	9.50	Case III	535.38	2,475
59+10	14.50	Case II	151.51	2,290
60+00	18.50	Case I	0.00	253
61+10	17.00	Case II	20.88	43
61+75	6.50	Case III	790.38	977
61+99	5.75	Case III	854.13	731
63+10	10.00	Case III	492.88	2,769
64+50	6.75	Case III	769.13	3,272
65+50	14.00	Case II	182.88	1,763
66+00	13.25	Case II	233.22	385
66+50	11.00	Case III	407.88	594
66+80	1.25	Case III	1236.63	914
67+15	1.25	Case III	1236.63	1,603
67+50	6.00	Case III	832.88	1,341
67+80	2.50	Case III	1130.38	1,091
69+00	1.50	Case III	1215.38	5,213
70+00	5.00	Case III	917.88	3,950
73+00	10.00	Case III	492.88	7,838
76+00	8.50	Case III	620.38	6,185
78+00	12.00	Case II	325.88	3,505
79+00	16.00	Case II	67.88	729
81+35	12.00	Case II	325.88	1,714
81+60	17.00	Case II	20.88	161
82+50	19.50	Case I	0.00	35
83+00	13.75	Case II	199.22	184
83+55	12.50	Case II	287.51	496
83+85	7.50	Case III	705.38	552

Table C-10
(Page 3 of 3)

Wasteway No. 3 - Reference Drawing 33-D-1716

Embankment Quantities

Station	Y1 (feet)	Typical Section	Area (sq. ft.)	Volume (cu. yds.)
84+10	10.00	Case III	492.88	555
85+00	9.00	Case III	577.88	1,785
88+00	15.00	Case II	121.88	3,888
88+70	9.50	Case III	535.38	852
89+70	8.75	Case III	599.13	2,101
90+90	13.50	Case II	216.01	1,811
92+00	13.00	Case II	250.88	951
93+00	26.00	Case I	0.00	465
95+00	25.00	Case I	0.00	0

Total Embankment Volume = 195,481 Cubic yards

APPENDIX D – DELIVERY TO SUNNYSIDE WATER USERS UPSTREAM FROM MP 3.83

Date: 2/1/05

Table D-1

Project: Black Rock Reservoir - Preliminary Design

Feature: Water Delivery to Sunnyside Division

Details: Pipe Hydraulics - Delivery to Sunnyside Water Users Upstream from MP 3.83

Notes: Flow delivery to individual users upstream from gravity delivery system at MP 3.83. Assumes a pressure flow delivery for possible conversion to pipe system. Assume a Hazen-Williams roughness coefficient C = 150.

Mile	Delivery Flow (cfs)	Total Flow (cfs)	Pipe Diameter (inches)	Pipe Length (feet)	Delivery Pressure (psi)
0.61	0.13	0.13	6	53	35.00
0.62	0.22	0.35	6	317	35.01
0.68	0.10	0.45	6	211	35.26
0.72	0.12	0.57	8	1267	35.53
0.96	0.22	0.79	8	475	36.14
1.05	0.15	0.94	8	1214	36.57
1.28	0.22	1.16	10	1690	38.04
1.60	0.27	1.43	10	1795	39.07
1.94	0.22	1.65	10	739	40.67
2.08	0.29	1.94	10	370	41.53
2.15	0.21	2.15	10	1056	42.12
2.35	2.78	4.93	10	53	44.13
2.36	0.19	5.12	10	53	44.60
2.37	0.21	5.33	16	686	45.10
2.50	0.25	5.58	16	1267	45.82
2.74	0.74	6.32	16	950	47.25
2.92	5.46	11.78	16	1426	48.61
3.19	1.28	13.05	16	1584	55.06
3.49	1.00	14.06	18	422	63.74
3.57	1.76	15.82	18	264	65.23
3.62	0.99	16.81	18	1109	66.40
3.83	<Powerplant>				

APPENDIX E – FIELD CONSTRUCTION COST ESTIMATE WORKSHEETS

Table E-1. ESTIMATE WORKSHEET

FEATURE:

Preliminary Appraisal Assessment of Black Rock Delivery System for Sunnyside Division

Downstream Plan 1 - Delivery Pipeline

PROJECT:

Yakima River Basin Water Storage Feasibility Study, Washington

REGION | **PRICE LEVEL:**

FILE: D:\Vickie Main Directory\Black Rock Feas Study\Sunnyside Rpt\Appendices\App E\[Table E-1 Estimate Worksheet Option 1w_del.xls]Sheet 2

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		12 ft. Dia. Steel Delivery Pipe					
	1	Clearing and grubbing		93	acres	$5,000.00	$465,000.00
	2	Excavation (common)		884,000	CY	$5.00	$4,420,000.00
	3	Excavation (rock)		156,000	CY	$12.00	$1,872,000.00
	4	Soil cement bedding		7,840	CY	$75.00	$588,000.00
	5	Placing and compacting backfill		890,000	CY	$6.00	$5,340,000.00
	6	12 ft. dia. steel pipe, A572 GR 60 steel		62,000,000	lbs	$2.00	$124,000,000.00
		Check Structure on Sunnyside Canal					
	7	Structural excavation (common)		1,060	CY	$7.00	$7,420.00
	8	Placing and compacting backfill		750	CY	$6.00	$4,500.00
	9	Concrete in structures		250	CY	$750.00	$187,500.00
	10	Langemann gates (26ft. long x 10 ft. tall)		2	ea	$45,000.00	$90,000.00
		Sunnyside Upstream Delivery Pipe					
	11	Pumping plant (pump, structure, elec.)		1	LS	$350,000.00	$350,000.00
	12	Excavation, pipe (common)		40,500	CY	$5.00	$202,500.00
	13	Placing and compacting backfill		39,500	CY	$6.00	$237,000.00
	14	PVC pipe (diameter varies 18-inch tp 6-inch)		1	LS	$440,000.00	$440,000.00
		Subtotal of Pay Items - Sheet 1 of 2					**$138,203,920.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW	DATE PREPARED	PEER REVIEW

Table E-1. ESTIMATE WORKSHEET

FEATURE:

Preliminary Appraisal Assessment of Black Rock Delivery System for Sunnyside Division

Downstream Plan 1 - Delivery Pipeline

PROJECT:

Yakima River Basin Water Storage Feasibility Study, Washington

REGION

PRICE LEVEL:

FILE: D:\Vickie Main Directory\Black Rock Feas Study\Sunnyside Rpt\Appendices\App E\[Table E-1 Estimate Worksheet Option 1w_del.xls]Sheet 2

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal of Pay Items - Sheet 1 of 2					$138,203,920.00
		Mobilization 5% (+/-)					$6,900,000.00
		Subtotal w/ mobilization					$145,103,920.00
		Unlisted Items 15% (+/-)					$19,896,080.00
		CONTRACT COST					**$165,000,000.00**
		Contingencies 25% (+/-)					$45,000,000.00
		FIELD COST					**$210,000,000.00**
		Right-of-way purchase		93	acres	$10,000.00	$930,000.00

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW	DATE PREPARED	PEER REVIEW

Table E-2. ESTIMATE WORKSHEET

FEATURE:

Preliminary Appraisal Assessment of Black Rock Delivery System for Sunnyside Division

Downstream Plan 2 - Modified Roza Canal

PROJECT:

Yakima River Basin Water Storage Feasibility Study, Washington

REGION PN | **PRICE LEVEL** Appraisal

FILE: D:\Vickie Main Directory\Black Rock Feas Study\Sunnyside Rpt\Appendices\App E\[Table E-2 Estimate Worksheet Option 2.xls]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Siphon, Sta. 1349+30 to Sta. 1351+95					
	1	Concrete demolition of existing siphon		620	CY	$80.00	$49,600.00
	2	Structural excavation (common)		18,400	CY	$7.00	$128,800.00
	3	Concrete		1,070	CY	$750.00	$802,500.00
	4	Placing and compacting backfill		15,100	CY	$6.00	$90,600.00
		Canal, Sta. 1351+95 to Sta. 1594+72					
	5	Concrete demoloition of existing lining		13,900	CY	$80.00	$1,112,000.00
	6	Excavation (common)		830,000	CY	$5.00	$4,150,000.00
	7	Embankment		23,000	CY	$6.00	$138,000.00
	8	Gravel surfacing		12,000	CY	$30.00	$360,000.00
	9	Concrete in canal lining		22,000	CY	$350.00	$7,700,000.00
	10	Concrete in bridges		390	CY	$750.00	$292,500.00
	11	Structural steel in bridges		455,000	lbs	$2.00	$910,000.00
		Tunnel No. 5, Sta.1594+72 to Sta.1634+60					
	12	Tunnel excavation (all classes)		31,500	CY	$155.00	$4,882,500.00
	13	Concrete in tunnel lining		7,000	CY	$500.00	$3,500,000.00
	14	Concrete in portal structures and transitions		150	CY	$750.00	$112,500.00
	15	Steel tunnel supports		450,000	lbs	$2.00	$900,000.00
	16	Steel tunnel liner plates		30,000	lbs	$2.00	$60,000.00
		Subtotal of Pay Items - Sheet 1 of 4					**$25,189,000.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW	DATE PREPARED	PEER REVIEW

Table E-2. ESTIMATE WORKSHEET

FEATURE:

Preliminary Appraisal Assessment of Black Rock Delivery System for Sunnyside Division

Downstream Plan 2 - Modified Roza Canal

PROJECT:

Yakima River Basin Water Storage Feasibility Study, Washington

REGION

PRICE LEVEL:

FILE: D:\Vickie Main Directory\Black Rock Feas Study\Sunnyside Rpt\Appendices\App E\[Table E-2 Estimate Worksheet Option 2.xls]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Canal, Sta.1634+60 to Sta.1689+89					
	17	Concrete demoloition of existing lining		1,260	CY	$80.00	$100,800.00
	18	Excavation (common)		115,000	CY	$5.00	$575,000.00
	19	Embankment		1,400	CY	$6.00	$8,400.00
	20	Gravel surfacing		2,700	CY	$30.00	$81,000.00
	21	Concrete in canal lining		5,000	CY	$350.00	$1,750,000.00
		Wasteway No. 3					
	22	Structural excavation for turnout structure		1,670	CY	$7.00	$11,690.00
	23	Concrete in turnout structure		300	CY	$750.00	$225,000.00
	24	Placing and compacting backfill for turnout structure		650	CY	$6.00	$3,900.00
	25	6' x 6' sluice gates		3	ea	$45,000.00	$135,000.00
	26	Concrete demolition of existing lining		4,100	CY	$80.00	$328,000.00
	27	Excavation for wasteway modification (common)		140,000	CY	$5.00	$700,000.00
	28	Embankment		195,000	CY	$6.00	$1,170,000.00
	29	Gravel surfacing		4,500	CY	$30.00	$135,000.00
	30	Concrete in canal lining		10,500	CY	$350.00	$3,675,000.00
	31	Structural excavation for check structures		12,700	CY	$7.00	$88,900.00
	32	Concrete in check structures		1,230	CY	$750.00	$922,500.00
	33	Placing and compacting backfill		3,800	CY	$6.00	$22,800.00
	34	Langemann gates (26 ft long x 10 ft tall)		9	ea	$45,000.00	$405,000.00
		Subtotal of Pay Items- Sheet 2 of 4					**$10,337,990.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW	DATE PREPARED	PEER REVIEW

Table E-2. ESTIMATE WORKSHEET

FEATURE:

Preliminary Appraisal Assessment of Black Rock Delivery System for Sunnyside Division

Downstream Plan 2 - Modified Roza Canal

PROJECT:

Yakima River Basin Water Storage Feasibility Study, Washington

REGION

PRICE LEVEL:

FILE: D:\Vickie Main Directory\Black Rock Feas Study\Sunnyside Rpt\Appendices\App E\[Table E-2 Estimate Worksheet Option 2.xls]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Pipeline to Sunnyside					
	35	Structural excavation for turnout structure		5,100	CY	$7.00	$35,700.00
	36	Concrete in turnout structure		480	CY	$750.00	$360,000.00
	37	Placing and compacting backfill		3,000	CY	$6.00	$18,000.00
	38	6' x 6' sluice gates		3	ea	$45,000.00	$135,000.00
	39	Clearing and grubbing for pipe construction		12	acres	$5,000.00	$60,000.00
	40	Excavation for pipe (common)		92,000	CY	$5.00	$460,000.00
	41	Soil cement pipe bedding		1,020	CY	$75.00	$76,500.00
	42	Placing and compacting backfill for pipe		73,000	CY	$6.00	$438,000.00
	43	12 ft dia. Steel pipe (A36 steel)		3,100,000	lbs	$2.00	$6,200,000.00
		Check Structure on Sunnyside Canal					
	44	Structural excavation (common)		1,060	CY	$7.00	$7,420.00
	45	Placing and compacting backfill		750	CY	$6.00	$4,500.00
	46	Concrete in structures		250	CY	$750.00	$187,500.00
	47	Langemann gates (26ft. long x 10 ft. tall)		2	ea	$45,000.00	$90,000.00
		Sunnyside Upstream Delivery Pipe					
	48	Pumping plant (pump, structure, elec.)		1	LS	$350,000.00	$350,000.00
	49	Excavation, pipe (common)		40,500	CY	$5.00	$202,500.00
	50	Placing and compacting backfill		39,500	CY	$6.00	$237,000.00
	51	PVC pipe (diameter varies 18-inch tp 6-inch)		1	LS	$440,000.00	$440,000.00
		Subtotal of Pay Items - Sheet 3 of 4					**$9,302,120.00**

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW	DATE PREPARED	PEER REVIEW

Table E-2. ESTIMATE WORKSHEET

FEATURE:

Preliminary Appraisal Assessment of Black Rock Delivery System for Sunnyside Division

Downstream Plan 2 - Modified Roza Canal

PROJECT:

Yakima River Basin Water Storage Feasibility Study, Washington

REGION

PRICE LEVEL:

FILE: D:\Vickie Main Directory\Black Rock Feas Study\Sunnyside Rpt\Appendices\App E\[Table E-2 Estimate Worksheet Option 2.xls]Sheet 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal of Pay Items - Sheet 1 of 4					$25,189,000.00
		Subtotal of Pay Items - Sheet 2 of 4					$10,337,990.00
		Subtotal of Pay Items - Sheet 3 of 4					$9,302,120.00
		Subtotal w/o mobilization					$44,829,110.00
		Mobilization 5% (+/-)					$2,200,000.00
		Subtotal w/mobilization					$47,029,110.00
		Unlisted Items 15% (+/-)					$6,970,890.00
		CONTRACT COST					**$54,000,000.00**
		Contingencies 25% (+/-)					$14,000,000.00
		FIELD COST					**$68,000,000.00**
		Right-of way purchase		80	acres	$10,000.00	$800,000.00

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
DATE PREPARED	PEER REVIEW	DATE PREPARED	PEER REVIEW

APPENDIX F – SUNNYSIDE VALLEY IRRIGATION DISTRICT COMMENTS

PRJ-1.10

SUNNYSIDE VALLEY IRRIGATION DISTRICT

SERVING AGRICULTURE SINCE 1906

BUREAU OF RECLAMATION
OFFICIAL FILE COPY

MAIL CODE	ACTION	INIT & DATE	COPY
1000			
1100			
1200			
1600			
1750			
2000			
5000			
1120		KJM 7/13/04	
1108			

ACTION TAKEN:
FOLDER #: 2944
CONTROL #: 4001229

July 7, 2004

Kim McCartney, Storage Study Manager
Bureau of Reclamation
1917 Marsh Road
Yakima, WA 98901-2058

Re: Comments on Black Rock Delivery System for Sunnyside Division

Dear Mr. McCartney:

Thank you for the opportunity to comment on the Black Rock Delivery System for Sunnyside Division. As we review the technical material, policy questions arise. Although you or others may not be able to address them immediately the Board of Directors want these issues identified early in the review process so that there is the understanding these issues will be addressed at some point along the way. As a result, the following comments contain both technical and policy issues some of which can be addressed sooner than others.

1. We have been advised informally that the Sunnyside Division will not be allocated any of the capital costs of the reservoir. Does that also include the delivery system?

2. Will the Sunnyside Division be responsible for any of the operation and maintenance costs for the reservoir storage or the delivery system? Even though there is a power generating plant at the point of discharge to the Sunnyside Canal, there will still be a net energy requirement. Has that been quantified?

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3. Will the delivery system be a reserved works or a transferred works? The chance of failure is remote but damages due to failure from either internal or external causes would be substantial and place an unreasonable financial burden on the Sunnyside Division.

4. Given the size of pumps, motors, transformers, valves, etc. replacement equipment will not likely be "off the shelf" items. Will the delivery system be built with any redundancy to provide assurance of service in the event of equipment failure?

5. On page 2, reference is made to the use of 12 foot diameter pipe to "keep velocities under 12 fps." Velocities in that range seem excessive.

6. On page 3, the report notes that 17 cfs is required upstream. 20 cfs was the amount submitted to the study team by SVID.

7. The tabulation of "Delivery Pressure" in Table A-4 in Appendix A shows pressures of less than 40 p.s.i. for the first 8 delivery points. The delivery pressure should be at least 40 p.s.i.

8. We are not aware of current thinking as to the need to keep Columbia River water (to the extent possible) out of the Yakima River. If that concern exists, then the first 3.83 miles of the Sunnyside Canal and its current point of diversion will need to remain in place and maintained to be operable for the months of March and October. This will require a structure to permit passage of water downstream certain months of the year and restrict water from flowing upstream other months of the year.

9. We have no technical comments regarding Option 2 in which the water supply for the Sunnyside Division would be transported through the Roza Canal. However there is a key policy issue of linking the Roza and Sunnyside Canal operations together which the Board of Directors will need to evaluate.

10. Finally, probably the most fundamental policy issues are the effect of the proposed water exchange on the priority dates of the Sunnyside Division water rights and the current contracts between the Bureau of Reclamation and the Sunnyside Division entities. The Sunnyside Division contains an aggregation of priority dates some of which are the oldest in the Yakima Basin. As a practical matter, a later priority date will not be an issue if upon evaluation of the water supply it is determined there would never be curtailments even with a later priority date. However it is sure to be a perception problem to some landowners in the Sunnyside Division. Potential questions concerning new or re-opened contracts seem self evident.

Thanks again for the opportunity to provide comments.

Sincerely,

James W. Trull

James W. Trull
District Manager