Yakima River Basin Study

Keechelus to Kachess Pipeline Technical Memorandum

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ, Task 4.6

Prepared by

HDR Engineering, Inc

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office

State of Washington
Department of Ecology
Office of Columbia River

February 2011

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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.

The Mission of the Washington State Department of Ecology is to protect, preserve and enhance Washington's environment, and promote the wise management of our air, land and water for the benefit of current and future generations.

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1.0 Introduction

This technical memorandum describes the design criteria, geology, facilities, and property easement needs, for a flow transfer pipeline project between Lake Keechelus and Lake Kachess. This project is located in west central Washington near Interstate 90 (I-90) just east of Snoqualmie Pass between Lake Keechelus and Lake Kachess (Figure 1 below shows general project location; Figure 2 of this technical memorandum shows a more detailed aerial view of the pipeline alignment.).

The purpose of the Keechelus to Kachess (K to K) pipeline is to increase the operational flexibility of the federal Yakima Project and to better utilize the water within the larger Keechelus hydrologic basin by conveying the water to Lake Kachess, which has a smaller hydrologic basin and more available storage capacity.

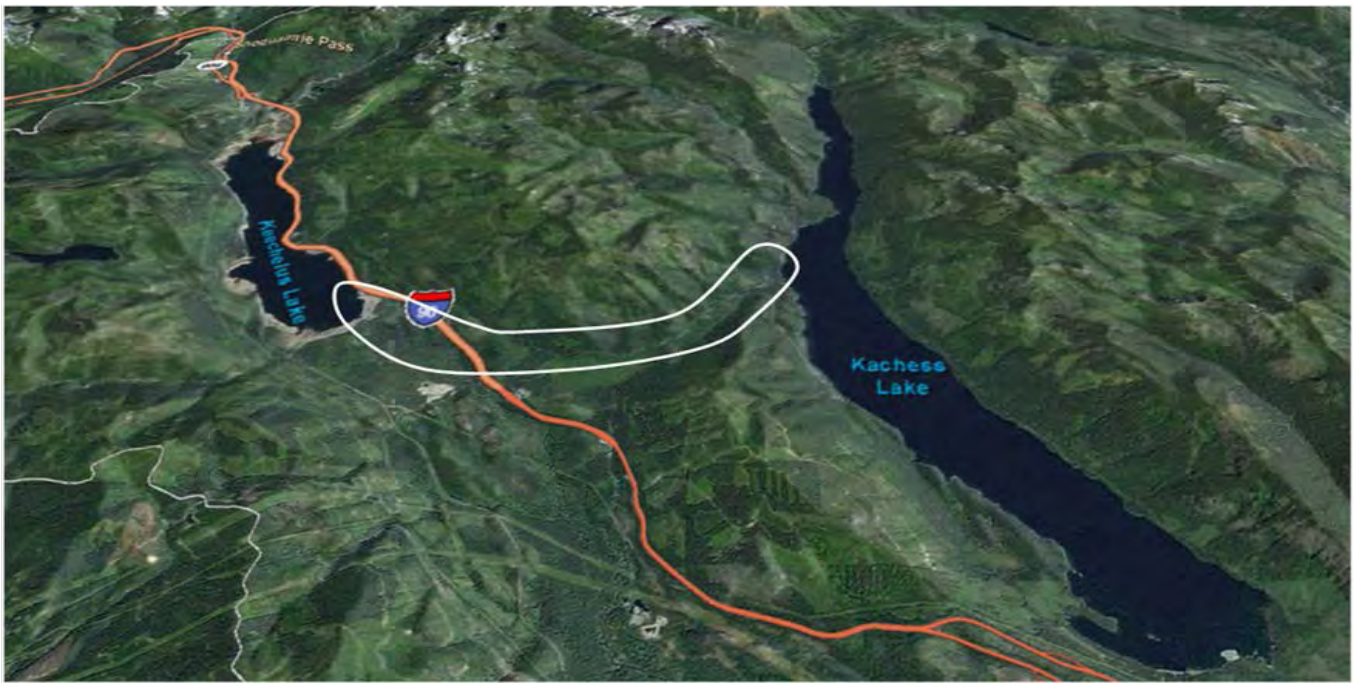

Figure 1. Keechelus-to-Kachess Project Location
(Note: Figure 1 shows the project location outlined in white.
Figure 2 shows a more detailed aerial view of the pipeline alignment.)

This project would modify the existing Lake Keechelus outlet tunnel with a new steel wye branch connected to a new 96-inch-diameter steel pipeline from the outlet structure to a control structure on the northwestern shore of Lake Kachess and then to a new outfall into Lake Kachess.

The existing outlet tower would be retrofitted with fish screens connected by a pipe to the base of the tower. The pipeline between the Keechelus outlet and the existing Lake Kachess high-water shoreline would be approximately 25,000 feet long. The outfall pipe would extend another 550 feet into Lake Kachess to discharge at least 20 feet below a proposed future minimum water lake surface elevation 2110. The current minimum lake elevation 2192.75 would be lowered to

elevation 2110 for the Kachess Inactive storage project. The total length of from the Lake Keechelus outlet to the end of the Lake Kachess outfall would be approximately 25,600 feet.

The K to K pipeline is one of five potential structural and operation changes being studied to improve water resources management in the Yakima Basin. Other alternatives include: conveyance improvements at the former Wapatox Power Plant, reducing or eliminating irrigation district diversions used for power production at the Roza and Chandler power plants during outmigration of juvenile anadromous fish, modifications of the Kittitas Reclamation District Main Canal and South Branch, and raising the pool level at Cle Elum Dam. These options are described in other technical memoranda as part of the Yakima River Basin Water Enhancement Project.

2.0 Design Criteria

2.0 Pipeline Flows

The volume of water transferred between Lake Keechelus and Lake Kachess would be based on water management criteria within the basin. The designed flow rate for the pipeline was selected to be an average of 400 cfs. This flow rate would occur at the average Lake Keechelus water surface elevation 2471, which is halfway between the Lake Keechelus spillway at elevation 2517 and the existing outlet gate sill at elevation 2425. The maximum flow rate when Lake Keechelus is full (near the spillway elevation 2517) is 600 cfs. The 400-cfs design criterion was accepted during the analysis of the Integrated Plan related to the Yakima River Basin Study.

2.1 Hydraulics Elevations and Pressures

The pipeline should be designed for static pressures up to a maximum of 407 feet (177 psi), which corresponds to a full Lake Keechelus at elevation 2517 feet and a low-water surface elevation in Lake Kachess at the invert of the proposed outlet. Sections of the pipeline at higher elevations could be designed for correspondingly lower pressures. Surge pressures can be minimized by controlling valve opening and closure times, but pending a detailed surge analysis, approximately 20 percent of the static pressure was added to account for temporary surge pressures.

The existing Lake Keechelus dam outlet tunnel should be evaluated for any increases in pressure that may result from the new wye outlet configuration; including hydraulic transients in the tunnel resulting from downstream valve adjustments.

The new outlet pipe into Lake Kachess would have a diffuser energy dissipation end section that would rest on the sloping lakeshore bottom to discharge the flow into the lake near the shoreline.

Figure 3 shows the existing Lake Keechelus area/capacity curves. Table 1 below shows Lake Keechelus and Lake Kachess elevation data, storage volume, and the estimated additional volume with a new Lake Kachess outlet. This figure and table illustrate approximate active storage volumes currently available and as proposed for the combined Lake Keechelus/Lake Kachess system.

Table 1. Lake Keechelus and Lake Kachess Elevation Data and Storage Volume and Estimated Additional Volume with New Lake Kachess Outlet

	SPILLWAY CREST ELEVATION (FT)	TOP OF DEAD STORAGE POOL ELEVATION (FT)	STORAGE DEPTH (FT)[1]	STORAGE VOLUME (ACRE FT)[2]
Existing Keechelus	2517	2425.00	92.00	157,800
Existing Kachess	2262	2192.75	69.25	239,000
Proposed Kachess with new Outlet	2262	2110.00	152.00	Additional 200,000

[1] Storage depth is difference between spillway crest elevation and top of dead storage pool.
[2] Existing storage volume is based on area capacity curves.

Provisions for an additional 200,000 AF of storage in Lake Kachess are discussed in the Kachess Inactive Storage Technical Memorandum.

2.2 Hydraulic Analysis

The pipeline is designed for an average flow rate of 400 cfs. To maintain that average flow over the range of Lake Keechelus water surface elevations, the hydraulic analysis was based on a maximum pipeline flow velocity of 12 feet-per-second (fps) at a flow of 600 cfs. This would be the flow rate when Lake Keechelus is full. The flow would gradually decrease as the reservoir is drawn down. Figure 4 shows the ground, pipeline, and hydraulic profiles of the pipeline alignment. The pipeline high point ensures that the static pressure design hydraulic grade line remains above the crown of the pipe to maintain positive pressure within the pipeline. A cut of up to approximately 50 feet would be required at the high point to keep the top of the pipe below the normal hydraulic grade line. A high-point standpipe and additional air and vacuum valves would allow sufficient air transfer during pipe filling, draining and during flow transition and surge conditions. Due to changing pipeline slopes and flow variations, transient conditions (including a partially full pipe) would require more detailed analysis during final design.

The hydraulic analysis resulted in a 96-inch-diameter pipe for the entire 25,000-foot length between the Lake Keechelus outlet bifurcation and Lake Kachess shoreline. Another 550 feet of outfall and diffuser pipe would extend into Lake Kachess so the discharge end of the pipe is always submerged, even if the lake is drawn down to approximately elevation 2110 as part of the Kachess Inactive Storage Project.

The velocity in the pipe would be 8.0 fps at the average design flow rate of 400 cfs and 11.9 fps at a high flow rate of up to 600 cfs under full pipe flow conditions when Lake Keechelus is full. The pipeline would be capable of a low flow rate of 350 cfs under full-pipe conditions when the water level in Lake Keechelus is only 25 feet above the invert of the existing outlet. In this case the flow velocity would be about 7 fps. Flows less than 350 cfs are possible, but the pipeline would be flowing partially full.

About 150 feet of remaining head would be available above the Lake Kachess spillway crest elevation at the shoreline of Lake Kachess. This residual head could either be dissipated through the lake outfall or, if economically feasible, by the future addition of an energy recovery hydropower system. A future hydropower turbine to generate power from the residual head could be located on the lake shoreline (above spillway crest elevation 2262).

3.0 Geology

Figure 5 shows the USGS geologic map of the Snoqualmie Pass Quadrangle along the pipeline alignment (Tabor, et al. 2000). The alignment passes through three surface geologic units: alluvium (Qa), bog deposits (Qb) and alpine glacial deposits (Qag), indicating that the pipeline excavation would encounter silty sand and gravel and cobbles of alluvial and glacial derivation, as noted by Magelby (1986).

Citing Frizzell et al. (1984) and a brief field examination conducted during an earlier routing analysis (Magelby 1986) concluded that rock would probably be found along the alignment near Swamp Lake and further to the east. Based on this conclusion and the review of the USGS geologic map, potential areas of rock excavation along the pipeline alignment are identified in Figure 5. The rock anticipated in these locations is expected to be hard, competent basalt belonging to the geologic units Tn and Tnbg.

4.0 Facilities Description

4.0 Pipeline Alignment

Figure 6 shows the pipeline alignment on a contour map of the area. (The profile of the alignment is shown in Figure 4.)

The 96-inch-diameter, 25,000-foot pipeline (to the Lake Kachess shoreline) starts at the Keechelus outlet tunnel and continues to the south and east, following the Yakima River to a crossing under I-90 just west of the interchange near I-90 milepost 62. The pipeline then continues east until it intersects Kachess Lake Road and follows the road alignment to the northeast until it diverges from the road alignment and down the lakeshore slope to connect to the outlet control structure and outfall pipe into Lake Kachess.

The pipeline west of the high point is lowest near Swamp Creek just to the east of I-90, approximately 9,000 feet from the Keechelus outlet works. If necessary for inspection and/or maintenance, this section of the pipeline could be drained through a valve discharging to Swamp Creek.

The pipeline profile then climbs a hill for about 7,500 feet until it crests the high point in the alignment at about elevation 2425. The pipeline then largely parallels the road for most of the remaining 8,500 feet of the alignment. The final section would include one intermediate high point and one low point.

Standpipes and/or combination air release/vacuum valves would be located at high points along the pipeline to allow air into or out of the pipe when it is filling or draining and during any potential pipeline surge conditions. Another drain would be required about 1,000 feet east of the high point to drain one small section of pipeline. East of the second high point the pipeline would drain through the outfall structure into Lake Kachess.

The following sections provide more detailed descriptions of the pipeline alignment from the Lake Keechelus intake to the Lake Kachess outfall.

4.1 Lake Keechelus Outlet Fish Screens

The existing Lake Keechelus outlet tower would be fitted with new fish screens consisting of four manifolded, cylindrical, stainless-steel wedgewire fish screens connected by a pipe to the base of the tower. Figure 7 illustrates plan and elevation views of the fish-screen retrofit concept. Although the average flow is 400 cfs, the fish screens need to be designed for the maximum flow of 600 cfs. The system also would be designed to be self cleaning.

4.2 Lake Keechelus Outlet Conduit Bifurcation

The existing outlet works at Lake Keechelus includes a gate in the outlet tower, a 22-inch bypass pipe, and an 11-foot-wide, concrete outlet conduit through the dam to the Yakima River channel. The pipeline diversion would be connected to the existing conduit by grouting the new steel pipe inside the downstream end of the conduit. Figure 8 shows a plan view schematic of this connection. The center section of the new steel pipe would consist of a steel pipe wye bifurcation to connect the existing outlet conduit to the new steel pipeline to Lake Kachess. Flow also could continue straight through the existing outlet and section of new pipe to the existing concrete open channel to the Yakima River.

The wye would be installed in the downstream end of the existing conduit between the conduit and the flume to avoid or minimize any excavation into the dam embankment. Motor-operated butterfly control valves in each branch of the wye would be used to divide and control the flow rates to the new Kachess pipeline and into the Yakima River. The existing low-flow, 22-inch bypass pipe would be rerouted outside the conduit to avoid conflicts with the new steel pipeline. The new fish screens and the outlet conduit bifurcation are the only modifications under consideration for the Keechelus Dam and outlet tower.

4.3 Pipeline from Lake Keechelus to Lake Kachess

4.3.1 Pipeline to I-90 Crossing

The pipeline between the Lake Keechelus outlet and I-90 would be buried with minimal cover but generally sloped down to elevation 2,400 at I-90. This first approximately 7,200-foot-long segment of the pipeline would be located north of the Yakima River and south of I-90. It would cross Price Creek and Noble Creek and is adjacent to the rest stop on I-90.

4.3.2 Pipeline Crossing Under I-90

The next section of pipeline is an approximately 400-foot-long 96-inch trenchless (using bore and jack or other tunneling methods) crossing under I-90 northwest of Exit 63. The outside diameter of the casing may be larger if a two-pass (casing and carrier pipe) system is used for the crossing. A casing installed by pipe jacking would typically be a minimum of one to two pipe diameters under the highway, but depth would depend on geological conditions and the detailed crossing design. There is an opportunity to reduce construction impacts by coordinating this crossing with a planned 600-foot-wide wildlife bridge over I-90 to facilitate animal crossings. This WSDOT Connectivity Emphasis Area project (called Bonnie Creek) is part of a WSDOT program that includes stream and habitat restoration and wildlife crossings along I-90.

4.3.3 Pipeline from I-90 to Saddle High Point

After crossing under I-90, the pipeline continues to slope downward to a low point at Swamp Creek, then climbs along Kachess Lake Road to a section of pipeline between Stations 150+00 and 185+00, which is the topographical high point saddle between the two lakes. Until the saddle area is reached, the pipe would be buried along the road with minimal cover, but is generally sloped up to Station 150+00 where it begins the traverse to the saddle area. A 40- to 50-foot-deep cut through the high point of the pipeline in the saddle area (likely through rock) would be at elevation 2425 to keep the pipe below the hydraulic grade line of the low-point elevation of the Lake Keechelus outlet during normal flow conditions. Combination air release/vacuum valves would be located at the high point to allow air out of or into the pipe when it is filling or draining and during any flow transition surge conditions that my require air transfers.

The cut could be reduced by up to 15 feet if the pipeline was operated as a siphon for the last 10 to 15 feet of its drawdown to the Lake Keechelus outlet or if the transfer pipeline was not used when Lake Keechelus was within 10 to 15 feet of its outlet elevation 2425. This is likely the case, because the Bureau avoids drawing Lake Keechelus down below elevation 2435 to avoid running out of water to meet minimum flows. Once through the saddle area, the pipe slopes downward toward Lake Kachess. The siphon option should be further evaluated during final design.

4.3.4 Pipeline from Saddle to Lake Kachess Shoreline

The next section of pipeline is between the end of the saddle at about Station 185+00 and the shoreline of Lake Kachess. The pipeline slopes downhill to Station 208+00 before a short uphill section to a crest, where it finally slopes steadily down to the Lake Kachess shoreline.

As described in Section 4.4.3, air release/vacuum valves would be installed at high points along this segment of the pipeline. Another drain would be required about 1,000 feet east of the high point to drain one small section of pipeline. The pipeline east of the second high point would drain through the outfall structure into Lake Kachess.

4.3.5 Outlet Control

Flow into the discharge pipeline would be controlled by the valve at the upstream end of the pipeline at the Lake Keechelus bifurcation. To reduce costs, the hydraulic concept would allow free discharge of the pipeline flow into Lake Kachess through a long, submerged outfall pipe drilled with orifices to dissipate the energy.

As an option, the outlet control structure could have at least two manifolded energy dissipation valves and a bifurcation for a future hydropower energy recovery facility. Since the energy would be dissipated through the valves or by the hydropower plant, this outlet would have to discharge to a more open-pipe outfall into the lake. This option should be evaluated during final design.

4.3.6 Outfall Pipeline into Lake Kachess

The outfall pipeline into Lake Kachess continues to slope downhill into the lake, extending to elevation 2090, which is approximately 20 feet below the proposed Lake Kachess minimum inactive storage project elevation 2110. Figure 9 shows a plan view of the outlet pipe imposed on bathymetric contours of Lake Kachess in this area.

The end section of the pipe would be designed with diffusers to dissipate velocity and flow for a length of the pipe. The first 200 feet of the outfall pipeline would be buried in the lake bottom for protection while the remainder of the pipe would be anchored on the lake bottom with concrete weights.

4.4 Metering and Controls

It is expected that the new project facilities would include remote monitoring of water-surface elevations, pipeline pressures, pipeline and river flows, and remote operation of control gates to vary flow rates in the pipeline and flow to the Yakima River.

Elevations and pressures would be monitored at the following locations:

- Keechelus Lake
- Keechelus fish screens (pressure differential across screens)
- Keechelus Lake outlet channel
- Kachess Lake
- The high point and the Kachess outlet structure (pipeline pressures)

Flows would be monitored at the following locations:

- Keechelus outlet in the pipe upstream of the wye
- K to K pipe below the wye bifurcation
- Yakima River at outlet (could use existing (Kee) gauge near Martin)
- K-to-K pipe at the Kachess Lake outlet

The in-pipe flows could be measured using multi-path transit time meters.

Gates and valves would be remotely operated at the following locations:

- Lake Keechelus outlet gates
- Wye bifurcation control valves

5.0 Real Estate

The Kittitas County Assessor's web site was used to determine the number of parcels that would be affected by the K-to-K pipeline alignment and number of easements needed for the project. Data was compiled using GIS tools on the website and by reviewing County parcel maps. Data was then collected for each parcel along the route and combined with parcels from surrounding property not on the route.

It was assumed that parcels where the pipeline crosses open space would need a 50-foot permanent easement and a 100-foot temporary construction easement, while parcels that run parallel with Kachess Lake Road would need a 25-foot temporary easement on each side of the road and no permanent easements.

The conceptual pipeline alignment would require easements for a total of 64 total parcels with 39 separate land owners. Forty six of those parcels are owned by private landowners, eight by the Kittitas Conservation Trust, six by the Wenatchee National Forest, and four by the federal government.

6.0 Considerations for Final Design

6.0 Special Considerations

- Retrofitting fish screens to the existing Lake Keechelus outlet tower
- Connecting a wye bifurcation to the existing outlet conduit without major modifications to the dam and outlet structures
- Minimizing impacts to Yakima River and wetlands in the area above the I-90 crossing
- The trenchless undercrossing of I-90, including coordination of the construction with WSDOT construction in the area
- Maintaining traffic access while installing a large-diameter pipeline along a relatively narrow rural road, including a deep cut through rock at the high point of the alignment profile
- Installation of the last section outfall pipe and diffuser into Lake Kachess

6.1 General Considerations

- Obtain more accurate survey and property ownership data and prepare a topographic map of the proposed route area
- Confirm the final pipeline operational criteria and perform a more detailed hydraulics analysis
- Further investigate and refine the design for fish screens on the existing outlet tower
- Further review and refine the outlet wye bifurcation and controls concept
- Complete a more detailed aerial and topographic survey of the proposed pipeline route
- Meet with WSDOT to confirm the schedule for construction of the their planned wildlife crossing
- Perform additional geotechnical investigation along the proposed route from the Lake Keechelus outlet to the Lake Kachess shoreline, especially confirming the areas of rock at the high points of the alignment

6.2 Cost Estimates

Cost estimates for the Keechelus to Kachess Pipeline will be outlined in a separate technical memorandum.

7.0 References

1. Tabor, R.W., Frizzell, V.A. Jr., Booth, D.B., Waitt, R.B., “Geologic Map of the Snoqualmie Pass 30x60 minute Quadrangle, Washington”, USGS, 2000.
2. Frizzell, V.A. Jr., Tabor, R.W., Booth, D.B, Ort, K.M., Waitt, R.B.,Jr., “Preliminary geologic map of the Snoqualmie Pass 1:100,000 Quadrangle, Washington”, Open-File Report 84-693, 1984.
3. Magelby, D., “United States Government Memorandum: Field Review, Keechelus-Kachess Pipeline Route, Yakima Project, Washington”, Geology Branch Files, September 26, 1986.
4. “Keechelus – Kachess Pipeline, Construction Cost Estimate”, U.S. Bureau of Reclamation, 1986.
5. “Keechelus Dam Outlet Works Rehabilitation Drawings”, U.S. Department of Interior, Bureau of Reclamation, March 17, 1976.
6. “Yakima River Basin Storage Alternatives Appraisal Assessment”, Technical Series No. TS-YSS-8, U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, May 2006.

8.0 List of Preparers

Name	Background	Responsibility
HDR Engineering, Inc.		
Jim Peterson	Professional Engineer	Task Manager
Keith Goss	Professional Engineer	Task Engineer
John Nelson	Professional Engineer	Task Engineer
Stan Schweissing	Professional Engineer	QC Reviewer

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Figures Appendix A

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K to K Pipeline Alignment Aerial
FIGURE 2

Keechelus to Kachess Pipeline, Yakima Basin Study

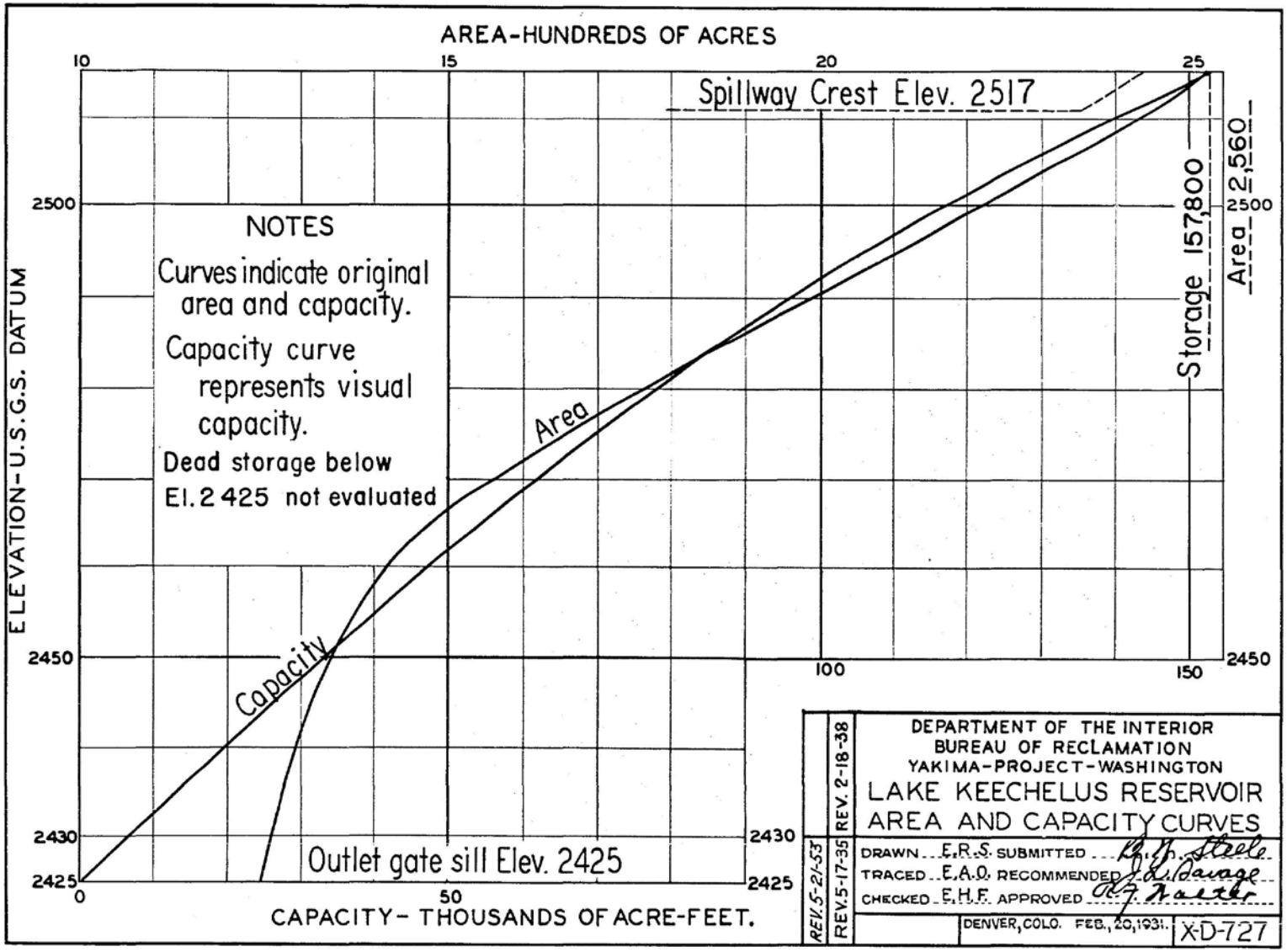

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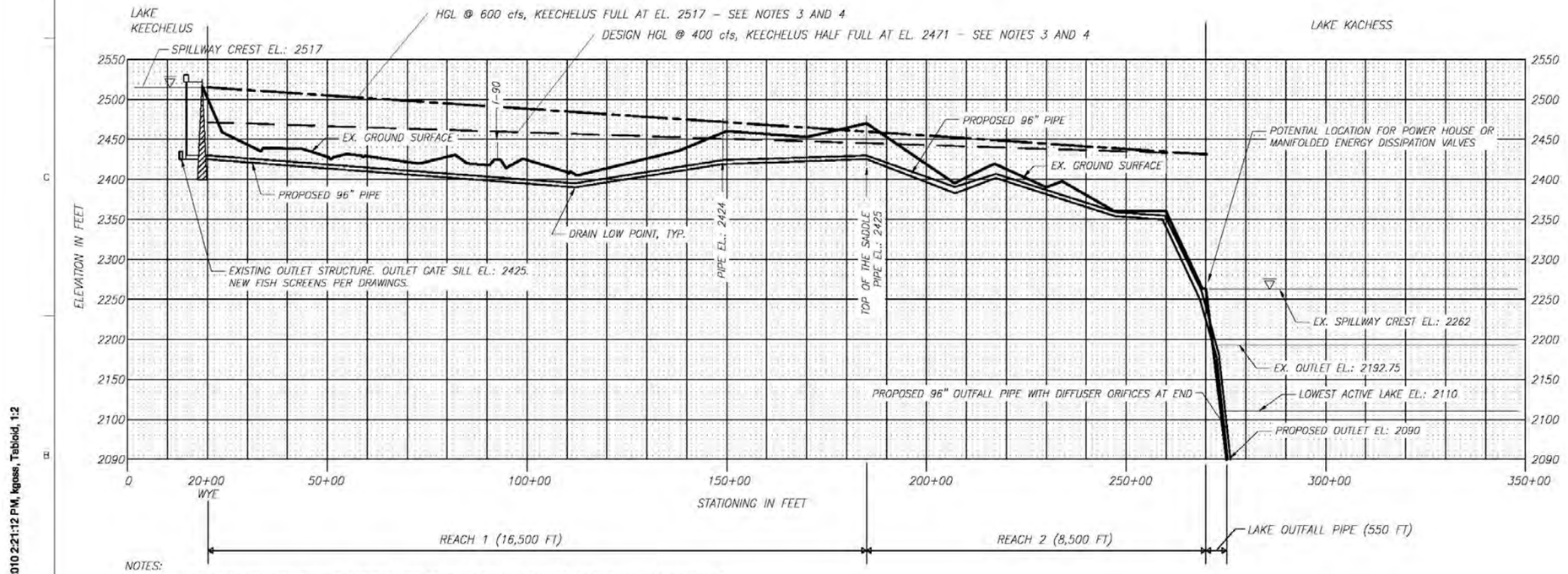
FIGURE 3



NOTES:

1) LAKE KEECHELUS STORAGE VOLUME BETWEEN SPILLWAY CREST AND OUTLET GATE SILL = 157,800 ac.ft.
2) STORAGE VOLUME OF LAKE KEECHELUS:
   BETWEEN SPILLWAY CREST AND EXISTING OUTLET = 239,000 ac.ft.
   BETWEEN EXISTING OUTLET AND PROPOSED OUTLET = 200,000 ac.ft.
3) DESIGN FLOW RATE: 400 CFS (AVERAGE); 600 CFS (MAXIMUM)
4) FLOW VELOCITIES IN PIPE ARE LIMITED TO 10 FPS DURING AVERAGE FLOW AND 12 FPS DURING MAXIMUM FLOW CONDITIONS. HYDRAULIC GRADELINES (HGL) SHOWN ASSUME DOWNSTREAM FLOW CONTROL.

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA RIVER BASIN STUDY

KEECHELUS KACHESS PIPELINE
PIPELINE PROFILE
FIGURE 4

DESIGNED
DRAWN
CHECKED
TECH. APPR. — NAME - TITLE
APPROVED — ADMINISTRATION APPROVAL - NAME - TITLE
BOISE, ID — 06.25.2009

FIGURE 4

SHEET X OF X

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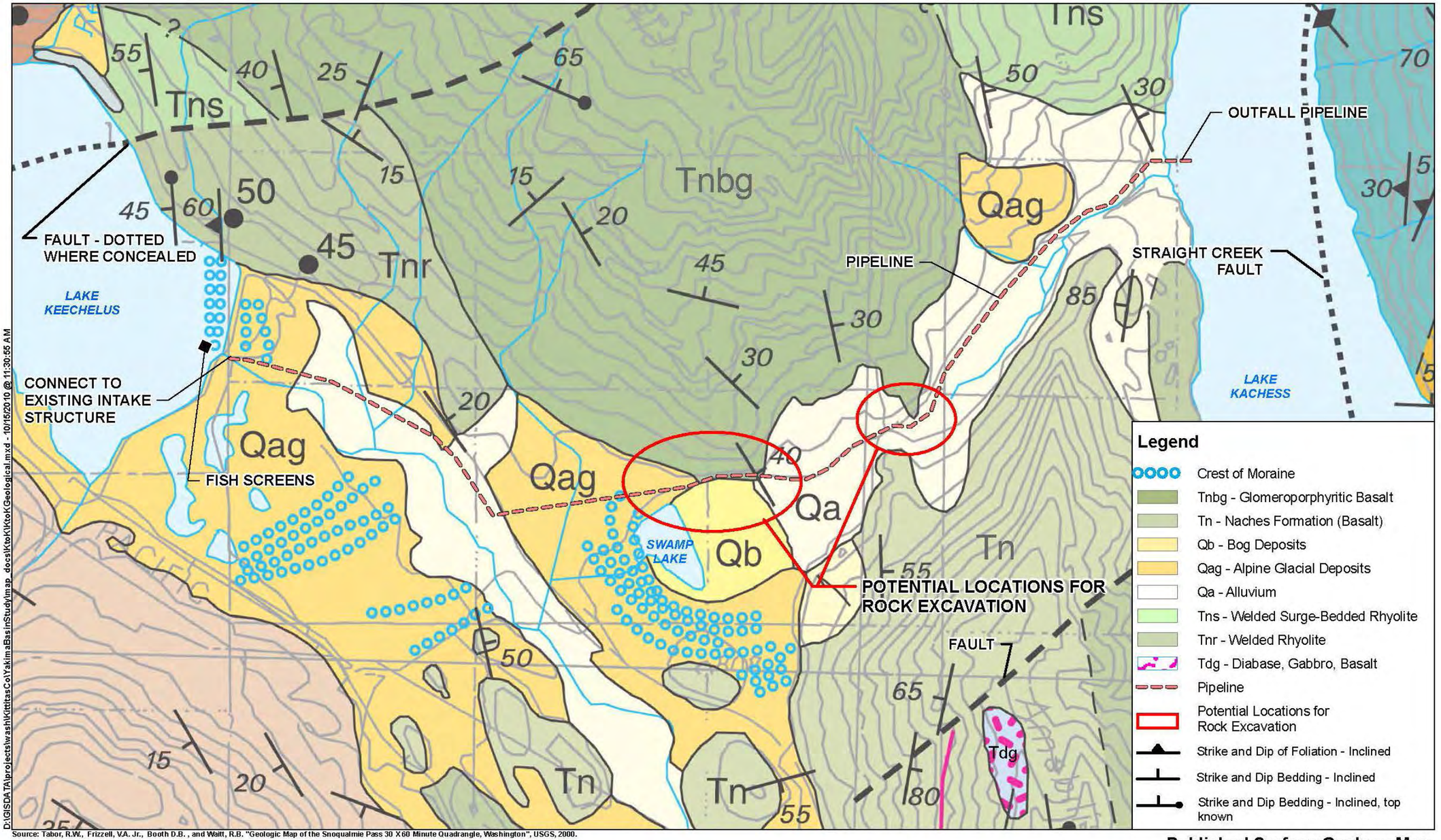

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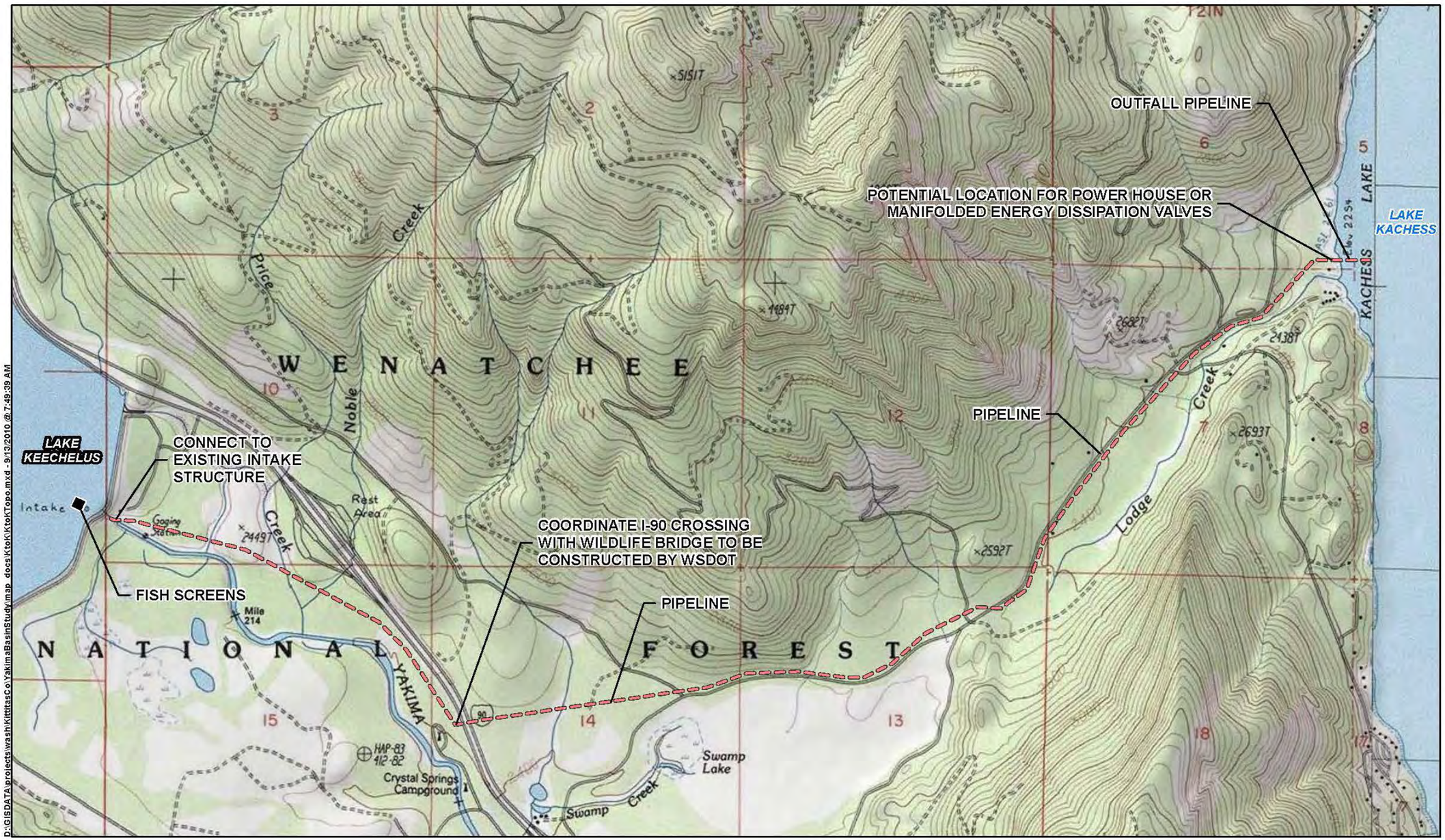
Source: Tabor, R.W., Frizzell, V.A. Jr., Booth D.B., and Waitt, R.B. "Geologic Map of the Snoqualmie Pass 30 X60 Minute Quadrangle, Washington", USGS, 2000.

Published Surface Geology Map

FIGURE 5

Keechelus to Kachess Pipeline, Yakima Basin Study



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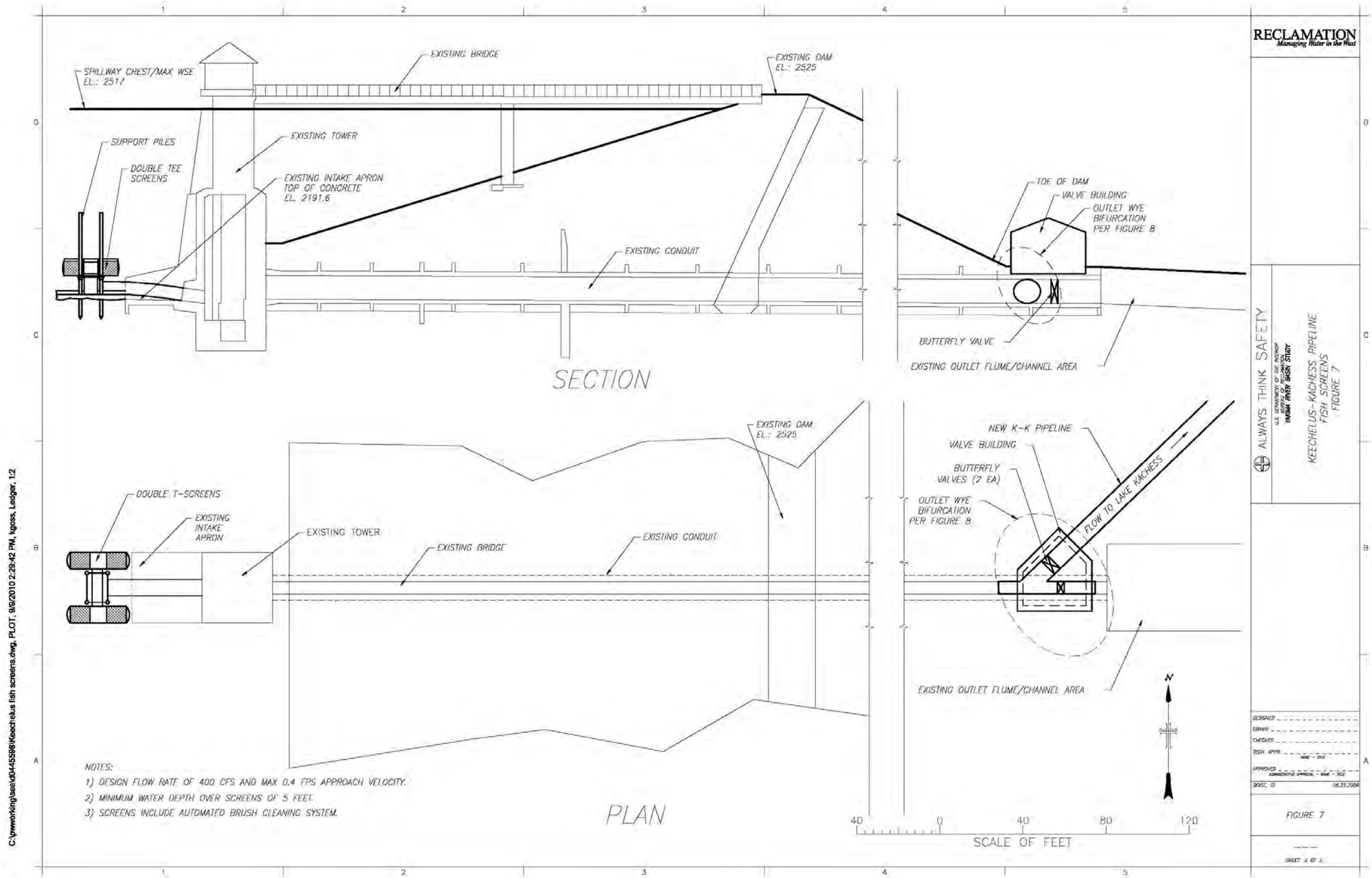
K to K Pipeline Alignment Topography
FIGURE 6

Keechelus to Kachess Pipeline, Yakima Basin Study


SPILLWAY CREST/MAX WSE
EL.: 2517
EXISTING BRIDGE
EXISTING DAM
EL.: 2525
SUPPORT PILES
DOUBLE TEE
SCREENS
EXISTING TOWER
EXISTING INTAKE APRON
TOP OF CONCRETE
EL. 2191.6
EXISTING CONDUIT
SECTION
TOE OF DAM
VALVE BUILDING
OUTLET WYE
BIFURCATION
PER FIGURE B
BUTTERFLY VALVE
EXISTING OUTLET FLUME/CHANNEL AREA
DOUBLE T-SCREENS
EXISTING
INTAKE
APRON
EXISTING TOWER
EXISTING BRIDGE
EXISTING CONDUIT
EXISTING DAM
EL.: 2525
NEW K-K PIPELINE
VALVE BUILDING
BUTTERFLY
VALVES (2 EA)
OUTLET WYE
BIFURCATION
PER FIGURE B
FLOW TO LAKE KACHESS
EXISTING OUTLET FLUME/CHANNEL AREA
N
NOTES:
1) DESIGN FLOW RATE OF 400 CFS AND MAX 0.4 FPS APPROACH VELOCITY.
2) MINIMUM WATER DEPTH OVER SCREENS OF 5 FEET.
3) SCREENS INCLUDE AUTOMATED BRUSH CLEANING SYSTEM.
PLAN
40 0 40 80 120
SCALE OF FEET
RECLAMATION
Managing Water in the West
ALWAYS THINK SAFETY
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA RIVER BASIN STUDY
KEECHELUS-KACHESS PIPELINE
FISH SCREENS
FIGURE 7
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DRAWN
CHECKED
TECH. APPR.
APPROVED
BOISE, ID 06.25.2009
FIGURE 7
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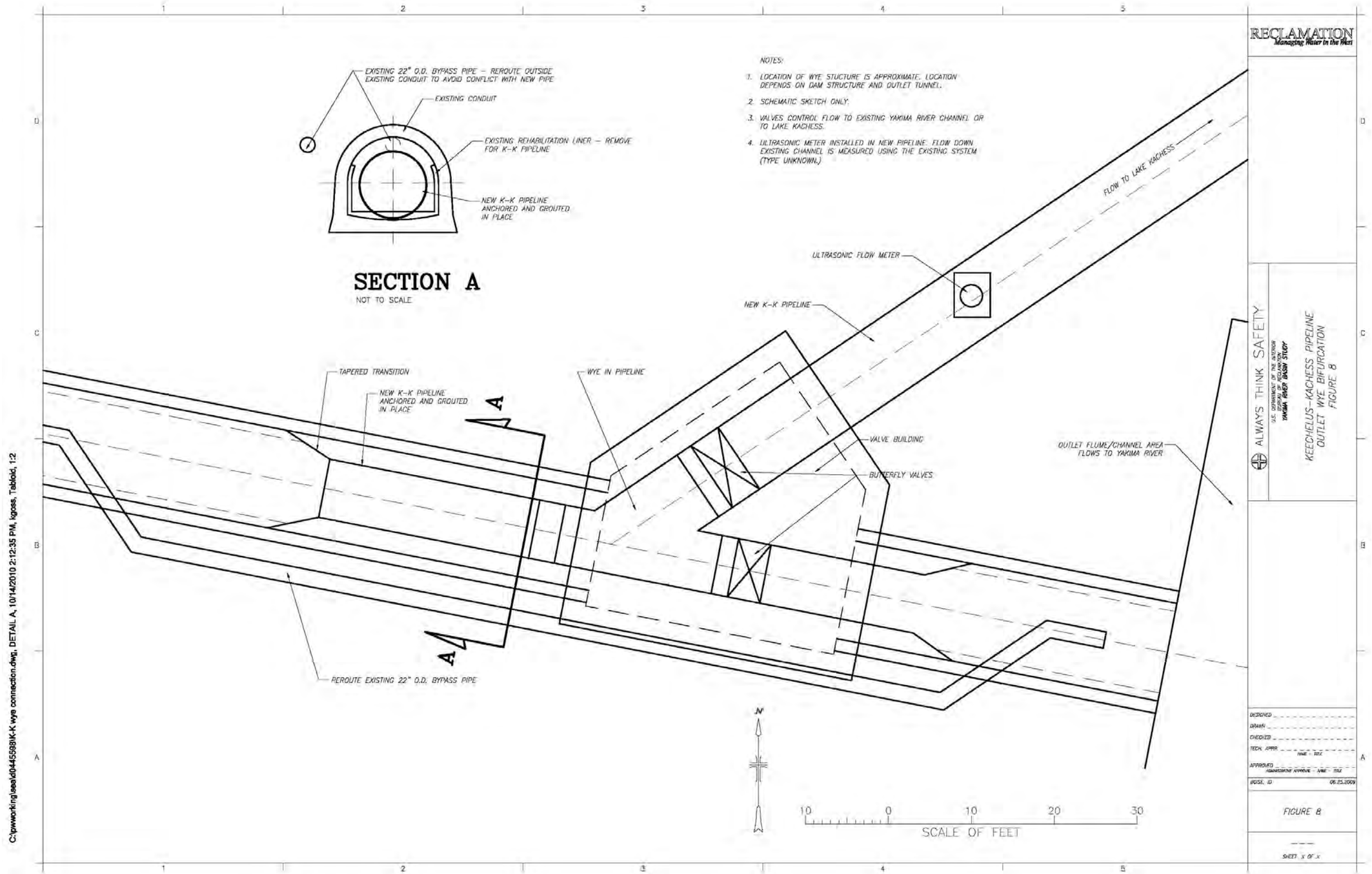
EXISTING 22" O.D. BYPASS PIPE – REROUTE OUTSIDE EXISTING CONDUIT TO AVOID CONFLICT WITH NEW PIPE
EXISTING CONDUIT
EXISTING REHABILITATION LINER – REMOVE FOR K-K PIPELINE
NEW K-K PIPELINE ANCHORED AND GROUTED IN PLACE
SECTION A
NOT TO SCALE
NOTES:
1. LOCATION OF WYE STUCTURE IS APPROXIMATE. LOCATION DEPENDS ON DAM STRUCTURE AND OUTLET TUNNEL.
2. SCHEMATIC SKETCH ONLY.
3. VALVES CONTROL FLOW TO EXISTING YAKIMA RIVER CHANNEL OR TO LAKE KACHESS.
4. ULTRASONIC METER INSTALLED IN NEW PIPELINE. FLOW DOWN EXISTING CHANNEL IS MEASURED USING THE EXISTING SYSTEM (TYPE UNKNOWN.)
FLOW TO LAKE KACHESS
ULTRASONIC FLOW METER
NEW K-K PIPELINE
TAPERED TRANSITION
NEW K-K PIPELINE ANCHORED AND GROUTED IN PLACE
WYE IN PIPELINE
VALVE BUILDING
BUTTERFLY VALVES
OUTLET FLUME/CHANNEL AREA FLOWS TO YAKIMA RIVER
REROUTE EXISTING 22" O.D. BYPASS PIPE
A
A
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10 0 10 20 30
SCALE OF FEET
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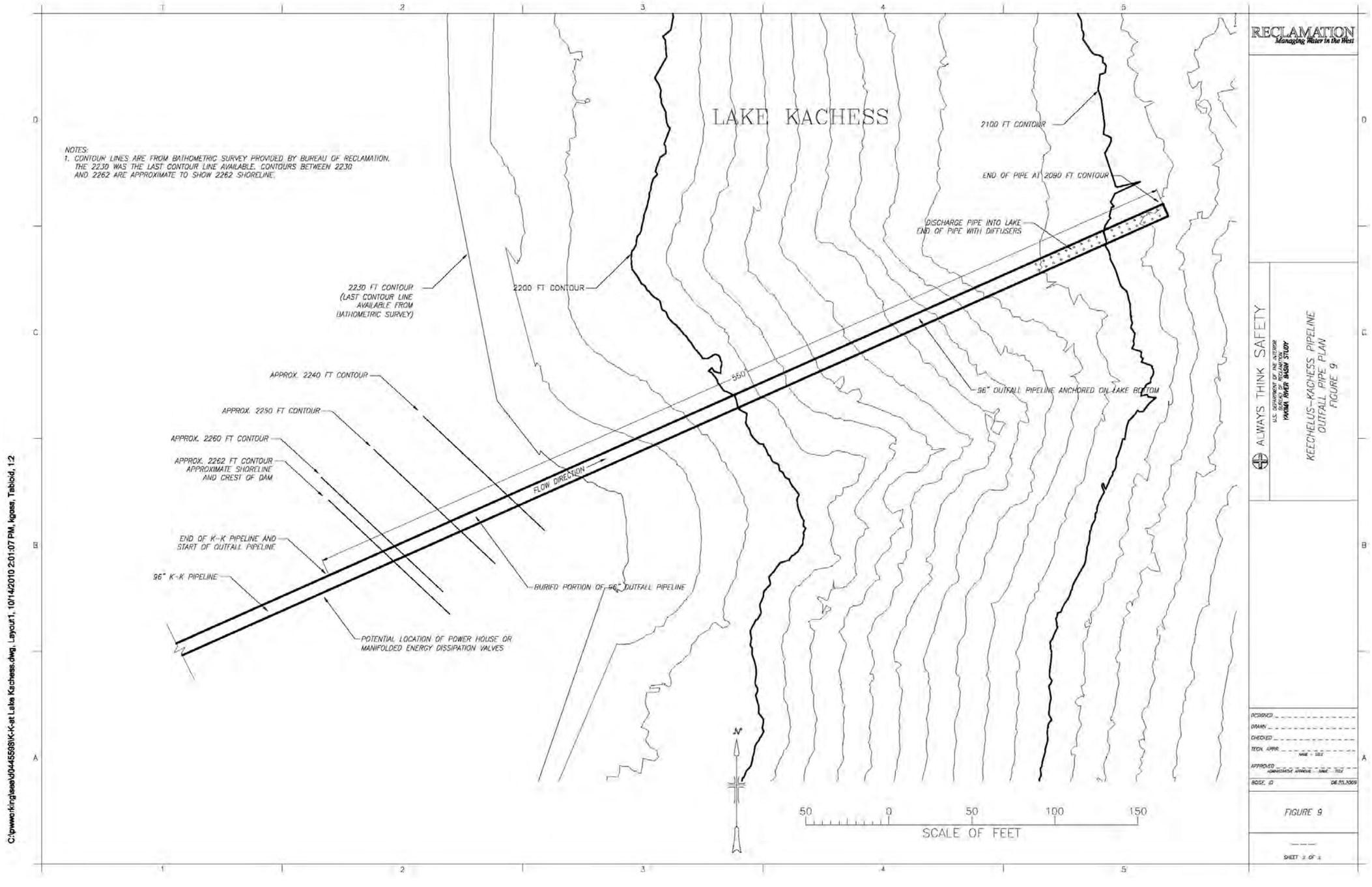
BUREAU OF RECLAMATION
YAKIMA RIVER BASIN STUDY
KEECHELUS-KACHESS PIPELINE
OUTLET WYE BIFURCATION
FIGURE 8
DESIGNED
DRAWN
CHECKED
TECH. APPR.
APPROVED
BOISE, ID
FIGURE 8
SHEET X OF X
C:\pwworking\seal\d0445598IK-K wye connection.dwg, DETAIL A, 10/14/2010 2:12:35 PM, kgoss, Tabloid, 1:2


LAKE KACHESS
NOTES:
1. CONTOUR LINES ARE FROM BATHOMETRIC SURVEY PROVIDED BY BUREAU OF RECLAMATION. THE 2230 WAS THE LAST CONTOUR LINE AVAILABLE. CONTOURS BETWEEN 2230 AND 2262 ARE APPROXIMATE TO SHOW 2262 SHORELINE.
2100 FT CONTOUR
END OF PIPE AT 2090 FT CONTOUR
DISCHARGE PIPE INTO LAKE END OF PIPE WITH DIFFUSERS
2230 FT CONTOUR (LAST CONTOUR LINE AVAILABLE FROM BATHOMETRIC SURVEY)
2200 FT CONTOUR
550'
96" OUTFALL PIPELINE ANCHORED ON LAKE BOTTOM
APPROX. 2240 FT CONTOUR
APPROX. 2250 FT CONTOUR
APPROX. 2260 FT CONTOUR
APPROX. 2262 FT CONTOUR APPROXIMATE SHORELINE AND CREST OF DAM
FLOW DIRECTION
END OF K-K PIPELINE AND START OF OUTFALL PIPELINE
96" K-K PIPELINE
BURIED PORTION OF 96" OUTFALL PIPELINE
POTENTIAL LOCATION OF POWER HOUSE OR MANIFOLDED ENERGY DISSIPATION VALVES
N
50 0 50 100 150
SCALE OF FEET
RECLAMATION
Managing Water in the West
ALWAYS THINK SAFETY
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA RIVER BASIN STUDY
KEECHELUS-KACHESS PIPELINE
OUTFALL PIPE PLAN
FIGURE 9
DESIGNED
DRAWN
CHECKED
TECH. APPR.
APPROVED
BOISE, ID
06.30.2009
FIGURE 9
SHEET 3 OF 4
C:\pwworking\seek\d0445598\K-K-at Lake Kachess.dwg, Layout1, 10/14/2010 2:01:07 PM, kgoss, Tabloid, 1:2