RECLAMATION
*Managing Water in the West*

# Summary of Groundwater Conditions in the Trail Lake Area, Feasibility Design for Main Canal Rehabilitation

## Columbia Basin Project, Washington

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

**September 2014**

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*Managing Water in the West*

# Summary of Groundwater Conditions in the Trail Lake Area, Feasibility Design for Main Canal Rehabilitation

## Columbia Basin Project, Washington

*Prepared by Donnie N. Stelma, Geologist*
*Under general supervision of*
*Richard A. Link, Regional Geologist*

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

**September 2014**

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# Introduction

Trail Lake extends about two miles below the Bacon Tunnel outlets through a natural low in Trail Lake Coulee. The Trail Lake section of the Main Canal consists of approximately 1.5 miles of lined canal along the west side of Trail Lakes Coulee. This portion of the Main Canal was considered for an unlined canal section during original design, but due to potentially large seepage losses and leakage into adjacent coulees and lakes it was decided to construct a concrete-lined canal through the reach.

In the late 1970's, the Trail Lake section of the Main Canal began leaking through concrete panels and embankment materials and filled the lower Trail Lake Coulee. The lake currently fills annually during the irrigation season due to continued leakage from the Main Canal. Since that period, differential hydrostatic head between the lake level and the empty canal prism has caused considerable damage to the concrete canal lining. Initial concepts contemplated abandoning the damaged section of the canal and utilizing the lake for additional storage for project uses. However, hydro-geological concerns about the disposition of the seepage losses from the lake posed a significant reason for not pursuing canal abandonment.

Reclamation is currently developing feasibility designs for infrastructure that will allow the dewatering of Trail Lake and the Main Canal simultaneously to eliminate these impacts. Preliminary design concepts proposed to drain the canal and lake concurrently includes a box culvert structure with operating gates to provide gravity drainage into the canal, and a pump station with intakes in the canal and lake to facilitate unwatering of the portion of the lake that cannot be drained by gravity flow.

## Purpose

Project personnel have discussed the various possibilities of groundwater movement from Trail Lake and the effect that annual unwatering of the lake may have on the local water table. This report was prepared to evaluate existing hydro-geologic information and describe the general direction of groundwater movement from the Trail Lake area.

## Location

Trail Lake is located approximately 6 miles south of Coulee City, Washington where Pinto Ridge Road crosses the Main Canal (refer to Figure 1).

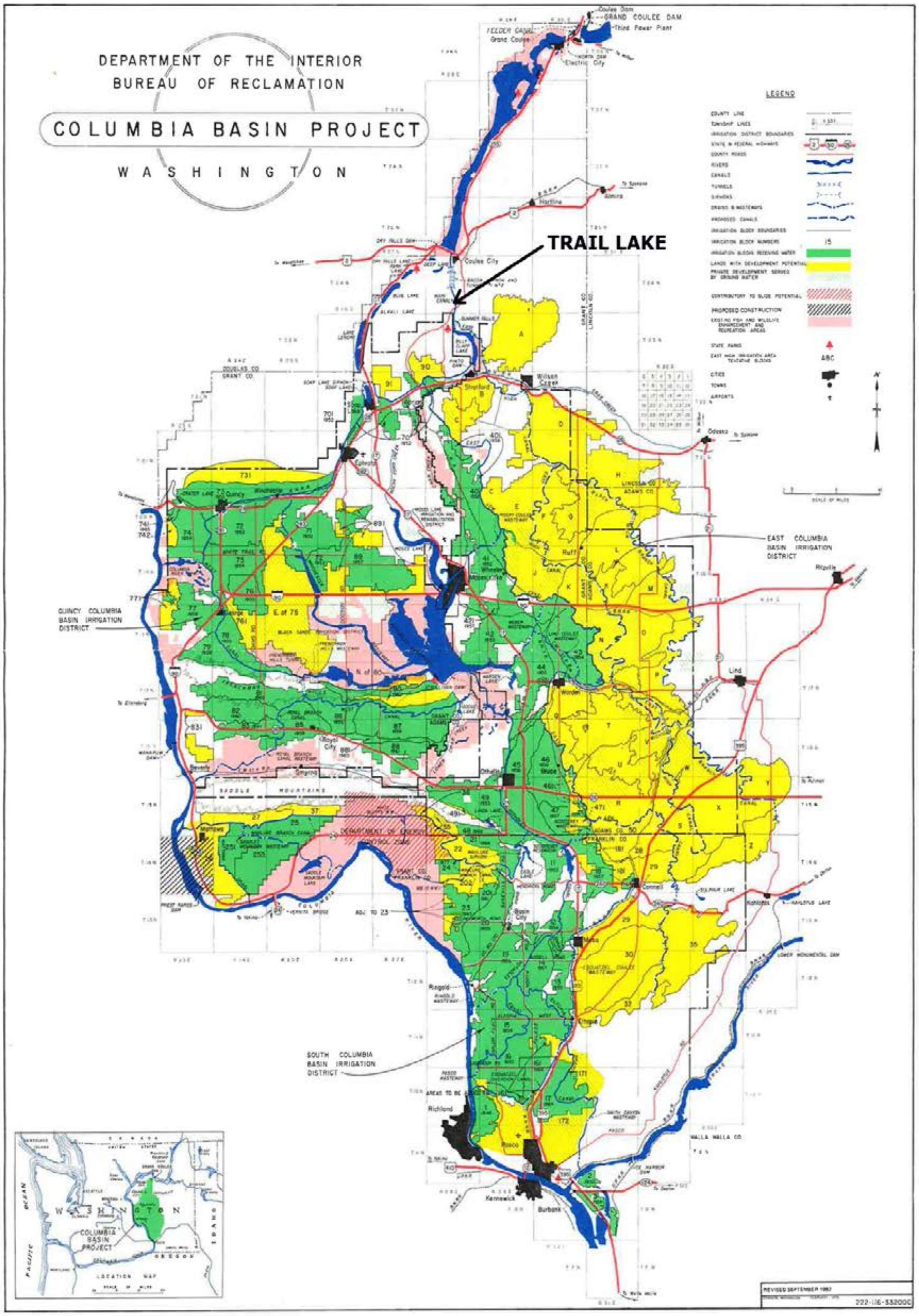

FIGURE 1

**Figure 1. Location Map**

## Previous Investigations

Numerous studies were conducted and memorandum reports were prepared by Reclamation between approximately 1924 and 1950 regarding design and construction of the Main Canal through the Trail Lake Coulee. Initially, the coulee was the proposed site of an "equalizing reservoir", but indications of potential seepage losses through the west arm of the Trail Lake, and adverse effects of groundwater from Trail Lake into lower coulee lakes raised concerns. The following two options were evaluated: (1) line Trail Lake with silt and construct a dike to isolate the west arm where significant seepage losses were known to occur, or (2) construct a lined canal around the area. A memorandum dated July 24, 1950 indicated that construction of the lined canal around Trail Lake Coulee outweighed the potential risk of having to construct the canal after operations had commenced, due to excessive seepage from the equalizing reservoir (Trail Lake).

An office memorandum dated June 9, 1960 documented the inspection of minor damage to the concrete lining along the Trail Lake section of the Main Canal. The memorandum indicated the lining on the "uphill" side of the canal had a "large hole", but conditions were not serious enough to warrant taking the canal out of service. The memo indicated the broken lining section would be monitored and repaired at the end of the irrigation season. Another memorandum dated August 14, 1986 discusses additional failures of the concrete lining, dye testing to determine seepage sources, and repair work. Since that time the leakage from the Main Canal has continued, and Trail Lake has been allowed to fill each season up to within about a foot of the operational level of the canal during irrigation season.

In 2007, project personnel considered abandoning the damaged section of the Main Canal and utilizing the lake for additional storage for project uses. Geologic investigations were performed to evaluate foundation conditions at three potential damsites near the south end of Trail Lake Coulee. The investigations included core drilling, down-hole pressure permeability testing, surface geologic mapping and an evaluation of potential seepage losses from the proposed reservoirs.

The pre- and post-project memorandums and results of the Trail Lake damsite investigations are presented in the reports titled *Trail Lake Storage Reservoir, Pre-Design Geologic Investigations and Seepage Evaluation, Trail Storage Study, Columbia Basin Project, Washington* (Reclamation 2007a) and *Supplemental Geologic Investigations, Lower Trail Lake Dam Alignments 2 and 3, Trail Lake Storage Reservoir, Trail Storage Study, Columbia Basin Project, Washington* (Reclamation 2007b).

## Current Investigations

The site geology, structural geologic features and groundwater trends in the Trail Lake area presented in this report are based primarily on interpretation of information and findings presented in the following reports, documents and communications:

- Basalt Flow Structures of the Coulee City-Long Lake –Soap Lake Area, Volumes I and II, Columbia Basin Project, Coulee City, WA (Reclamation 1950).
- Bauer, H.H. and Hansen, A.J., Hydrology of the Columbia Plateau Aquifer System, Washington, Oregon and Idaho, U.S. Department of Interior, U.S. Geological Survey Water Resources Investigations Report 96-4106, Tacoma, WA (Bauer and Hansen 2000).
- Trail Lake Storage Reservoir, Pre-Design Geologic Investigations and Seepage Evaluation, Trail Storage Study, Columbia Basin Project Washington, U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Ephrata Field Office, Yakima, WA (Reclamation 2007).
- Dry Coulee Well Log Report No. 23/27-14W1, Washington State Department of Ecology, 2003.
- Personal communication with John O’Callaghan, Supervisory Hydraulic Engineer, Irrigation Operations and Technical Services, Ephrata Field Office, 2014.

# Regional Geology

Trail Lake is located in the northwest portion of the Columbia Basin, a structural and depositional basin that forms much of eastern Washington. The basin is the site of large basaltic flood lava flows known as the Columbia River Basalt Province. The basalts were erupted between 6 and 18 million years ago from vents near the present boundary between Washington, Oregon, and Idaho. Flows were up to 100 feet thick and cover hundreds to thousands of square miles. Basaltic eruptions over millions of years resulted in a stack of relatively horizontal flows that are referred to as the Columbia Plateau. The western portion of the Columbia Plateau underwent north-south directed compression resulting in faulting and generally east-west trending folds. This area is referred to as the Yakima Fold Belt subprovince. Trail Lake is near the extreme northeastern margin of the Yakima Fold Belt.

The Quaternary history and current form of the area is characterized by prolonged periods of loess and soil accumulation and discrete episodes of catastrophic flooding. A glacial ice dam impounded water in western Montana, forming Glacial Lake Missoula. The glacial dam failed repeatedly, releasing large amounts of water into the Columbia River drainage. Flood water diverted by the Okanogan Ice Sheet flowed across the Columbia Plateau where it formed the region named the Channeled Scabland. High-velocity flood water eroded the basaltic layers and formed the large deep to flat-bottomed channels in the Grand Coulee and smaller coulees such as Trail Lake Coulee.

## Structural Geology

Deformation of the Columbia River Basalt sequence was most extensive during the Pliocene. The entire Columbia Plateau was regionally tilted from an elevation of about 2,500 feet in the northeast to about 400 feet in the southwest near Pasco, Washington (Baker and Nummedal 1978). Regional north-south compression in the western part of the Columbia Plateau produced intense folding forming a series of east-west trending anticlinal ridges and synclinal valleys termed the Yakima Fold Belt.

The Trail Lake area is structurally simple and the least deformed region in the Yakima Fold Belt. With only minor faults and low amplitude, long-wavelength folds, these structures alter an otherwise gently southwestward-dipping slope. The northeast trending Trail Lake (High Hill) Anticline, Bacon Syncline and Pinto Ridge (Dome) Anticline, and Pinto and Dry Coulee Faults are the primary structural features identified in the area.

Trail Lake is located in the crest of the Trail Lake Anticline (flexure). The axis of the southwest trending Trail Lake Anticline crosses Trail Lake, the south limb dips gently south, the basalt flows flatten out at the axis of the Bacon Syncline and begins to slope gently upward along the north limb of the Pinto Ridge Anticline. The north limb of the Pinto Ridge Anticline is terminated at the base by the Pinto Fault. The Pinto Fault forms a prominent scarp on the side of the upper end of the Long Lake Coulee. The Dry Canyon Fault is a low angle fault that extends from the south limb of the Trail Lake (High Hill) Anticline toward the north flank of Pinto Ridge. For general locations of the structural features in the Trail Lake vicinity refer to Appendix C.

# Site Geology

The Trail Lake area is underlain by thick sequences of volcanic rocks of the Columbia River Basalt Group mantled by late Pliocene- to Holocene-age sediments which include Pleistocene-age Lake Missoula outburst flood gravel deposits.

## Glacial-Fluvial Gravel and Talus Deposits

The Trail Lake Coulee is a moderately deep erosional channel, created by Pleistocene age Missoula outburst flood events. Surface deposits of loess in the vicinity of Trail Lake Coulee were eroded out by the Missoula Floods. The coulee bottom is backfilled with coarse glacial-fluvial gravel deposits and partially lined with talus at depth. The glacial-fluvial gravel deposits related to the Missoula Floods cover most of the surfaces surrounding Trail Lake and nearby deposits were mined for concrete aggregate during construction of the Main Canal. Trail Lake was a small body of water that rested in one of the many normally dry coulees in the area prior to construction of the project. Exploratory hole DH-17 was drilled in 1944 during the design phase of the project, and was located near the “west arm” of Trail Lake where the greatest seepage flows were observed from the natural lake during the 1941 study. The boring penetrated about 278-feet of glacial-fluvial material composed of a heterogeneous mixture of clay- to boulder-size clasts with mostly gravel- to sand- size materials. Basalt talus (broken basalt) material plucked and scoured from the coulee walls by the tremendous erosional energy of the repeated outburst flood events line the downstream slope and floor of the scour basin. Refer to Appendix C for the drill hole location and geologic sections through Trail Lake Coulee and surrounding areas. The geologic log of DH-17 is included in Appendix B.

## Columbia River Basalt

Bedrock underlying the Trail Lake area is composed of volcanic rocks of the Columbia River Basalt Group. Classification of the various units of the Columbia River Basalt Group has evolved over the years, the following section attempts to meld the earlier (Reclamation 1950) stratigraphy with currently accepted nomenclature of the Columbia River Basalt Group. The Columbia River Basalt Group flows identified in the Trail Lake area are based on current mapping and classifications (Gulick and Korosec 1990). The basalt and interflow horizons outlined in (Reclamation 1950), refer to “feldspar basalt flows” as a marker for the correlation of basalt flows in the area. This early report also identifies interflow horizons 1 through 7 in the Trail Lake area, refer to Appendix C. The interflow horizons are the rubbly flow tops between individual basalt flows. Based on modern geochemical analysis, the “feldspar basalt flow” described in the earlier (Reclamation 1950) report is generally analogous with the Frenchman Springs Member of the Wanapum Formation of the Columbia River Basalt Group.

The upper-most bedrock units at the site, exposed near the south end of Trail Lake Coulee and overlying the “feldspar basalt flows”, encompassing interflow horizon 1 and basalt flows above interflow horizon 2 are part of the Priest Rapids and Roza Members of the Wanapum Formation. The Frenchman Springs Basalt Member of the Wanapum Formation forms the “feldspar basalt flows”, extending from interflow horizon 2 downward to interflow horizon 4. Interflow (interbed) horizon 4 appears to the Vantage Member of the Ellensburg Formation, which is a sedimentary unit between the Frenchman Springs Member and the Grande Ronde Basalt Formation. The underlying basalt units encompassing interflow horizons 5, 6, and 7 described in (Reclamation 1950), are part of the Grande Ronde Formation of the Columbia River Basalt Group.

The Priest Rapids Member is the upper most basalt flow in the Wanapum Basalt Formation. The basalt forms several prominent bluffs in the vicinity of Trail Lake and was encountered in drill holes at the south end of the lake (Reclamation 2007). The unit is approximately 25-feet thick at the site and appears to roughly coincide with basalt flows overlying “Horizon 1”, refer to Appendix C. Core samples taken consisted of black to gray, fine-grained, hard, slightly weathered, dense basalt. Fracturing was variable, the upper part of the formation was moderately fractured, and the base of the unit was very intensely to intensely fractured (basal platy parting planes).

The Roza Member is near the middle of the Wanapum Basalt Formation and underlies the Priest Rapids Basalt at the site. The Roza Basalt was also encountered in drill holes at the south end of the coulee and roughly coincides with basalt flows overlying interflow horizon 2, refer to Appendix C. Core samples from the upper part of the formation consisted of black to gray, fine-grained, hard to moderately hard, slightly to moderately weathered, and intensely to slightly fractured vesicular basalt. The lower portion of the formation sampled consisted of black to gray, fine-grained, hard, slightly weathered, very slightly to moderately fractured, dense basalt.

The Frenchman Springs Member is the lowest flow in the Wanapum Basalt Formation. The Frenchman Springs Basalt is dark gray, fine to medium grained, and porphyritic. The unit consists of four flows and is estimated to be about 200 feet thick in the Trail Lake area and coincides with the “Feldspar basalt flows” underlying interflow horizon 2 and overlying interflow horizon 4 (Vantage Member), refer to Appendix C. The unit is exposed at the surface within the Trail Lake basin.

The Vantage Member of the Ellensburg Formation forms the boundary, or interbed, between the Frenchman Springs and underlying Grande Ronde Formation. The unit corresponds with interflow horizon 4, refer to Appendix C. The Vantage is described as gray to greenish, micaceous, semi-consolidated sand or silt containing considerable amounts of fossil wood. Where the sediment interflow is not present, horizon 4 occurs as a zone of considerable weathering in the underlying vesicular basalt (Reclamation 1950). Hydro-geologically, the Vantage is a confining layer imposing a hydraulic separation between the basalt flows due to the consolidated fine-grained nature of the sediments (Bauer and Hansen 2000).

The Grande Ronde is the most aerially extensive unit of the Columbia River Basalt Group. The basalt is black or dark gray, fine-grained to aphanitic basalt. Hackly jointing is common, columns are commonly smaller than in the Frenchman Springs, Roza and Priest Rapids Members, and the unit includes thick interflow zones of pillows and palagonite. The Grande Ronde consists of multiple flows; contacts between individual flows are sometimes rubbly and fractured. The formation appears to roughly coincide with basalt flows underlying interflow horizon 4, and includes interflow horizons 6 and 7, refer to Appendix C. The unit is exposed at the surface in the Trail Lake basin. Where drill holes penetrated interflow horizon 7, water tests indicated a very pervious interflow zone (Reclamation 1950).

# Groundwater

Initial project designs considered either an open-water flow channel or a small reservoir along the Trail Lake section of the main canal. However, the possibility of excessive leakage from Trail Lake prompted Reclamation to take preventive measures, which included construction of a concrete-lined canal along the west edge of the coulee (Reclamation 1950).

Seepage from the Trail Lake area along the Main Canal has been recorded in Reclamation memos and reports since the early 1940’s. An early report described the conditions observed during a high run-off event in January 1941 which raised the water surface in Trail Lake approximately 25 feet. Over the following 11 days the lake dropped, losing an estimated volume of about 300 acre-feet. The total discharge (seepage) rate was estimated at 36 cubic feet per second during this period. As the water surface dropped, the lake divided into three separate lakes or “arms”. A subsequent study of the lake topography, geology and underlying structure led to the conclusions that the “west arm” of the lake appeared to be the area of greatest seepage.

A memo to the Supervising Engineer dated May 1950, suggested measures to decrease leakage from the west arm area by building a canal around that zone or constructing a dike and silt blanket to isolate the area from the proposed Trail Lake reservoir. However, the memo concluded that other measures to deal with the expected seepage would be more cost effective, and eventually a concrete-lined canal was constructed over the west arm of Trail Lake.

In the late 1970’s, the Trail Lake section of the Main Canal began leaking through concrete panels and embankment materials and subsequently filled the Trail Lakes. In 1985, a failure of the concrete lining of the Main Canal in the Trail Lake section initiated additional measurements to estimate seepage rates from Trail Lake. Seepage losses into Trail Lake are judged to be minor, based on measurements of losses from the 1980’s through the present during operational periods of the Main Canal which have been estimated at an annual rate of approximately 5 cubic feet per second, considerably less than preconstruction estimates of 36 cubic feet per second (Reclamation 2007).

Lake measurements in 1991 and 1992 also indicate a seepage rate of about 5 cubic feet per second. A digital logger was installed in late 2002 and continuous recording of the lake level has provided additional information about inflows and outflows. The lake level ends each calendar year at a higher level than the previous year, from elevation 1485.0 feet at the end of 2002 to 1489.5 feet at the end of 2006 (preliminary field data received from John O’Callaghan, 2007). An average seepage rate of about 5 to 6 cubic feet per second is indicated during each winter season, after the canal water has been turned off. The seepage rate does not appear to have changed significantly since the 1980’s; however, the average lake level has increased over time, presumably due to increased seepage into the lake from the Main Canal. An alternate explanation may also be that the seepage rate from the canal may be somewhat higher than the estimated seepage rate into bedrock. This could explain increased average lake levels over time even if the seepage rate from the canal remains steady.

## Groundwater Flow Direction

Pre-project geologic reports were prepared to address potential seepage from Trail Lake and describe hydrogeological conditions that would control the direction of flow. The primary report used to evaluate geologic and groundwater conditions was the “Report on Basalt Flow

Structures of the Coulee City-Long Lake – Soap Lake Area, Volumes I and II, Columbia Basin Project, Coulee City, WA (Reclamation 1950). The authors concluded that seepage from Trail Lake could travel north to Deep Lake, south to Long Lake (Billy Clapp Lake), northwest to Blue Lake or southwest through Dry Coulee.

Presently, no additional inflow at any of these locations has been observed or measured throughout the operation of the project (personal communication from John O'Callaghan, 2014). The Riverware hydrologic model of the Columbia Basin project does not show a gain or loss of significant water due to Trail Lake seepage (Reclamation 2007).

The "west arm" of Trail Lake Coulee is a 278-foot deep erosional channel in-filled with glacial-fluvial sediment and talus, refer to Site Geology section. The lake that forms annually in Trail Lake Coulee rests on these glacial-fluvial and talus deposits. This course-grained backfill can increase the vertical hydraulic connection between basalt units; the median hydraulic conductivity for the coarse-grained sediments (overburden) can be roughly two orders of magnitude higher than that of the underlying basalt units (Bauer and Hansen 2000).

Structurally the Trail Lake area is simple with only minor faults and low amplitude, long-wavelength folds that alter an otherwise gently southwestward-dipping slope. The northeast trending Trail Lake (High Hill) Anticline, Bacon Syncline and Pinto Ridge (Dome) Anticline, and Pinto and Dry Coulee Faults are the primary structural features identified in the area, refer to Appendix C.

These geologic conditions suggest vertical infiltration of groundwater into the deep erosional channel underlying Trail Lake that could provide an avenue for seepage into the lower Grande Ronde Basalt Formation, which includes interflow horizons 6 and 7, refer to Appendix C. The hydraulic conductivity of the rubbly vesicular flow tops (interflow horizons) tend to have the highest permeability, as opposed to the denser middle portions of the basalt flows which are relatively impervious, indicating that potential seepage would be expected to follow interflow zones.

The structural trend of the basalt flows indicates the direction of groundwater flow from Trail Lake would be generally south and southwest. Monitoring of Billy Clapp Reservoir (Long Lake Coulee), located south of Trail Lake, by project personnel has shown no discernable recharge from groundwater (personal communication from John O'Callaghan, 2014). This confirms the idea of a southwesterly groundwater flow along interflow horizons 6 and 7, which would be deeper than the floor of Long Lake Coulee; and therefore, not intersect the reservoir; refer to Appendix C. A southwestern groundwater migration path is also supported by the static water level in domestic irrigation well 23/27-14W1 in Dry Coulee which generally corresponds with inflow horizons 6 and 7, refer to Appendix C. The geologic log of well 23/27-14W1 is included in Appendix A.

It appears reasonable that the groundwater from Trail Lake would tend to follow basalt interflow horizons 6 and 7 in a general south to southwest direction. Since the water does not intersect the ground surface in the immediate vicinity, as no point of discharge has been established in the surrounding coulees in the form of springs or new lakes, it is fair to assume the seepage from Trail Lake probably contributes to recharge of the deeper basalt aquifer further south in the basin.

## Summary and Conclusions

In the late 1970's, the Trail Lake section of the Main Canal began leaking through concrete panels and embankment materials and filled the lower Trail Lake Coulee. The lake currently fills annually during irrigation season due to continued leakage from the Main Canal. Since that period, differential hydrostatic head between the lake level and the empty canal prism has caused considerable damage to the concrete canal lining. Reclamation is currently developing feasibility designs for infrastructure that will allow the dewatering of Trail Lake and the Main Canal simultaneously to eliminate these impacts.

This report was prepared to evaluate existing geologic data in the Trail Lake area. No new explorations have been performed for this study. The existing data was evaluated in order to describe hydrogeological conditions that would control the direction of seepage flow from Trail Lake Coulee.

Pre-project reports question the disposition of the potential seepage from Trail Lake and describe geologic conditions that would control the direction of flow. The reports indicated that seepage could travel north to Deep Lake, south to Long Lake, northwest to Blue Lake or southwest through Dry Coulee. No additional inflow at any of these locations has been indicated or measured throughout the operation of the project. Monitoring of Billy Clapp Reservoir (Long Lake Coulee), located south of Trail Lake, by project personnel has shown no discernable recharge from groundwater.

Trail Lake Coulee is a deep erosional channel in-filled with glacial-fluvial sediment and talus. The lake that forms annually in Trail Lake Coulee rests on these glacial-fluvial and talus deposits. The median hydraulic conductivity for the coarse-grained deposits (overburden) can be roughly two orders of magnitude higher than that of the underlying basalt units. The structural trend of the basalt flows indicates the direction of groundwater flow from Trail Lake would be generally south and southwest.

These geologic conditions suggest vertical infiltration of groundwater into the deep erosional channel underlying Trail Lake could provide an avenue for seepage into the lower Grande Ronde Basalt Formation, where the groundwater would tend more or less laterally through basalt interflow horizons in a general south to southwest direction. Since the water does not intersect the ground surface in the immediate vicinity, as no point of discharge has been established in the surrounding coulees in the form of springs or new lakes, it is fair to assume the seepage from Trail Lake contributes to recharge of the deeper basalt aquifer further south in the basin.

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| Reclamation 2007b | Bureau of Reclamation. 2007. Supplemental Geologic Investigations, Trail Lake Dam Alignments 2 and 3, Trail Lake Storage Reservoir, Trail Storage Study, Columbia Basin Project, Washington. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Ephrata Field Office, Yakima, Washington, October. |

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# Appendix A

## Water Well Report 23/27-14W1 (2003)

# Well 23/27-14W1 Lower Dry Coulee Damsite

## WATER WELL REPORT

ECOLOGY Original & 1st copy Ecology 2nd copy owner 3rd copy driller

Construction/Decommission ( x in circle) Tr 140844
○ Construction
○ Decommission ORIGINAL CONSTRUCTION Notice of Intent Number W 170814

CURRENT Notice of Intent No W 170814
Unique Ecology Well ID Tag No AHK 969
Water Right Permit No
Property Owner Name Jim Bennett
Well Street Address 27116 Dry Coulee Rd
City Soap Lake County Grant
Location SW 1/4 1/4 SE 1/4 Sec. 14 Twn 23 R 27 [✓ EWM] or WWM circle one
Lat/Long (s,t,r still REQUIRED) Lat Deg Lat Min/Sec
Long Deg Long Min/Sec
Tax Parcel No 16 2038 000

**PROPOSED USE** ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other

**TYPE OF WORK** Owners number of well (if more than one)
☒ New Well ☐ Reconditioned Method ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

**DIMENSIONS** Diameter of well 6 inches drilled ft
Depth of completed well 300 ft

**CONSTRUCTION DETAILS**
Casing Installed ☒ Welded 6 Diam from +2 ft to 158 ft
☐ Liner installed Diam from ft to ft
☐ Threaded Diam from ft to ft

Perforations ☐ Yes ☒ No
Type of perforator used
SIZE of perfs in by in and no of perfs from ft to ft

Screens ☐ Yes ☒ No ☐ K Pac Location
Manufacturer s Name
Type Model No
Diam Slot Size from ft to ft
Diam Slot Size from ft to ft

Gravel/Filter packed ☐ Yes ☒ No ☐ Size of gravel/sand
Materials placed from ft to ft

Surface Seal ☒ Yes ☐ No To what depth? 18 ft
Materials used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? Depth of strata
Method of sealing strata off

**PUMP** Manufacturers Name
Type H P

**WATER LEVELS** Land surface elevation above mean sea level ft
Static level 148 ft below top of well Date 9/18/03
Artesian pressure lbs per square inch Date
Artesian water is controlled by
(cap valve etc )

**WELL TESTS** Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes by whom?
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
*Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)*

| Time | Water Level | Time | Water Level | Time | Water Level |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

Date of test
Bailer test gal /min with ft drawdown after hrs
Airtest 45 gal /min with stem set at 197 ft for 2 hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? ☐ Yes ☒ No

**CONSTRUCTION OR DECOMMISSION PROCEDURE**
Formation Describe by color character size of material and structure and the kind and nature of the material in each stratum penetrated with at least one entry for each change of information Indicate all water encountered
(USE ADDITIONAL SHEETS IF NECESSARY )

| MATERIAL | FROM | TO |
|---|---|---|
| Top Soil | 0 | 3 |
| Soil & Cobbles | 3 | 6 |
| gravel Large | 6 | 156 |
| Black Basalt | 156 | 238 |
| Gray Basalt | 238 | 281 |
| Hard Porous Black Basalt | 281 | 285 |
| Brown Porous Basalt & Water | 285 | 297 |
| Black Basalt | 297 | 300 |

RECEIVED
NOV - 6 2003
DEPARTMENT OF ECOLOGY

Start Date 9/17/03 Completed Date 9/18/03

**WELL CONSTRUCTION CERTIFICATION** I constructed and/or accept responsibility for construction of this well and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Mitch Mathews
Driller/Engineer Trainee Signature Mitch Mathews
Driller or Trainee License No 1267

If trainee, licensed driller s Signature and License no

Drilling Company Mathews Drilling
Address 2317 Rd 10.2 NE
City State Zip Moses Lake Wa 98837
Contractor s Registration No MATHEDC117R6 Date 9/18/03

Ecology is an Equal Opportunity Employer ECY 050 1 20 (Rev 4/01)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

# Appendix B

# Drill Log – DH-17 (1944)

Sheet 1 of 4

UNITED STATES-DEPARTMENT OF THE INTERIOR-BUREAU OF RECLAMATION

# GEOLOGIC LOG OF DRILL HOLE

FEATURE Long Lake PROJECT Columbia Basin STATE Washington

HOLE NO 17 LOCATION 1356.5 ' N. 49°26' W of S¼ Cor., Sec. 27, ~~COORDINANTES~~ T24N, R28E., W.M. GROUND ELEVATION 1453.7' ANGLE FROM VERTICAL 0°

BEGUN 2-19-44 FINISHED 4-28-44 DEPTH OF OVERBURDEN 282.0' TOTAL DEPTH 352.1' BEARING OF ANGLE HOLE

DEPTH OR ELEV OF WATER TABLE 1349.3' HOLE LOGGED BY F. O. Jones FOREMAN E. D. Rhoades

| NOTES On water table levels, water return, character of drilling etc. | TYPE AND SIZE OF HOLE | CORE RECOVERY (%) | PERCOLATION TESTS DEPTH (FT.) FROM (P, Cs or Cm) | TO | LOSS IN (G.P.M.) | PRESSURE (P.S.I.) | LENGTH OF TEST (min) | ELEVATION | DEPTH | LOG SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4x4 test pit | No core | | | | | | | |  | 0' - 3' Boulders, large |
| | | | | | | | | | | | 3' - 4' Loam (broken rock) |
| | | | | | | | | 1446.7 | | | 4' - 7' Loam, silty |
| | | | | | | | | | | | 7' - 17' Sand, gravelly (broken rock) |
| | | | | | | | | | | | 17' - 18' Sand and gravel |
| | | | | | | | | | | | 18' - 24' Rocks, large, open |
| | | | | | | | | 1427.7 | | | 24' - 26' Sand and gravel |
| | | | | | | | | | | | 26' - 31' Clay loam, silty |
| | | | | | | | | | | | 31' - 34' Loam |
| | | | | | | | | 1411.7 | | | 34' - 42' Loam, silty |
| | | | | | | | | | | | 42' - 43' Clay and broken rock |
| | | | | | | | | | | | 43' - 45' Gravel, sandy |
| | | | | | | | | | | | 45' - 48' Silt and boulders |
| | | | | | | | | | | | 48' - 53' Sand and broken rock |
| | | | | | | | | 1395.7 | | | 53' - 58' Broken rock and clay |
| | | | | | | | | | | | 58' - 73' Gravel, sandy |
| | | | | | | | | | | | 73' - 83' Gravel, coarse with clay deposits |
| Bottom of Test Pit<br>Water level 95.6' | 6"Cs<br>W 4½" | 0 | | | | | | 1359.7 | | | 83' to 99' Gravel, sandy |
| Lost water at 99' | | | | | | | | | | | 99' to 101' Gravel |

## EXPLANATION

☐ CORE LOSS

■ CORE RECOVERY

Type of hole........ D = Diamond, H = Haystellite, S = Shot, C = Churn

Hole sealed........ P = Packer, Cm = Cemented, Cs = Bottom of casing

Approximate size of hole (X series)........ Ex = 1 1/2", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"

Approximate size of core (X-series)........ Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"

Outside diameter of casing (X-series)........ Ex = 1 13/16", Ax = 2 1/4", Bx = 2 7/8", Nx = 3 1/2"

Inside diameter of casing (X-series)........ Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

ANGLE HOLE ☐

VERTICAL HOLE ☐

X-D-2677
REV. & REDR. 3-15-47

HOLE NO 17

Sheet 2 of 4

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION

# GEOLOGIC LOG OF DRILL HOLE

FEATURE Long Lake PROJECT Columbia Basin STATE Washington

HOLE NO. 17 LOCATION 1356.5' N 49°26' W of S¼ Cor., Sec. 27, ~~COORDINANTES~~ T24N, R28E, W.M. GROUND ELEVATION 1453.7' ANGLE FROM VERTICAL 0°

BEGUN 2-19-44 FINISHED 4-28-44 DEPTH OF OVERBURDEN 282.0' TOTAL DEPTH 352.1' BEARING OF ANGLE HOLE -

DEPTH OR ELEV OF WATER TABLE 1349.3' HOLE LOGGED BY F. O. Jones FOREMAN E. D. Rhoades

NOTES On water table levels, water return, character of drilling etc | TYPE AND SIZE OF HOLE | CORE RECOVERY (%) | PERCOLATION TESTS: DEPTH (FT.) FROM (P, Cs or Cm) TO; LOSS IN (G.P.M.); PRESSURE (P.S.I.); LENGTH OF TEST (min) | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION

**NOTES**

Hole at 101.0', 4 p.m., 2-19-44, no water return.
Hole at 110' at 12 mn, 2-19-44, $4\frac{1}{2}$" casing to 110'.
Water level 102.2', 8 a.m., 2-21-44.
Hole at 113' at 4 p.m., 2-21-44, $4\frac{1}{2}$" Casing to 113'.
Water level 102.6', 4 p.m., 2-21-44.
Hole at 122' at 12 mn, 2-21-44.
Water level 102.3', 8 a.m., 2-22-44.
Hole at 126' at 4 p.m., 2-22-44. No water return. Shot boulders at 122.9' & 126.5'. $4\frac{1}{2}$" Casing to 126'.
Water level 102.4', 4 p.m., 2-22-44.
Hole at 131' at 12 mn, 2-22-44.
Water level 101.9', Hole at 135' at 4 p.m., 2-23-44. $4\frac{1}{2}$" pipe to 135'.
Water level 102.4', 4 p.m., 2-23-44.
Hole at 138' at 12 mn, 2-23-44. Hole shot at 137'.
Hole at 143' at 4 p.m., 2-24-48. Hole shot at 143.4'.
Hole at 145' at 4 p.m., 2-25-44. Hole shot at 145.3'.
Hole at 149' at 4 p.m., 2-26-44, $4\frac{1}{2}$" pipe to 149'.
Water level 102.4', 8 a.m., 2-28-44.
Hole at 151', 4 p.m. 2-28-44. Hole shot at 151.4'.
Hole at 156', 12 mn, 2-28-44. 3" pipe to 153.4'.
Water level 102.5', 8 a.m., 2-29-44.
Hole at 159', 12 mn 2-29-44. Shot hole at 160'.
Hole at 162', 4 p.m. 3-1.44. Shot hole at 162.3'.
Hole at 167' at 12 mn, 3-1-48.

**TYPE AND SIZE OF HOLE**

W $4\frac{1}{2}$"
W 3" then W $4\frac{1}{2}$"

**CORE RECOVERY (%)**

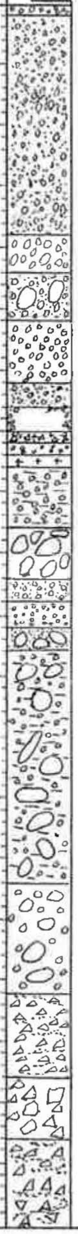
0
0
0
0
0
0
13
0
88
92
0
0
50
43
37
40
32
20
0
0
1
0
0

**ELEVATION**

1334.7
1319.7
1302.7
1272.7

**DEPTH**

110
120
130
140
150
160
170
180
190



| | |
|---|---|
| 99' - 101' | Gravel |
| 101' - 119' | Sand and gravel |
| 119' - 122' | Gravel |
| 122' - 126' | Sand, gravel, and boulders. |
| 126' - 131' | Gravel |
| 131' - 133' | Sand and gravel |
| 133' - 135' | Open hole |
| 135' - 136' | Basalt, broken |
| 136' - 137' | Gravel |
| 137' - 138' | Basalt (boulder) |
| 138' - 143' | Clay and basalt gravel |
| 143' - 147' | Boulders |
| 147' - 149' | Sand and gravel |
| 149' - 151' | Gravel, small, loose |
| 151' - 153' | Sand and boulders |
| 153' - 172' | Boulders, gravel and clay |
| 172' - 181' | Gravel and boulders - loose material |
| 181' - 188' | Basalt, broken, loose, with sand seams |
| 188' - 193' | Broken rock, very loose |
| 193' - 200' | Basalt, broken, loose, with sand seams |

☐ CORE LOSS
■ CORE RECOVERY

EXPLANATION

Type of hole D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (X series) Ex = $1\frac{1}{2}$", Ax = $1\frac{7}{8}$", Bx = $2\frac{3}{8}$", Nx = 3"
Approximate size of core (X-series) Ex = $\frac{7}{8}$", Ax = $1\frac{1}{8}$", Bx = $1\frac{5}{8}$", Nx = $2\frac{1}{8}$"
Outside diameter of casing (X-series) Ex = $1\frac{13}{16}$", Ax = $2\frac{1}{4}$", Bx = $2\frac{7}{8}$", Nx = $3\frac{1}{2}$"
Inside diameter of casing (X-series) Ex = $1\frac{1}{2}$", Ax = $1\frac{29}{32}$", Bx = $2\frac{3}{8}$", Nx = 3"

ANGLE HOLE ☐
VERTICAL HOLE ☐

$L_3$ 5782-27-a Rev. & ReDr. 5-6-49 (G.E.N.)

Sheet 3 of 4

UNITED STATES-DEPARTMENT OF THE INTERIOR-BUREAU OF RECLAMATION

# GEOLOGIC LOG OF DRILL HOLE

FEATURE Long Lake PROJECT Columbia Basin STATE Washington

HOLE NO. 17 LOCATION 1356.5' N 49°26' W of S¼ Cor., Sec. 27, ~~COORDINANTES~~ T24N, R28E, W.M. GROUND ELEVATION 1453.7' ANGLE FROM VERTICAL 0°

BEGUN 2-19-44 FINISHED 4-28-44 DEPTH OF OVERBURDEN 282.0' TOTAL DEPTH 352.1' BEARING OF ANGLE HOLE —

DEPTH OR ELEV OF WATER TABLE 1349.3' HOLE LOGGED BY F. O. Jones FOREMAN E. D. Rhoades

**NOTES** On water table levels, water return, character of drilling etc

Hole at 172' at 4 p.m., 3-2-44.
Hole shot at 174.5' and at 177.5'.
Hole at 177.5' at 12 mn, 3-2-44.
Water level 102.3' at 4 p.m., 3-3-44.
Hole at 181' at 12 mn, 3-3-44.
Water level 102.3' at 8 a.m., 3-6-44.
Hole at 188' at 4 p.m., 3-6-44.
Hole at 193' at 12 mn, 3-6-44.
Hole shot at 195.8'.
Hole at 205' at 4 p.m., 3-7-44.
Hole shot at 208.3' and 209.6'.
Hole at 210' at 12 mn, 3-7-44. No water return to here. 3" pipe to 210'.
Hole shot at 210.4' and 211.0'.
Hole at 211' at 4 p.m., 3-8-44. 90% water return. 3" pipe to 211.5'.
Hole at 213.3', 90% water return.
Water level 99.4', 4 p.m., 3-9-44. 2" pipe to 213.3'. Lost water gradually from 213.3'-216.4'.
Hole at 218' at 12 mn, 3-9-44. No water return.
Water level 102.4', 8 a.m., 3-10-44.
Hole at 222' at 4 p.m., 3-10-44.
Hole at 227.6' at 12 mn, 3-10-44.
Hole cemented but no cement found.
Hole shot from 213.4' to 223.4'.
3" casing driven to 218', 4 p.m., 3-14-44.
Hole shot 217.7' - 222.7'. 3" pipe driven to 225' at 12 mn, 3-14-44.
Hole shot 223.8' to 227.8'. No water return.

**TYPE AND SIZE OF HOLE**

4½"Cs
W 3"
3"Cs
DBX
2"Cs
DAX then W 3"
AX open hole ↓
W 3"
3"Cs
2"Cs
DAX open hole

**CORE RECOVERY (%)**

0
0
0
63
60
48
43
0
0
47
18
0
0
0
0
0
0
0
0
69
96
89
100

**PERCOLATION TESTS**

| DEPTH (FT.) FROM (P, Cs or Cm) | DEPTH (FT.) TO | LOSS IN (G.P.M.) | PRESSURE (P.S.I.) | LENGTH OF TEST (min) |
|---|---|---|---|---|
| P-282 | P-292 | 5.2 | 98 | 30 |
| P-292 | | 0.35 | 97 | 30 |

**ELEVATION**

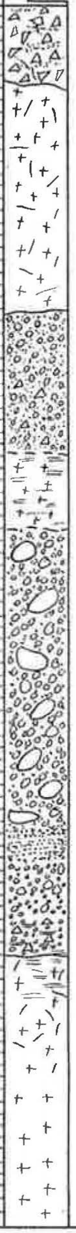
1260.7
1228.0
1210.7
1175.7
1171.7
1161.7

**DEPTH**

210
220
230
240
250
260
270
280
290

**LOG**

SAMPLES FOR TESTING



**CLASSIFICATION AND PHYSICAL CONDITION**

200' - 207' Basalt, broken, loose, with sand seams
207' - 210' Basalt, broken
210' - 211' Basalt, soft
211' - 215' Basalt, badly broken
215' - 224.8' Basalt, broken, hard, vesicular
224.8' - 225.7' Basalt, broken, soft, vesicular
225.7' - 230' Sand and gravel
230' - 236.7' Sand, gravel and broken basalt
236.7' - 243' Basalt, broken, contains mud seams
243' - 268' Gravel and boulders, with some sand

(See note on Sheet 4 for general description of conditions from 207' to 279'.)

268' to 270.5' Sand, hard-packed, or soft rock
270.5' - 275' Gravel
275' - 278' Gravel and broken rock with clay seams
278' - 282' Basalt, broken, dense, with mud seams
282' - 286' Basalt, broken, hard, dense.
286' - 321' Basalt, more or less broken, hard, dense

L3 5782-28 Rev. & ReDr. 5-6-49 (G.E.N.)

☐ CORE LOSS

■ CORE RECOVERY

## EXPLANATION

Type of hole D = Diamond, H = Hayslellite, S = Shot, C = Churn
Hole sealed P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (X series) Ex = 1 1/2", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (X-series) Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (X-series) Ex = 1 13/16", Ax = 2 1/4", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (X-series) Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

ANGLE HOLE ☐

VERTICAL HOLE ☐

X-D-2677
REV & REDR 3-15-47

HOLE NO 17

Sheet 4 of 4

UNITED STATES-DEPARTMENT OF THE INTERIOR-BUREAU OF RECLAMATION

# GEOLOGIC LOG OF DRILL HOLE

FEATURE Long Lake PROJECT Columbia Basin STATE Washington
HOLE NO. 17 LOCATION 1356.5' N 49°26' W of S¼ Cor., Sec. 27, ~~COORDINATES~~ T24N, R28E, W.M. GROUND ELEVATION 1453.7' ANGLE FROM VERTICAL 0°
BEGUN 2-19-44 FINISHED 4-28-44 DEPTH OF OVERBURDEN 282.0' TOTAL DEPTH 352.1' BEARING OF ANGLE HOLE —
DEPTH OR ELEV OF WATER TABLE 1349.3' HOLE LOGGED BY F. O. Jones FOREMAN E. D. Rhoades

**NOTES** On water table levels, water return, character of drilling etc

Hole at 230' at 4 p.m., 3-15-44. 3" casing to 230'.
Hole at 236.6' at 12 mn, 3-15-44. Hole shot at 236.4'. 3" pipe to 241'.
Hole at 242' at 4 p.m., 3-16-44. Hole shot at 241.6'. 3" pipe driven to 243' - broke at 133.5'.
Hole at 243' at 12 mn, 3-16-46. 4½" pipe driven to 201.6' by 2 p.m., 4-17-44.
Hole shot at 225.9', 238.4, and 240. 3" pipe reached 243' at 12 mn, 4-18-44.
Hole shot at 243'.
Hole at 247', 4 p.m., 4-19-44. 3" pipe to 247', no water return. Water level stays at 102.4'.
Hole shot at 247'. 3" pipe to 258' at 12 mn, 4-19-44.
Hole shot at 258'. 3" pipe to 264' at 4 p.m., 4-20-44.
Hole shot at 264.5'. 3" pipe to 270' at 12 mn, 4-20-44.
Hole shot 267' to 270.6'. 3" pipe to 275' at 4 p.m., 4-21-44.
Hole shot at 275.7'. 3" casing set at 278.8'.
Hole at 279.5' at 12 mn, 4-21-44. 75% water return.
Water level 102.6' at 8 a.m., 4-22-44.
Hole at 280.3' at 4 p.m., 4-22-44. 100% water return. 2" casing set to 280.3'.
Hole at 282' at 12 mn, 4-22-44. 100% water return. Water level 102.8', 8 a.m., 4-24-44.
Hole at 291' at 4 p.m., 4-24-44.

NOTES (cont)

Hole at 297' at 12 mn., 4-24-44. 100% water return.
Hole at 305' at 4 p.m., 4-25-44.
Hole at 315' at 12 mn, 4-25-44.
Hole at 323' at 8 a.m., 4-26-44. 90% water return.
Water level 103.5' at 8 a.m., 4-26-44.
Hole at 331' at 4 p.m., 4-26-44. 100% water return.
Hole at 339' at 12 mn, 4-26-44. 100% water return.
Water level 98.7', 12 mn, 4-26-44.
Lost water at 344'.
Hole at 345' at 8 a.m., 4-27-44. No water return.

NOTES (cont)

Water level 99.6' at 8 a.m., 4-27-44.
Hole at 346' at 10 a.m., 4-27-44.
STABILIZATION TEST: Upper seal at 324'. Bottom of hole at 346'. 2 hr. test. Water level 104.4'. Elevation 1349.3'.
Hole at 347' at 8 a.m., 4-28-44. No water return.
Water level at 103.3'.
Hole completed to 352' at 4 p.m., 4-28-44. No water return.

TYPE AND SIZE OF HOLE: DAX-open hole

| CORE RECOVERY (%) |
|---|
| 100 |
| 98 |
| 66 |
| 89 |
| 71 |
| 73 |
| 33 |
| 100 |
| 46 |

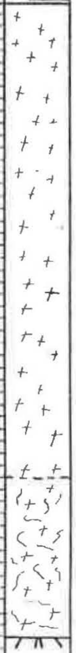
PERCOLATION TESTS

| DEPTH (FT.) FROM (P, Cs or Cm) | DEPTH (FT.) TO | LOSS IN (G.P.M.) | PRESSURE (P.S.I.) | LENGTH OF TEST (min) | ELEVATION |
|---|---|---|---|---|---|
| P-302 | P-312 | 0.0 | 50 | 30 | 1151.7 |
| | | 0.0 | 100 | 30 | 1141.7 |
| P-311 | P-321 | 1.2 | 50 | 30 | |
| | | 1.5 | 100 | 30 | 1131.7 |
| P-321 | Bottom of hole | 24.7 (all available) | 11 | 30 | 1125.3<br>1114.7 |
| P-343 | Bottom of hole | 27.3 (all available) | 25 | 30 | 1109.7<br>1101.7 |

DEPTH 310 320 330 340 350 360 370 380 390

LOG

SAMPLES FOR TESTING



CLASSIFICATION AND PHYSICAL CONDITION

286' - 321' Basalt, more or less broken, hard, dense

321' - 328.4' Basalt, more or less, broken, hard, slightly vesicular with large vesicles.

328.4' - 339' Basalt, hard, broken, vesicular

Vesicular zone possibly marks flow contact

339' - 351' Basalt, soft, very broken, vesicular, with small clay seams.

Lost water at 344'

351' - 352' Basalt, medium hard, broken, vesicular - Bottom of hole #17

Note: (from old log)

The material from 207' to 279' was reported as broken rock and slide rock. This material may be overburden within the Trail Lake Plunge Pool or it may be shattered bedrock unidentified as such by the drillers. The position in the test hole near the Trail Lake flexure suggests such a possibility. All of the fragmental cores and samples recovered between 210' and 282' looks like the same type of basalt. This questionable situation developed in drilling near the Coulee Monocline for South Damsite investigations.

L3 5782-28-4 Rev. & ReDr 5-6-49 (GEN)

EXPLANATION

☐ CORE LOSS
■ CORE RECOVERY

| | |
|---|---|
| Type of hole | D=Diamond, H=Haystellite, S=Shot, C=Churn |
| Hole sealed | P=Packer, Cm=Cemented, Cs=Bottom of casing |
| Approximate size of hole (X series) | Ex = 1 ½", Ax = 1 ⅞", Bx = 2 ⅜", Nx = 3" |
| Approximate size of core (X-series) | Ex = ⅞", Ax = 1 ⅛", Bx = 1 ⅝", Nx = 2 ⅛" |
| Outside diameter of casing (X-series) | Ex = 1 13/16", Ax = 2 ¼", Bx = 2 ⅞", Nx = 3 ½" |
| Inside diameter of casing (X-series) | Ex = 1 ½", Ax = 1 29/32", Bx = 2 ⅜", Nx = 3" |

ANGLE HOLE ☐
VERTICAL HOLE ☐

# Appendix C

# Drawings

Geologic Plan Map – Figure 1
Geologic Sections D-D’ and J-J’ – Figure 2
Geologic Sections F-F’ – Figure 3

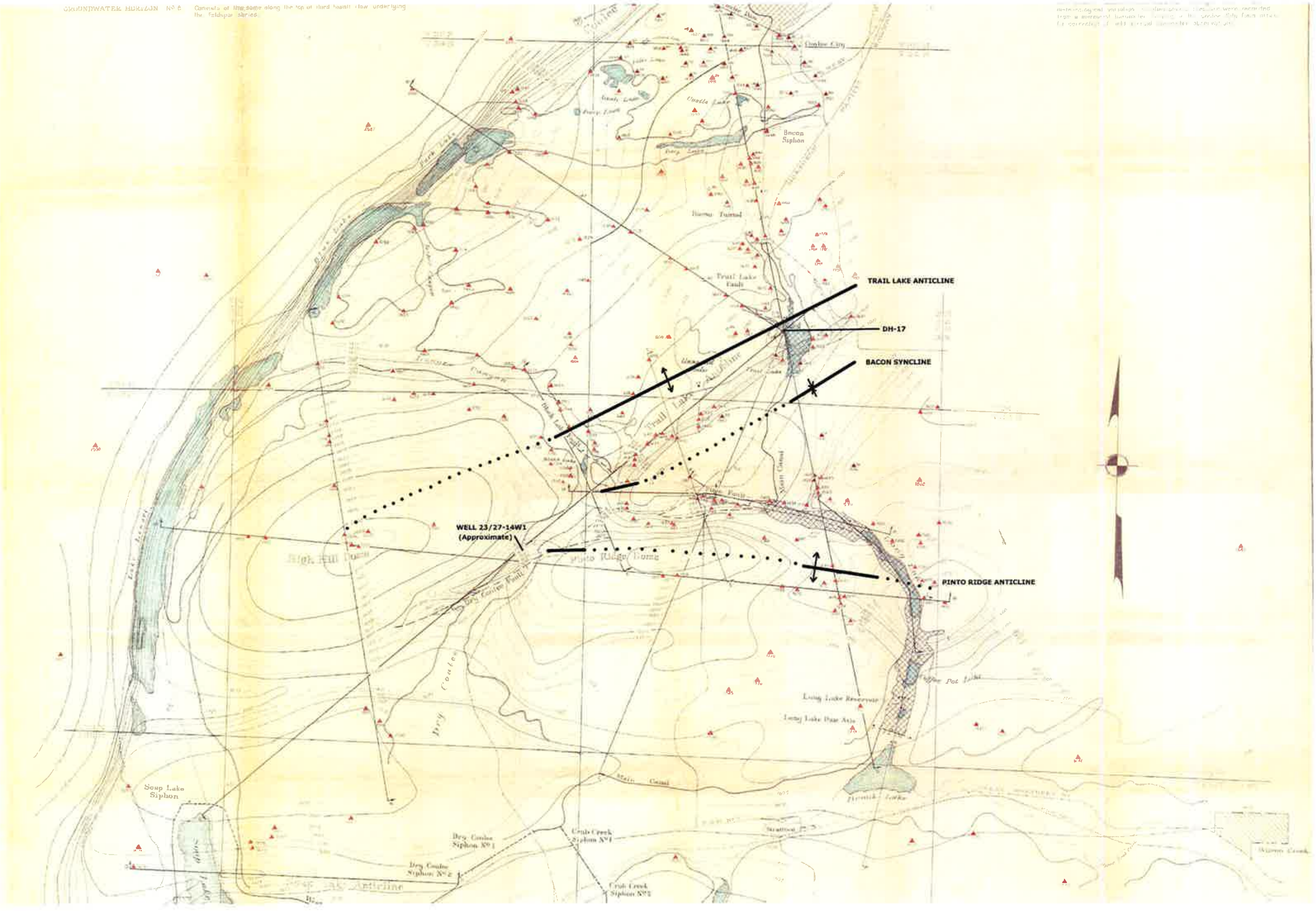
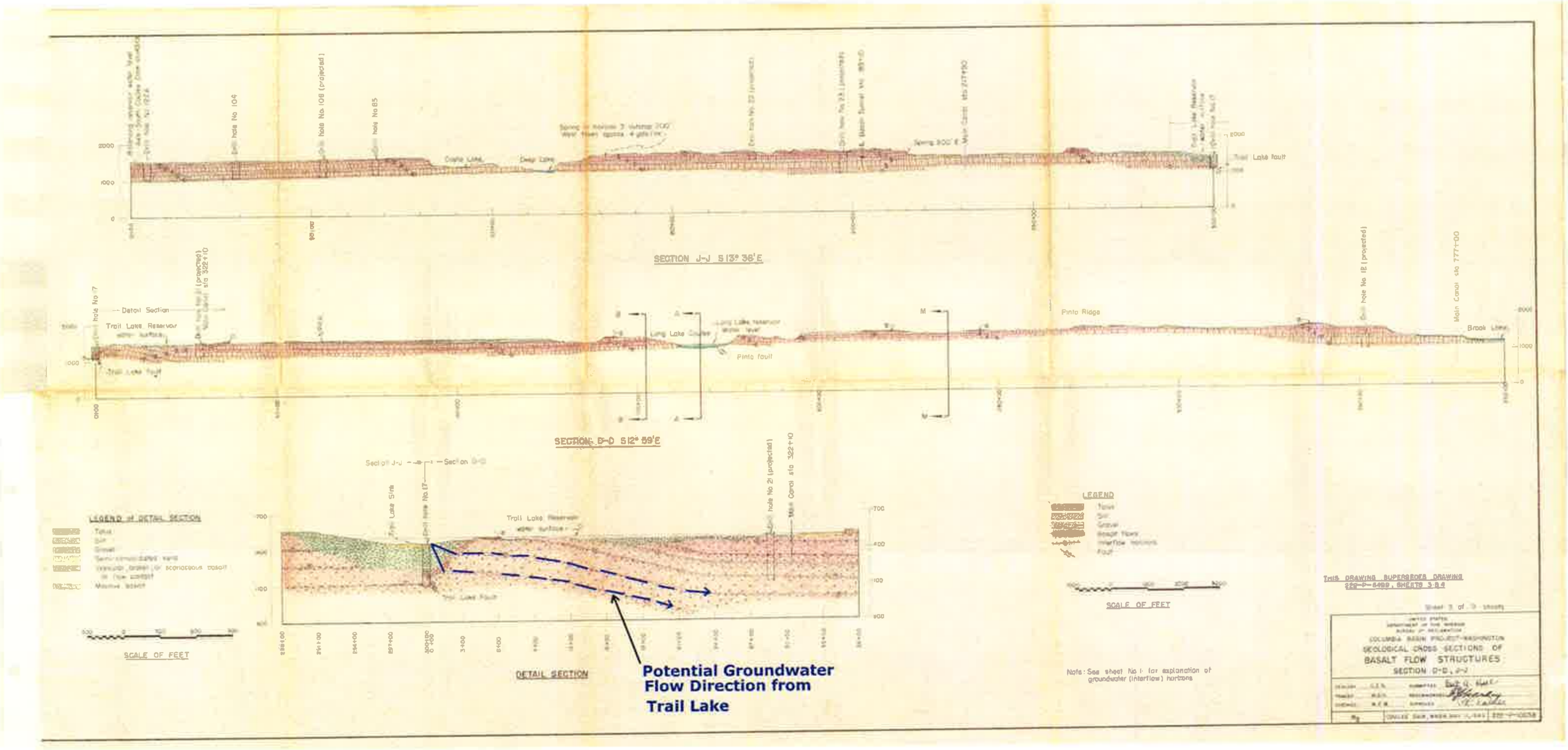

GROUNDWATER HORIZON No 6 Consists of the same along the top of third basalt flow underlying the Feldspar series.
TRAIL LAKE ANTICLINE
DH-17
BACON SYNCLINE
WELL 23/27-14W1
(Approximate)
PINTO RIDGE ANTICLINE
Coulee City
Bacon Siphon
Bacon Tunnel
Trail Lake Fault
Trail Lake Anticline
High Hill Dome
Pinto Ridge Dome
Dry Coulee Fault
Dry Coulee
Park Lake
Blue Lake
Lake Lenore
Long Lake Reservoir
Long Lake Dam Axis
Coffee Pot Lake
Main Canal
Billy Clapp Lake
Soap Lake Siphon
Dry Coulee Siphon No 1
Dry Coulee Siphon No 2
Crab Creek Siphon No 1
Crab Creek Siphon No 2
Soap Lake Anticline
Stratford
Wilson Creek

Figure 1



Note: See sheet No 1 for explanation of groundwater (interflow) horizons

THIS DRAWING SUPERSEDES DRAWING 222-D-6499, SHEETS 3 & 4

Sheet 3 of 3 sheets

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT-WASHINGTON
GEOLOGICAL CROSS SECTIONS OF
BASALT FLOW STRUCTURES
SECTION D-D, J-J

**Potential Groundwater Flow Direction from Trail Lake**

Figure 2

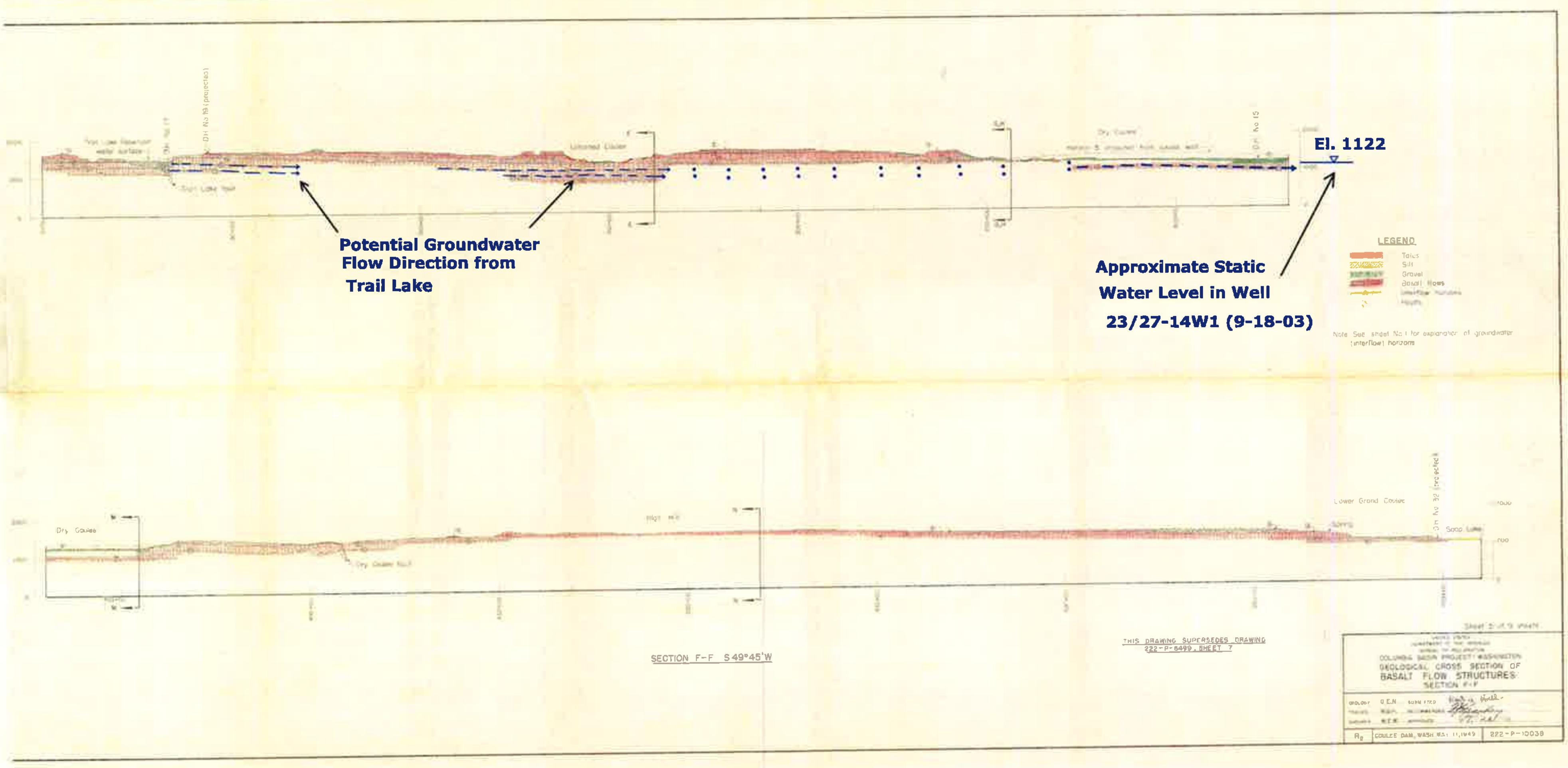

El. 1122
Potential Groundwater Flow Direction from Trail Lake
Approximate Static Water Level in Well 23/27-14W1 (9-18-03)
Trail Lake Reservoir water surface
D.H. No. 17
D.H. No. 18 (projected)
Trail Lake fault
Unnamed Coulee
Dry Coulee
D.H. No. 15
LEGEND
Talus
Silt
Gravel
Basalt flows
Interflow horizons
Faults
Note: See sheet No. 1 for explanation of groundwater (interflow) horizons
Dry Coulee
Dry Coulee fault
High Hill
Lower Grand Coulee
D.H. No. 32 (projected)
Soap Lake
SECTION F-F S 49°45'W
THIS DRAWING SUPERSEDES DRAWING 222-P-6499, SHEET 7
GEOLOGICAL CROSS SECTION OF BASALT FLOW STRUCTURES SECTION F-F
COLUMBIA BASIN PROJECT - WASHINGTON
COULEE DAM, WASH. MAY 11, 1949
222-P-10038

Figure 3