see pocket 2 for Enclosure

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MAR 9 1987

WM Record File 101

WM Project 10
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PDR ✓
LPDR ✓ (B)

Distribution:

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Enclosure 11 + 12 in BWIP Lib

MEMORANDUM FOR: Philip S. Justus, Acting Chief
Geotechnical Branch, WM

FROM: Tilak Verma, Senior Hydrogeologist
Geotechnical Branch, WM

Neil M. Coleman, Hydrogeologist
Geotechnical Branch, WM

Michael F. Weber, Hydrogeologist
Geotechnical Branch, WM

SUBJECT: TRIP REPORT - BWIP HYDROLOGY REVIEW TEAM TRIP TO WASHINGTON STATE AND IDAHO (DEC 1-8, 1986)

On November 30, members of NRC's BWIP hydrology review team traveled to Washington State and Idaho for a series of meetings and field trips. These are briefly summarized below:

Dec. 1	Presentation by In Situ, Inc. in Spokane, Washington
Dec. 1	Two concurrent field trips: Bunker Hill Mine, Kellogg, Idaho, and Creston Site, Creston, Washington
Dec. 2-5	BWIP hydrology data review in Richland, Washington
Dec. 6	Annual Convention of the Northwest Mining Association
Dec. 8	Visit to USGS offices in Takoma, Washington

BWIP Hydrology Data Review

The primary purpose of the trip was to visit Richland, Washington during the period from December 2-5 and perform a review of BWIP hydrologic data collected since the last such review was held in January 1984. The enclosed summary notes, dated December 5, 1986 comprise the complete record of the data review (see enclosure 1). Suggestions for improving future data reviews were transmitted to DOE in a separate communication.

Presentation by In Situ Inc.

On December 1st, prior to the data review, NRC staff and consultants attended a presentation delivered by In Situ, Inc. held at the Gateway Motel in Spokane, Washington. This meeting provided an overview of the hydrogeologic research being conducted by In Situ Inc. under the RES contract FIN D1163.

The overall objective of the RES contract is to improve NRC's ability to characterize and assess flow and contaminant transport in saturated fractured rock. During the contract overview in Spokane, staff from In Situ Inc. summarized past contract activities related to the characterization of a site located west of Spokane, Washington, near the town of Creston. The overview was held from 8:00 to 9:30 a.m. In addition to In Situ Inc. and NRC technical

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staff, the review was attended by representatives of NRC's technical assistance contractors, DOE/RL, Rockwell-Hanford Operations, Washington State, and the Yakima Indian Nation. Enclosure 2 provides a list of participants who attended the meeting.

Following the presentation, the group of NRC staff, contractors, and guests split into two groups to visit either the Bunker Hill mine near Kellogg, Idaho located east of Spokane or the Creston site west of Spokane. After these visits, both groups traveled to Richland, Washington to prepare for the BWIP hydrology data review, which began the next morning on December 2 and continued through December 5.

Bunker Hill Mine Visit

On December 1, following the overview by In Situ Inc., NRC staff members and contractors visited the Bunker Hill Mine complex. Attendees included Tilak Verma, Neil Coleman, and Harold Lefevre, along with NRC contractors Roy Williams, Adrian Brown, Dale Ralston, and Paul Davis. This visit provided the attendees with a unique look at mine hydrology in a country rock characterized by fracture-controlled groundwater flow. This kind of flow regime is believed to be especially significant at the BWIP site.

The visit to the mine began with the presentation of a 3-D physical model of the mine complex, followed by a safety lecture and a walking tour of several miles of drifts in the upper workings of the mine. Most of the drifts were located above the water table in a vadose zone artificially created by a long-term and continuous dewatering program.

The geology of the mine site was characterized by a terrane of structurally deformed and metamorphosed sedimentary rocks. We observed numerous locations where the mine drifts were intersected by high-angle fault zones. The discontinuous and heterogeneous nature of the unsaturated flow regime was demonstrated by the observation that some fault zones actively conducted groundwater while other fault zones were completely dry. We also observed varying amounts of fault "gouge" (clay-like material) within the fault zones.

Of special interest during the tour was an opportunity to observe underground monitoring stations prepared by the University of Idaho. These stations were used to monitor formation pressures, fault-controlled groundwater flow rates, and groundwater chemistry. Near one of these stations, Dr. Williams pointed out an intriguing geochemical phenomenon. The surfaces of the walls of the drifts in the older workings of the mine were veneered with a thin coating of mineralization. It is believed that the mineral deposits may have been produced by diffusion of groundwater through the rock matrix, followed by evaporation of fluids from the surfaces of the drift walls and precipitation of dissolved solids. This phenomenon was not observed in the newer drifts, but is expected to evolve over decades of continued matrix diffusion. The entire group of attendees found this possible evidence of active matrix diffusion to be quite

intriguing. Additional information about ongoing research activities being conducted at the Bunker Hill Mine complex is attached as enclosure 3.

Creston Site Visit

Following the In Situ Inc. presentation on Dec. 1, Michael Weber, along with NRC contractors Gerry Winter, Fred Marinelli, and Michael Galloway, visited the Creston site west of Spokane. Other participants included In Situ, Inc. staff members, DOE staff (K. Michael Thompson), and RHO staff (Randolph Stone). Mr. Weber appreciated the opportunity to discuss and visit the Creston site with In Situ Inc. and Don Chery (NRC-RES). Overall, research planned by In Situ Inc. could contribute significantly to NRC's HLW program if the field characterization and theoretical research is well-planned and conducted. Mr. Weber is concerned, however, that In Situ Inc. is not fully cognizant of the lessons learned in DOE's testing at the Hanford site and may not be developing testing plans based on defensible analysis of available site information. His detailed observations of the Creston site visit are provided in enclosure 4.

Visit to Annual Convention of the NW Mining Association in Spokane, Washington

On Saturday, December 6th, Tilak Verma and Neil Coleman visited Spokane, Washington and attended the final day of the 92nd Annual Convention of the NW Mining Association. In view of DOE's current proposals for the construction of an exploratory shaft at BWIP, this convention afforded an opportunity to examine a variety of commercially available underground mining equipment. A copy of the activities program for the convention is attached as enclosure 5.

Convention activities on this date included the final day of the Pacific Intermountain Mining Show and the afternoon session of professional presentations entitled "Recent Precious Metal Discoveries." Topics presented at this session included documented recent discoveries of precious metals in the states of Washington, Nevada, Montana and Idaho. During the session we were able to obtain a published reprint of one of the presentations (see enclosure 6). Also enclosed are copies of two commercial bulletins that give characteristics and performance specifications for a number of modern submersible pumps (enclosures 7 and 8).

Visit to USGS Offices in Takoma, Washington

On December 8, Tilak Verma, Neil Coleman, and Roy Williams (NRC contractor) visited the offices of the U. S. Geological Survey in Takoma, Washington. The purpose of this visit was to re-establish technical contacts with the staff of the Survey, and to become acquainted with the current status of the Survey's ongoing project work in eastern Washington. USGS participants in the visit included, among others, Bill Meyer, Frank Packard, Bill Lum, John Vacarro, and Brian Drost (see enclosure 9). We were also joined by Ralph Patt of the Oregon Water Resources Department.

Discussions during this visit centered around the program of Columbia Plateau studies being conducted by the Survey. We received status reports on the following: RASA Project, Sodium Project, Benton-Franklin (Tri-Cities) Study, Pullman-Moscow Basin Study, Interagency Hydrology Working Group, and other studies regarding groundwater pumpage, remote sensing, and regional groundwater recharge.

During the visit we received a bibliography of recent USGS reports that are relevant to the BWIP site and the Columbia Plateau region (see enclosure 10). Copies of two recently published reports of relevance to BWIP hydrology are attached as enclosures 11 and 12. The relevant references are provided below:

Bauer, H. H. et al., 1985. Maps Showing Ground-Water Levels in the Columbia River Basalt and Overlying Materials, Spring 1983, Southeastern Washington, US Geological Survey Water-Resources Investigations Report 84-4360, Tacoma, Washington.

Hearn, P. P. et al., 1985. Geochemical Controls on Dissolved Sodium in Basalt Aquifers of the Columbia Plateau, Washington, US Geological Survey Water-Resources Investigations Report 84-4304, Tacoma, Washington.

Central to our discussions with Survey personnel were the activities of the Interagency Hydrology Working Group. This group is in the process of developing a groundwater flow model for the general region of the Pasco Basin. Participants in the group include the USGS, US DOE, and DOE contractors, including Rockwell and Pacific Northwest Labs. During the last several years the NRC has not been invited to send participants or observers to the group's meetings. We emphasized that NRC would like to participate in future meetings in any possible capacity. Survey staff, including Bill Meyer and Bill Lum, were optimistic about this possibility and offered to raise the topic at the next meeting of the working group.

Please contact Neil M. Coleman at ext. 74131 if you have any questions regarding this trip report or the enclosures.

/S/

Tilak Verma, Senior Hydrogeologist
Geotechnical Branch, WM

/S/

Neil M. Coleman, Hydrogeologist
Geotechnical Branch, WM

/S/

Michael F. Weber, Hydrogeologist
Geotechnical Branch, WM

Enclosures: As stated

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WM-10

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OFFICIAL CONCURRENCE AND DISTRIBUTION RECORD

MEMORANDUM FOR: Philip S. Justus, Acting Chief
Geotechnical Branch
Division of Waste Management

FROM: T. Verma, Sr. Hydrogeologist
Geotechnical Branch, WM

N. Coleman, Hydrogeologist
Geotechnical Branch, WM

M. Weber, Hydrogeologist
Geotechnical Branch, WM

SUBJECT: TRIP REPORT - BWIP HYDROLOGY REVIEW TEAM TRIP TO WASHINGTON STATE AND IDAHO (DEC. 1-8, 1986)

DATE: 87/03/

MAR 9 1987

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Encl. 4

OBSERVATIONS FROM THE CRESTON SITE VISIT
Michael Weber, WMGT, December 1, 1986

Summary

After the project review of In Situ Inc.'s NRC research contract FIN-D1163 at the Gateway Hotel in Spokane, Washington, approximately half of the meeting participants travelled west to the field site near Creston, Washington. Participants in the Creston site visit included:

Don Chery, NRC-RES
Jim Paschis, In Situ Inc.
Tim Steele, In Situ Inc.
Fred Marinelli, Terra Therma, Inc.
Michael Galloway, Terra Therma, Inc.
Gerry Winter, Williams and Associates, Inc.
K. Michael Thompson, DOE-RL
Randolph Stone, Rockwell Hanford Operations
Michael Weber, NRC-WMGT

Representatives from the Yakima Indian Nation expressed interest in attending the site visit, but did not accompany the rest of the group in visiting the Creston site.

The first stop of the site visit was north of Creston along a road outcrop to observe the local characteristics of the Roza basalt flow (as identified by In Situ Inc. staff). In this outcrop, the Roza basalt was weathered and densely fractured, and contained plagioclase phenocrysts up to 1 cm long. In Situ Inc. staff identified the partially-exposed basalt flow beneath the Roza flow as a flow in the Grande Ronde Formation. These two flows were separated by a thin clay seam identified as the Vantage Interbed by In Situ Inc. staff.

The next stop was at corehole 3-C south of the town of Creston on the actual site (cf. Figure 6 in the enclosure). The four-inch casing installed in the core hole was flowing when we arrived at the site. The corehole had been drilled at an angle inclined from the vertical to obtain fracture data. In Situ Inc. had been monitoring two pressure transducers in the corehole. The participants questioned the reliability of the pressure measurements because of the discharge from the corehole. The group also discussed two completion problems associated with the corehole: (1) that most of the discharge from the corehole was occurring below the ground surface around the surface casing and (2) that the bottom of the corehole was open to several units because a "collapsed zone" near the bottom had not been packed-off prior to pressure measurements. In addition, participants questioned the driving force for the flowing artesian heads observed at relatively shallow depths in the corehole.

After a brief stop at a shallow monitoring well installed by Terra Inc. prior to initiation of In Situ Inc.'s research, the group travelled to the site of corehole 16-C. In Situ Inc. indicated that the monitoring wells installed by Terra Inc. may not be reliable because of completion problems and, therefore, would not be useable for their study. Participants commented that the piezometers installed by In situ Inc. may also not be suitable for use in the hydraulic testing because of completion problems. At corehole 16-C, In Situ Inc. demonstrated the use of the portable data loggers ("Hermit") used to collect water level data from the transducers and the use of a brass rod used for slug testing the small diameter piezometers. NRC staff, NMSS contractors, RHO staff disagreed with In Situ, Inc. staff (Kunkle), who asserted that perched groundwater cannot exist under artesian pressure.

As the last stop of the field visit, the group visited the Dreger observation well south of the site. This well was completed with multiple piezometers by the USGS after the borehole was abandoned after it drained when deepened to improve well yield. Water levels in the the piezometers are monitored periodically the USGS to establish long-term water level trends in the Creston area. In Situ, Inc. plans on monitoring water levels in the Dreger well in conjunction with the hydraulic testing planned for 1987. The distance of the well from the main area of testing and the limited duration of the planned hydraulic tests, however, may limit the utility of the Dreger well as a monitoring location in support of the tests.

The visitors thanked In Situ Inc. for hosting the visit to the Creston site and expressed interest in participating in the upcoming review of the testing planned by In Situ Inc. at the Creston site. According to Don Chery, this project review is currently planned for late January 1987 in the Washington, D. C. metropolitan area. After the Dreger well visit, NRC review team members drove to Richland, Washington to complete preparations for the BWIP Hydrology Data Review.

Enclosure:
Hand-outs from the Creston Site Visit

PROGRAM WORK SUMMARY AND FIELD-SITE TRIP

NRC & Subcontractor Field Visit -- Creston Study Area, Washington
December 1, 1986

NRC Contract No. NRC-04-85-114, Flow of Groundwater and Transport of Contaminants through Saturated Fractured Geologic Media from High-Level Radioactive Waste (In-Situ Project No. 1057)

Meeting 0800 hours, Gateway Hotel, Spokane, Washington

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1. Following introductions of attendees, In-Situ, Inc. will present a 35-mm slide program on the following aspects of the Creston Study Area: location, land use, site setting, basalt stratigraphy and selected well data; the second half of the presentation will highlight vertical and angle core drilling results, geophysical logging, acquisition of hydrologic data, and plans for the 1987 field season.

2. Materials available for examination include: Creston Study Area map, representative samples of drill core, color photographs of cored wells 16-C and 3-C, and selected reference materials.

Field Site Trip: Spokane to Creston, Washington

To meet the schedule of the Hanford site participants, the trip schedule of June 26th (enclosed) will be abbreviated. Today's trip will incorporate several prior stops but also several stops relating to recent field activities. These new stops include:

13. View of basement granite east of Creston.

14. Outcrop inspection of stratigraphy showing PriestRapids / Roza / Vantage / Grande Ronde.

15. Core drilled well 16-C, showing nitrogen-inflated packer, piezometers and hydrologic-data collection.

Additional materials supplied include:

Figure 11. Spokane, Creston, Richland road map

Figure 12. Geologic map of Washington

Figure 13. Geologic story of the Columbia Basin

Figure 14. Geologic cross section, based upon 16-C and 3-C core drilling

Figure 15. Well 16-C packer placement and water-level monitoring

Figure 16. Well 3-C packer placement and water-level monitoring

Item 17. Highlights of planned hydrologic testing, 1987 field season

Figure 18. Pump-performance curves for Model SP 27.

FIELD-SITE TRIP
Creston, Washington

JUNE 26, 1986
NRC Project 1057

Time	Stop	TOPICS OF DISCUSSION AND OBSERVATION
0715-0800	1	In Spokane: purchase lunch, supplies, etc.
0800-0915	2	Drive Spokane-Creston via US Highway 2.
0915-1000	3	Columbia River, near Lincoln: view basement granite, fractures, and early Grande Ronde basalts.
1000-1015	4	Grande Ronde quarry, sample site for tracer study: view entablature structure.
1015-1045	5	Creston relief stop: Meet Carl Nelsons, study area landowner; drive to top of Creston Butte, observe WWPCo environmental site and study area setting.
1045-1130	6	Tera well OW-3, completed in Wanapum basalt aquifers: view vesicular and colonnade cooling features.
1130-1300	7	Sinking Creek and Stratigraphic Section II: three types of basalt flow cooling structure; lunch in the shade.
1300-1315	8	Meet Merwin Hougers; view installation of high-production water well in "irrigation zone aquifer;" remote water-level monitoring in Flow Top A, a Wanapum aquifer, using a Hermit and transducers.
1315-1330	9	Washington State Section 16: planned southern well cluster site.
1330-1415	10	Dreger well: discussion by Ted Olson.
1415-1430	11	Creston ice-cream store and relief stop.
1430-1545	12	Drive Creston-Spokane.

FIELD-SITE TRIP JUNE 26, 1986
Creston, Washington NRC Project 1057

This one-day site visit to Creston, Washington, pertains to topics in the "Geologic Report, Creston Study Area, Lincoln County, Washington," discussed at the Laramie Project Review Meeting on June 25, 1986.

Figure 1 shows the location of the study area, south of Creston, about 60 miles west of Spokane, Washington. US Highway 2 west from Spokane passes near the northern edge of the Columbia River Plateau. The rocks here are mainly basalts covered by unconsolidated sediments (which make very productive cropland) and minor granite, as shown in Figure 2.

The basalts underlying the Creston study area emanated from chemically distinct mantle magmas conveyed through particular sets of crustal fissures (Swanson et al., 1979), shown in Figure 3. This diagram illustrates the widespread distribution of the Grande Ronde Formation and Priest Rapids Member of the Wanapum Formation. These basalts were deposited in a series of voluminous lava flows and constitute the earlier portion of the Columbia River Basalt Group shown in Figures 4 and 5 (after Hooper, 1982). Field Stops 3 and 4 will provide an opportunity to view Grande Ronde features northeast of the study area.

Older basement rocks of granite and quartzite (Stop 5) floor the two basalts of the study area, shown in Figures 6 and 7. The cross section of Figure 7 is oriented across the northern part of the study area.

A series of pumping and observation wells (designated "P" and "OW," respectively, on Figure 6) were installed for the Washington Water Power Company as part of a baseline study at

the proposed Creston coal-fired electric-power site. These wells may be used where applicable in the present study. This research will include detailed observations for the characterization of water and tracer flow in fractured basalts of the Wanapum Formation.

The covering soils and vegetation allow only segmented evaluation of the study-area rock units and their contacts. At Stop 6, two portions of basalt cooling structures near OW-3 may be seen. An entire basalt flow cooling unit is exposed at Sinking Creek and depicted in Figure 8. The outcrop exposure at Stop 7 affords an opportunity to examine details of the basalt cooling texture and accompanying fracture sets. Sinking Creek, immediately to the east, is a narrow channel, commonly flowing during spring runoff. At this date and location, the flow has disappeared beneath pasturelands. Sinking Creek represents a location on the upper piezometric surface coinciding with the "first shallow aquifer" or flow top A.

At Stop 8, approximately two miles south-southeast, an irrigation well yielding a flow in excess of 500 gallons per minute (gpm) is operated by the Hougers. This well taps waters from the "middle zone aquifer" of Wildrick (1982). The Hougers also have a nearby domestic well which taps water in the "upper zone aquifer." The productive zone may be coincident with flow top A. They report no impairing drawdown in the domestic well during heavy pumping of the adjacent irrigation well. These wells are shown in cross section in Figure 9, taken from Plate 3 of Wildrick (1982).

The southern cluster of wells is planned on Section 16, Stop 9. Very little outcrop can be seen here. Diamond-core dril-

ling and geophysical logging will contribute to interpretations and understanding of the subsurface hydrogeology.

At Stop 10, Ted Olson will discuss the Dreger observation well. Figure 10 illustrates the piezometer arrangements; further detail about these piezometers is given in Appendix 1.

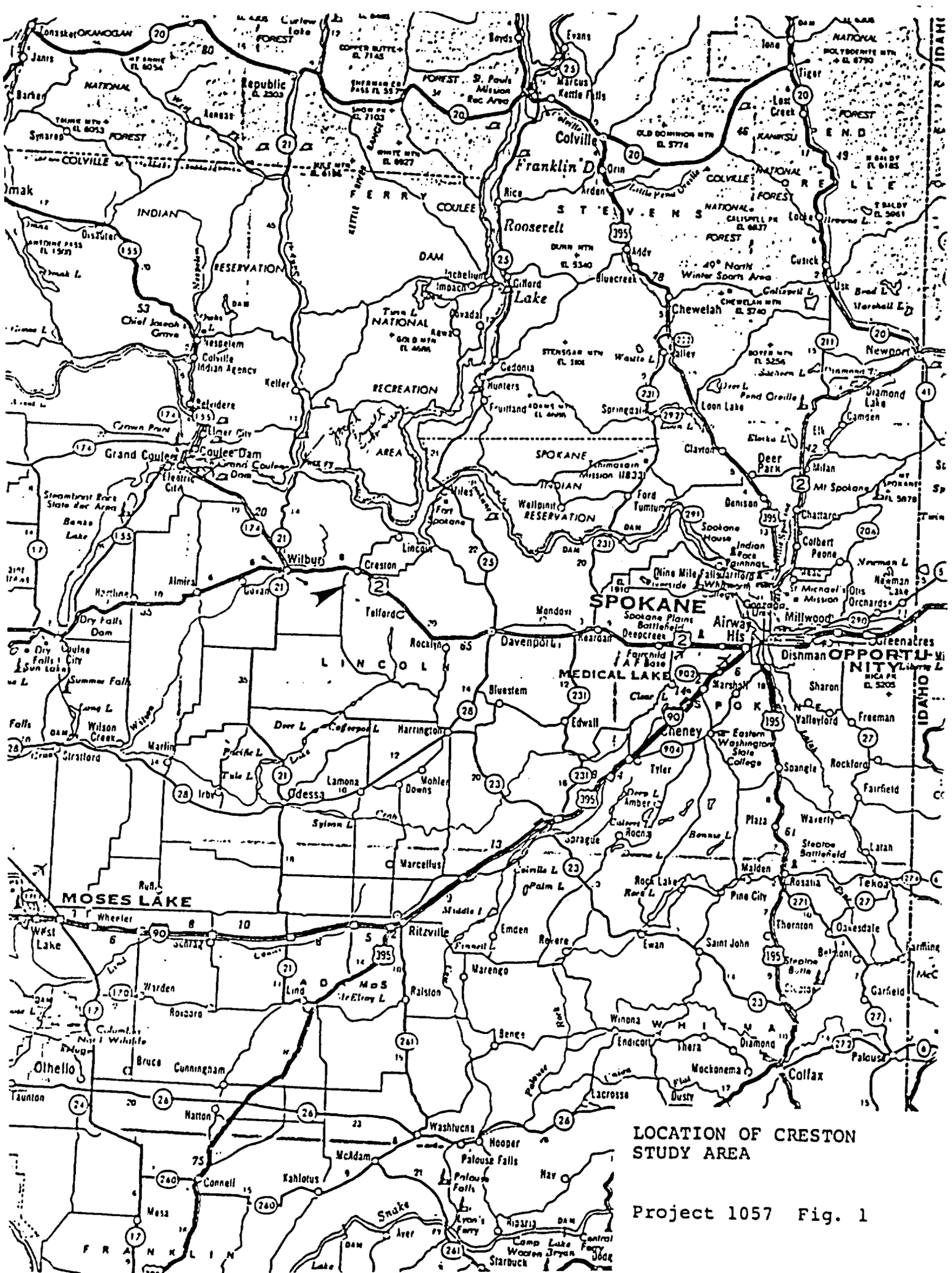
REFERENCES

Hooper, P. R., 1982. The Columbia River basalts. Science, v. 215, pp. 1463-1468.

Olson, T. M., 1984. Dreger observation well near Creston, Washington. Washington State Department of Ecology, Olympia, Office Rept. ER843, December.

Swanson, D. A., T. L. Wright, P. R. Hooper, and R. D. Bentky, 1979. Revisions in stratigraphic nomenclature of the Columbia River Basalt group. U.S. Geological Survey Bull. 1457-G.

Wildrick, Linton, 1982. Decreasing stream flow and possible ground water depletion in the Sinking Creek watershed, Lincoln County, Washington. Washington State Department of Ecology, Olympia, December.

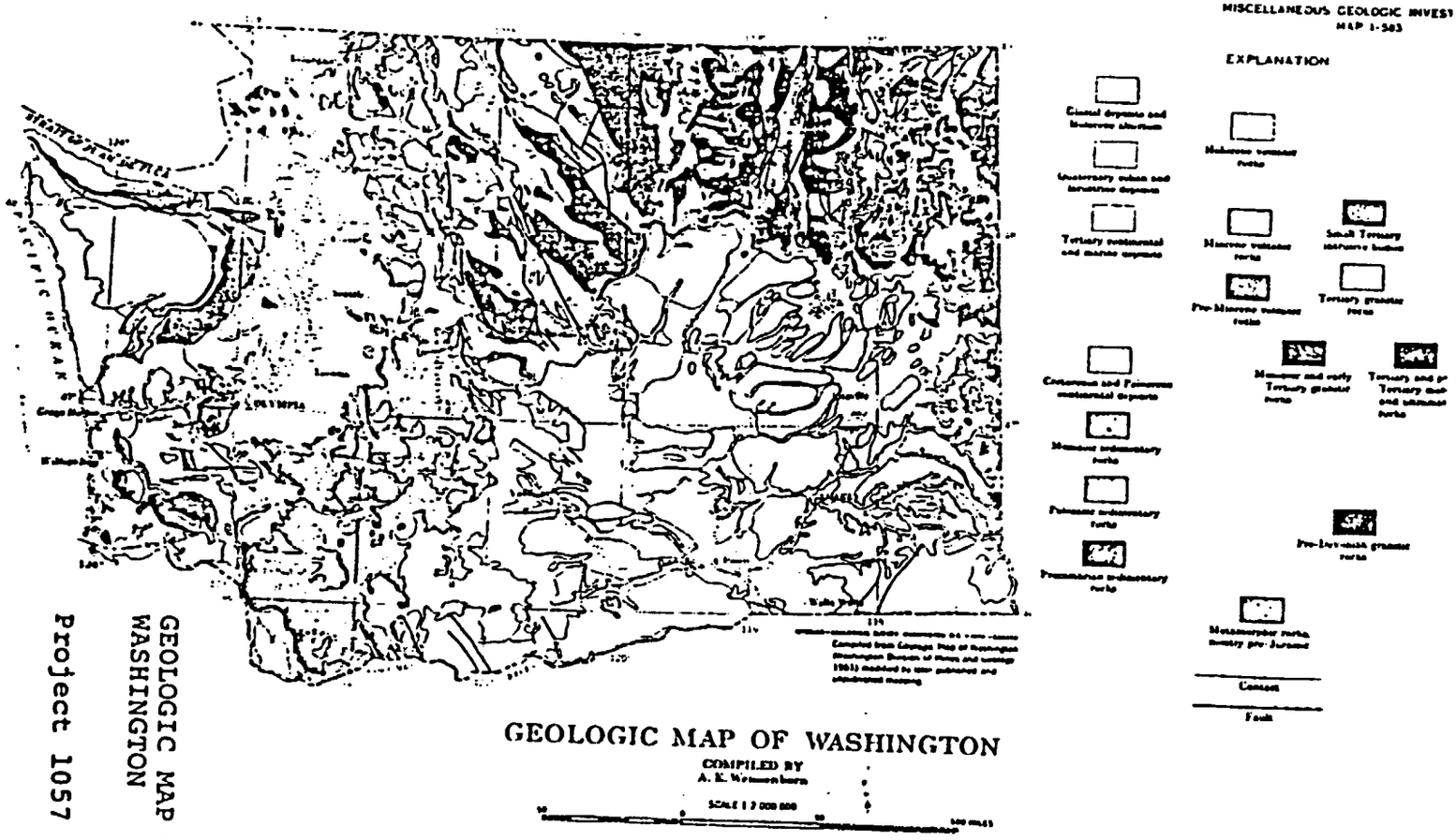


LOCATION OF CRESTON STUDY AREA

Project 1057 Fig. 1

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS GEOLOGIC INVEST
MAP I-583



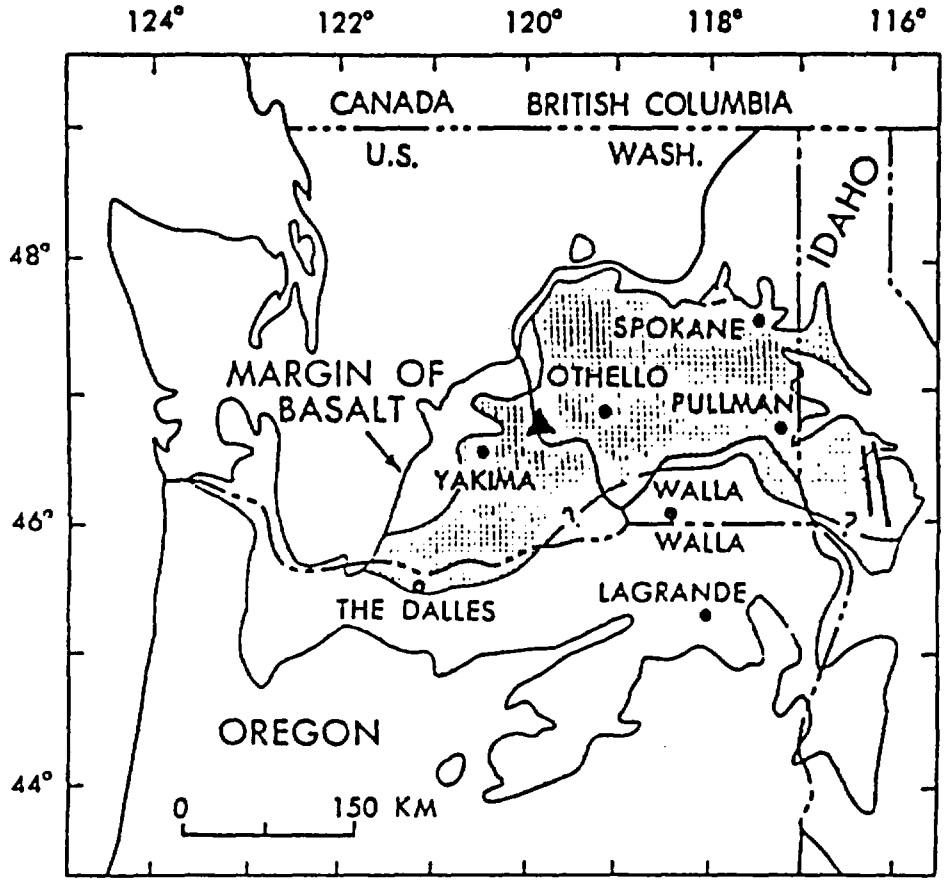
GEOLOGIC MAP OF WASHINGTON

COMPILED BY
A. E. Weissenborn

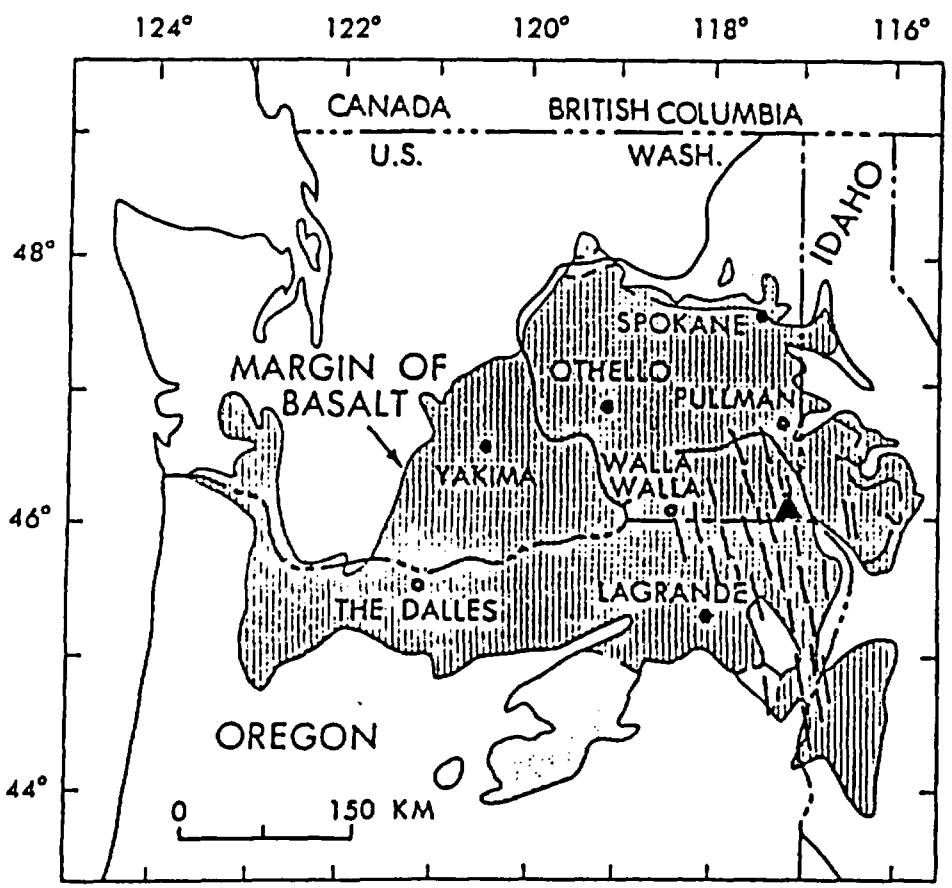
SCALE 1:2 000 000

GEOLOGIC MAP OF
WASHINGTON

Project 1057 Fig. 2



G PRIEST RAPIDS MEMBER



C GRANDE RONDE BASALT

Wanapum Basalt

and Grande Ronde Basal

▲ Type locality

Known and inferred feeder dikes
Shown schematically

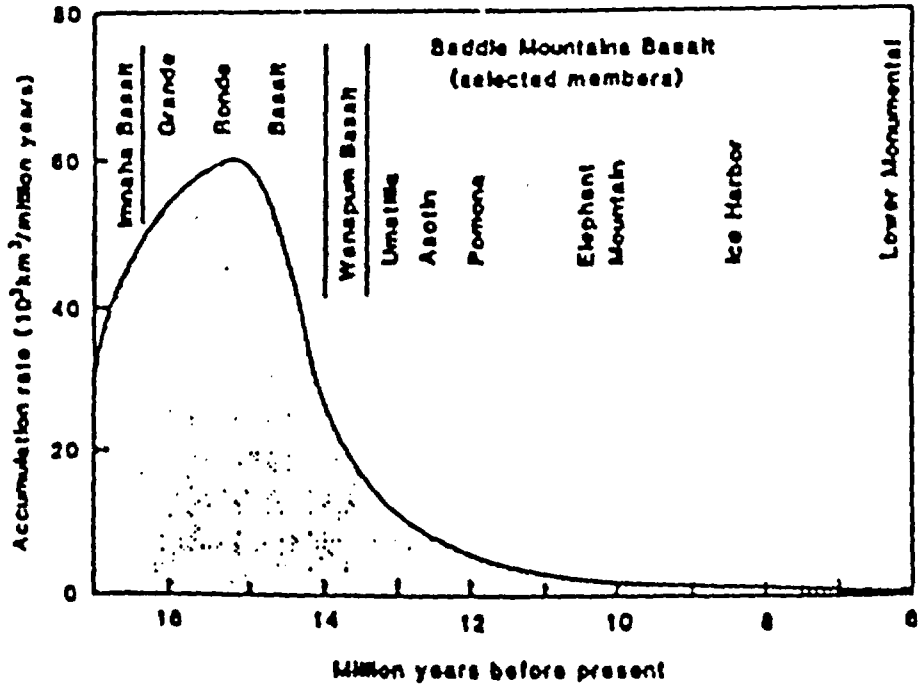
DISTRIBUTION OF WANAPUM AND GRANDE RONDE BASALTS

Project 1057 Fig. 3

		Formation	Member	Magnetic Polarity	K / Ar Dates
Columbia River Basalt Group	Yakima Basalt Subgroup	Saddle Mountains Basalt	Lower Monumental	N	6 my
			Ice Harbor	N, R	8 my
			Buford	R	
			Elephant Mountain	N, T	
			Pomona	R	12 my
			Esquatzel	N	
			Weissenfels Ridge	N	
			Asotin	N	
			Wilbur Creek	N	
			Umatilla	N	13.5 my
		Wanapum Basalt	Priest Rapids	R_3	
			Roza	T, R_3	
			Frenchman Springs	N_2	
			Eckler Mountain	N_2	14.5 my
		Grande Ronde Basalt		N_2	
		Picture Gorge Basalt R_2		R_2	
		Picture Gorge Basalt N_1		N_1	
				R_1	16.5 my
		Imnaha Basalt	T	N_0	
			R_0?		17.0 my

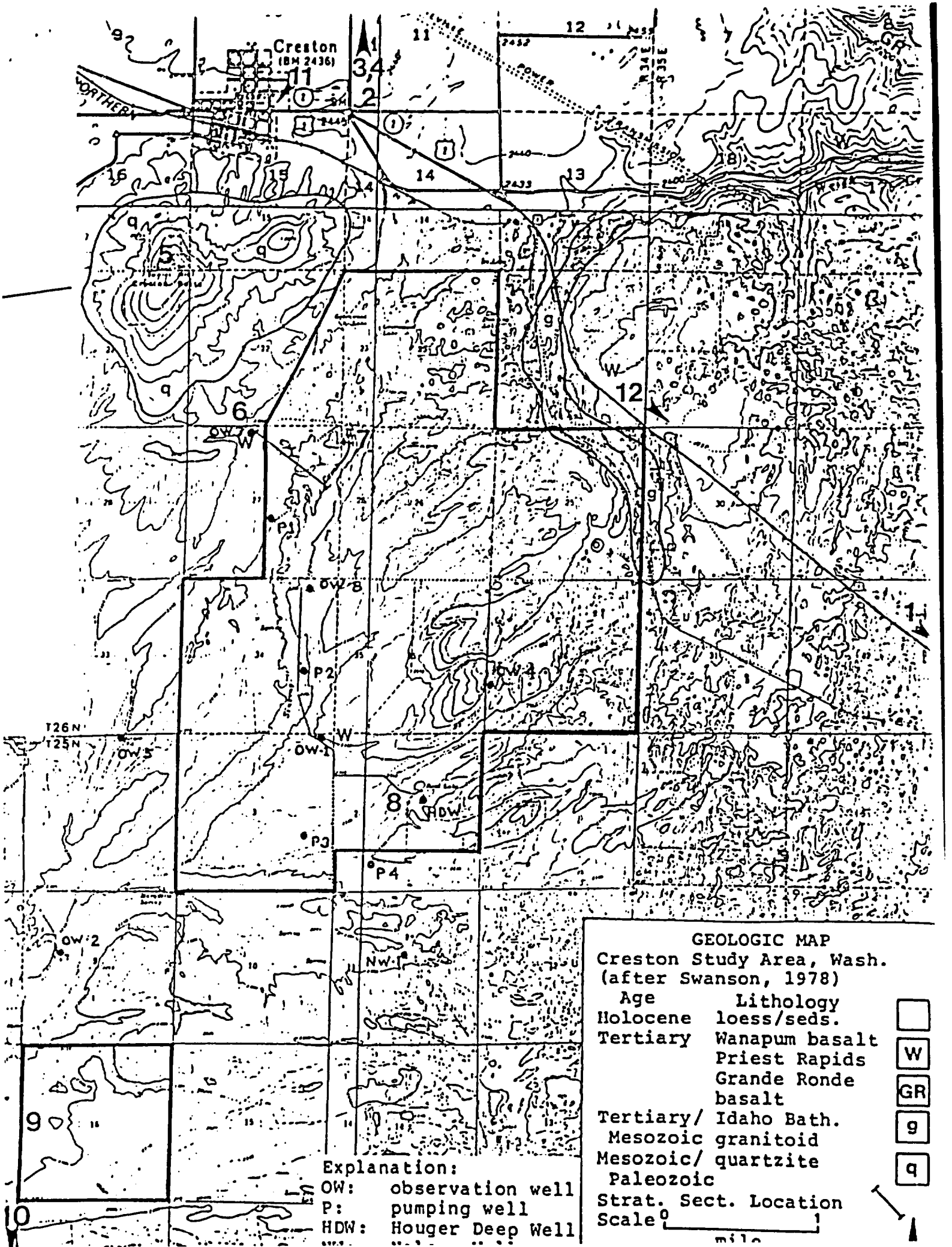
STRATIGRAPHY OF THE COLUMBIA RIVER BASALT GROUP

Project 1057 Fig. 4

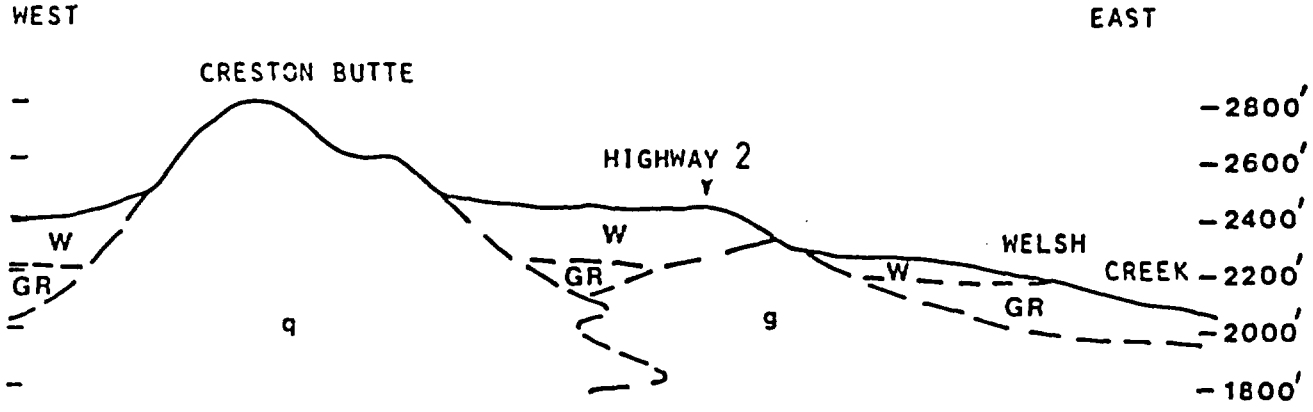


VOLUME OF ERUPTIONS OVER TIME ON THE COLUMBIA RIVER PLATEAU

Project 1057 Fig. 5


Creston
(BM 2436)
NORTHERN
T26N
T25N
OW-1
OW-2
OW-4
OW-5
OW-7
OW-8
P1
P2
P3
P4
HDW
NW-1
GEOLOGIC MAP
Creston Study Area, Wash.
(after Swanson, 1978)
Age
Lithology
Holocene
loess/seds.
Tertiary
Wanapum basalt
Priest Rapids
Grande Ronde
basalt
Tertiary/
Mesozoic
Idaho Bath.
granitoid
Mesozoic/
Paleozoic
quartzite
Strat. Sect. Location
Scale
0
1
mile
Explanation:
OW: observation well
P: pumping well
HDW: Hooger Deep Well

GEOLOGIC CROSS SECTION



EXPLANATION

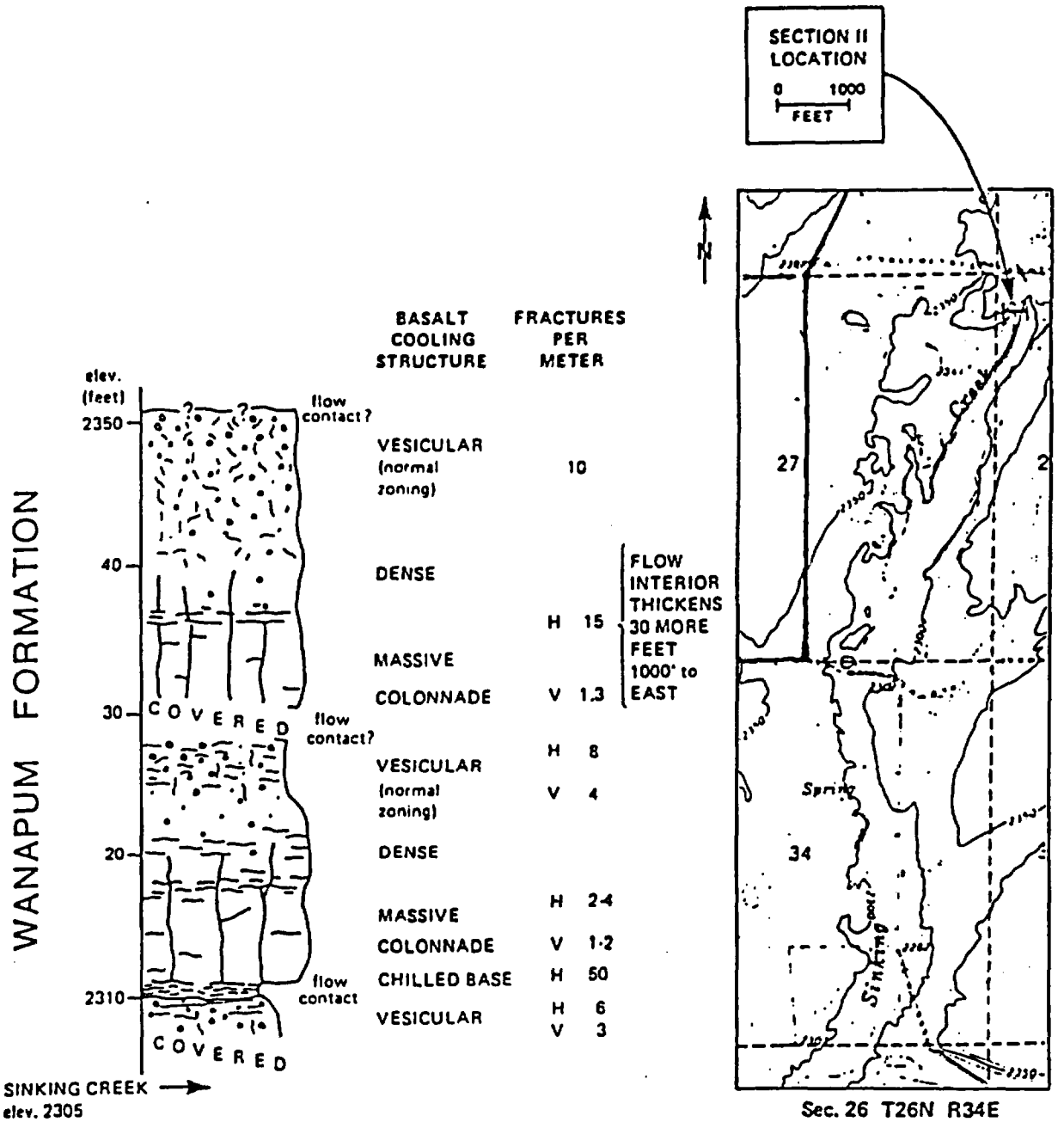
VERTICAL EXAGGERATION x7

ONE MILE

AGE	LITHOLOGY	
TERTIARY	WANAPUM BASALT (PRIEST RAPIDS MEMBER)	W
	GRANDE RONDE BASALT	GR
TERTIARY/ MESOZOIC	IDAHO BATHOLITH GRANITOID	g
MESOZOIC/ PALEOZOIC	UNNAMED QUARTZITE	q

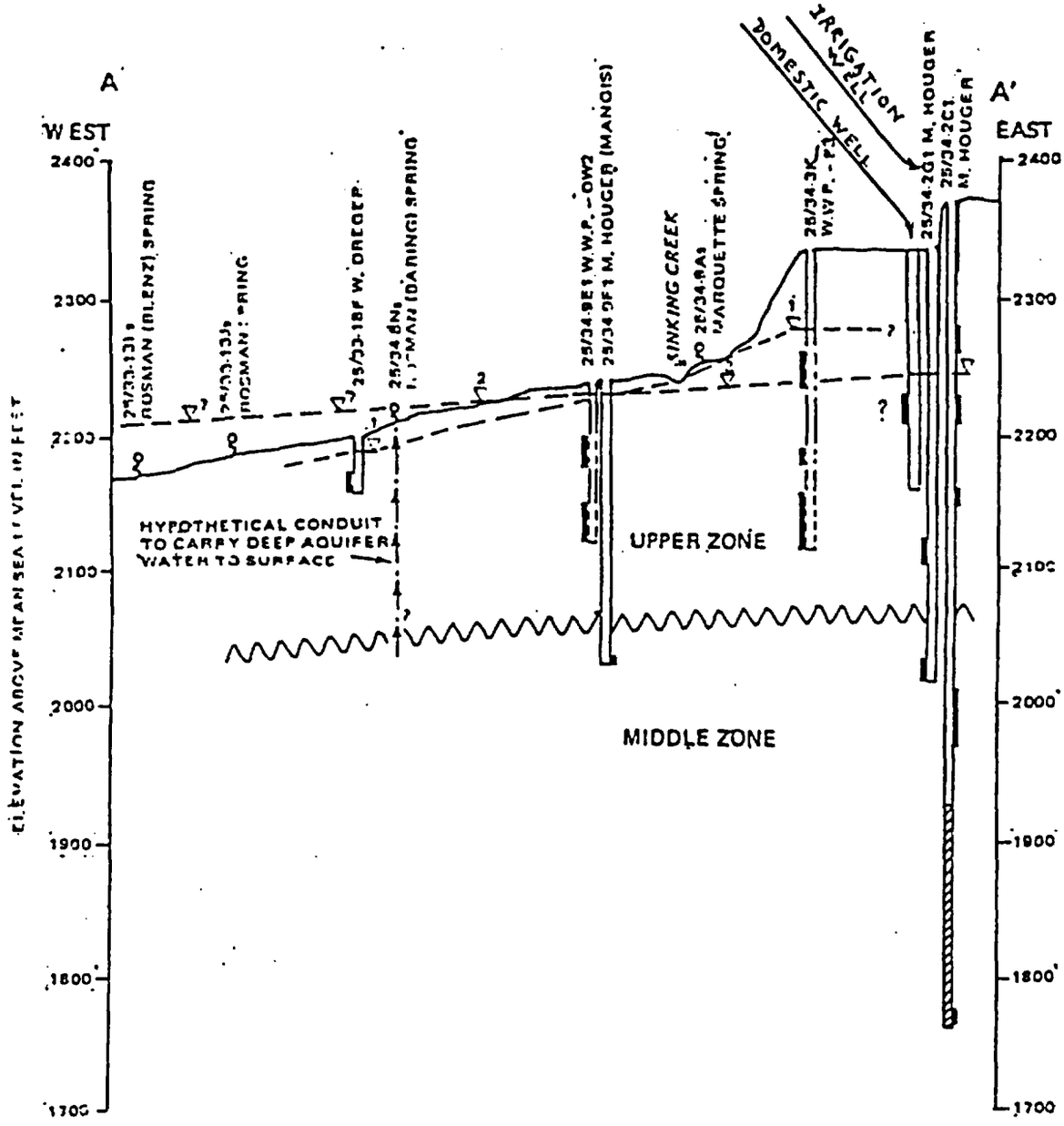
Creston Butte-Welsh Creek Geologic Cross Section (LOCATION SHOWN IN FIGURE 6)

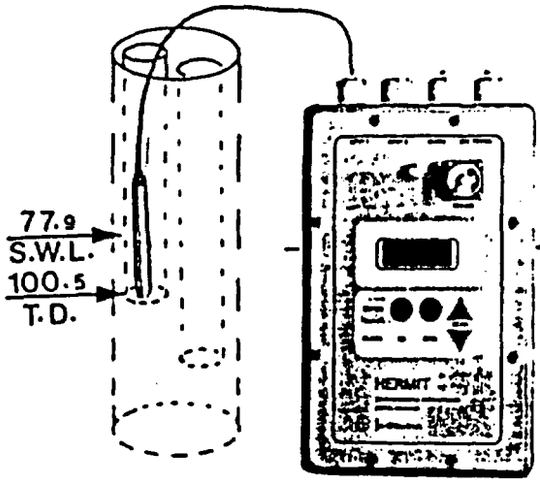
Project 1057 | Figure 7



Stratigraphic Section II, Section 26, T26N, R34E, near Creston Washington

Project 1057 | Figure 8





OW-4
Seven day level test

The HERMIT is a versatile, two-channel, programmable data logger built to measure, record, and electronically transfer data to data processing equipment. It is designed to measure and store water level data for both surface and ground water applications under extreme environmental conditions.

SELECTED WELLS, SOUTHERN PART OF THE CRESTON STUDY AREA

Project 1057 Fig. 9

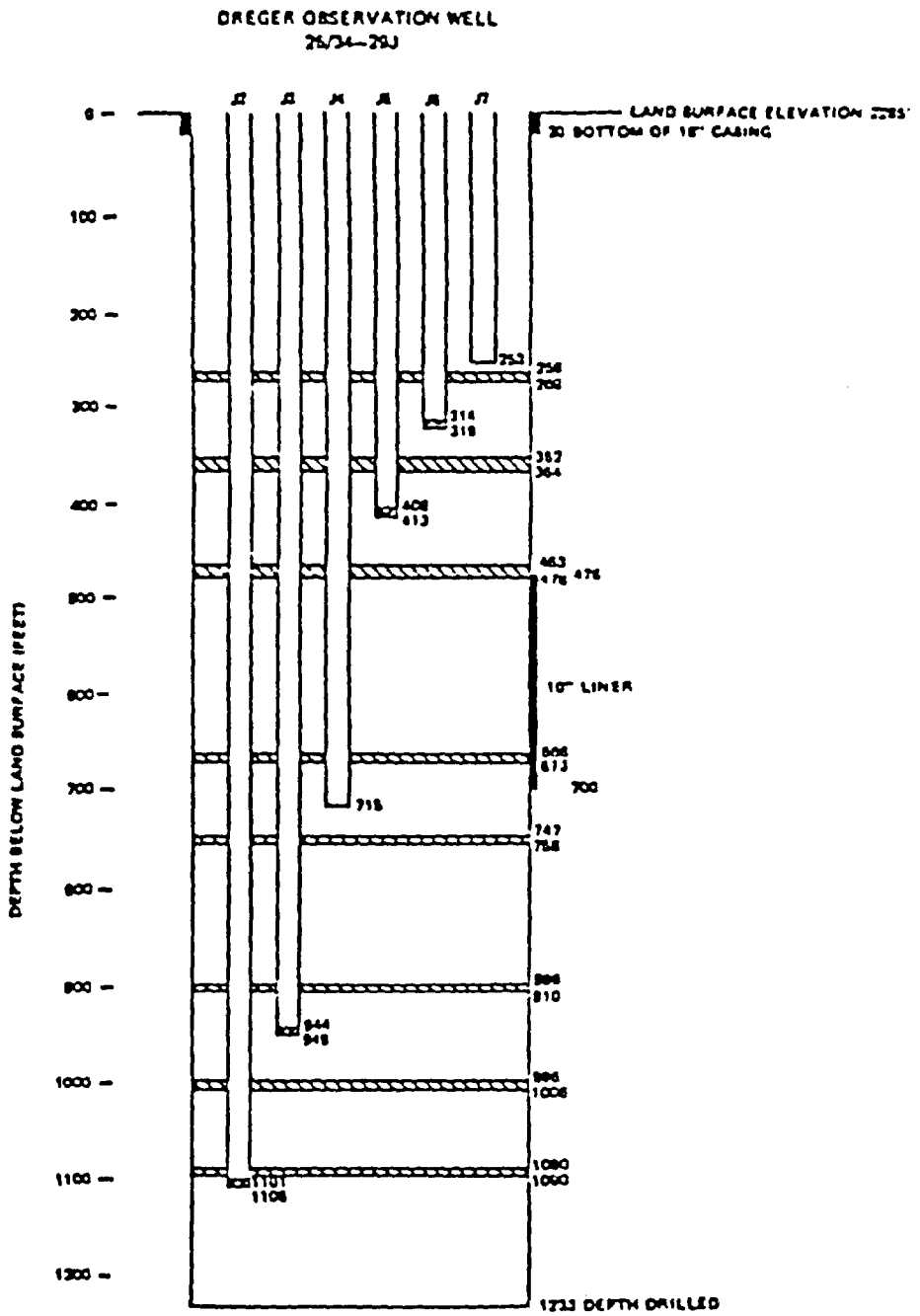


DIAGRAM OF PIEZOMETER INSTALLATION.

DREGER OBSERVATION WELL
PIEZOMETER INSTALLATION

Project 1057 Fig. 1(

APPENDIX 1

Piezometers

Piezometers are installed to determine zones of differing head in the multiple aquifers. (A piezometer is a pipe that extends from land surface to a predetermined depth in the well. The lower end of the pipe is open to a water-bearing zone within the borehole and is isolated from water-bearing zones above and below by sealing material.)

Each piezometer allows monitoring of the potentiometric head in the isolated zone. Without piezometers and plugs, the water level in a well represent a composite hydraulic head of all the water-bearing zones open to the well. (Figure 6 shows the installation of the piezometers in the Dreger well.)

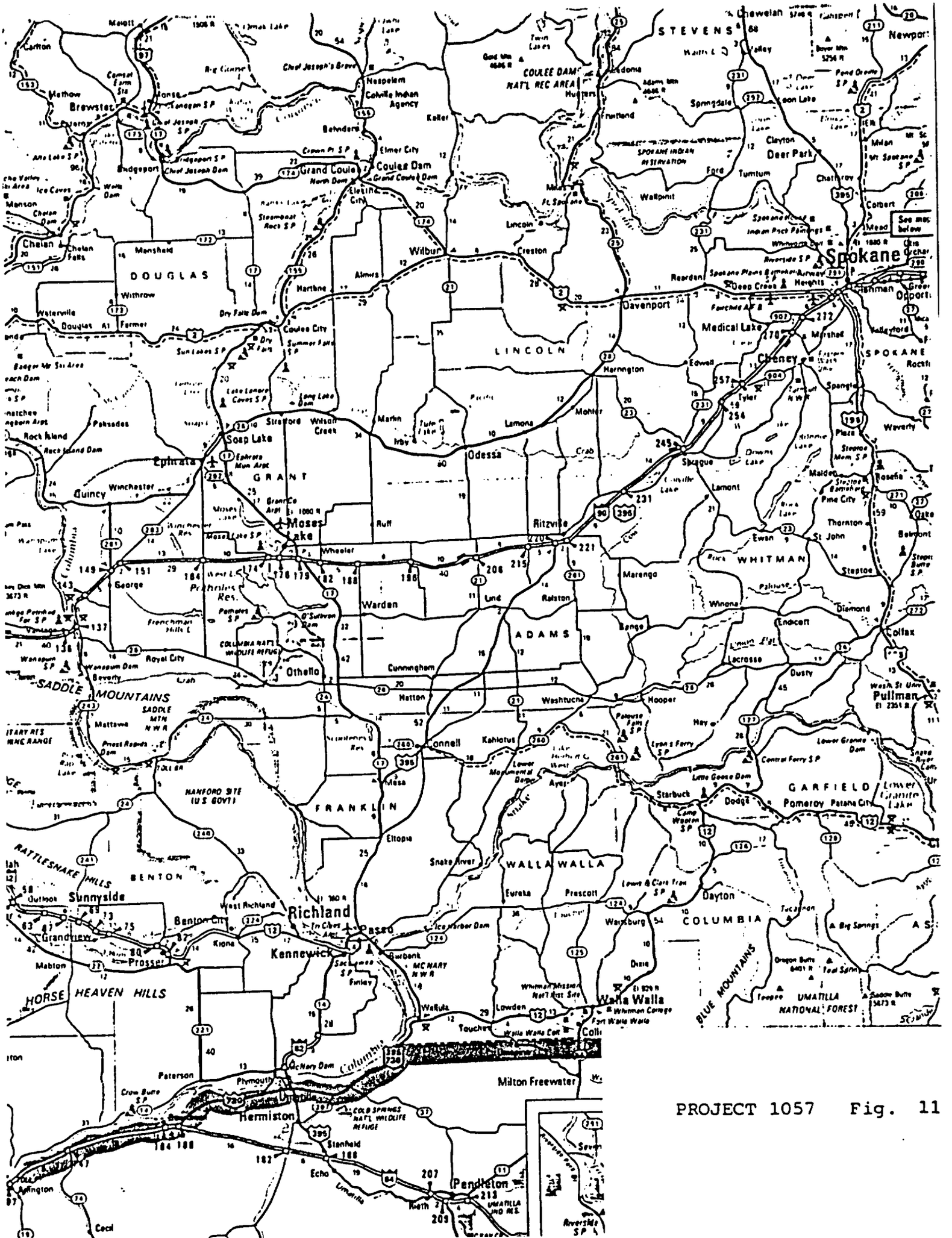
The piezometers were installed between September 23 and 29, 1983 by Marlatt Drilling Company of Milton-Freewater, Oregon, under supervision of USGS. The measured depth of the well was 1,233 feet (as compared to a reported total drilled depth of 1,225 feet on the water well report).

Six piezometer pipes were installed using 1½-inch galvanized pipe with a 5-foot stainless steel, wire-wound screen at the bottom of the pipe. Slot size of all screens is 0.060 inch.

Details of the piezometer installation:

Piezometer	Interval Monitored	Plug Depth
J2	1,090 - 1,233	1,080 - 1,090 996 - 1,006
J3	910 - 996	899 - 910 747 - 758
J4*	673 - 747	666 - 673 463 - 478
J5	364 - 463	352 - 364
J6	269 - 352	253 - 259
J7	0 - 253	

* The 5-foot stainless steel screen broke off at 476 feet as the piezometer was being lowered through the 10-inch liner.



PROJECT 1057 Fig. 11

GCP-417
(10/83)-140

THE GEOLOGIC STORY OF THE COLUMBIA BASIN

The rock formations of the Columbia Basin were formed by some of the most unusual and catastrophic processes in geologic history.

During the early stages of the Columbia Basin formation, granite rock was slowly created by heat and pressure deep in the crust of the earth. Then the crust was uplifted, exposing the granite, creating mountains similar to the Okanogan Highlands north of Grand Coulee Dam.

Forty to sixty million years ago the formation of the outline of the Columbia Basin was complete. The land had subsided below sea level, and a large inland sea had formed.

The land was again uplifted and then, 10-15 million years ago, was flooded with volcanic lava. The boundaries of the "flood lava" were located in almost the same position as the former seashore. Many layers of lava were needed to build up to a 5,000-feet (1500 meter) thickness and form the smooth surfaced Columbia Plateau.

The Ice Age (or Pleistocene epoch) began at the end of the Pliocene epoch, 2 million years ago. Glaciers 5-10,000 feet (1500-3000 meters) thick in northern Washington pushed down the Okanogan Valley and crossed the Columbia River near the present site of Chief Joseph Dam. Ice filled the Columbia Valley and pushed onto the Waterville Plateau as far south as Coulee City. Water, backed up by the ice dam, spilled over the Columbia Plateau into the Columbia Basin.

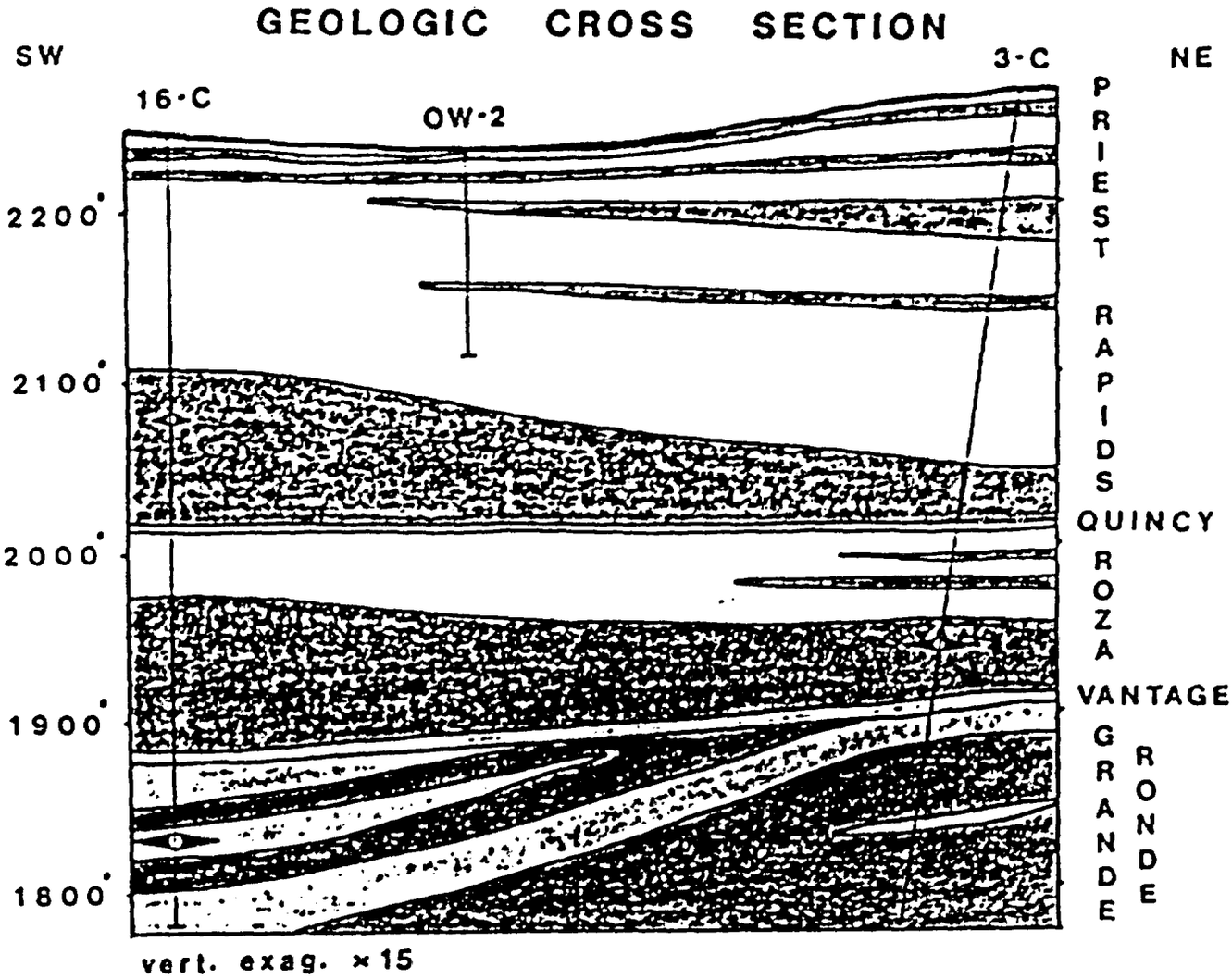
During this time, the Grand Coulee began its process of formation since the original river channel had been lost by burial in ice. The length of time that it took to form the Grand Coulee has been the subject of much controversy. Some geologists think that it was formed by a succession of large floods, others believe that it was formed by a gradual process of erosion as the Columbia River sought to form a new river channel.

During the Ice Age, the old Cascade Mountains were also formed. Their outline still remains on the western slopes of the Cascades. The uplifting mountains were not able to completely block the flow of the Columbia River, and a deep Columbia River gorge was formed.

Near the end of the Ice Age the volcanoes of the high Cascades rose to elevations of 14,000-15,000 feet (4000-4500 meters). Older volcanoes, such as Mt. Hood and Mt. Rainier, were sculptured by glaciers of the Ice Age; others such as Mt. St. Helens remained unsculptured, retaining their original volcanic form.

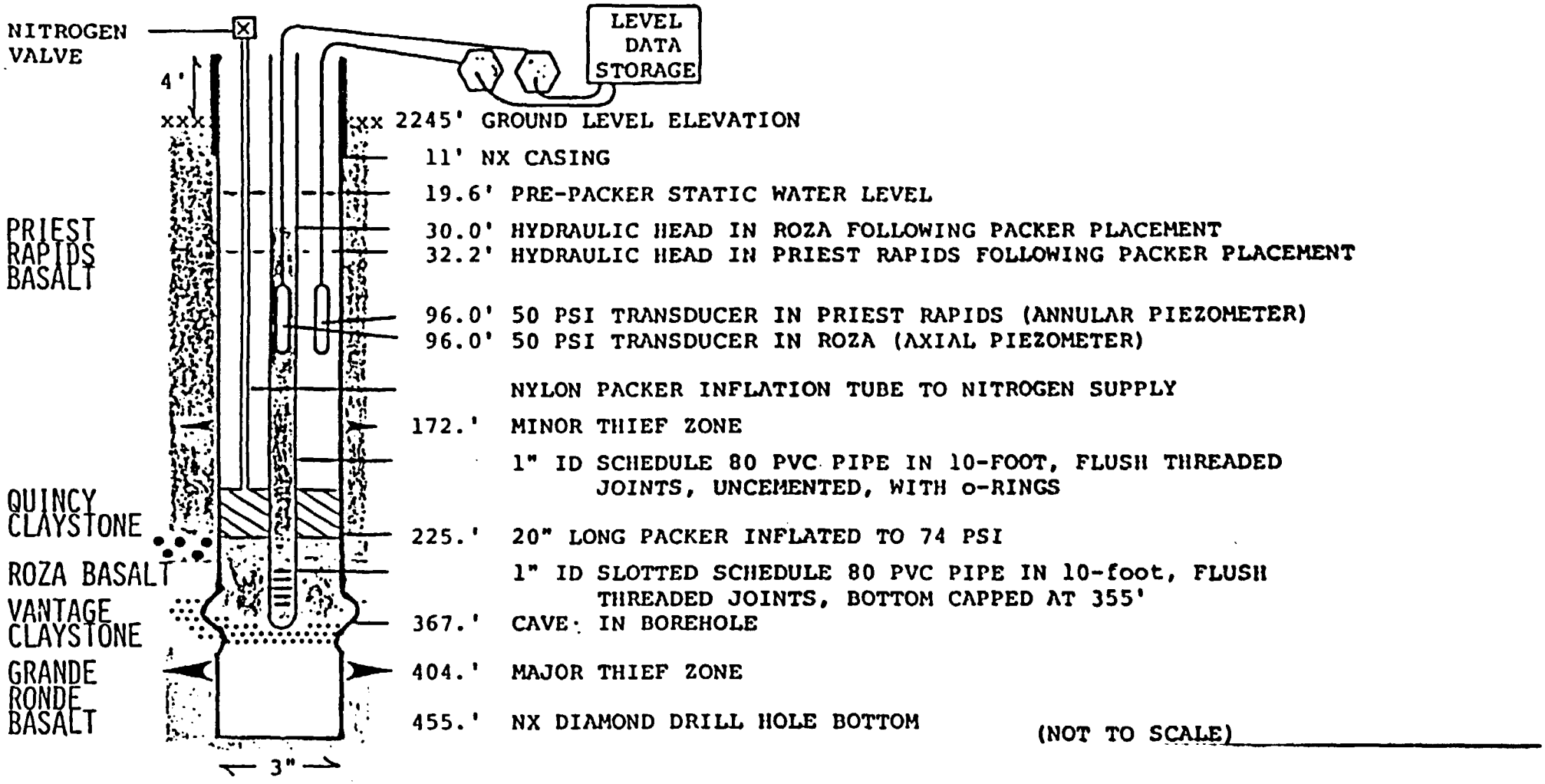
Eighteen thousand years ago the Columbia Basin was nearly covered by floodwaters when an ice dam at Lake Missoula in western Montana broke. Large boulders were strewn near the outlet of the Lower Coulee (Lake Lenore). Other boulders were carried in icebergs as far as western Oregon. The floodwaters were 800 feet (250 meters) deep near Pasco and 400 feet (125 meters) deep at Portland.

After the Ice Age, the Columbia River returned to its former channel. The channeled scablands and large coulees that had been formed were left stranded 500-1600 feet (150-500 meters) above the present river floor and serve as a constant reminder of some of the most unusual episodes in geologic history.



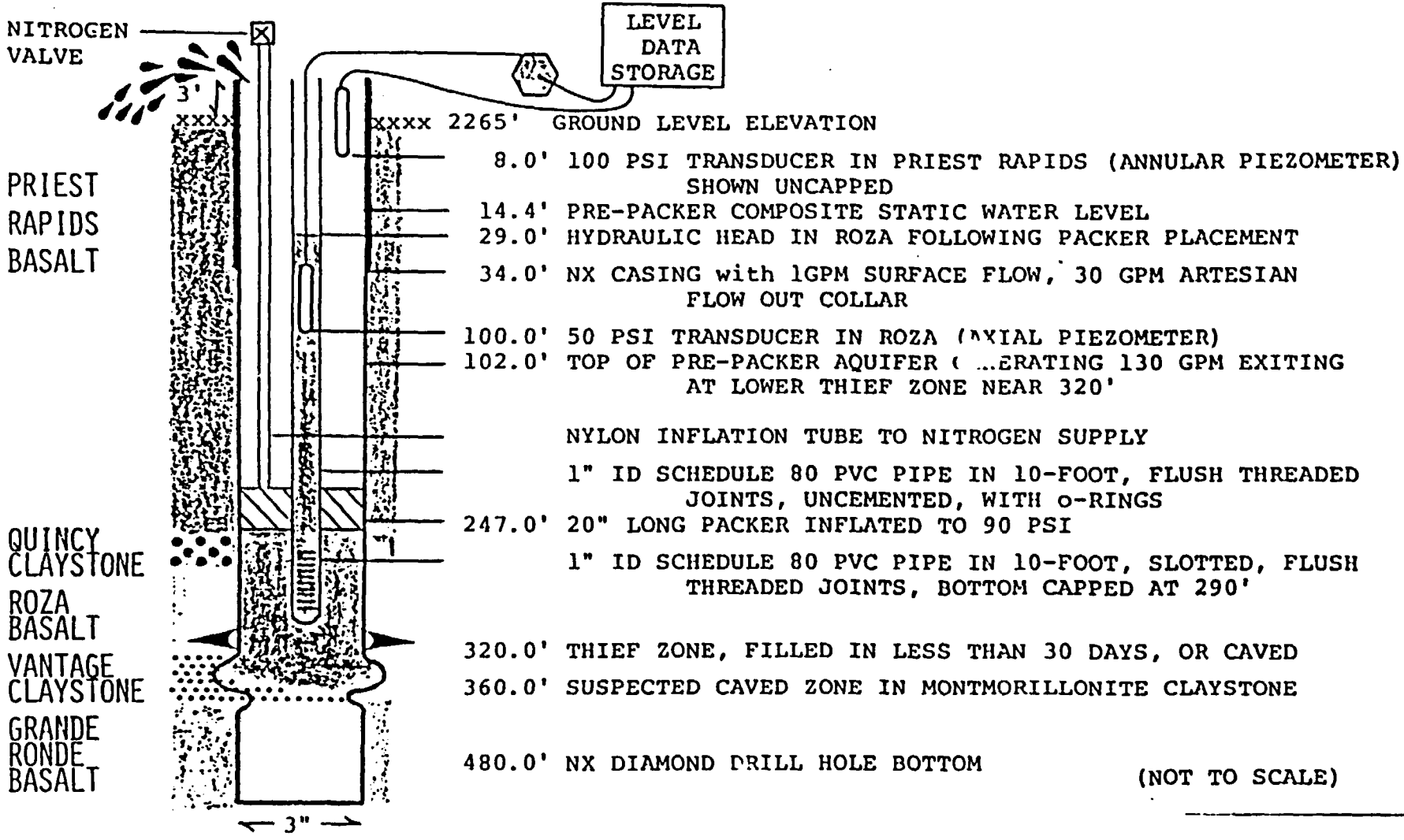
PROJECT 1057 Fig. 14

WELL 16-C PACKER PLACEMENT AND WATER LEVEL MONITORING, CRESTON, WASHINGTON



PROJECT 1057 Fig. 15

WELL 3-C PACKER PLACEMENT AND WATER LEVEL MONITORING, CRESTON, WASHINGTON



(NOT TO SCALE)

PROJECT 1057 Fig. 16

Project No. 1057 NRC Basalt Aquifer Study

Wellfield Design Criteria

I. Tracer-Test Design Criteria

A. Dilution factor (by natural ground-water flow)

B. Instrument-detection limit

C. Ground-water velocity - effective porosity
hydraulic gradient
hydraulic conductivity

II. Pump-Test Design Criteria

A. Pumping rate - available drawdown
hydraulic conductivity
storage coefficient

B. Selection of pump - minimum well size

C. Drawdown versus distance (instrument detection limit)

III. Purposes of Testing

A. Directional properties of the formation (wells at different directions)

B. Scaling effect (wells at different distances)

IV. Barametric Efficiency - gives indication of storage coefficient

A. Barometric pressure change

B. Static water-level change

V. Slug Tests - hydraulic-conductivity profiles

VI. Linear-Flow Testing versus Radial-Flow Testing

A. Linear-flow testing - tracer test (let natural flow carry the tracer)

B. Radial-flow testing - tracer test (under conditions of induced ground-water flow)

- pump test (to get directional properties)

TDS/for SCW
11/28/86

Encl. 10

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Approved

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5) Whiteman, K. J., 1986, Ground-water levels in three basalt hydrologic units underlying the Columbia Plateau, spring 1984, Washington and Oregon: U.S. Geological Survey Water Resources Investigations Report 86-4046, 3 sheets.

6) Bauer, H. H., Vaccaro, J. J., 1986, DPM: Documentation of a Deep Percolation Model for estimating ground-water recharge. U.S. Geological Survey, to be open-file report pending publication as Water Supply Paper, submitting to Region.

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11) Bauer, H. H., and Vaccaro, J. J., 1986, Effect of Climatological Variability on Ground-Water Availability, in: Proceedings Conference on Climate and Water Management: A Critical Era, American Meteorological Society.

12) Hearn, P. P., Steinkampf, W. C., and Brown, Z. A., 1984, Characterization of secondary alteration in the Columbia River basalt by backscattered electron imaging and energy-disperisve x-ray spectroscopy: Berkeley, California, San Francisco Press Proceedings of Meetings, p. 745-748.

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In Process of Being Readied for Colleague Review

15) Steinkampf, W. C., Water-quality characteristics of the Columbia Plateau Regional Aquifer System, Washington and Oregon: U.S. Geological Survey Water Resources Investigations Report, maps. July 1986. (0) Colleague

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17) Cline, D. R. Knadle, M. E., Ground-water pumpage in the Columbia Plateau Regional Aquifer System, 1984, Washington: U.S. Geological Survey Water Resources Investigations Report, 4 maps. June 1986. Back

18) Collins, C. A., Ground-water pumpage in the Columbia Plateau Regional Aquifer System, 1984, north-central Oregon: U.S. Geological Survey Water Resources Investigations Report, 4 maps. May 1986. Approved

19) Nelson, L. M., Surface-water resources of the Columbia Plateau Regional Aquifer System: U.S. Geological Survey Water Resources Investigations Report, 6 maps. May - June 1986. To Region

20) Whiteman, K. J. and Gonthier, J. B., Geology, structure, and thickness of selected units of the Columbia Plateau Regional Aquifer System: U.S. Geological Survey Water Resources Investigations Report, 10 maps. June 1986. To Region

To Colleague by October 1986

21) Bauer, H. H., and Vaccaro, J. J., Estimates of predevelopment and current ground -water recharge and a discussion of the major factors controlling the recharge, for the Columbia Plateau Regional Aquifer System, in parts of Washington, Oregon and Idaho. Parts reviewed.

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22) Cline, D. R., Collins, C. A., Knadle, M. E., Gonthier, J. B., Ground-water pumpage in the Columbia Plateau Regional Aquifer System, 1950 to 1984, Washington and Oregon.

23) Geohydrologic framework of the Columbia Plateau Regional Aquifer System: Professional Paper (chapter B) - outline done, introductory material written, working on rest, various authors.

To be Written (to colleague review dates listed)

24) Hansen, A. J., Whiteman, K. J., and Vaccaro, J. J., Ground-water flow model simulation of the Columbia Plateau Aquifer System: U.S. Geological Survey Water Resources Investigations Report. August 1987.

25) Steinkampf, W. C., Geochemical Framework of the Columbia Plateau Regional Aquifer System: Professional Paper, Chapter D. To colleague May 1987.

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27) Vaccaro, J. J., Summary Appraisal of the Columbia Plateau Regional Aquifer System: Professional Paper, Chapter A. To colleague July 1988.

Encl. 2

NRC Meeting
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NRC - U.S.G.S. Meeting
Dec. 8, 1980.

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