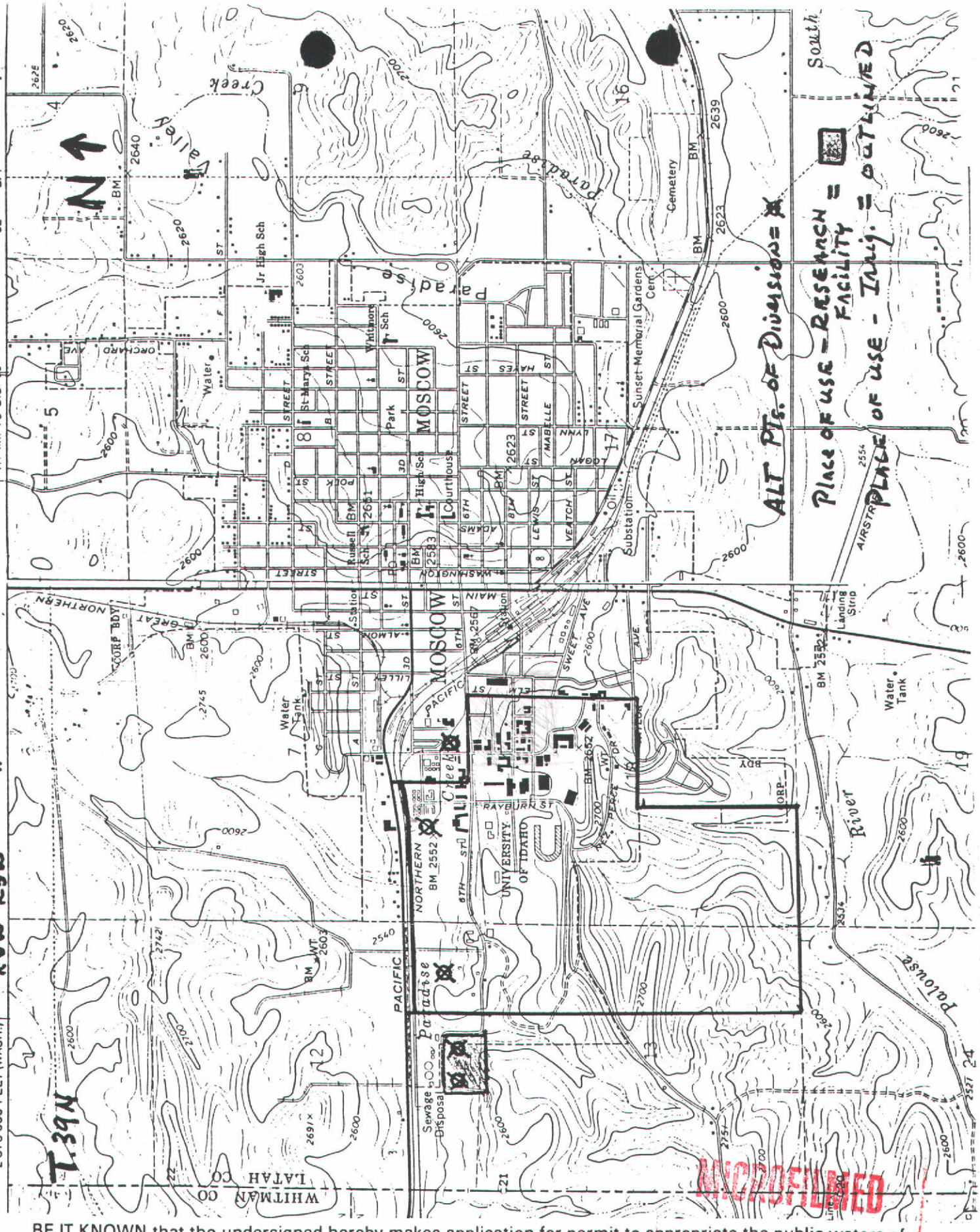


BE IT KNOWN that the undersigned hereby makes application for permit to appropriate the public waters of the State of Idaho as herein set forth.

MICROFILMED
MAR 19 1990

Dr. Joseph Geiger
(Applicant)

DR. JOSEPH GEIGER, VICE PRESIDENT
FINANCIAL AFFAIRS

State of Idaho

License and Certificate of Water Right

Water License No. 25634 — Amount .51 second foot

Water District No. — Priority April 21, 1955

THIS IS TO CERTIFY that THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, Idaho, made application for a permit to appropriate the public waters of the State of Idaho, dated April 21, 19 55; that Permit No. 25634 was issued under said application; that Certificate of Completion of works, with a carrying capacity of 1.0 second foot, was issued thereunder on November 29 55, showing that said works were completed on the 23rd day of September, 19 55; and that on the 27th day of April, 19 56,

THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, State of Idaho, made proof to the satisfaction of the State Reclamation Engineer of Idaho, of the right to use the waters of Paradise Creek, a tributary of Palouse River, for the purpose of irrigation under Use Permit No. 25634, of the Department of Reclamation and that said right to the use of said waters has been perfected in accordance with the laws of Idaho, and is hereby confirmed by the State Reclamation Engineer of Idaho and entered of record in Volume 9 of Licenses at page 5816, on the 29th day of October, 19 56;

The right hereby confirmed dates from April 21, 19 55;

The Point of Diversion is located

in the SE¼ SW¼ Sec. 12, Tp. 39 N., R. 6 W., B. M. Latah County

That the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually needed and beneficially used for said purposes, and shall not exceed .51 cubic feet per second.

Description and location of use:

Twp.	Range	Sec.	Forty-acre Tract	No. Acres Described in Permit	No. Acres Actually Irrigated
39 N.	6 W.	12	SE¼ SE¼ 16th (S½ SW¼)	25.5	26

The right to the use of the water aforesaid hereby confirmed is restricted to the lands or place of use herein described, as provided by the laws of Idaho.

WITNESS the seal and signature of the State Reclamation Engineer, affixed at Boise, Idaho, this 29th day of October, 19 56.

MARK R. KULP
State Reclamation Engineer.

(SEAL)

MICROFILMED

FEB 17 1995

87 2014

.51 x 448 x 60 x 24 x 365 = 120,089,000 gal/yr PARADISE CREEK

WHITMAN CO
LATAH CO
T 15 N
T 14 N
UNION
PACIFIC
BURLINGTON
NORTHERN
Sewage Disposal
Paradise Creek
MOSCOW
UNIVERSITY OF IDAHO
Trailer Park
Trailer Parks
Water Tank
Landing Strip
State Line
Gravel Pit
Palouse River
South Fork
BM 2552
BM 2603
BM 2652
BM 2644
BM 2567
BM 2600
WT
6TH ST
SWEET AVE
TAYLOR AVE
PERCH
RAYBURN ST
ELM ST
ALMON ST
CEDAR ST
LILLEY ST
2742
2745
2758
2751
2787
2534
2521
2518
2678
3003
2641
2691
2540
2548

FEB 17 1995

State of Idaho
License and Certificate of Water Right

Water License No. 26886 Amount .41 c.f.s.

Water District No. Priority May 7, 1957

THIS IS TO CERTIFY that THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, Idaho, made application for a permit to appropriate the public waters of the State of Idaho, dated May 7, 1957; that Permit No. 26886 was issued under said application: that Certificate of Completion of works, with a carrying capacity of 0.8 second feet, was issued thereunder on May 12, 1961, showing that said works were completed on the 9th day of May, 1961; and that on the 14th day of May, 1964

THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, State of Idaho, made proof to the satisfaction of the State Reclamation Engineer of Idaho, of the right to use the waters of Paradise Creek, a tributary of Palouse River, for the purpose of irrigation under Use Permit No. 26886 of the Department of Reclamation and that said right to the use of said waters has been perfected in accordance with the laws of Idaho, and is hereby confirmed by the State Reclamation Engineer of Idaho and entered of record in Volume 13 of Licenses at page 7974, on the 1st day of September, 1964

The right hereby confirmed dates from May 7, 1957

The Point of Diversion is located in the SW ¼ SW ¼, Sec. 12, Tp. 39 N., R. 6 W., B. M. Latah County

That the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually needed and beneficially used for said purposes, and shall not exceed .41 cubic feet per second.

Description and location of use:

Twp.	Range	Sec.	Forty-acre Tract	No. Acres Described in Permit	No. Acres Actually Irrigated
39 N.	6 W.	13	NE¼ NW¼	23	12.5
			NW¼ NW¼ (Lot 1)	8.8	8.0
			Total number of acres to be irrigated:		20.5

This appears to be the White Pine Forest Water permit.

.41 cfs ⇒ .82 AF/day = 267,320 gpd = 50 x 10⁶ gal/6 mos

The right to the use of the water aforesaid hereby confirmed is restricted to of use herein described, as provided by the laws of Idaho.

WITNESS the seal and signature of the State Reclamation Engineer, affixed at Boise, Idaho, this 1st day of September, 1964.

(SEAL)

s/ RALPH W. THOMAS
Deputy State Reclamation Engineer.

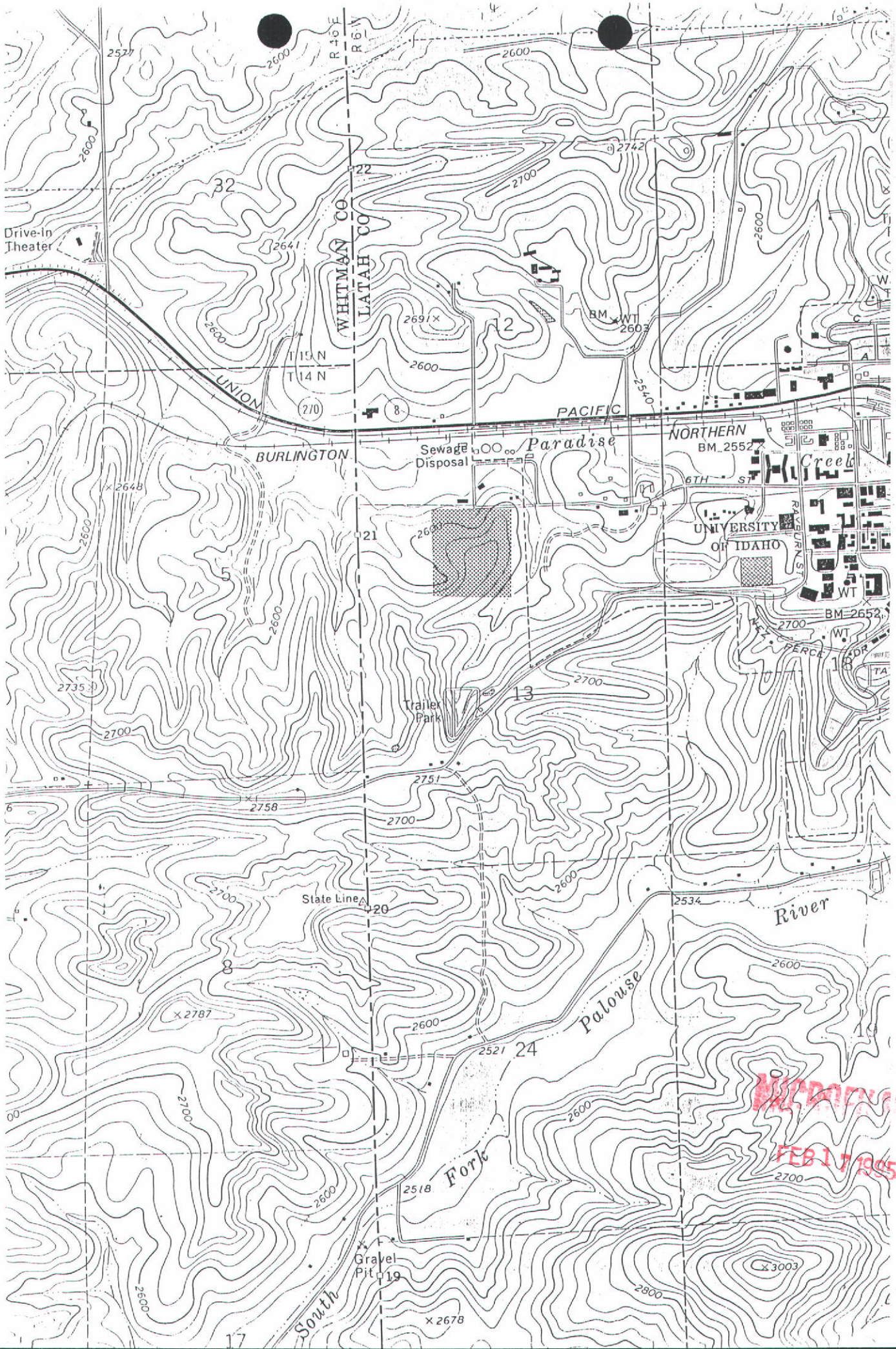
MICROFILMED

FEB 17 1995

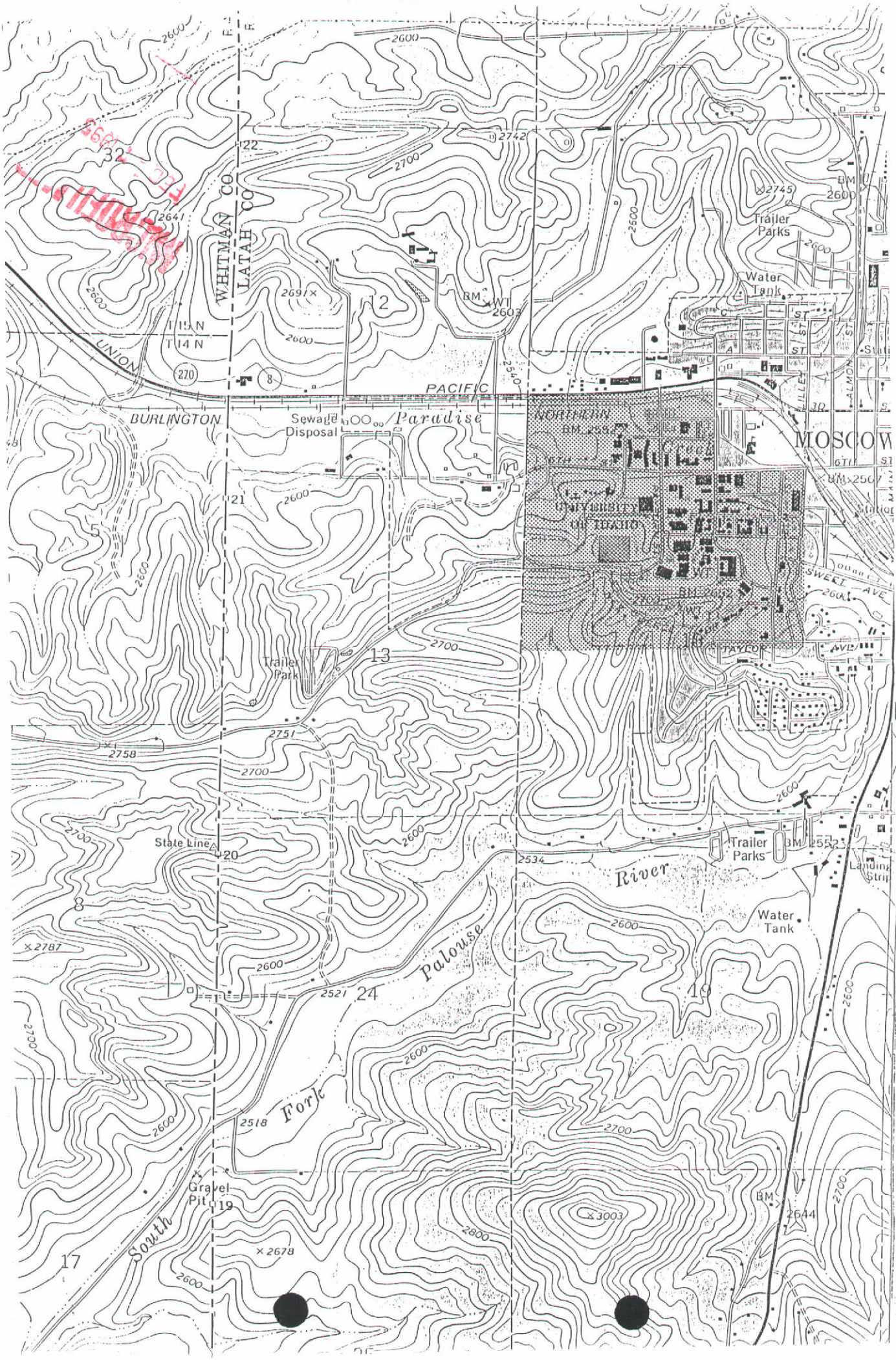
87 2018

.41 x 448 x 60 x 24 x 365 = 96,542,200

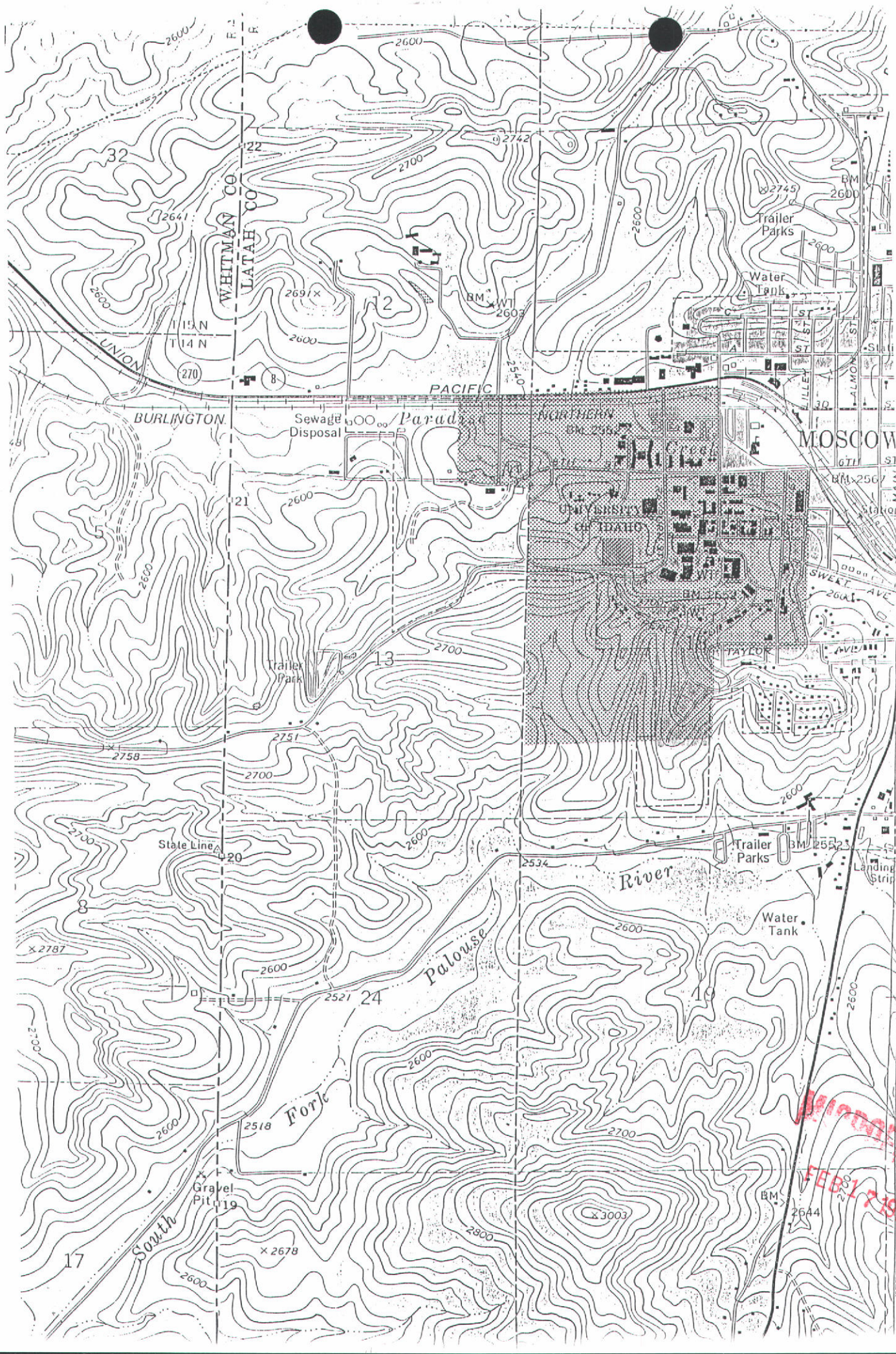
PARADISE CREEK



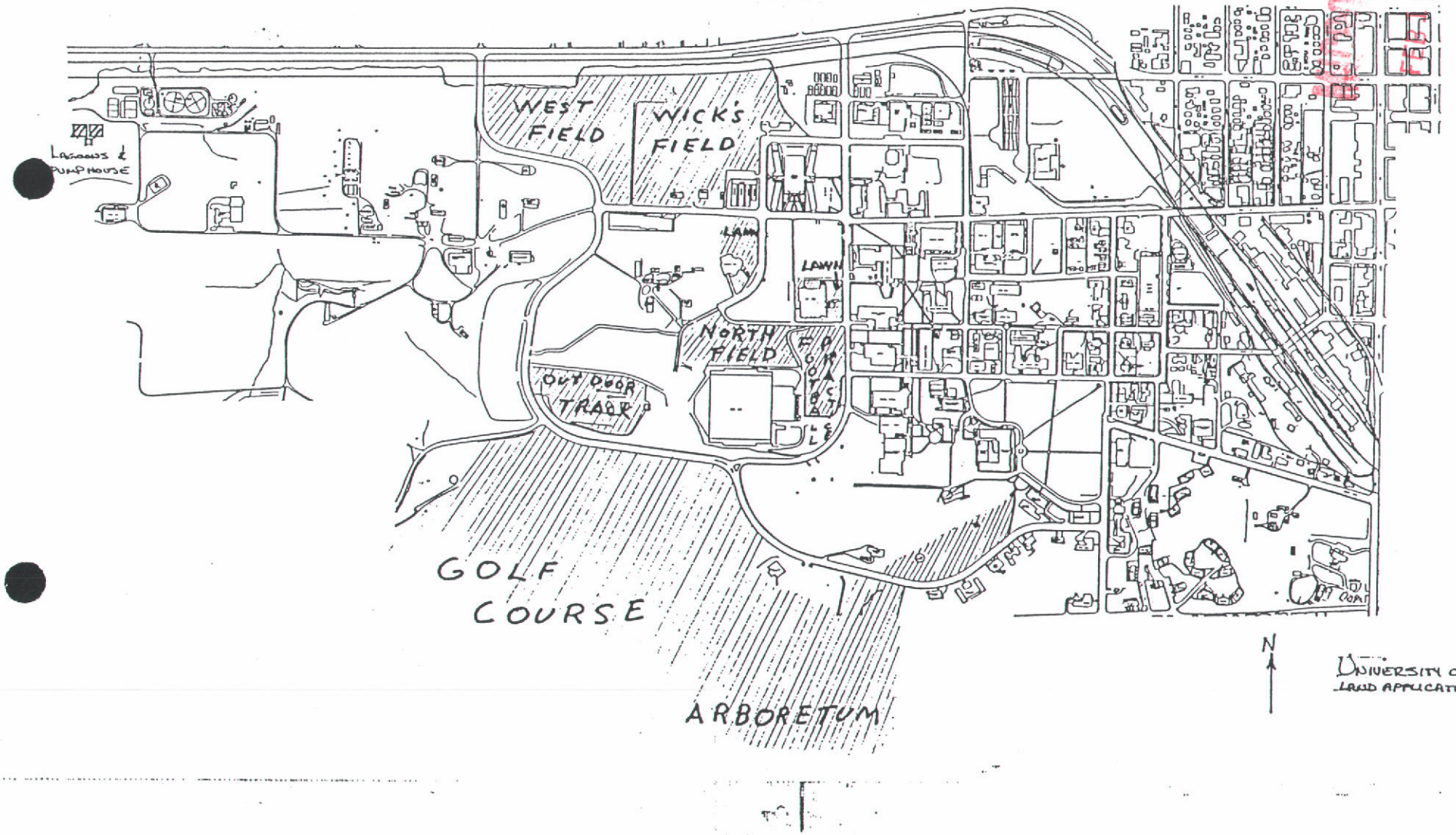
RECEIVED
FEB 17 1995



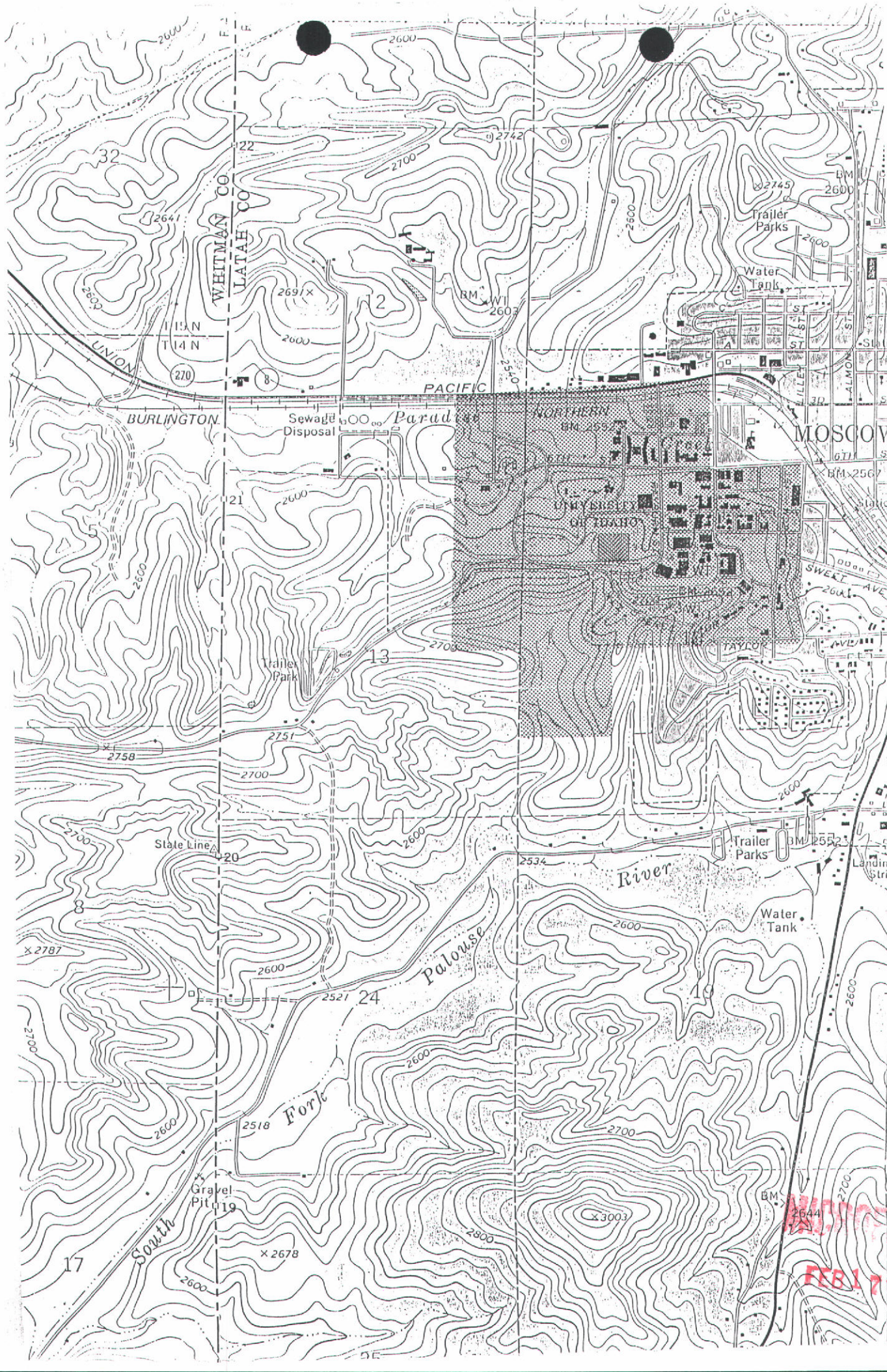
WHITMAN CO
LATAH CO
T 15 N
T 14 N
UNION
PACIFIC
BURLINGTON
NORTHERN
Sewage Disposal
Paradise
Creek
MOSCOW
UNIVERSITY OF IDAHO
Trailer Parks
Water Tank
Trailer Park
State Line
Palouse
River
South
Fork
Gravel Pit
Landing Strip
SWEET AVE
TAYLOR AVE
2600
2700
2800
2742
2745
2641
2691
2603
2540
2751
2758
2534
2787
2521
2518
2678
3003
2644



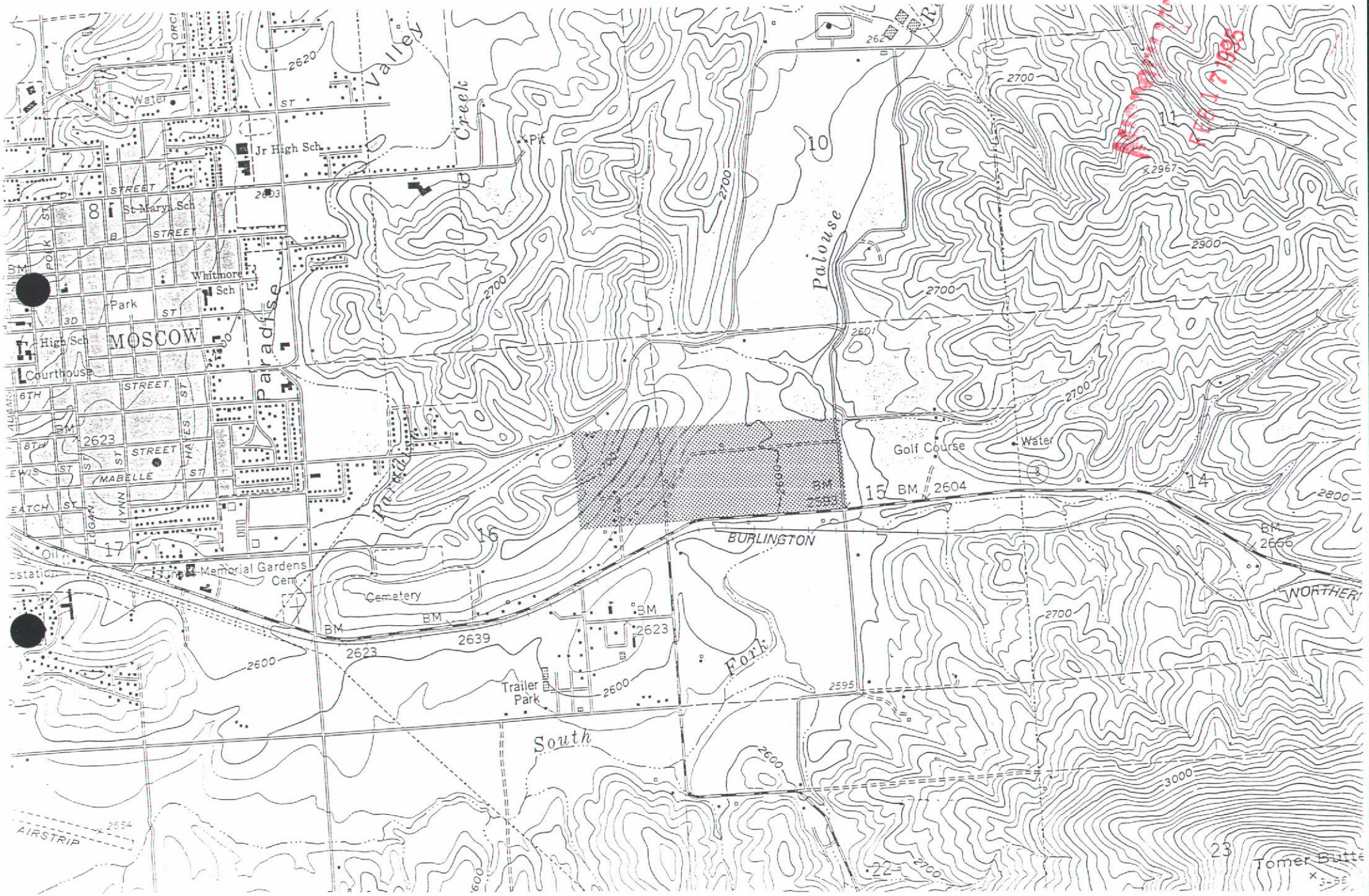
RECEIVED
FEB 27 1995



RECEIVED
FEB 7 1995

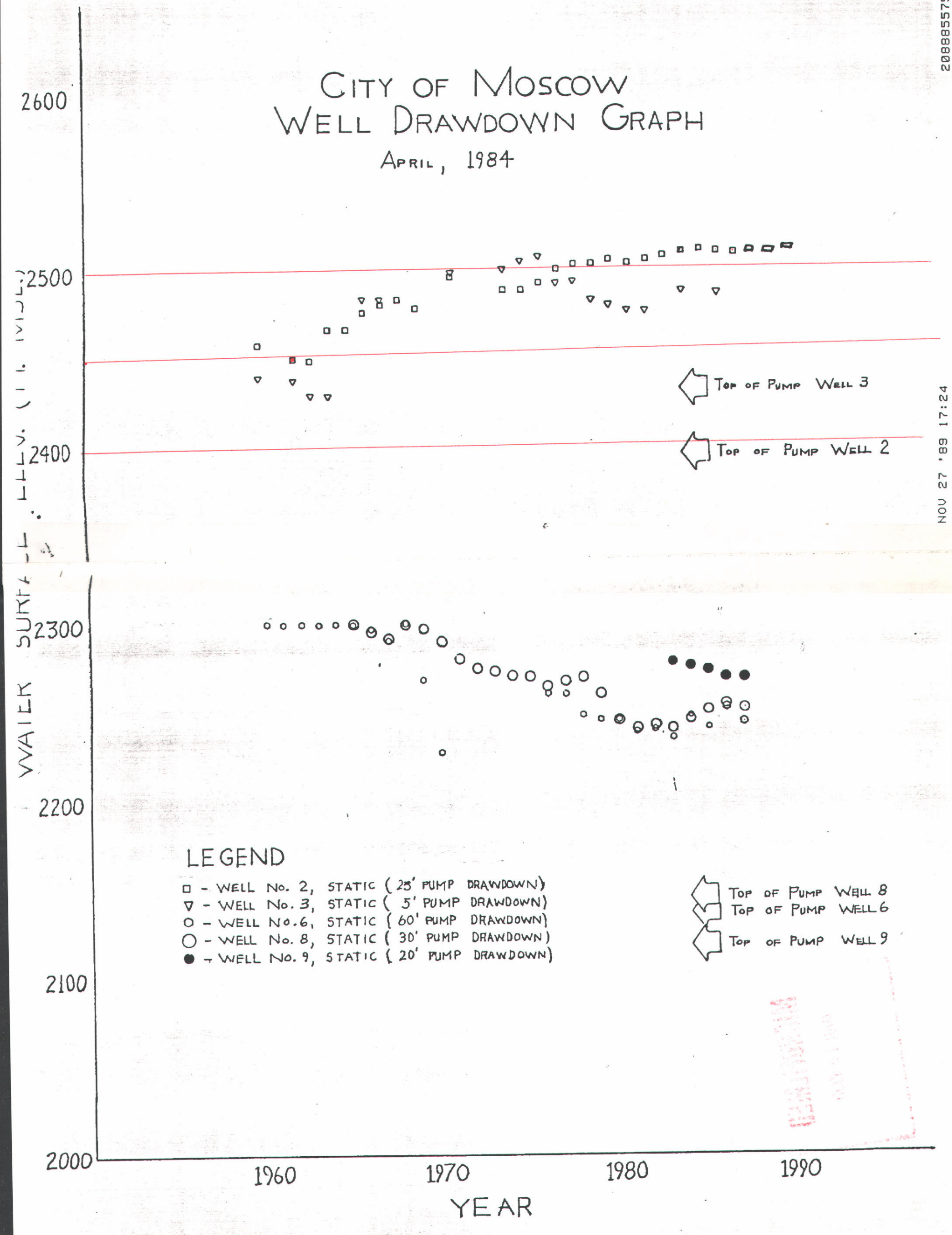

WHITMAN CO
LATAH CO
T 15 N
T 14 N
UNION PACIFIC
BURLINGTON NORTHERN
Sewage Disposal
Paradise
MOSCOW
UNIVERSITY OF IDAHO
Trailer Parks
Water Tank
Trailer Park
State Line
Palouse River
South Fork
Palouse
Gravel Pit
Landing Strip
BM 2600
BM 2552
BM 2644
WI 2603
2742
2745
2691
2787
2678
3003
2758
2751
2534
2521
2518
2540
32
22
12
21
13
20
8
24
19
17
5
SWEET AVE
TAYLOR
6TH ST

FEB 17 1995


Water
Jr High Sch
Pit
Creek
Valley
Paradise
Palouse
St Marys Sch
Whitmore Sch
Park
High Sch
MOSCOW
Courthouse
STREET
MABELLE
Golf Course
Water
BM 2604
BM 2666
BURLINGTON
Memorial Gardens Cem
Cemetery
BM 2623
BM 2639
Trailer Park
South
Fork
AIRSTRIP
Tomer Butte
2700
2600
2800
2900
3000
2595
2601
2967
10
11
14
15
16
17
22
23

2088855752 PAGE.003

CITY OF MOSCOW
WELL DRAWDOWN GRAPH
APRIL, 1984



NOV 27 '89 17:24

2088855752 PAGE.004

NOV 27 '89 17:25

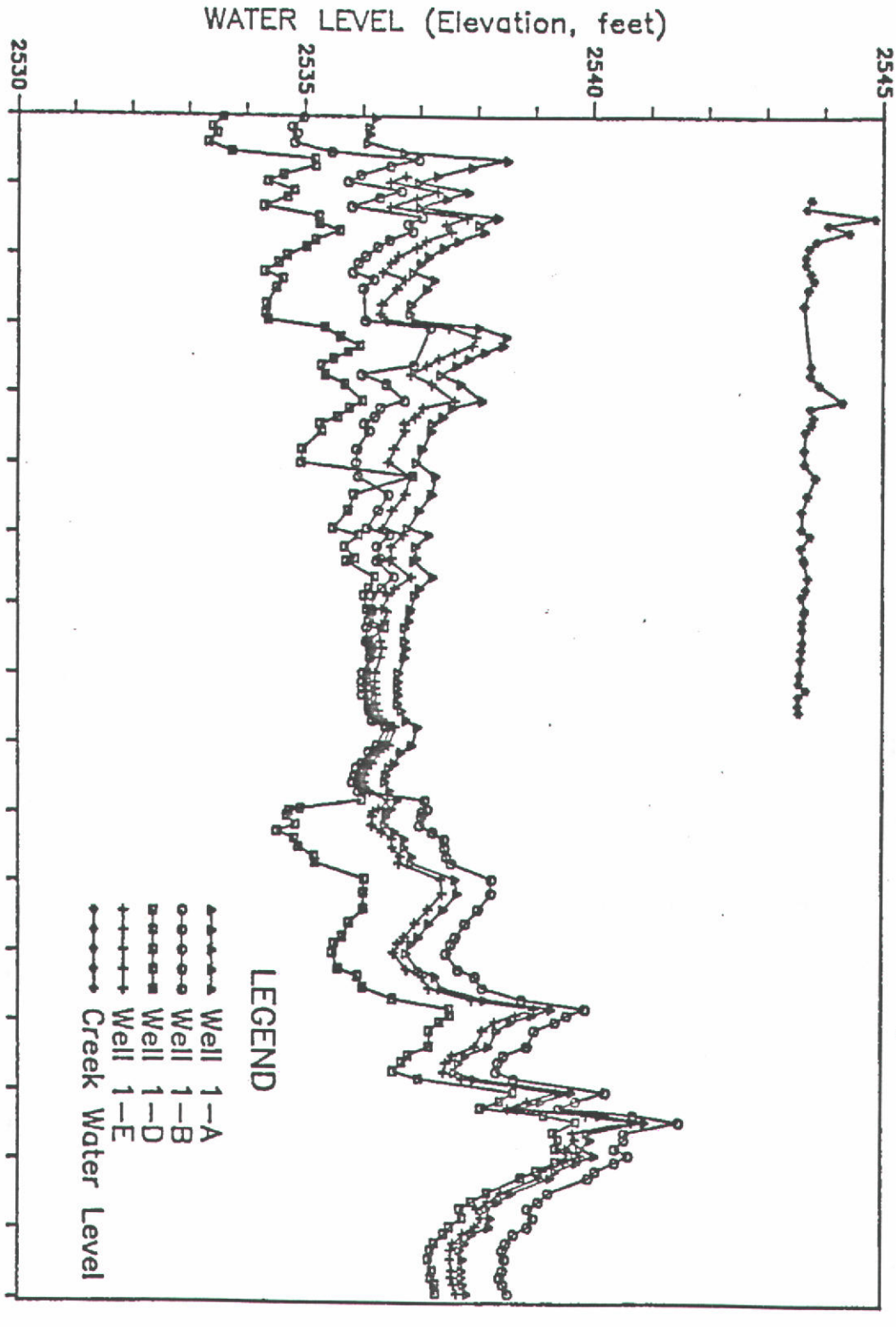


Figure 5. Water Level Records for Wells 1-A, 1-B, 1-D and 1-E Plus the Stage of Paradise Creek, GRS

MICROFILMED
MAR 1 9 1990

HYDROGEOLOGY AND A MATHEMATICAL MODEL OF GROUND-WATER FLOW IN THE PULLMAN-MOSCOW REGION, WASHINGTON AND IDAHO

by

John Leach Smoot
Dale R. Ralston

Department of Geology

MICROFILMED
MAR 19 1990

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho 83843

April, 1987

Applicants Exhibit 4
Admitted

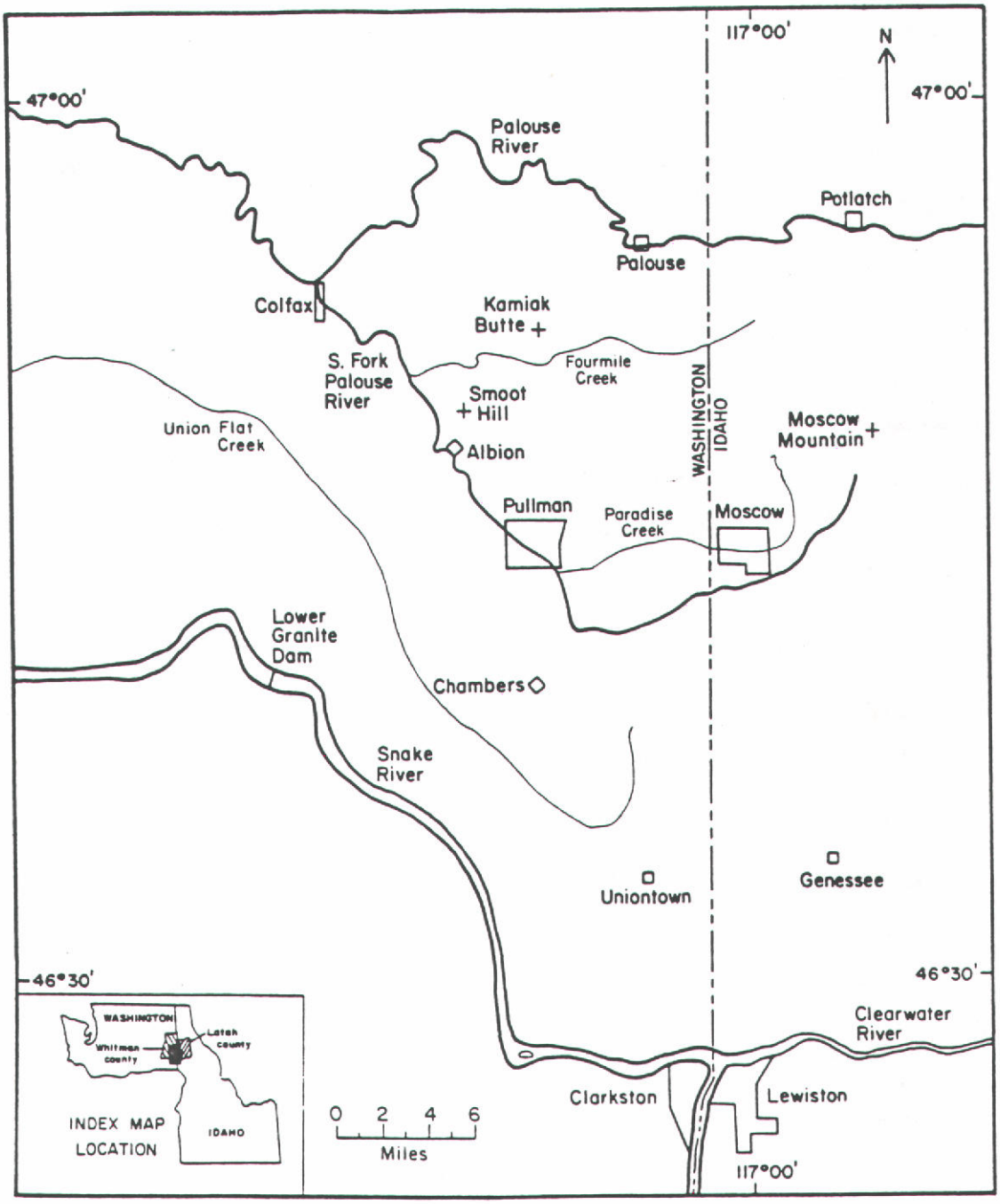


Figure 1. Location of Pullman-Moscow region.

MICROFILMED
MAR 19 1990

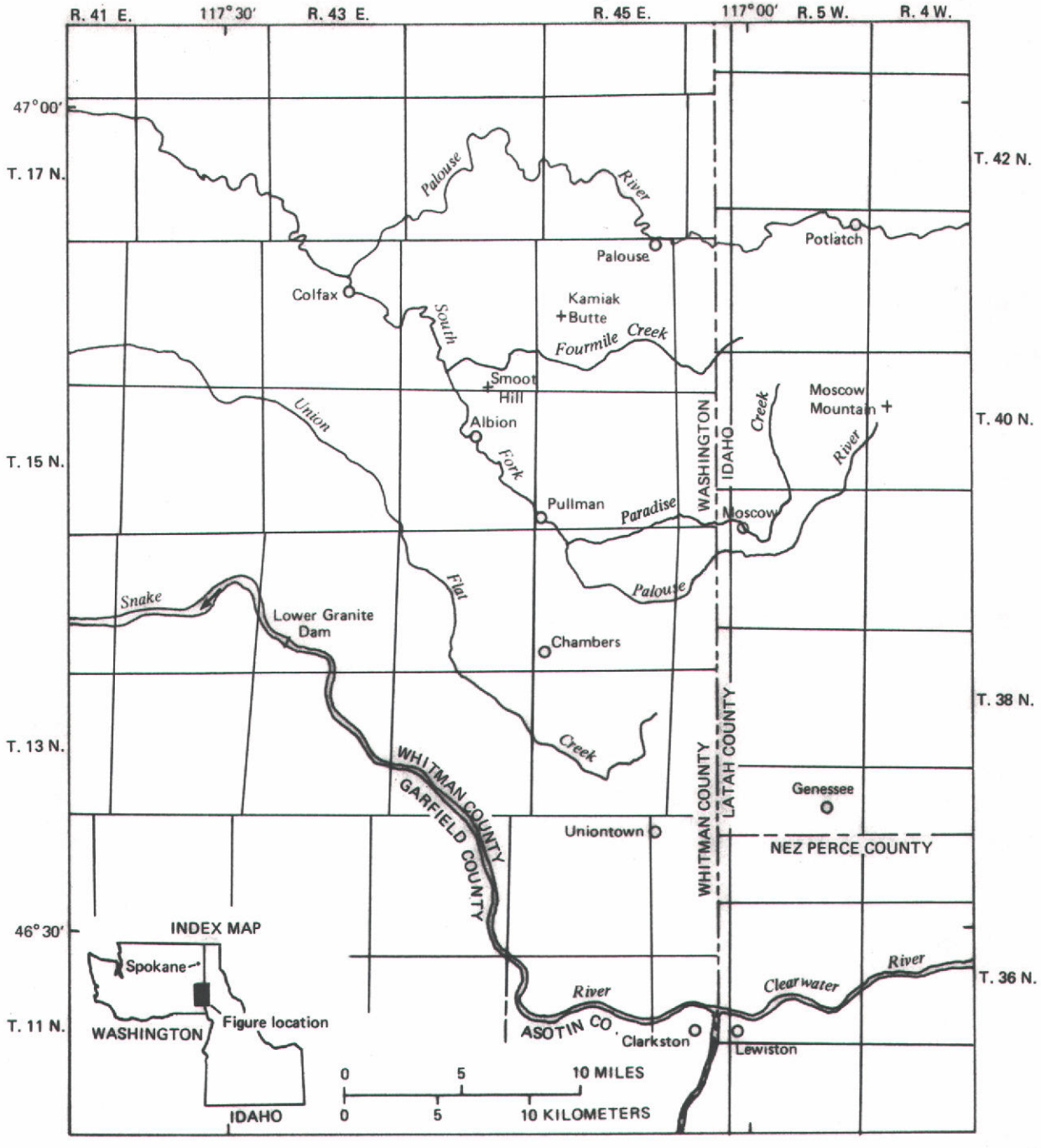


Figure 2.--Location of Pullman-Moscow area.

MICROFILMED
MAR 19 1990

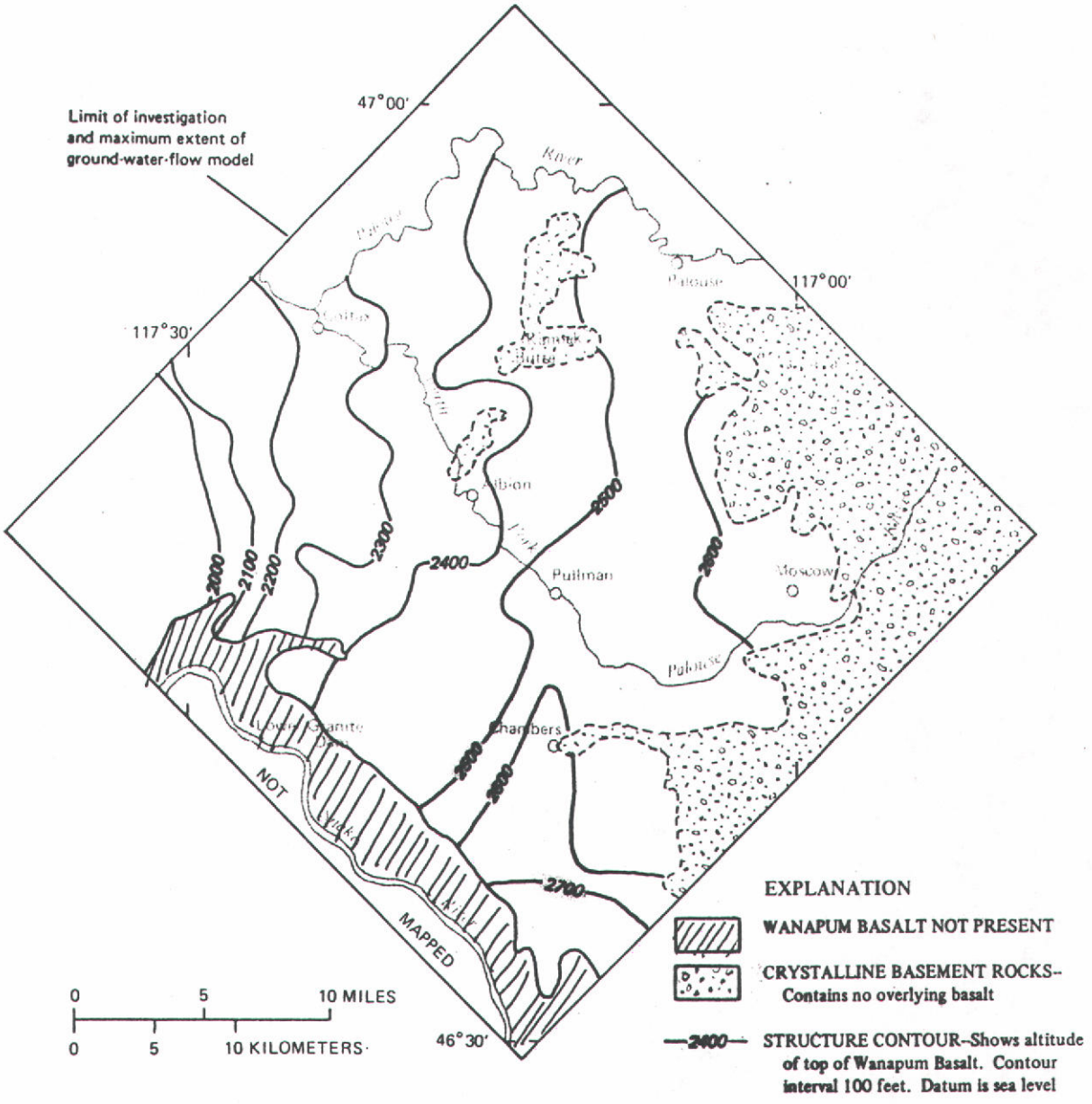


Figure 4.--Altitude of the top of the Wanapum Basalt.

MICROFILMED
MAR 19 1990

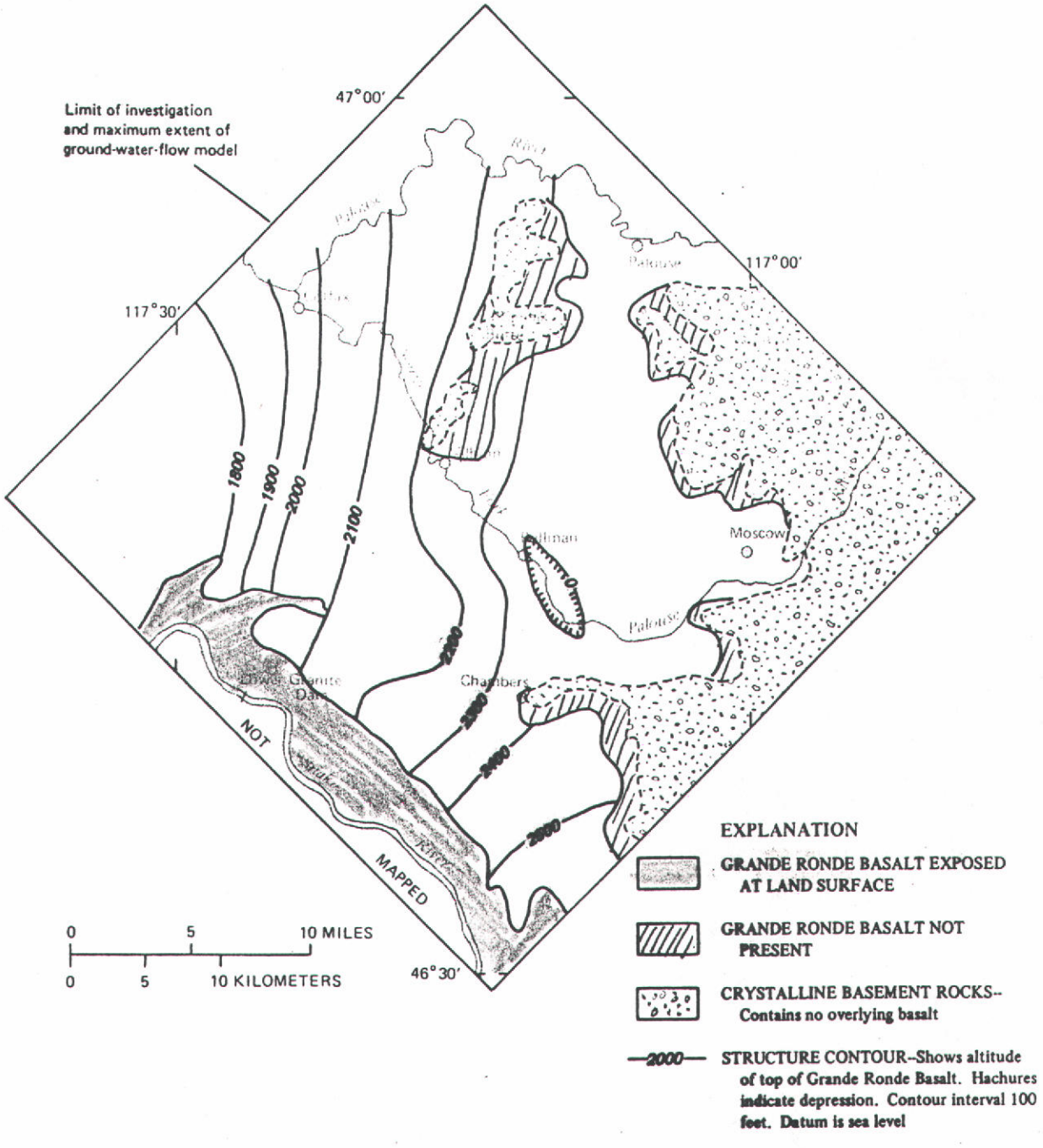


Figure 5.--Altitude of the top of the Grande Ronde Basalt.

MICROFILMED
MAR 19 1990

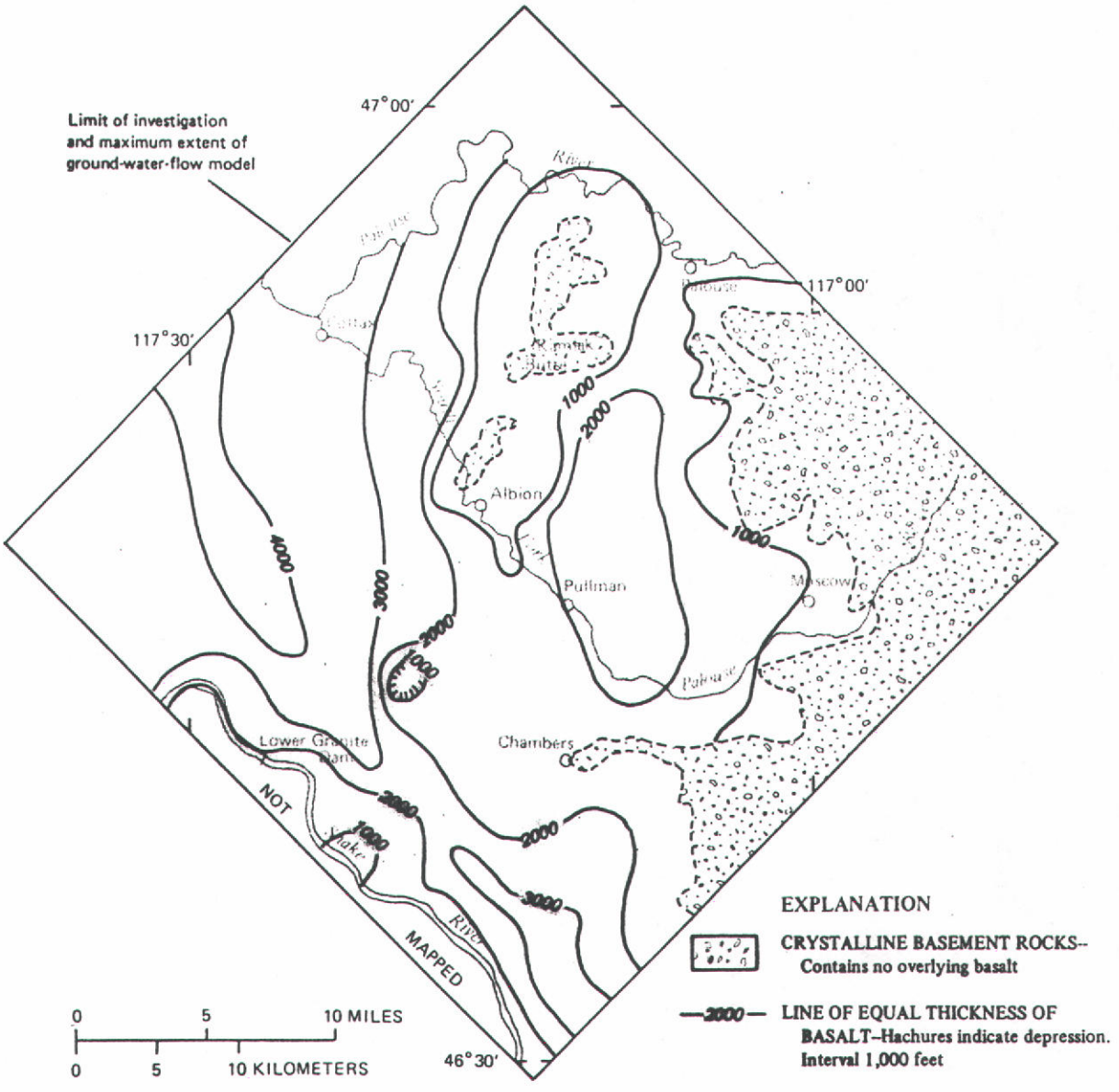


Figure 6.–Thickness of the basalt (modified from Klein and others, 1987).

MICROFILMED
MAR 1 9 1990

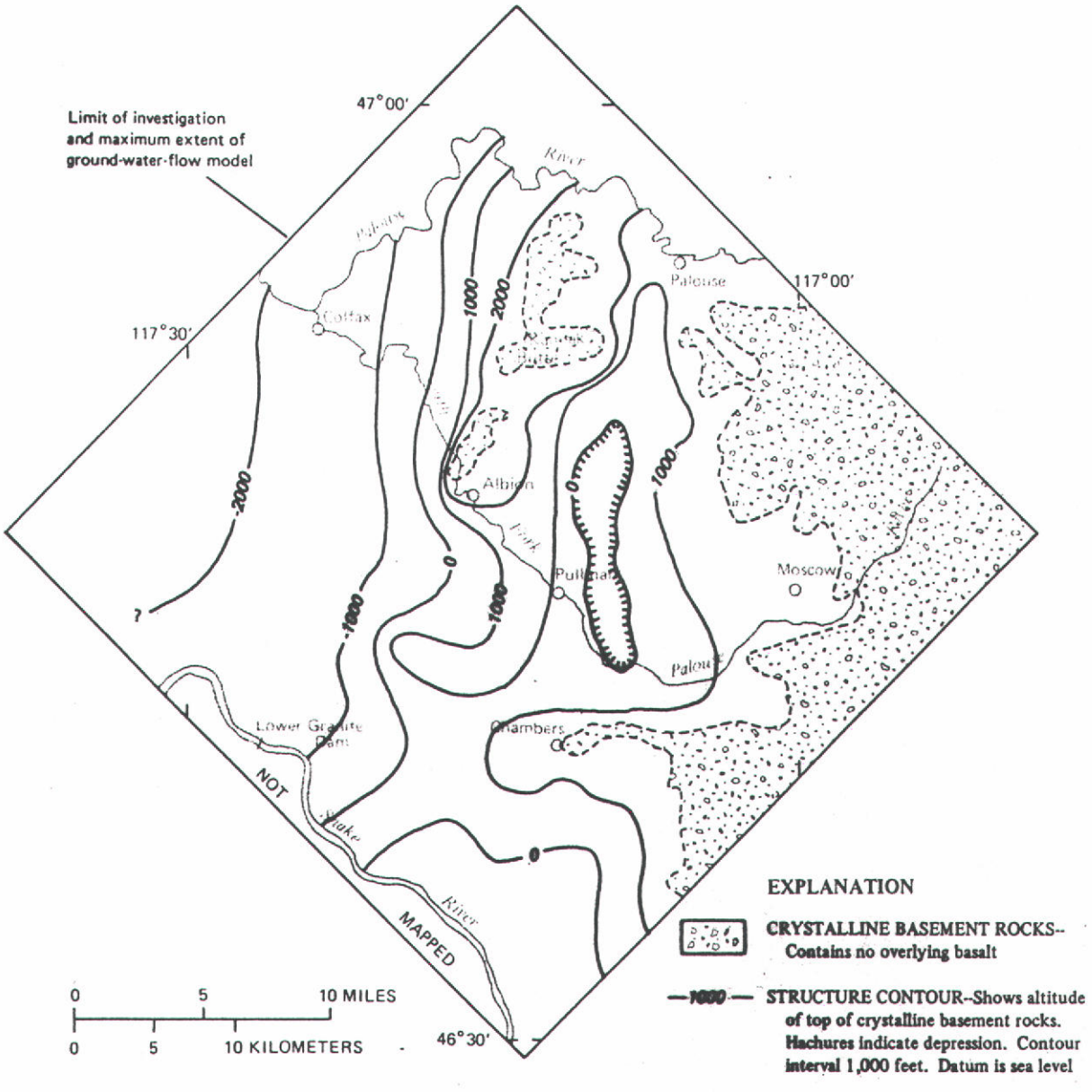


Figure 7.--Altitude of the top of the crystalline basement rocks.

MICROFILMED
MAR 19 1990

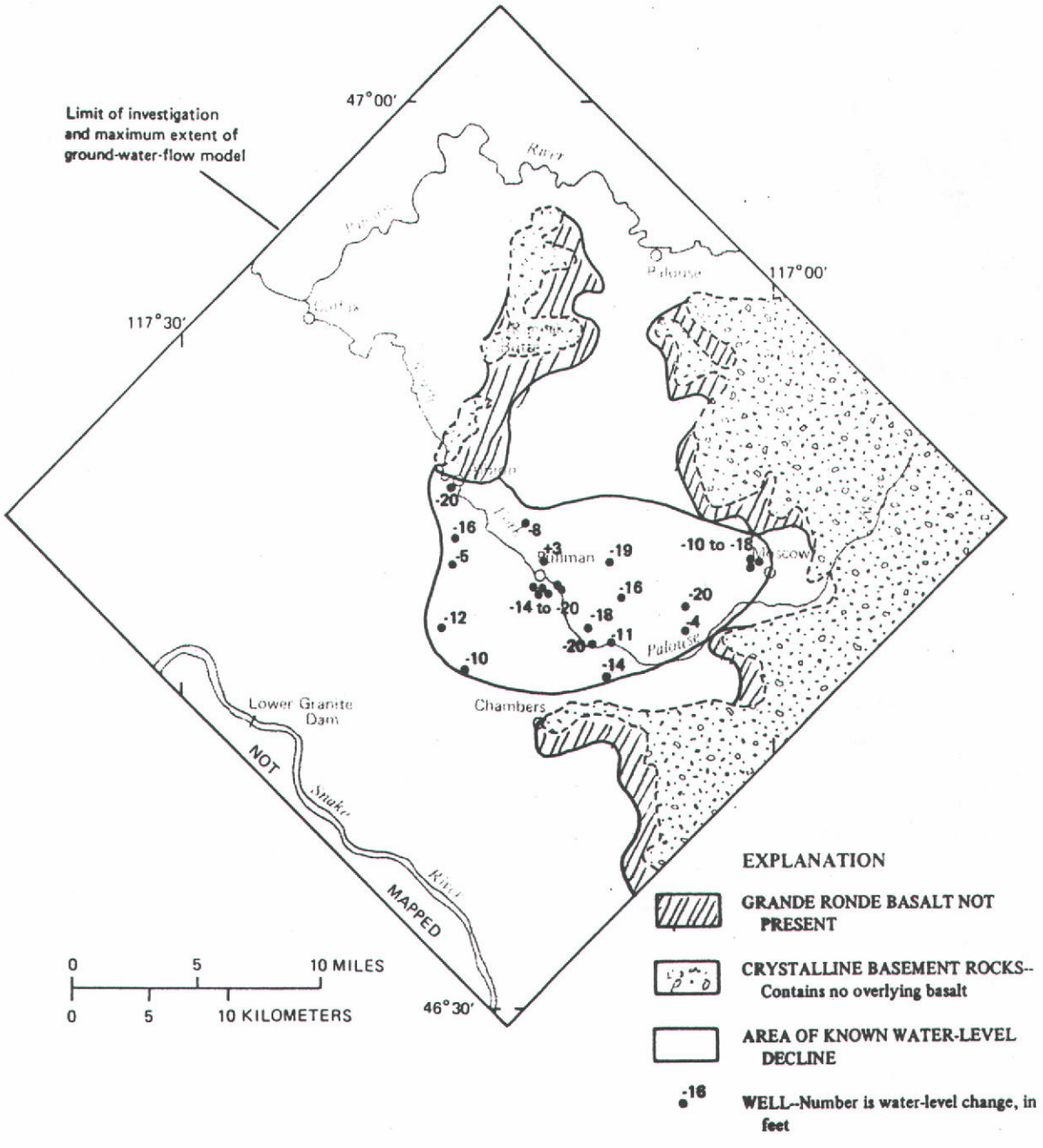


Figure 11.--Water-level changes in the Grande Ronde Basalt, 1974-1985.

MICROFILMED
MAR 19 1990

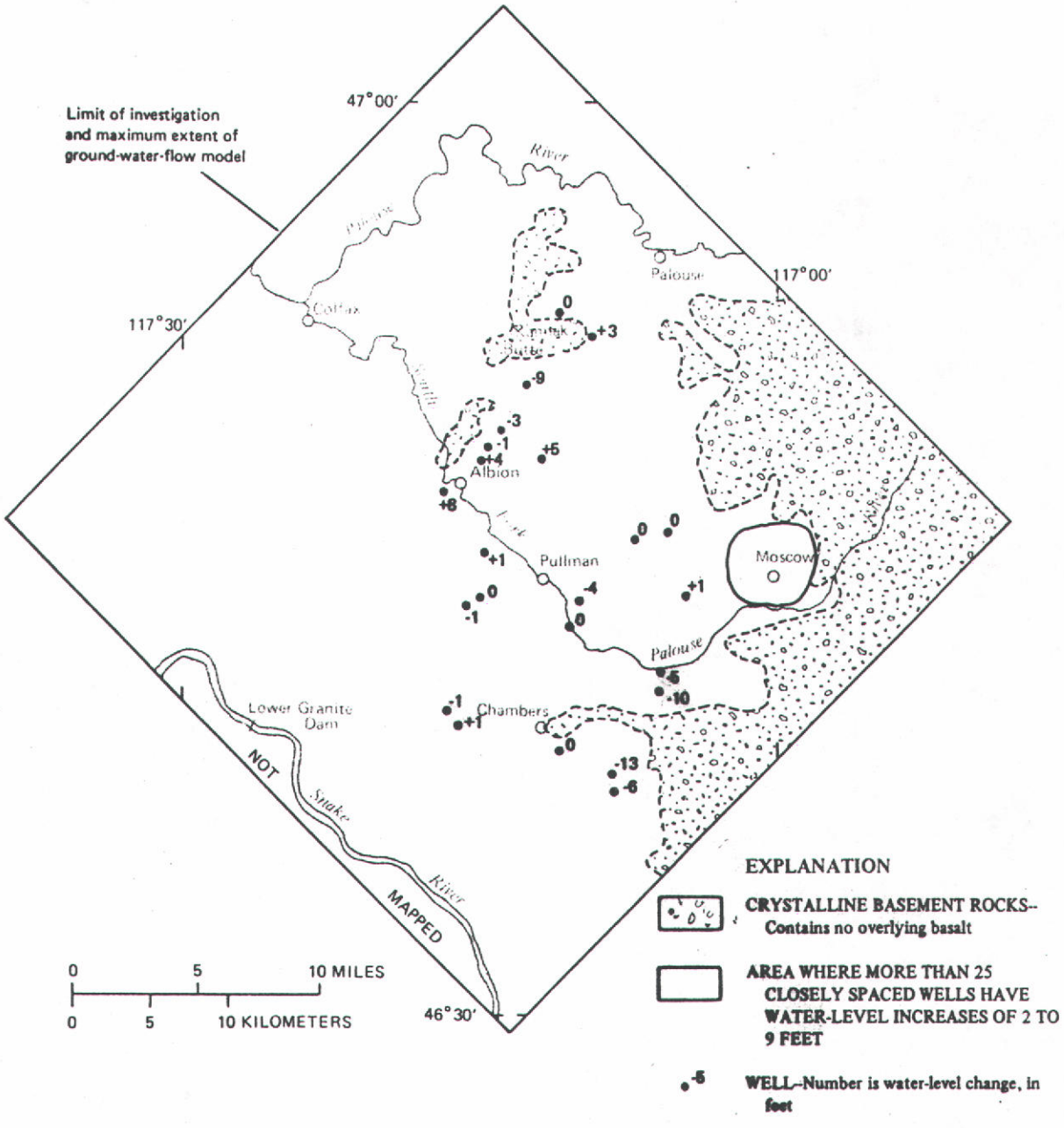


Figure 12.--Water-level changes in the Wanapum Basalt, 1974-1985.

MICROFILMED
MAR 19 1990

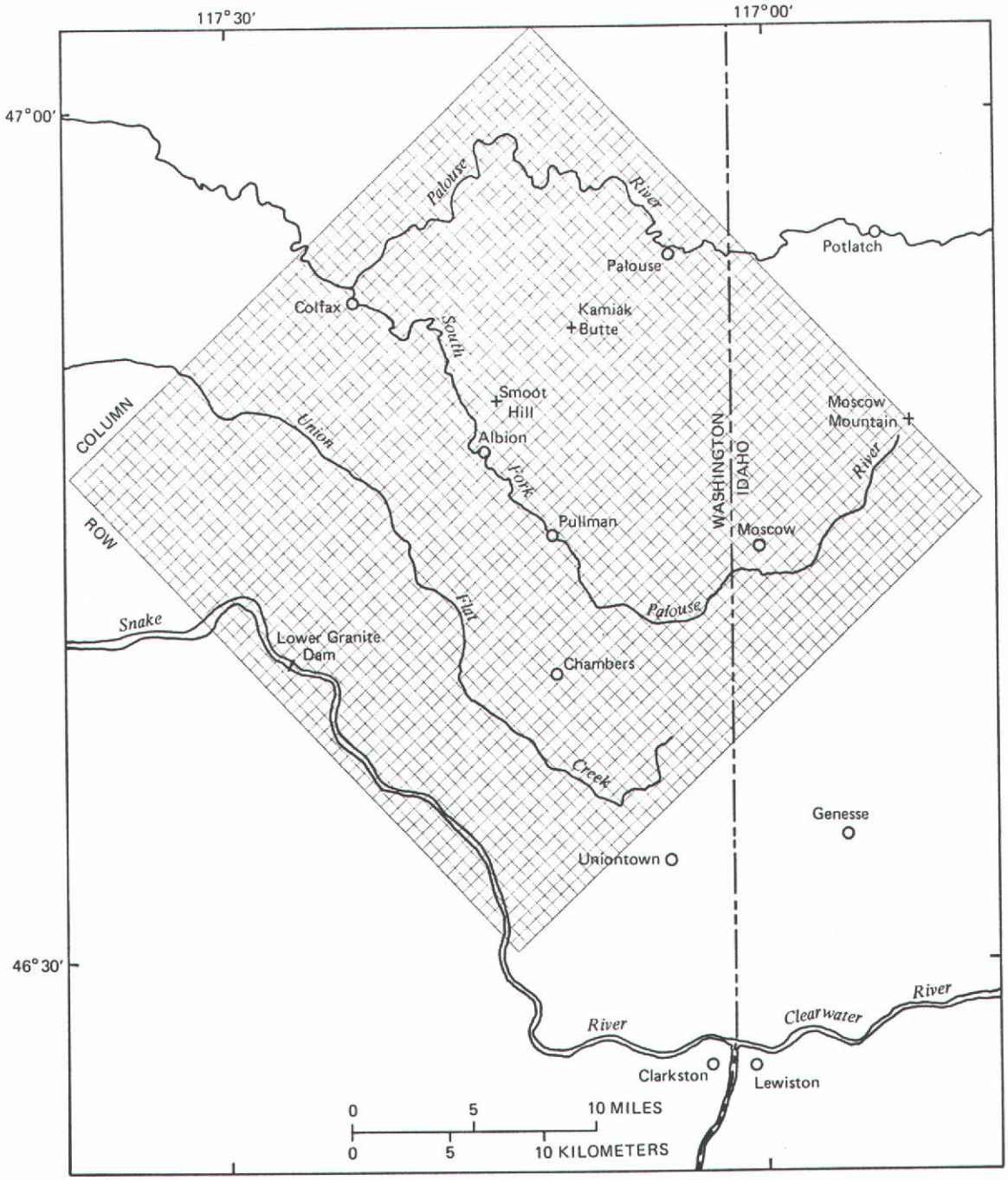


Figure 13.--Location and orientation of the modeled area.

MICROFILMED
MAR 19 1990

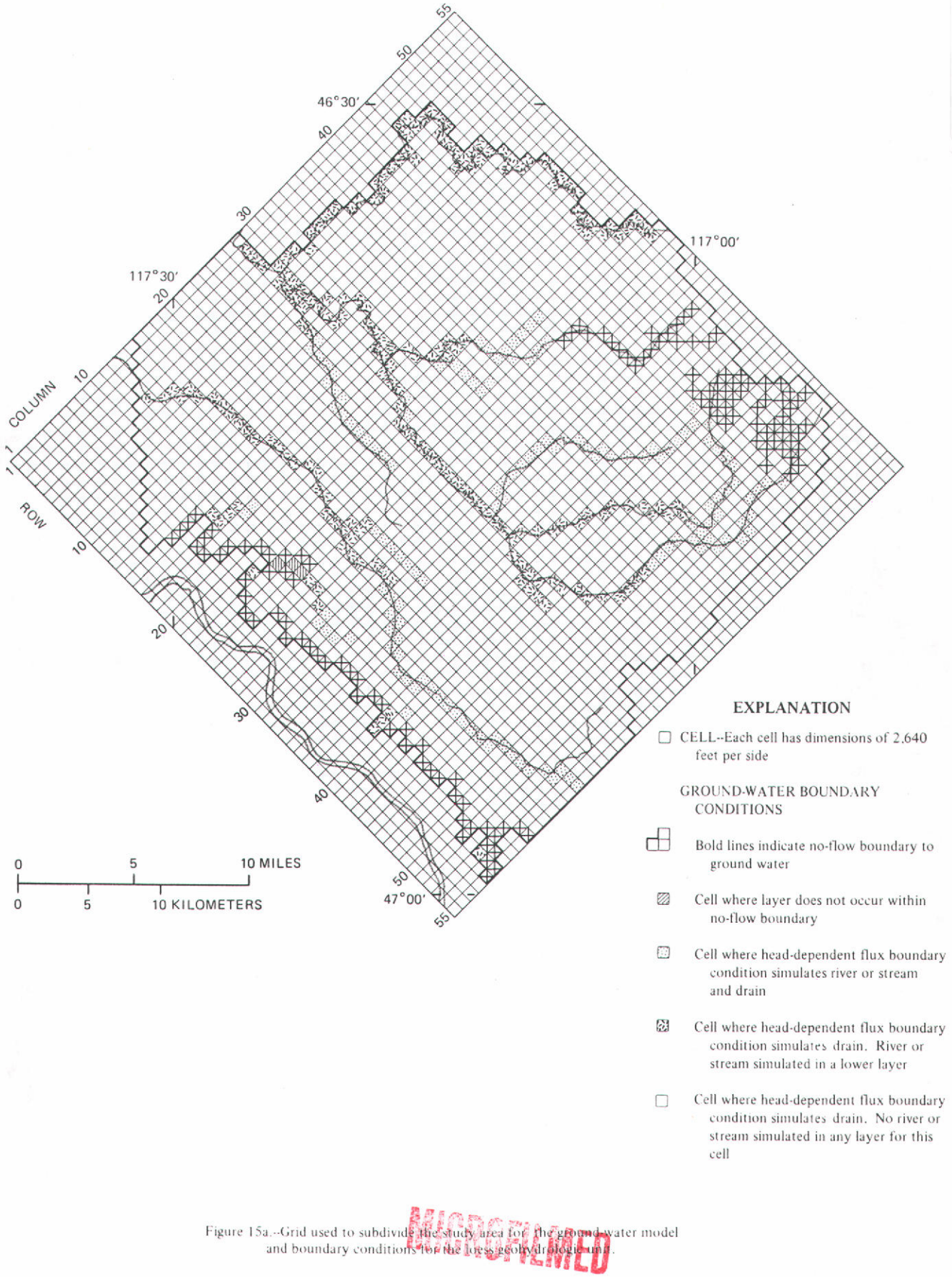


Figure 15a.--Grid used to subdivide the study area for the ground-water model and boundary conditions for the loess geohydrologic unit.

MICROFILMED
MAR 19 1990

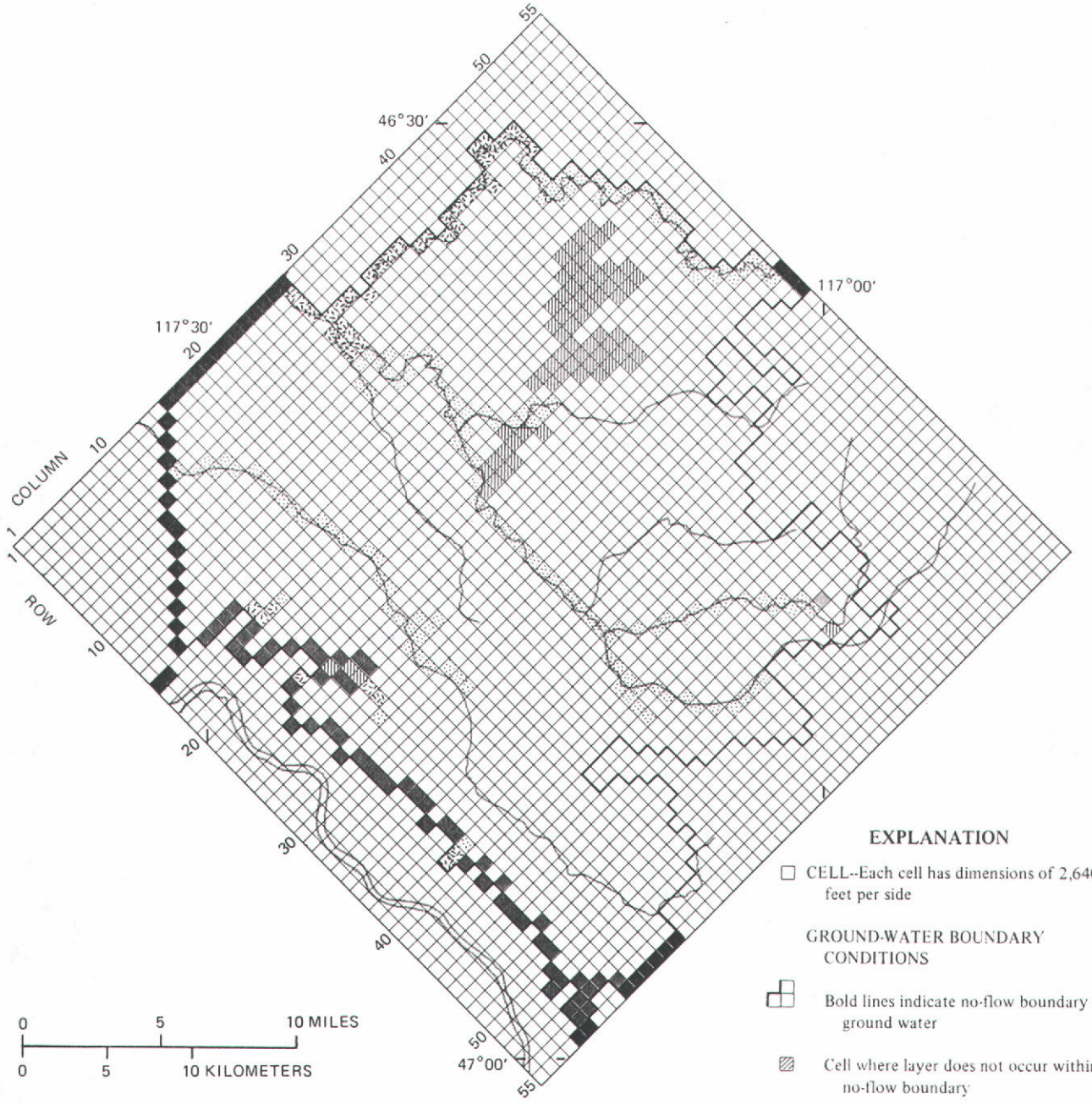


Figure 15b.--Grid used to subdivide the study area for the ground-water model and boundary conditions for the Wanapum geohydrologic unit.

MICROFILMED
MAR 19 1990

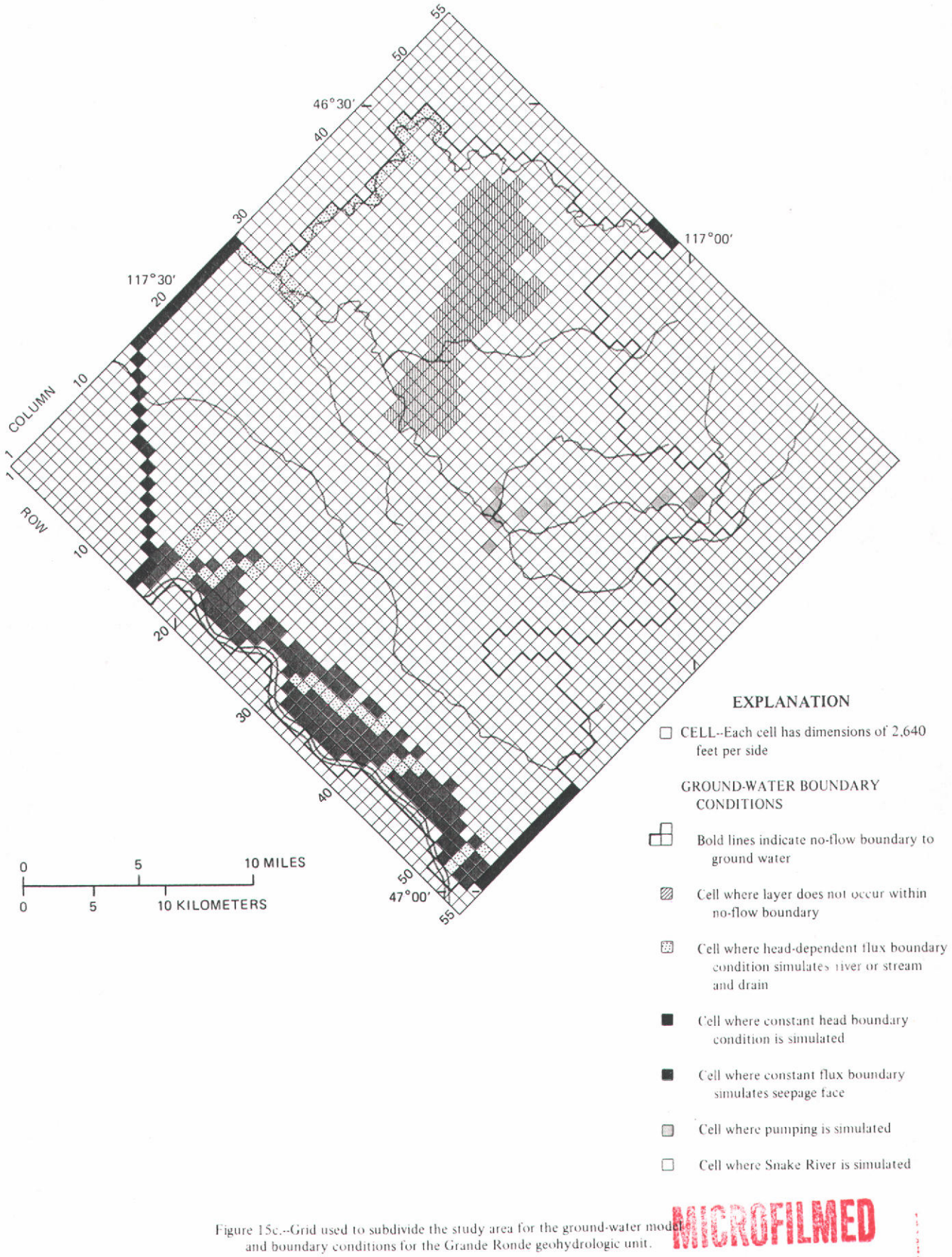


Figure 15c.--Grid used to subdivide the study area for the ground-water model and boundary conditions for the Grande Ronde geohydrologic unit.

MICROFILMED
MAR 19 1990

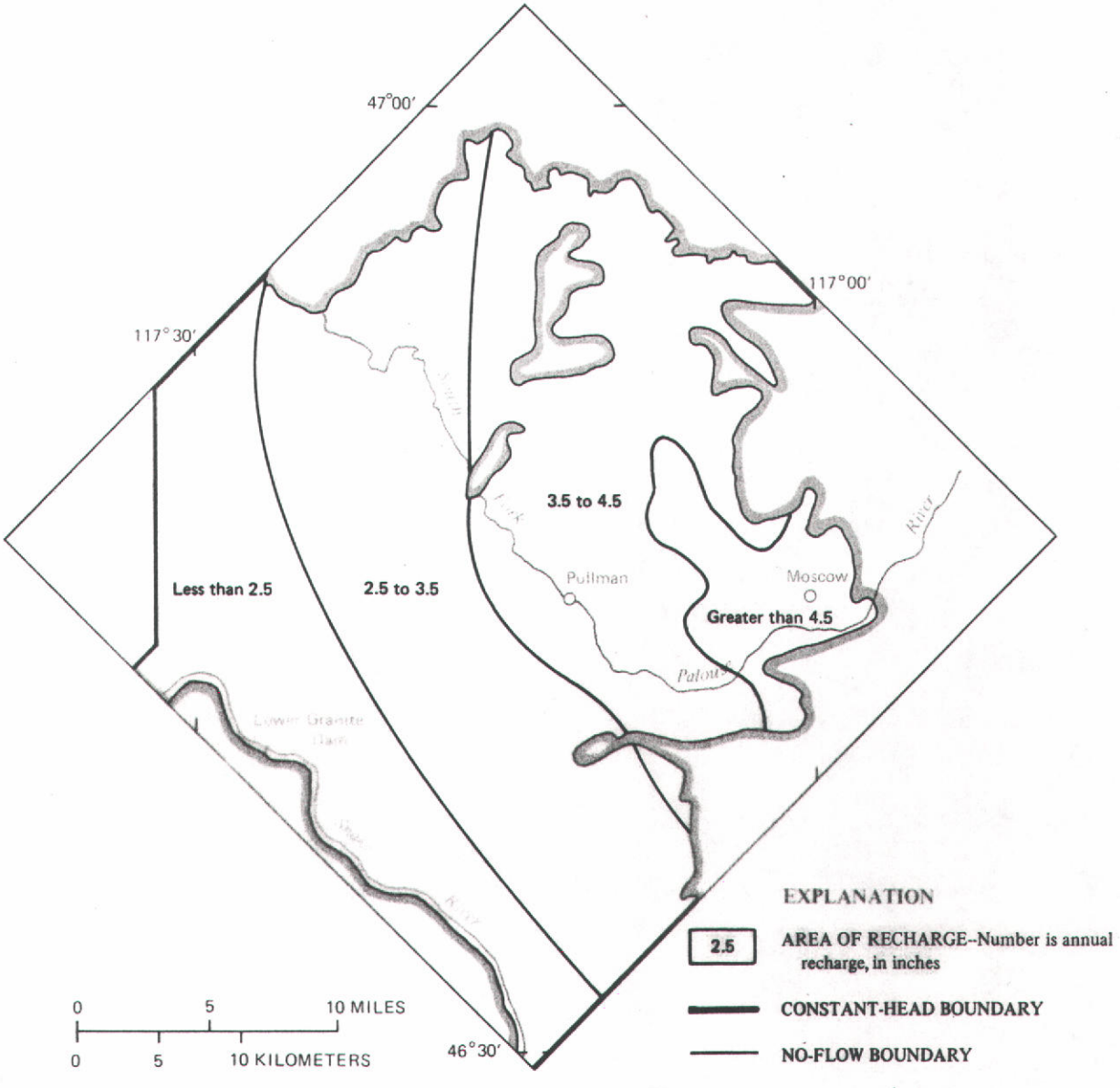


Figure 16a.--Areal distribution of recharge to the three-dimensional ground-water-flow model based on predevelopment conditions

MICROFILMED
MAR 19 1990

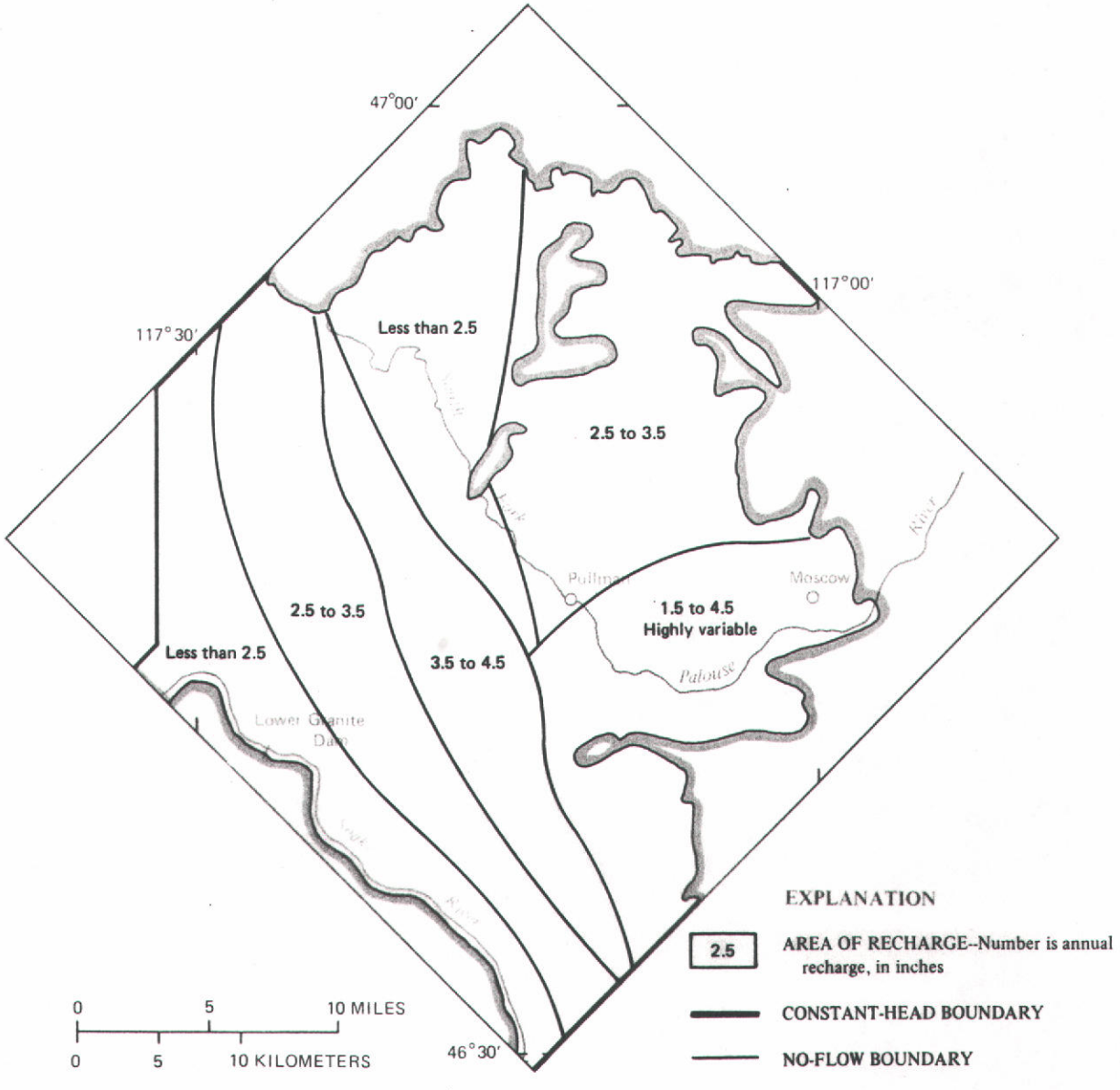


Figure 16b.--Areal distribution of recharge to the three-dimensional ground-water-flow model based on current land use and farming practices.

MICROFILMED
MAR 19 1990

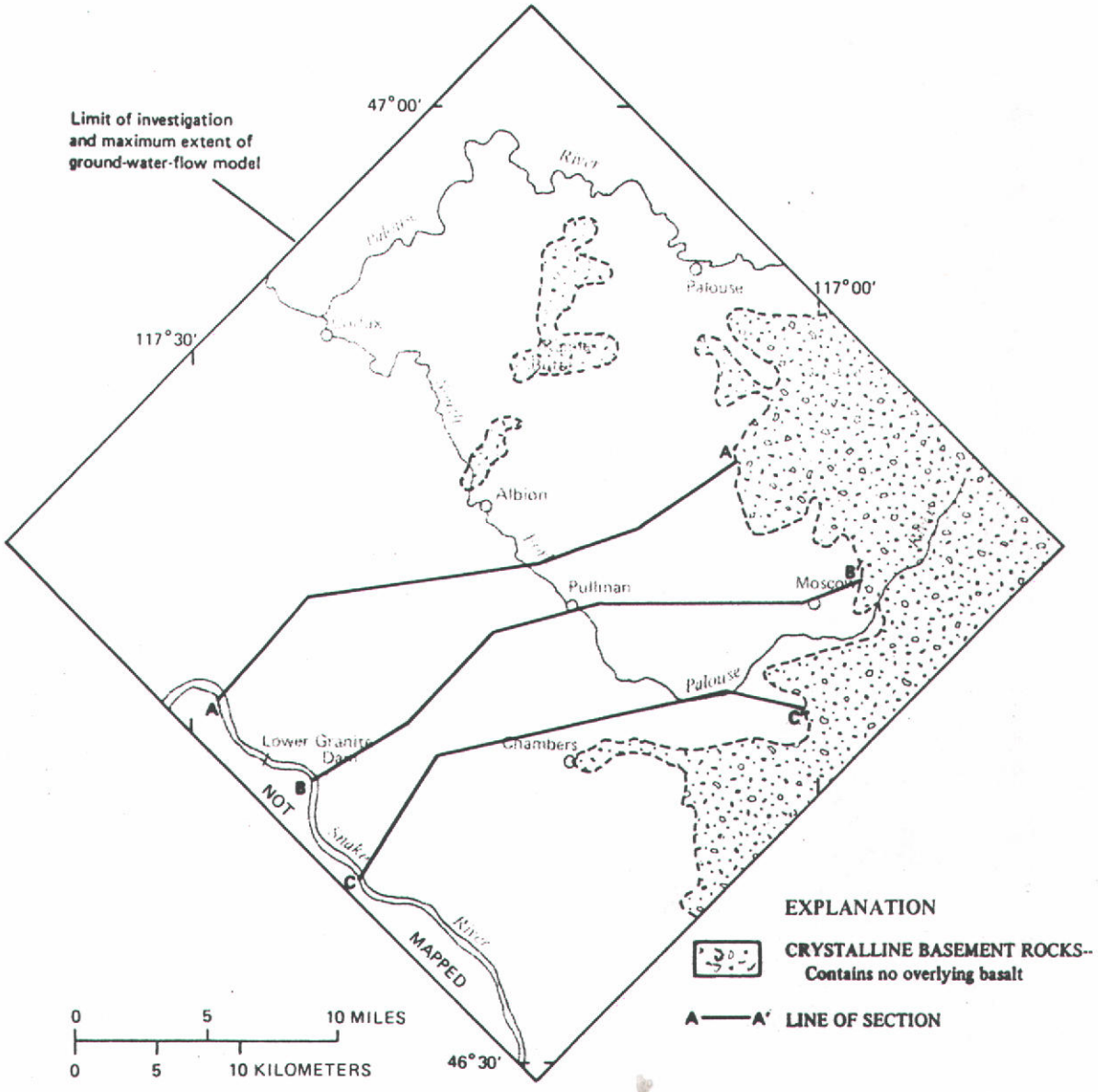


Figure 17.--Location of cross-sectional models in the domain of the three-dimensional model.

MICROFILMED
MAR 19 1990

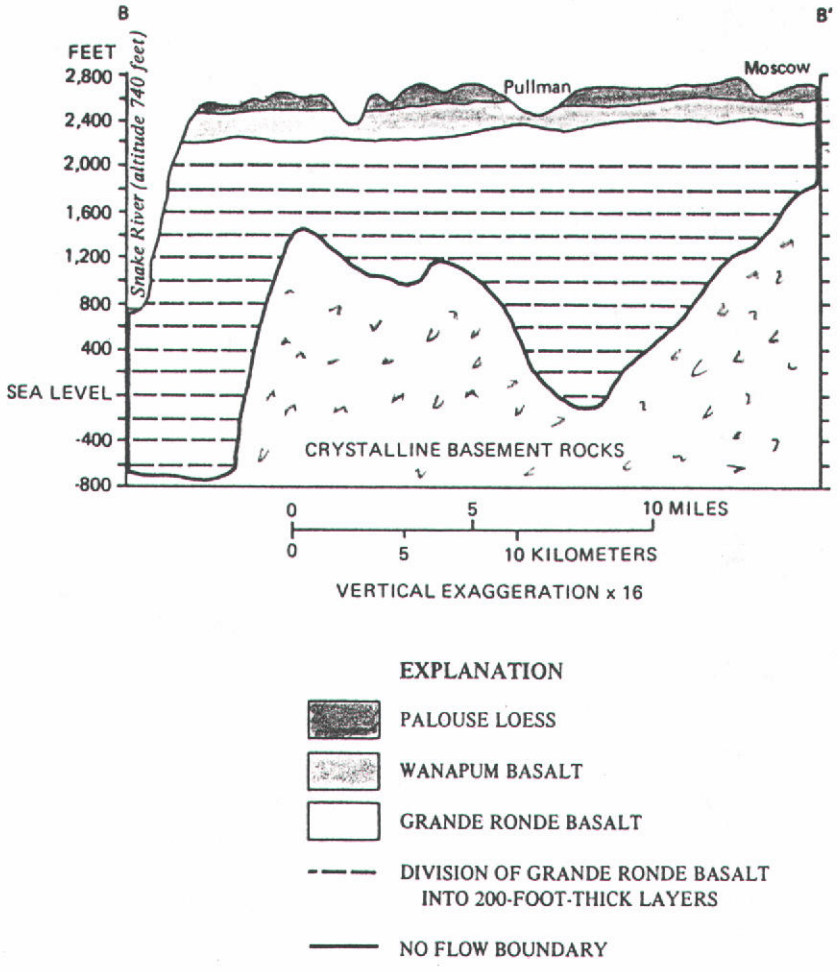
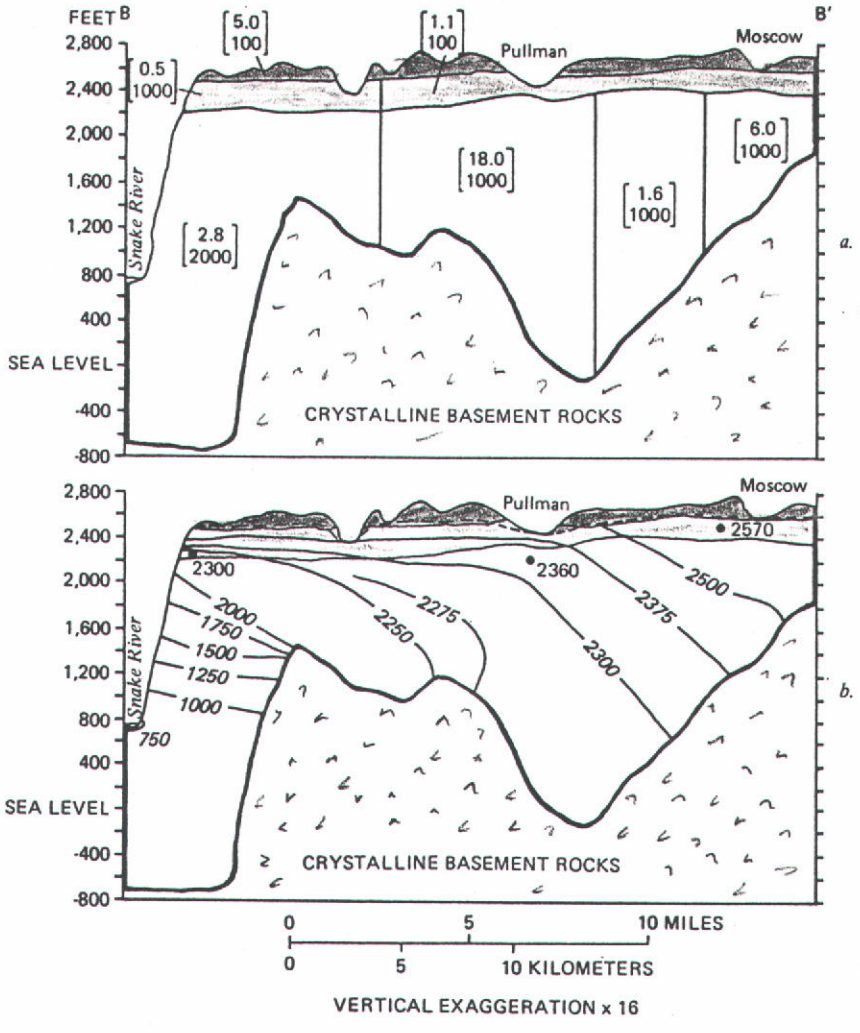


Figure 18.--Diagrammatic sketch of cross-sectional model B-B', showing layering.

MICROFILMED
MAR 19 1990



EXPLANATION

PALOUSE LOESS

WANAPUM BASALT

GRANDE RONDE BASALT

[0.5 / 1000] ZONES OF CALIBRATED HYDRAULIC CONDUCTIVITY--Upper number is horizontal hydraulic conductivity, in feet per day. Lower number is ratio of horizontal to vertical hydraulic conductivity, anisotropy

—1500— WATER-LEVEL CONTOUR--Shows altitude of calculated hydraulic head. Contour interval in feet, is variable. Datum is sea level

•2360 MEASURED WATER-LEVEL SITE--Number is altitude in feet above sea level

NO-FLOW BOUNDARY

WATER TABLE

Figure 19.--Calibrated cross-sectional model B-B': a) calibrated hydraulic conductivity distribution, b) calibrated hydraulic head distribution.

MICROFILMED
MAR 19 1990

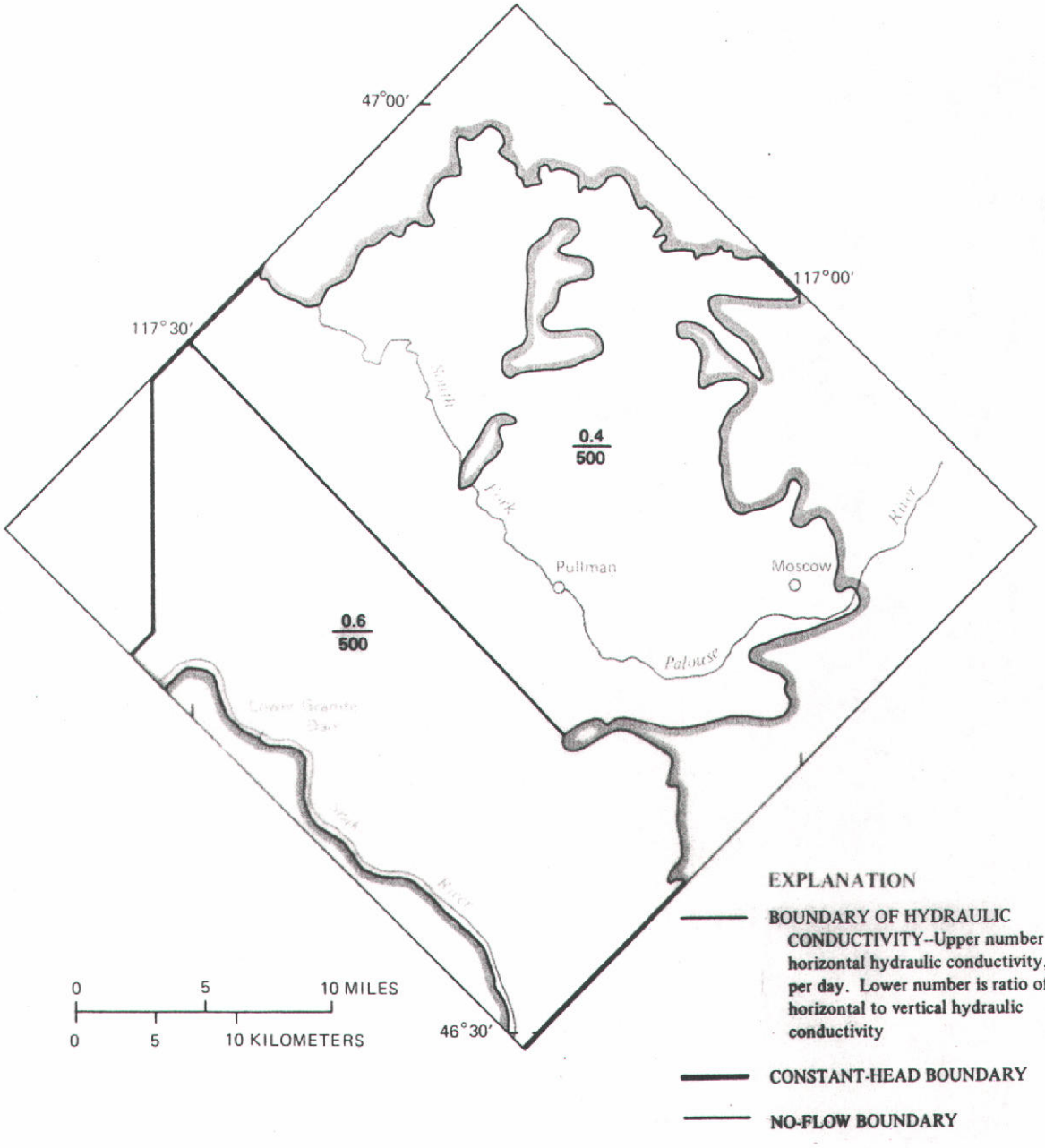


Figure 20.--Distribution of horizontal hydraulic conductivity and ratio of horizontal to vertical hydraulic conductivity for the Wanapum geohydrologic unit. Based on the cross-sectional model calibration and the time-averaged three-dimensional model calibration.

MICROFILMED
MAR 19 1990

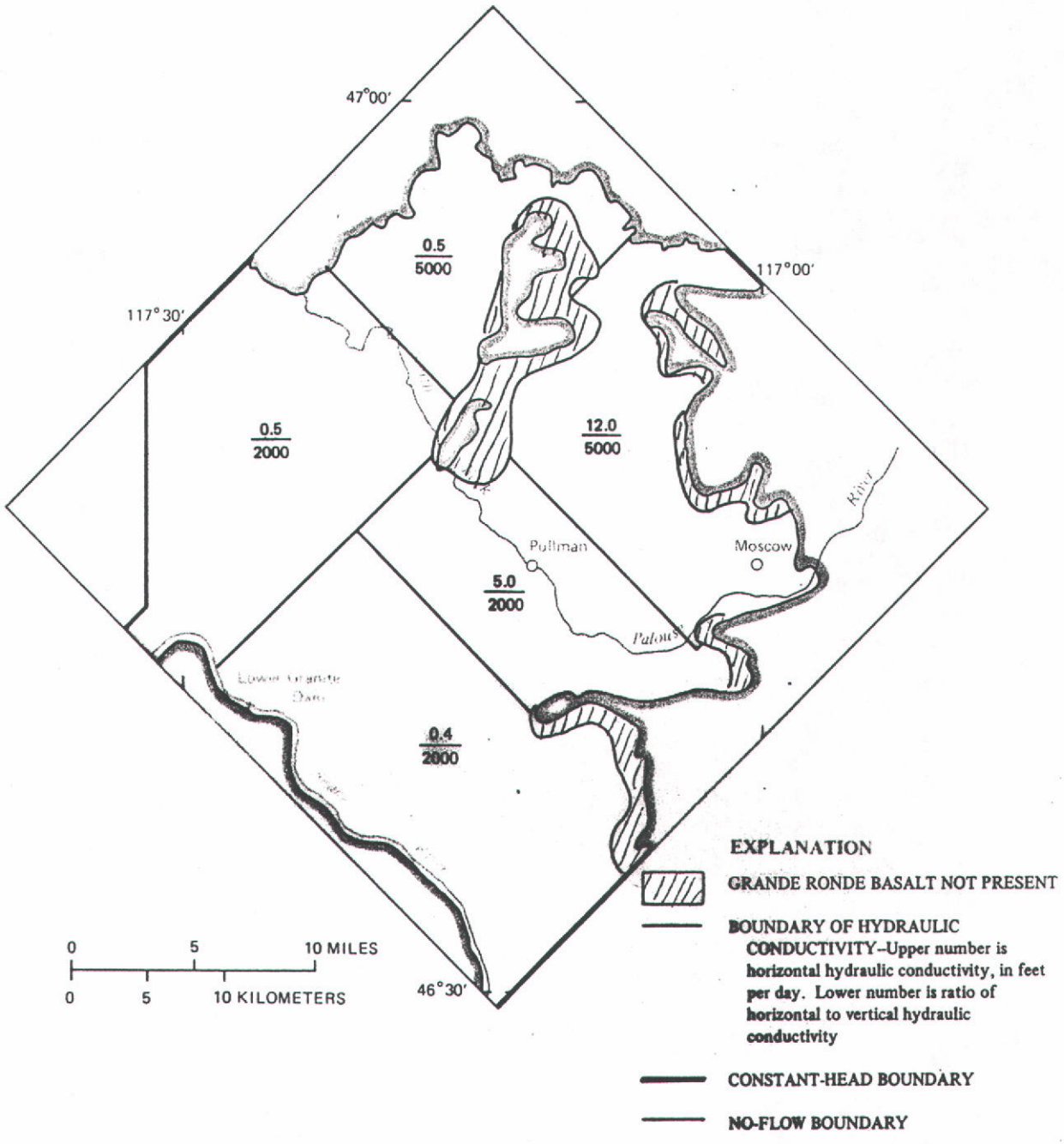
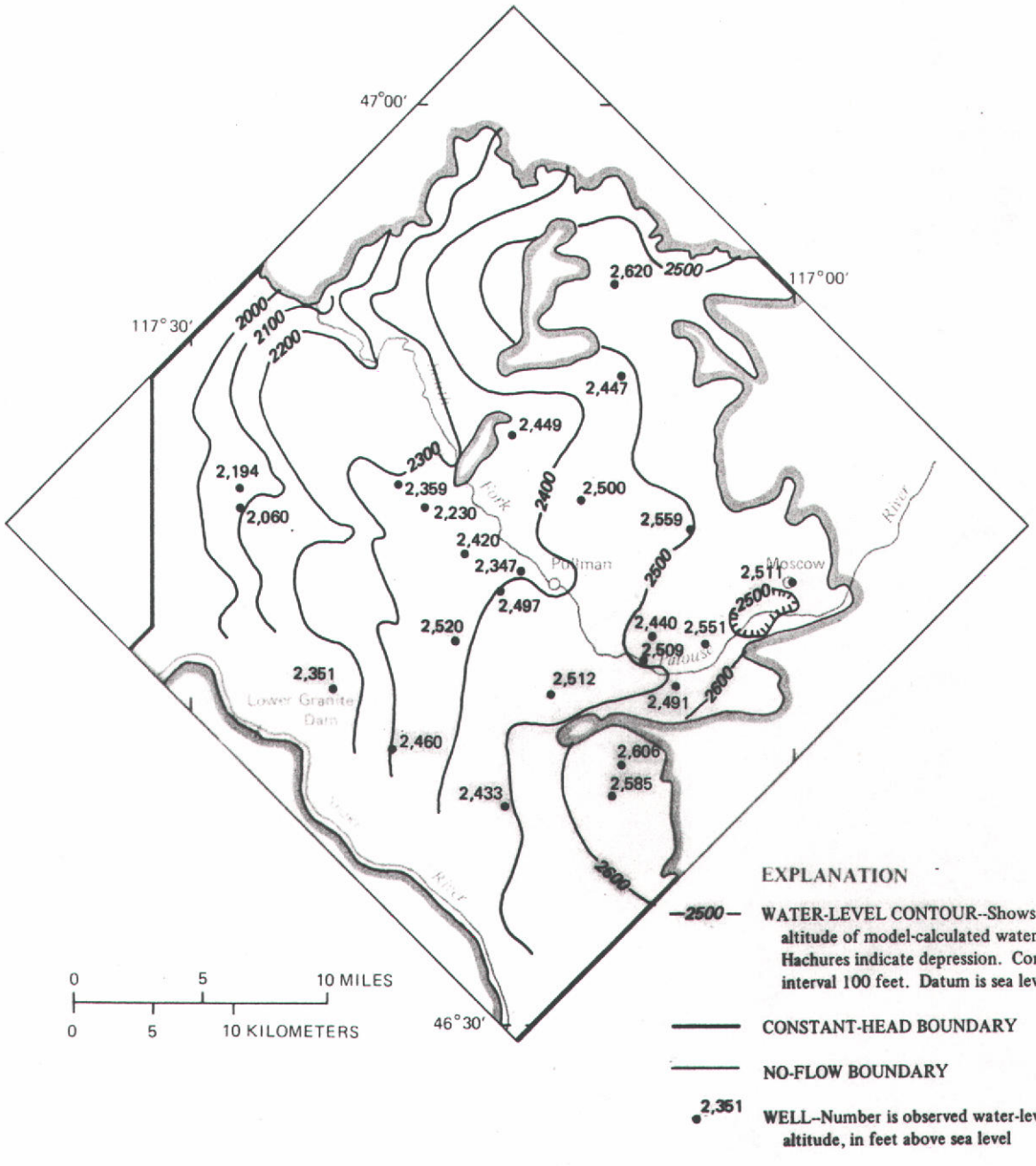


Figure 21.--Distribution of horizontal hydraulic conductivity and ratio of horizontal to vertical hydraulic conductivity of the Grande Ronde geohydrologic unit. Based on the cross-sectional model calibration and the time-averaged three-dimensional model calibration.

MICROFILMED
MAR 1 9 1990



geohydrologic unit

Figure 22.--Calibrated distribution of hydraulic head for the Wanapum Basalt for time-averaged conditions, 1974-1985.

MICROFILMED
MAR 19 1990

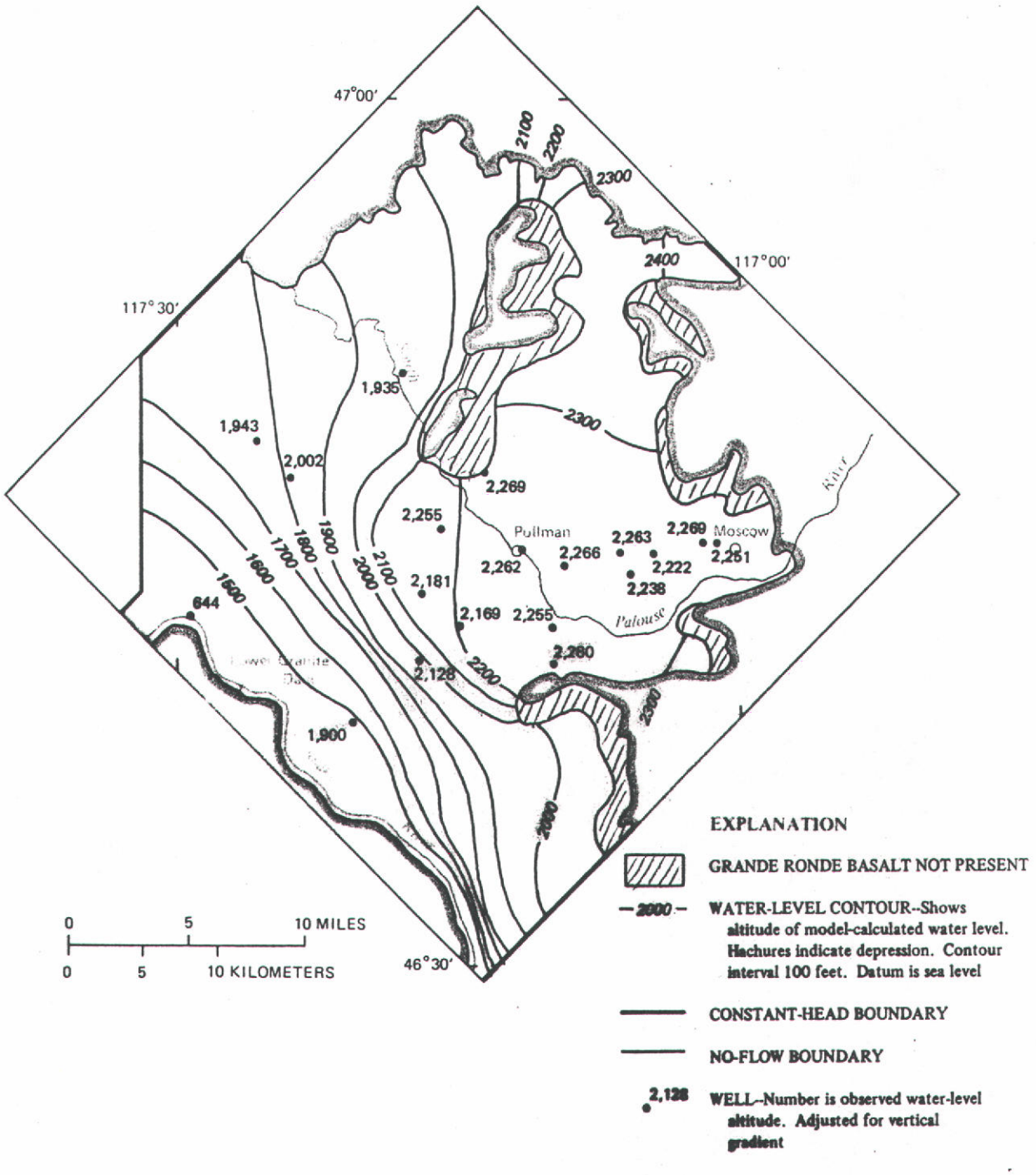


Figure 23.--Calibrated distribution of hydraulic head for the Grande Ronde Basalt for time-averaged conditions, 1974-1985.

MICROFILMED
MAR 1 9 1990

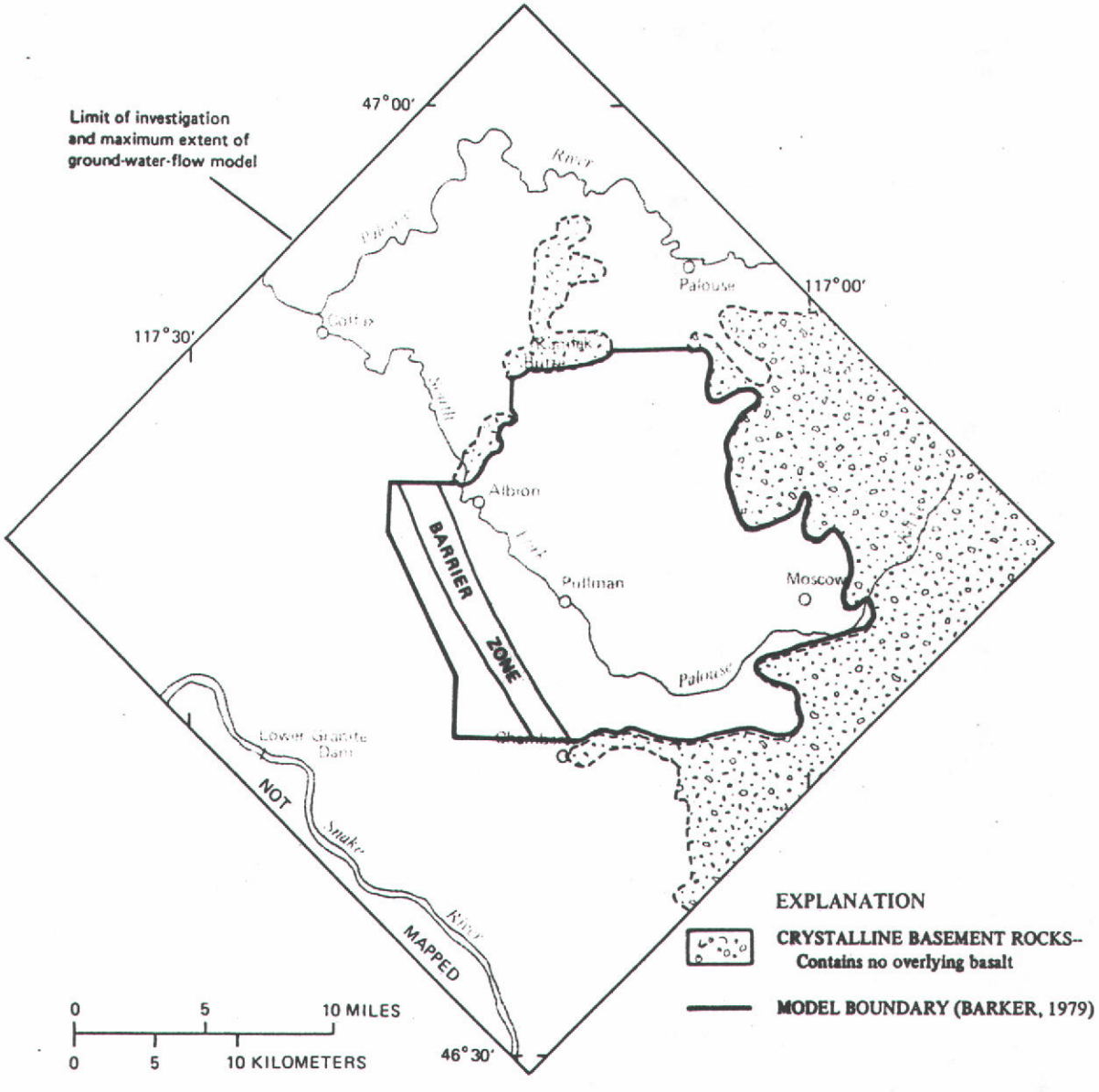


Figure 28.--Location of the ground-water-flow model boundaries and the 'barrier zone' of Barker (1979).

MICROFILMED
MAR 19 1990

Form No. 217
12/99

RECEIVED
JAN 24 2000
Department of Water Resources

FOR OFFICE USE ONLY
Amt. of Fee $: 125 00
Receipt No. C247864
Receipt By: GW
Date Receipted: 1-24-00

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

PROOF OF BENEFICIAL USE

*The Idaho Department of Water Resources considers this form a statement that the permit holder(s) has/have completed all development that will occur under this permit and that water has been applied according to the provisions of the permit for the beneficial use(s) described below. This form must be accompanied by a license examination fee, when necessary, **or** be accompanied by a completed field examination report prepared by a certified water right examiner.*

1. Permit No. 87-07141 Telephone No. 208-885-6288

2. Name of Permit Holder(s): University of Idaho

3. Mailing Address: Dept of Facilities, ~~Moscow, ID~~ 83844-1231

City Moscow, ~~ID~~ State ID Zip 83844-1231

4. Source of Water: Groundwater If **GROUNDWATER** (well), Date Drilled: mo.____ / yr.____

a. Well Driller: _____ Drilling Permit Number: ___ - ___ - ___ - ____ - ____

5. Use(s) (as authorized by the water right permit):

Domestic (No. of households): _____ Stockwater (No. and type of stock): _____

Irrigation (No. of acres): _____ Other: Research

6. Total rate of diversion and/or volume for which proof is submitted: 1.5 cfs **OR** _____ acre feet

7. Measuring Device Requirement: **(refer to the approval conditions on your permit and respond accordingly)**
(*This question is **not optional**. Please check either yes or no. Proofs returned not checked accordingly, will be considered incomplete)*

Measuring Device: Is a measuring device required? Yes ____ **or** No ____
Has the measuring device been installed? Yes X **or** No ____

8. Fee Enclosed: $ #125 00 (See Fee Schedule on back of the instructions for filing proof of beneficial use)

9. Person to contact to accompany the Department representative during field examination of the water system.

Name: Michael Holthaus Telephone Number: 208-885-6288

Address: Dept of Facilities, University of Idaho, Moscow ID 83844-1231

10. ***The information given on this form is my true statement of the extent to which the above numbered permit has been developed and water has been diverted. I agree to relinquish any undeveloped portion of the permit to the State of Idaho.***

Signature of permit holder: [signature] Date: 1-6-2000
(include your title, if on behalf of company of organization)
Water System Coordinator

MICROFILMED
JAN 31 2000

BEFORE THE DEPARTMENT OF WATER RESOURCES

OF THE STATE OF IDAHO

IN THE MATTER OF REQUEST FOR EXTENSION OF TIME FOR PERMIT NO. 87-07141 IN THE NAME OF UNIVERSITY OF IDAHO	)	**PRELIMINARY ORDER**

This matter having come before the Idaho Department of Water Resources (Department), as a result of a request for extension of time in which to submit proof of beneficial use of water, the Department makes the following Findings of Fact, Conclusions of Law and Order:

FINDINGS OF FACT

1. On January 19, 1990, the Department issued Permit No. 87-07141 (permit) to the University of Idaho (permit holder) requiring that proof of application of water to beneficial use (proof) be submitted to the Department on or before February 1, 1995.

2. On January 23, 1995, the permit holder requested an extension of time to February 1, 2000 in which to submit proof for the permit The Department extended the proof due date to February 1, 1999.

3. On December 7, 1998, the permit holder contacted the department seeking amendment of the prior extension request approval to show February 1, 2000 as the proof due date.

CONCLUSIONS OF LAW

1. The permit holder has shown sufficient cause why the department should amend its prior approval.

2. The department should extend the proof due date for the permit to February 1, 2000.

ORDER

IT IS THEREFORE, HEREBY ORDERED that proof of beneficial use submittal date for Permit No. 87-07141 is amended to be **February 1, 2000**, subject to the following conditions and limitations:

MICROFILMED

JAN 3 4 1999

1. The permit holder shall comply with the original conditions of approval on the permit.

2. Additional extensions of time pursuant to Section 42-204(5), Idaho Code, will not be granted by the Department.

Dated this 16th day of December, 1998.

L. GLEN SAXTON, P.E.
Chief, Water Allocation Bureau

MICROFILMED
JAN 04 1999

CERTIFICATE OF MAILING

I DO HEREBY CERTIFY that on the 17th day of December, 1998, a true and correct copy of the foregoing **PRELIMINARY ORDER** was forwarded, by regular U.S. Mail, to the parties listed below:

University of Idaho
c/o Michael Holthaus
Water Systems Coordinator
Moscow ID 83844-1232

Julie L. Yarbrough

JULIE L. YARBROUGH
Senior Secretary, Water Allocation Bureau

MICROFILMED
JAN 04 1999

Form 204
11-91

RECEIVED

JAN 2 3 1995

Department of Water Resources

For Office Use Only
$15 Fee Receipted by RT
Date 1-23-95
Receipt No. 0032020

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

REQUEST FOR EXTENSION OF TIME

TO PROVIDE ADDITIONAL TIME IN WHICH TO SUBMIT PROOF OF BENEFICIAL USE FOR A WATER RIGHT PERMIT

The Idaho Department of Water Resources will consider this form as a request that the permit holder(s) be granted an additional period of time in which to complete development of water right under the provisions of Section 42-204, Idaho Code.

Permit No. 87-7141

Name(s) of Permit Holder: University of Idaho

Mailing Address: Dept of Facilities Management, Moscow ID 83844-1031

Date Proof is Due Feb 1, 1995 Telephone No. 208-885-7350

Describe what work has been completed toward the development of this water right:
(This must be filled out! If no work has been completed, show "none".)

Building Built, 2 wells Drilled, 2 Pumps Installed

Costing $ 878,269

The permit holder(s) has been unable to complete the remainder of the work for the following reasons:

Need to Install Larger Pump in Last Drilled Well, Research Hasn't Reached Full Potential.

Permit holder(s) request an extension to Feb 1, ~~19~~ 2000.

FEE: ~~$15.00~~ 50.00

Donald R Hushyn, Utility Manager
(Signature)*

*If other than permit holder, Power of Attorney must be supplied.

ACTION OF THE DEPARTMENT OF WATER RESOURCES FEB 17 1995

IT IS HEREBY ORDERED that the above request for extension of time be APPROVED and the time within which to submit proof of beneficial use is extended to **February 1, 1999.**

Signed this 3rd day February, 19 95

Chief, Water Allocation Bureau

BEFORE THE DEPARTMENT OF WATER RESOURCES

OF THE STATE OF IDAHO

IN THE MATTER OF APPLICATION FOR PERMIT NO. 87-7141 IN THE NAME OF THE UNIVERSITY OF IDAHO	SOURCE:	GROUND WATER (SHALLOW AQUIFER)
	COUNTY:	LATAH

MEMORANDUM DECISION AND ORDER

BY THE DIRECTOR

This matter came on for hearing before the Director of the Department of Water Resources. The director has considered the testimony and evidence introduced at the hearing and has examined the files and records of the department pertaining to this matter. The Director now enters the following findings of fact, conclusions of law and order:

FINDINGS OF FACT

1. The University of Idaho filed application for permit no. 87-7141 on September 18, 1989. The university by this application seeks to appropriate 1.5 cfs of ground water from the shallow aquifer. The application identifies five alternative points of diversion, at least one of which is an existing university well site. The water is to be used from January 1 through December 31 for domestic and research purposes and from March 15 to November 15 for irrigation purposes. The total volume of water sought to be withdrawn from the aquifer under the application is 1,085 acre feet per annum or approximately 353,500,000 gallons per year.

MICROFILMED

MAR 19 1990

2. The five alternative points of diversion listed in the application are in the SE¼SW¼, the SW¼SE¼, and the SE¼SE¼ of Sec. 12, T. 39N., R. 6W; and the SW¼SE¼, and the SE¼SW¼ of Sec. 7, T. 39N, R. 5W, B.M., Latah County. The new well is proposed to be 16 inches in diameter and 300 feet deep.

3. Water sought under the application will be used in conjunction with water diverted from two deep aquifer wells represented by water right license 87-2031 (university well no. 3) and license 87-7012 (university well no. 4), and with water pumped from the Moscow City sewage lagoons under permit 87-7026.

4. Notice of the application was published in The Idahonian, Moscow, Idaho, on October 5 and 12, 1989. A protest against the granting of the permit was filed by Thomas A. Townsend on October 17, 1989. The department held a hearing on the protested application in Moscow on November 30, 1989.

5. The primary purpose for the proposed appropriation is to provide water for a planned aquaculture research facility to be located on the west side of the university campus. The discharge from this use will be treated and placed into the Moscow City sewage lagoons from which it will be rediverted by the university along with water under permit 87-7026 and used for irrigation purposes.

6. The university proposes to divert water from what is described as the shallow aquifer, or the Wanapum Basalt Formation. In the past, the shallow aquifer was extensively used by the university and other entities, incl of Moscow.

MICROFILMED

MAR 19 1990

7. Diversions from the shallow aquifer have decreased substantially in recent years because the university and the city shifted to the area's deep aquifer known as the Grande Ronde Basalt Formation.

8. Total withdrawal from the shallow aquifer by the university and the city reached a maximum of 690,690,899 gallons per year in 1955 and decreased to less than ten percent of that volume by 1989. (Applicant's Exhibit No. 5)

9. Since 1965, the university has made no use of its wells no. 1 and no. 2 which drew water from the shallow aquifer.

10. The university's present principal water supply is provided by well nos. 3 and 4 which divert from the deep aquifer. Well no. 3 is located in the SW¼NW¼ of Sec. 7, T. 39N, R. 5W, B.M. and is covered by license 87-2031. Well no. 4 is located in the NE¼SE¼ of Sec. 12, T. 39N, R. 5W, B.M. and is covered by license 87-7012.

11. The city has reduced its use of the shallow aquifer from a volume of over 500 million gallons annually to less than 100 million gallons annually during each of the last eight years.

12. The water level in the shallow aquifer, as measured at the city's wells, raised more than fifty feet between the years 1965 and 1989. (Applicant's Exhibits 5 and 6)

13. Applicant's Exhibits Nos. 2 and 3, although somewhat conflicting, and the testimony of applicant's witness, Dr. Ernest Brannon, indicate that the proposed project will be developed in stages with an initial research facility which will require a water supply equal to or less than 48 million gallons per year.

MICROFILMED
MAR 15 1990

Exhibit 2 states, "Expansion of the initial University of Idaho campus facility will not occur until the impact upon the total aquifer system has been analyzed and found to be acceptable."

14. The university's proposed use of water from the shallow aquifer under this application would replace, in part, water presently being diverted for irrigation from the deep aquifer. This would help conserve water from the deep aquifer which has experienced water level declines varying from 4 to 20 feet throughout the Moscow area during the period from 1974 to 1985. (Applicant's Exhibit No. 8, Figure 11)

15. At a conference preceding the hearing, the applicant and the protestant agreed that the issues to be addressed in the hearing were those set forth in I.C. § 42-203A(5).

16. The protestant, Thomas A. Townsend, presented a written statement, admitted as Protestant's Exhibit No. 1, which includes an Opening Statement and a Statement As To Issues which was read and entered into the record. The Statement As To Issues addresses the five criteria to be consider by the director in acting upon an application for permit under I.C. § 42-203A(5).

17. The protestant asserts that issuance of the permit will substantially reduce the quantity of water available to senior water right holders. The protestant did not identify any particular right which he believes will be adversely affected but did make reference to the use of water from the shallow aquifer by the city of Moscow and to the recovery of water levels following the reduction of diversions from this source by both the city and university over the last 25 or more years. The

MICROFILMED
MAR 19 1990

protestant concludes that there is a correlation between pumpage and the elevation of the water table in the shallow aquifer.

18. Concerning the available water supply, the protestant did not present any evidence indicating that water levels in the shallow aquifer are declining, or that present uses or the university's proposed use has or will exceed the "full economic development of underground water resources" or that water levels have or will exceed reasonable ground water pumping levels as referenced in I.C. § 42-226.

19. The protestant did not present any evidence indicating that the university's proposed use of water from the shallow aquifer would affect the present or future use of any prior water right or result in the withdrawal of the ground water supply at a rate beyond the reasonably anticipated average rate of future natural recharge as referenced in I.C. § 42-237a.g.

20. Protestant asserts that issuance of a permit as requested would allow the university to withdraw 353.5 million gallons of water per year from the shallow aquifer and that such rate of withdrawal would be a heavy demand upon the aquifer.

21. Applicant's witness, Dr. Dale Ralston, testified that annual recharge to the shallow aquifer was in the magnitude of 63 cfs or 14.8 billion gallons per year, which is approximately equal to 45,500 acre feet per year.

22. Protestant suggested that the university's proposed use of 353.5 million gallons of water per year from the shallow aquifer would be greater than that historically used by the city of Moscow. However, Applicant's Exhibit No. 5 shows that

MICROFILMED
MAR 19 1990

city has withdrawn as much as 530 million gallons annually from the shallow aquifer.

23. Protestant Townsend questions the good faith of the university and references the university's participation in a Resolution of Understanding among the Pullman-Moscow Water Resources Committee, the Idaho Department of Water Resources and the Washington Department of Ecology signed in May 1989. The resolution, reviewed by the director in this proceeding, provides that the parties agree that the potential exists for the overuse of quality ground water resources within the Pullman-Moscow basin and that the parties are desirous of developing and implementing a ground water management plan in accordance with state and local laws and regulations.

24. Protestant points to Applicant's Exhibit Nos. 2 and 3 which indicate potential staged development of an aquaculture research facility requiring a maximum use of as much as 240 million gallons of water per year from the shallow aquifer. Protestant suggests that a program with such an ultimate goal of potential water use constitutes speculation.

25. Protestant questioned whether the university has secured the necessary funding to complete the project. Applicant's witness, Dr. Ernest Brannon, testified that funds for the initial facility are available and committed by the university's administration.

26. The protestant indicates at Protestant's Exhibit No. 1, p. 20, that he cannot prove exactly where the public interest lies in this matter but suggests that the lack of positive

MICROFILMED
MAR 19 1990

support in the form of a vote of the local city and county governments should be considered.

27. The applicant produced evidence as to the local public interest benefits which will result from the development of the planned aquaculture research facility, including the partial replacement of water for irrigation presently being diverted from the deep aquifer which has experienced recent water level declines.

CONCLUSIONS OF LAW

1. The director's consideration of this application is governed by the provisions of I.C. § 42-203A(5) which reads, in part, as follows:

> In all applications ... where the proposed use is such (a) that it will reduce the quantity of water under existing water rights, or (b) that the water supply itself is insufficient for the purpose for which it is sought to be appropriated, or (c) where it appears to the satisfaction of the department that such application is not made in good faith, is made for delay or speculative purposes, or (d) that the applicant has not sufficient financial resources with which to complete the work involved therein, or (e) that it will conflict with the local public interest ... the director ... may reject such application and refuse issuance of a permit therefor, or may partially approve and grant a permit for a smaller quantity of water than applied for, or may grant a permit upon conditions.

2. I.C. § 42-222(2) provides that a right to the use of water shall be lost and forfeited by a failure for a term of five (5) years to apply it to the beneficial use for which it was appropriated.

3. The diversion of 48 million gallons per year of water at the rate of 1.5 cfs from the shallow aquifer will not reduce

MICROFILMED

MAR 19 1990

the quantity of water under existing water rights. However, the effects of such use will need to be monitored before a decision can be made whether a greater withdrawal may be permitted.

4. The shallow aquifer water supply is sufficient for the initial development stage of the project for which it is being appropriated.

5. The application is made in good faith and not for delay or speculation.

6. The applicant has sufficient financial resources with which to complete the project.

7. The use of water as approved under this permit is in the local public interest.

ORDER

Based on the foregoing findings of fact and conclusions of law, IT IS HEREBY ORDERED that application for permit 87-7141 is APPROVED IN PART, subject to the following conditions:

1. Because it is probable that the rights of the university to divert shallow aquifer water from wells No. 1 and 2 have been forfeited due to nonuse, this permit is approved upon the condition that the university not divert water from the shallow aquifer pursuant to any claimed water rights for these wells in addition to the quantity approved under this permit.

2. The amount of water diverted under this permit shall not exceed a diversion rate of 1.5 cfs and an annual volume of 48 million gallons or 147.3 acre feet per year.

3. The amount of water rediverted by the university for irrigation purposes under this permit from the Moscow City sewage

MICROFILMED
MAR 1 9 1990

lagoons shall not exceed the rate of flow and volume of water being diverted under this permit for the university's aquaculture research facility and thereafter treated and discharged into the sewage lagoons.

4. Upon completion of the initial project development phase and the utilization of the authorized 48 million gallons per year for at least two years the university may request the director for additional diversion authority under this permit. Such request must be accompanied by records of pumpage from the shallow and deep aquifers and studies showing that the additional diversion authority being requested will not exceed the water supply available and will not reduce the quantity of water under existing rights.

5. The university shall provide written notice to the protestant of any request to the director for additional diversion authority under this permit. The protestant shall be entitled to respond to the university's request for additional diversion authority and the protestant shall be entitled to a hearing on such response if requested in writing.

6. The use of water under this permit is subject to all prior water rights.

7. The rate of diversion of water used for irrigation under this permit, when combined with all other water rights for the same land shall not exceed 0.02 cfs for each acre of land.

8. Proof of construction of works and application of water to beneficial use shall be submitted on or before the date

MICROFILMED

MAR 19 1990

specified on the permit form.

9. A flow measurement port or other device as specified by the Department shall be installed by the permit holder at each point of diversion to provide for the installation of measuring equipment and the determination of the rate of diversion by the Department.

Dated this 19th day of January, 1990.

R. Keith Higginson
Director

MICROFILMED
MAR 19 1990

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that on this 23rd day January, 1990, I served a true and correct copy of the foregoing ORDER GRANTING ENLARGEMENT OF TIME by placing a copy thereof in the United Sates mail addressed to the following:

University of Idaho
c/o Mr. Larry Kirkland
Physical Plant
Moscow, Idaho 83843

John A. Rosholt, Esq.
NELSON,ROSHOLT,ROBERTSON,
TOLMAN & TUCKER
P.O. Box 1906
Twin Falls, Idaho 83303-1906

Mr. Thomas A. Townsend
447 E. 8th St.
Moscow, Idaho 83843

Rita I. Fleck

RITA I. FLECK
Secretary/Records Manager
Department of Water Resources

MICROFILMED
MAR 19 1990

Form 202
6/85

RECEIVED
SEP 18 1989
Idem. No. 87-67141
Department of Water Resources

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
APPLICATION FOR PERMIT

To appropriate the public waters of the State of Idaho

APPROVED

1. Name of applicant UNIVERSITY OF IDAHO c/o LARRY KIRKLAND Phone 208-885-6222

   Post office address PHYSICAL PLANT, MOSCOW, IDAHO 83843

2. Source of water supply GROUNDWATER which is a tributary of _____

3. Location of point of diversion is SW ¼ of SE ¼ of _____ ¼, Govt. Lot _____
   Sec. 12 Township 39N Range 6W B.M. LATAH County; additional
   points of diversion if any: SESW SESE OF SECTION 12, T. 39 N., R. 6 W.; SWSE AND SESW OF SECTION 7, and ~~NWNE OF SECTION 18~~, T. 39 N., R. 5 W., ALL IN LATAH COUNTY, IDAHO. - per telcon. with Larry Kirkland--pms 9/28/89

4. Water will be used for the following purposes:

   Amount 1.5 (cfs or acre-feet per annum) for DOMESTIC purposes from Jan 1 to Dec 31 (both dates inclusive)

   Amount 1.5 (cfs or acre-feet per annum) for RESEARCH purposes from JAN 1 to Dec 31 (both dates inclusive)

   Amount 1.5 (cfs or acre-feet per annum) for IRRIGATION purposes from March 15 to Nov 15 (both dates inclusive)

   Amount _____ (cfs or acre-feet per annum) for _____ purposes from _____ to _____ (both dates inclusive)

5. Total quantity to be appropriated is (a) 1.5 cubic feet per second and/or (b) ~~1085~~ * 147.3 acre feet per annum

6. Proposed diverting works: *per Memorandum Decision and Order

   a. Description of ditches, flumes, pumps, headgates, etc. DRILL WELL IN SHALLOW AQUIFER. INSTALL PUMP, MOTOR, PANEL AND PIPELINES TO CONNECT TO EXISTING UNIVERSITY SYSTEM SO TO FACILITATE WATER USES FOR ABOVE LISTED PURPOSES.

   b. Height of storage dam _____ feet; active reservoir capacity _____ acre-feet; total reservoir capacity _____ acre-feet; period of year when water will be diverted to storage: _____ to _____ inclusive.

   c. Proposed well diameter is 16 inches; proposed depth of well is 300 feet.

   d. Is ground water with a temperature of greater than 90°F being sought? NO

7. Time required for the completion of the works and application of the water to the proposed beneficial use is 5 years (*minimum 1 year*).

MICROFILMED
MAR 19 1990

8. Description of proposed uses (*if irrigation only, go to item 9*):

a. Hydropower; show total feet of head and proposed capacity in KW. _____

b. Stockwatering; list number and kind of livestock. _____

c. Municipal; show name of municipality. _____

d. Domestic; show number of households. UNIVERSITY BUILDINGS ON SYSTEM

e. Other; describe fully. ALL RESEARCH USES PRESENT AND FUTURE IN ALL DISCIPLINES PURSUED AT IDAHO'S LAND GRANT UNIVERSITY, PLUS ALL DOMESTIC NEEDS OF A UNIVERSITY WHICH OPERATES ITS OWN WATER SUPPLY SYSTEM.

9. Description of place of use:

a. If water is for irrigation, indicate acreage in each subdivision in the tabulation below.

b. If water is used for other purposes, place a symbol of the use (*example: D for Domestic*) in the corresponding place of use below. See instructions for standard symbols.

TWP	RANGE	SEC.	NE¼				NW¼				SW¼				SE¼				TOTALS
			NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	
39N	R6W	12												R D			R D	D 6	6
		13	40			40									40			40	160
39N	R5W	7											R D 20	R D 20					40
		18		R D 40	R D 40		R D 40	R D 40	R D 40	R D 40	20	40	40	20					360

R2 = Research

Total number of acres to be irrigated 566

10. Describe any other water rights used for the same purposes as described above. 87-02031, 87-07012, 87-07026

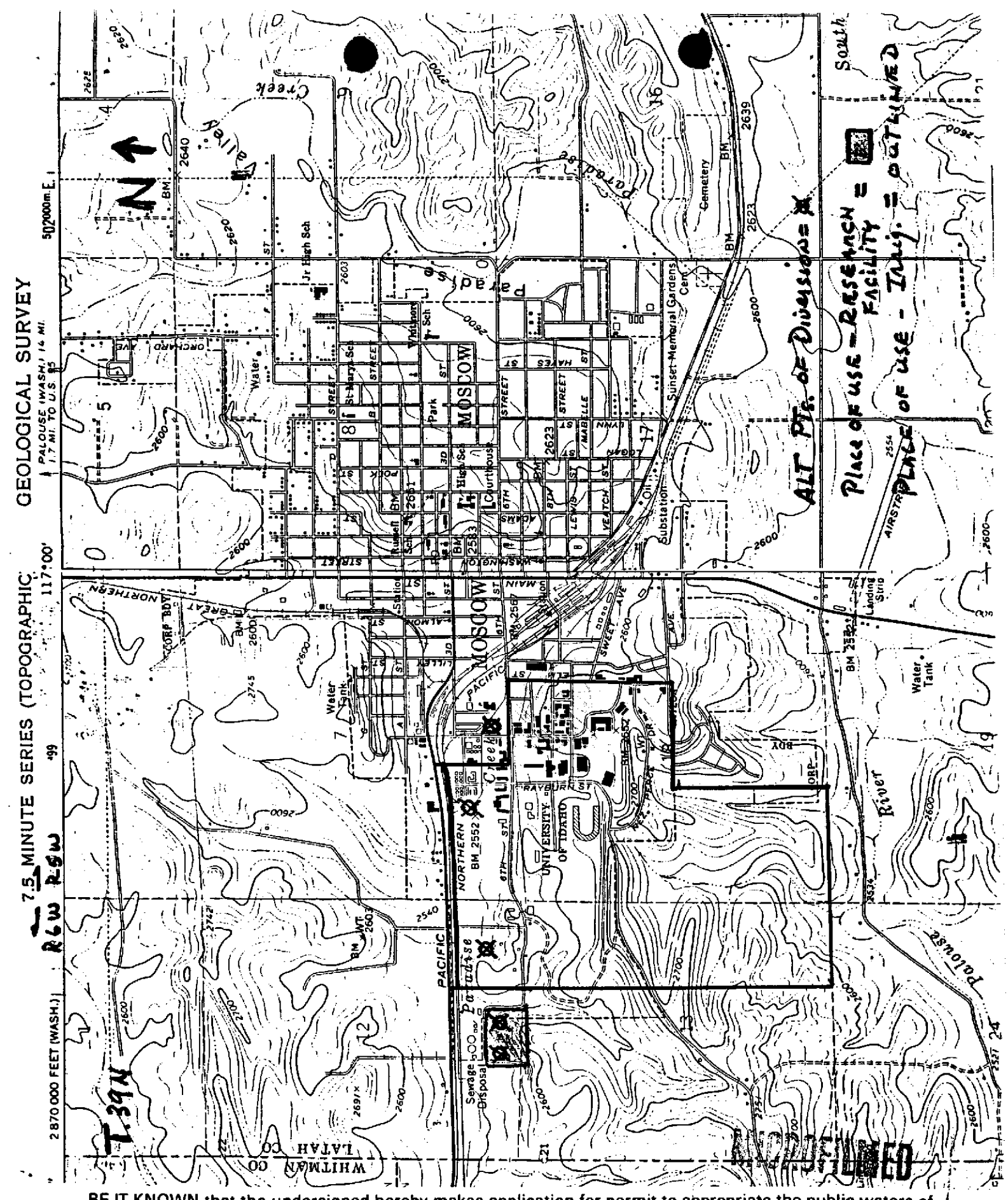
11. a. Who owns the property at the point of diversion? APPLICANT

b. Who owns the land to be irrigated or place of use? APPLICANT

c. If the property is owned by a person other than the applicant, describe the arrangement enabling the applicant to make this filing. _____

12. Remarks: Applicant has not used the shallow aquifer well licensed as 87-02005 since 1966. Use was discontinued because of water quality and because the well pumped sand which destroyed the equipment. Water from Licenses 87-02031, 87-07012 and 87-07026 has since supplied all of the University's needs. The shallow aquifer has recharged to the approximate levels that existed in the year 1900. This application would facilitate diversion from the shallow aquifer, which should have minimal impact on the deep aquifer. Since domestic and research uses are nonconsumptive, reuse of the same water for irrigation will reduce demand on deep aquifer acre foot for acre foot. The water not consumed in irrigation will provide some recharge to the shallow aquifer.

MICROFILMED
MAR 19 1990



BE IT KNOWN that the undersigned hereby makes application for permit to appropriate the public waters of the State of Idaho as herein set forth.

MAR 15 1990

Dr. Joseph Geiger
(Applicant)

DR. JOSEPH GEIGER, VICE PRESIDENT
FINANCIAL AFFAIRS

Received by C. Wong Date 9/18/89 Time 4:17 1:45 pm Preliminary check by DK

Fee $ 65.00 Receipted by DK # C011681 Date 9-19-1989

Publication prepared by [illegible] Date 9/27/89 Published in Idaho Sun / Daily News 10/5 & 12/89

Publication approved _____ Date _____

ACTION OF THE DIRECTOR, DEPARTMENT OF WATER RESOURCES

This is to certify that I have examined Application for Permit to appropriate the public waters of the State of Idaho No. 87-7141, and said application is hereby APPROVED IN PART.

1. Approval of said application is subject to the following limitations and conditions:

   a. SUBJECT TO ALL PRIOR WATER RIGHTS.

   b. Proof of construction of works and application of water to beneficial use shall be submitted on or before February 1, 19 95.

   c. The rate of diversion, if water is to be used for irrigation under this permit, when combined with all other water rights for the same land shall not exceed 0.02 cubic feet per second for each acre of land.

   d. The water right acquired under this permit if for hydropower purposes shall be junior and subordinate to all rights to the use of water, other than hydropower, within the State of Idaho that are initiated later in time than the priority of this permit and shall not give rise to any right or claim against any future rights to the use of water, other than hydropower, within the State of Idaho initiated later in time than the priority of this permit.

   e. Other: PURSUANT TO MEMORANDUM DECISION AND ORDER.

Dated this 19th day of January, 1990.

R. Keith Higginson
Director

MICROFILMED
MAR 19 1990

Affidavit of Publication

STATE OF IDAHO
County of Latah ss.

Theresa Myers

being first duly sworn, on oath, deposes and says:

That he is the printer of The IDAHONIAN, a newspaper of general circulation, printed and published daily except Sunday at Moscow, Latah County, Idaho, in compliance with Sections 60-106, 60-107, and 60-108 of the Idaho Code and the amendments thereto; that the notice of which the annexed is a full, true and correct printed copy was published in the regular and entire issues of said newspaper and not in a supplement thereto, upon the following dates:

Oct 5, 12, 1989

the same being the dates designated for the publication of said notice.

Theresa Myers

Subscribed and sworn to before me this 12 day of Oct 19 89

Notary Public,
residing at Moscow, Idaho
My commission expires: 12-16-93

10/16/89

NOTICE OF APPLICATION FOR WATER RIGHT

The following application(s) have been filed to appropriate the public waters of the State of Idaho:

86-07268
CRAIG, RONALD L.
3636 TEARE RD.
MOSOCW, ID 83843
Source: UNNAMED STREAM Trib.: SINKS
Diversion Pt: NENW Sec 18 T 39N R 04W
USE: RECREATION STORAGE (28.00 AF)
FIRE PROTECTION (.800 CFS)
FIRE PROTECTION STORAGE (10.00 AF)
DIVERSION TO STORAGE (.800 CFS)
Date Filed: 5/19/1989
In: T39N R04W S18 NENW

87-07140
BAIN, MARVIN
RT 2 BOX 19
POTLATCH, ID 83855
Source: GROUNDWATER
Diversion Pt: SENWNW Sec 2 T 41N R 05W
Use: DOMESTIC (.120 CFS)
COMMERCIAL (.020 CFS)
STOCKWATER (.020 CFS)
Date Filed: 9/25/1989
In: T41N R05W S02 NENW NWNW

87-07141
UNIVERSITY OF IDAHO
C/O LARRY KIRKLAND
PHYSICAL PLANT
MOSCOW, ID 83843
Source: GROUNDWATER (SHALLOW AQUIFER)
Diversion Pt: SESW Sec 7 T 39N R 05W
SESW Sec 12 T 39N R 06W
SWSE Sec 12 T 39N R 06W
SESE Sec 12 T 39N R 06W
SWSE Sec. 7 T 39N R 05W
Use: IRRIGATION (1.500 CFS)
RESEARCH (1.500 CFS)
DOMESTIC (1.500 CFS)
Date: Filed: 9/18/1989
In: T39N R05W S07 SWSW SESW S18 NWNE SWNE NENW NWNW SWNW SENW NESW NWSW SWSW SESW
R06W S12 SESW SWSE SESE S13 NENE SENE NESE SESE
566.0 ACRES TOTAL

For additional information concerning the property location, call the Northern Regional Office at 765-4639.

The permit(s) will be subject to all prior water rights. Protests must be filed with the Director, Dept. of Water Resources, Northern Region, 1910 Northwest Blvd., Suite 210, Coeur d'Alene, Idaho 83814 on or before OCTOBER 23,1989.

R. KEITH HIGGINSON, Director
Oct. 5, 12, 1989

RECEIVED
OCT 16 1989
NORTHERN REGION
IDWR

MICROFILMED
MAR 19 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, P.O. Box 83720, Boise, Idaho 83720-0098
Phone: (208) 327-7900 FAX: (208) 327-7866

January 28, 2000

DIRK KEMPTHORNE
GOVERNOR

KARL J. DREHER
DIRECTOR

UNIVERSITY OF IDAHO
DEPT OF FACILITIES
MOSCOW, ID 83844-1231

PROOF ACKNOWLEDGMENT LETTER

RE: PERMIT NO. 87-07141

Dear Permit Holder:

The department acknowledges receipt of the proof of beneficial use form submitted for the above referenced permit. The next step in the process of developing a water right is for the department to conduct a field examination to determine and confirm the use being made of the water.

Be advised that Section 42-248, Idaho Code, requires you or the owner of this water right to maintain current ownership and address records on file with the department. Forms to file a change of ownership of a water right and/or a change in the address of the water right owner are available from any department office.

If you have questions concerning the field examination, please contact the **NORTHERN** Regional Office of the department in Coeur d' Alene at (208) 769-1450.

Sincerely,

L. GLEN SAXTON, Chief
Water Allocation Bureau

c: IDWR - Regional Office

MICROFILMED
JAN 31 2000

ANALYSIS SHEET FOR PROOF OF BENEFICIAL USE

Permit No. 87-7141 Reviewed by YYS Date 1-28-00

GENERAL CONSIDERATIONS

yes Name same as permit?

no Address same as permit?

yes Proof timely received? Correct Uses? yes

If not, complete calculation below.

TYPES OF USE

Research

SOURCE OF WATER

_____ Surface water source

✓ Ground water source

_____ Drilling permit required?

_____ Copy in the file? Drilling Permit No._____

_____ Amount paid for permit _____Correct?

_____ Well log in the file?

LICENSE EXAMINATION FEE

yes Required?

125 Amount Submitted

yes Correct?

MEASURING DEVICE

_____ Required?

yes Installed?

_____ Waiver requested?

PRIORITY CALCULATION

Date proof received	_____		_____
Date proof due	_____	-	_____
No. of days late	_____	=	_____
Priority Date	_____	+	_____
New Priority Date	_____		_____

DEFICIENCIES OR ACTION ITEMS

none/ok proof

DATA ENTRY

New Address U. of I
Dept of Facilities
Moscow, ID 83844-1231

Proof Made 1-24-00

November 30, 1999

UNIVERSITY OF IDAHO
DEPT OF FACILITIES MGMT
MOSCOW ID 838441231

PROOF DUE NOTICE

RE: PERMIT NO. 87-07141

Dear Permit Holder:

One of the conditions of approval of the above referenced water permit was that proof of the extent of your beneficial use must be submitted to this office on or before February 1, 2000. (See last page of your approved permit or your last approved extension request.) Enclosed is a form which when accompanied by the license examination fee or a complete field examination report prepared by a certified water right examiner may be used to submit the required proof.

If you have not fully completed your project, and you or a previous owner of this permit have not received a prior extension of time, you may request an extension of time if the delay is for reasonable cause as provided in Section 42-204, Idaho Code. If you have been prevented from proceeding by a governmental agency or by litigation which might bring title to the water in question, more than one extension of time can be granted. An extension of time request form is enclosed for your convenience.

Either an acceptable proof of beneficial use submittal or an acceptable request for an extension of time must be received by this department on or before the above described proof due date. If neither is received, the department will send you a lapse notice. Within sixty (60) days of the mailing of the lapse notice, the permit will no longer be of any force nor effect.

SINCERELY,

JULIE L. YARBROUGH
Senior Secretary

Enclosures

MICROFILMED
JAN 3 1 2000

CERTIFIED MAIL
NO. 269224677

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, P.O. Box 83720, Boise, Idaho 83720-0098
Phone: (208) 327-7900 FAX: (208) 327-7866

PHILIP E. BATT
GOVERNOR

KARL J. DREHER
DIRECTOR

December 17, 1998

RE: In the matter of Application for Permit No. 87-07141 in the name of University of Idaho

Dear Interested Parties:

The accompanying order is a "**preliminary order**" issued by the department pursuant to section 67-5243, Idaho Code. It can and will become a final order without further action of the department unless a party petitions for reconsideration within fourteen (14) days after issuance as further described below:

PETITION FOR RECONSIDERATION

Any party may file a petition for reconsideration of a preliminary order with the hearing officer within fourteen (14) days of the service date of this order. The hearing officer will act on a petition for reconsideration within twenty-one (21) days of its receipt, or the petition will be considered denied by operation of law. See section 67-5243(3) Idaho Code.

EXCEPTIONS AND BRIEFS

Within twenty-one (21) days after (a) the service date of a preliminary order, (b) the service date of a denial of a petition for reconsideration from this preliminary order, or (c) the failure within twenty-one (21) days to grant or deny a petition for reconsideration from this preliminary order, any party may in writing support or take exceptions to any part of a preliminary order and may file briefs in support of the party's position on any issue in the proceeding to the Director. Otherwise, this preliminary order will become a final order of the agency.

If any party appeals or takes exceptions to this preliminary order, opposing parties shall have twenty-one (21) days to respond to any party's appeal. Written briefs in support of or taking exceptions to the preliminary order shall be filed with the Director. The director retains the right to review the preliminary order on his own motion.

ORAL ARGUMENT

If the Director grants a petition to review the preliminary order, the Director shall allow all parties an opportunity to file briefs in support of or taking exceptions to the preliminary

MICROFILMED
JAN 0 4 1999

order and may schedule oral argument in the matter before issuing a final order. If oral arguments are to be heard, the Director will within a reasonable time period notify each party of the place, date and hour for the argument of the case. Unless the Director orders otherwise, all oral arguments will be heard in Boise, Idaho.

CERTIFICATE OF SERVICE

All exceptions, briefs, requests for oral argument and any other matters filed with the Director in connection with the preliminary order shall be served on all other parties to the proceedings in accordance with Rules of Procedure 302 and 303.

FINAL ORDER

The Director will issue a final order within fifty-six (56) days of receipt of the written briefs, oral argument or response to briefs, whichever is later, unless waived by the parties or for good cause shown. The Director may remand the matter for further evidentiary hearings if further factual development of the record is necessary before issuing a final order. The department will serve a copy of the final order on all parties of record.

Section 67-5246(5), Idaho Code, provides as follows:

> Unless a different date is stated in a final order, the order is effective fourteen (14) days after its issuance if a party has not filed a petition for reconsideration. If a party has filed a petition for reconsideration with the agency head, the final order becomes effective when:
>
> (a) the petition for reconsideration is disposed of; or
> (b) the petition is deemed denied because the agency head did not dispose of the petition within twenty-one(21) days.

APPEAL OF FINAL ORDER TO DISTRICT COURT

Pursuant to sections 67-5270 and 67-5272, Idaho Code, if this preliminary order becomes final, any party aggrieved by the final order or orders previously issued in this case may appeal the final order and all previously issued orders in this case to district court by filing a petition in the district court of the county in which:

i. A hearing was held,
ii. The final agency action was taken,
iii. The party seeking review of the order resides, or
iv. The real property or personal property that was the subject of the agency action is located.

MICROFILMED

JAN 0 4 1999

The appeal must be filed within twenty-eight (28) days of this preliminary order becoming final. See section 67-5273, Idaho Code. The filing of an appeal to district court does not itself stay the effectiveness or enforcement of the order under appeal.

Sincerely,

L. Glen Saxton

L. GLEN SAXTON, Chief
Water Allocation Bureau

Enclosure

c: IDWR - Region

MICROFILMED
JAN 04 1999

RECEIVED
DEC 11 1998
Department of Water Resources

University of Idaho
FACILITIES
Architectural & Engineering Services
Capital Planning & Capital Budget
Facilities Maintenance & Operations

December 7, 1998

Julie L.Yarbrough
State of Idaho
Dept. of Water Resources
1301 N. Orchard Street
PO Box 83720
Boise, ID 83720-0098

RE: Permit No. 87-07141

Dear Julie:

As per our phone conversation on Friday, 12-4-98, we would like to petition that our beneficial use be delayed until February 1, 2000 as was requested for in the extension in January 1995. We are now in the final phase of installing a pump and increasing the pump house for this permit. Please let me know as soon as possible if this petition is granted. If you have any questions, my direct number is 208-885-6288.

Sincerely,

Michael Holthaus
Water Systems Coordinator
University of Idaho

MICROFILMED
JAN 04 1999

November 30, 1998

UNIVERSITY OF IDAHO
DEPT OF FACILITIES MGMT
MOSCOW ID 838441231

PROOF DUE NOTICE

RE: PERMIT NO. 87-07141

Dear Permit Holder:

One of the conditions of approval of the above referenced water permit was that proof of the extent of your beneficial use must be submitted to this office on or before February 1, 1999. (See last page of your approved permit or your last approved extension request.) Enclosed is a form which when accompanied by the license examination fee or a complete field examination report prepared by a certified water right examiner may be used to submit the required proof.

If you have not fully completed your project, and you or a previous owner of this permit have not received a prior extension of time, you may request an extension of time if the delay is for reasonable cause as provided in Section 42-204, Idaho Code. If you have been prevented from proceeding by a governmental agency or by litigation which might bring title to the water in question, more than one extension of time can be granted. An extension of time request form is enclosed for your convenience.

Either an acceptable proof of beneficial use submittal or an acceptable request for an extension of time must be received by this department on or before the above described proof due date. If neither is received, the department will send you a lapse notice. Within sixty (60) days of the mailing of the lapse notice, the permit will no longer be of any force nor effect.

SINCERELY,

JULIE L. YARBROUGH
Senior Secretary

Enclosures

MICROFILMED
JAN 04 1999

CERTIFIED MAIL
NO. 2238915344

ANALYSIS SHEET FOR EXTENSION OF TIME

Permit No. 87-07141 Reviewed by [signature] Date 2-3-95

BASIC INFORMATION

1-23-95 Date stamp received

yes Extension received timely

yes Fee received and receipted

yes Name and signature same as permit

yes Address Change

BASIS FOR EXTENSION REQUEST

yes Has adequate work been completed to demonstrate due diligence?

_____ Has the permit been involved in litigation?
Is supporting documentation needed to complete the file?_____ Requested?_____

_____ Is delay by a government agency?
Is supporting documentation needed to complete the file?_____ Requested?_____

_____ Is the project more than 25,000 acre feet for irrigation or 10,000 acre feet for a reservoir?

ACTION TAKEN Should extend to Feb 1, 1999, for due diligence.

PRIORITY CALCULATION

Date extension received	_____	=	_____
Proof due date	_____	=	_____
Number of days late	_____	=	_____
Priority date	_____	=	_____
New Priority Date	_____	=	_____

DATA ENTRY

New Address Dept. of Facilities Mgmt. Moscow, Id. 83844-1231

Change Proof Due Date 2-1-99

Change Priority Date X

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720-9000
Phone: (208) 327-7900 FAX: (208) 327-7866

PHILIP E. BATT
GOVERNOR

R. KEITH HIGGINSON
DIRECTOR

February 3, 1995

University of Idaho
Dept. of Facilities Mgmt.
Moscow, ID 83844-1231

RE: Permit No. 87-07141

Dear Permit Holder:

Enclosed is a copy of the approved request for extension of time. The time within which to submit proof of beneficial use is extended to **February 1, 1999** . Please note that the department has granted this extension based on **due diligence**. It is important that you work diligently toward the completion of this project during the construction period allowed since the department **will not** be able to grant additional extensions based on due diligence.

If you have any questions or if I can be of any further assistance, please feel free to contact this office.

Sincerely,

Julie L. Yarbrough

JULIE L. YARBROUGH
Senior Secretary

Enclosure

C: IDWR - Regional Office

RECEIVED
FEB 17 1995

November 30, 1994

UNIVERSITY OF IDAHO
C/O LARRY KIRKLAND
PHYSICAL PLANT
MOSCOW ID 83844

PROOF DUE NOTICE

RE: PERMIT NO. 87-07141

Dear Permit Holder:

One of the conditions of approval of the above referenced water permit was that proof of the extent of your beneficial use must be submitted to this office on or before February 1, 1995. (See last page of your approved permit or your last approved extension request.) Enclosed is a form which when accompanied by the license examination fee or a complete field examination report prepared by a certified water right examiner may be used to submit the required proof.

If you have not fully completed your project, and you or a previous owner of this permit have not received a prior extension of time, you may request an extension of time if the delay is for reasonable cause as provided in Section 42-204, Idaho Code. If you have been prevented from proceeding by a governmental agency or by litigation which might bring title to the water in question, more than one extension of time can be granted. An extension of time request form is enclosed for your convenience.

Either an acceptable proof of beneficial use submittal or an acceptable request for an extension of time must be received by this department on or before the above described proof due date. If neither is received, the department will send you a lapse notice. Within sixty (60) days of the mailing of the lapse notice, the permit will no longer be of any force nor effect.

SINCERELY,

JULIE L. YARBROUGH
Senior Secretary

Enclosures

FEB 1 7 1995

CERTIFIED MAIL
NO. 141850

THOMAS A. TOWNSEND
447 EAST EIGHTH STREET
MOSCOW, IDAHO 83843

13 MARCH 1993

Mr. Robert Haynes, P.E.
Regional Manager, Northern Division
Idaho Department of Water Resources
1910 Northwest Boulevard, Suite 210
Coeur d' Alene, Idaho 83814

RECEIVED
MAR 15 1993
NORTHERN DIVISION
IDWR

RECEIVED
OCT 25 1993
Department of Water Resources

SUBJ: Water Right, University of Idaho

Dear Bob,

Based on the enclosed bid advertisement the UI appears ready to put in a new production well to replace the failed Aquaculture well.

I am curious as to the water right situation for this new well. At the moment I dont know the planned location and would assume it it is in the same quarter section as the faled well that perhaps the existing water right (87-7141) would be transferred.

My basic concern is that there be no increased allocation beyond the current 147.3 AF/annum or 48 mgy. Actually, based on pumping records for the past two years, the allocation might in fact be reduced since UI's total use in the Aquaculture Facility ranged between 16.3 - 17.6 mgy. That suggests that the UI will never be able to perfect beneficial use to the 48 mgy level.

I have alerted the UI to these concerns most recently in a letter of 29 January 1993, copy to you, however never received a response.

RECEIVED
FEB 17 1995

Will ya please advise status of the water right for this proposed new production well? In the meantime I do some on-site walkabouts.

Regards,

Tom Townsend

INTY LEGALS

UNIVERSITY OF IDAHO
Moscow, Idaho
Mar. 10, 11, 12, 1993

ADVERTISEMENT FOR BIDS
UI AQUACULTURE PROGRAM
PRODUCTION WELL
University of Idaho
Moscow, Idaho
W.O. #3231

OWNER: THE REGENTS
UNIVERSITY OF IDAHO
ISSUED BY: Facility Design
University of Idaho

CONSULTING GEOLOGIST: Dale Ralston, 1122 East D, Moscow, Idaho 83843

PROJECT MANAGER: Raymond Pankopf, Project Architect. Facility Design, University of Idaho, Moscow, Idaho 83844-1231

Sealed proposals will be received by the acting agent for Facilities Management, University of Idaho, until 2:00 P.M. prevailing local time March 26, 1993. Proposals will be opened and publicly read at:

Facilities Management
University of Idaho, Moscow, Idaho 83844-1231

Plans, specifications, bid proposal forms and other information are available for examination at:

Associated Builders and Contractors, P.O. Box 3787, Spokane, Washington 99220

F. W. Dodge/Intermountain Contractor, 415 North Curtis Road, Boise, Idaho 83706

Construction Data/F.W. Dodge, E. 9212 Montgomery, Suite 601, Spokane, Washington 99206

Associated General Contractors, 8884 N. Government Way, Suite B, P.O. Box 130, Hayden Lake, Idaho 83835-0130

Associated General Contractors, P.O. Box 3266, T.A., Spokane, Washington 99220

Lewiston-Clarkston Plan Service, 1008 - 16th Avenue, Lewiston, Idaho 83501

Spokane Construction Council, P.O. Box 2968, Spokane, Washington 99220

Facility Design, Facilities Management, University of Idaho, Moscow, Idaho 83844-1231

Plans, specifications and bidding materials may be obtained at: Facility Design, Facilities Management, University of Idaho, Moscow, Idaho 83844-1231; (208) 885-6246 for a bid deposit of $25.00 on or after March 12, 1993.

DESCRIPTION OF WORK: The work consists of drilling and development of a 10" production shallow aquifer water well in support of the University Aquaculture research effort.

BID BOND: A bid bond equal to 5% of the amount bid must accompany the bid proposal. (See instructions to bidders.)

PUBLIC WORKS CONSTRUCTOR'S LICENSE: Public Works Contractor's License for the State of Idaho is required to bid on this project. (See instructions to bidders and general conditions for further bidder qualifications.)

ESTIMATED COST: $30,000.00 (base bid)

CONTRACT TIME: 30 calendar days (see instructions to bidders, bid proposal and agreement.)

Signed by:

Jerry Wallace,
Financial Vice President
UNIVERSITY OF IDAHO
Moscow, Idaho
March 12, 13, 15, 1993

12 MARCH 1993
Daily News, Moscow

RECEIVED
FEB 17 1995

RECEIVED
MAR 15 1993
IDAHO

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720 -(208) 327-7900

CECIL D. ANDRUS
GOVERNOR
R. KEITH HIGGINSON
DIRECTOR

October 30, 1990

Thomas A. Townsend
447 E. 8th St.
Moscow, ID 83843

RE: PERMIT 87-07141 - UNIVERSITY OF IDAHO

Dear Mr. Townsend:

I have reviewed your letter dated October 24, 1990 and have briefly reviewed the above referenced water right file.

The Memorandum Decision of the Director issued on January 19, 1990, indicates in Finding of Fact No. 13 that the initial research facility would require a water supply equal to or less than 48 million gallons per year. This testimony is likely the supporting information relative to the conditioned approval that the annual diversion not exceed the 48 million gallons per year unless additional diversion authority is sought by the permit holder and is subsequently granted.

Any permit issued by the department is in terms of a maximum authorized amount whether in terms of rate, volume or both. It is common that the amount actually diverted and beneficially used under many permits (the amount to be licensed) is less than the amount authorized by the permit. In this sense, the amount authorized by the Director can be considered to be "reduced", since the water right developed can not consist of more water than beneficially used.

I hope this letter provides the information you need.

Sincerely,

L. Glen Saxton

L. GLEN SAXTON, Chief
Water Allocation Bureau

c: IDWR - N. Region

FEB 17 1995

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

24 OCTOBER 1990

Mr. L. Glen Saxton
Chief, Water Allocation Bureau
Idaho Department of Water Resources
1301 North Orchard Street
Statehouse Mail
Boise, Idaho 83720

RECEIVED
OCT 26 1990
Department of Water Resources

Re: Permit 87-7141

Dear Mr. Saxton,

The Director's Order in the hearing related to this permit allowed a diversion of 48 million gallons per year.

Do the case files/records indicate upon what basis this quantitative judgement was made? Paragraph 13 of the Memorandum Decision notes that the Applicant said the initial development would require such a diversion; however, the engineering plans of the facility using this allocation (to-be-built) seem to require a much reduced volume, perhaps 65% less.

This engineering data was not available at the time of the hearing or at the completion date of the Order. If after operations begin, for perhaps a period of a year, the measured diversion reflects the actual requirements can the volume authorized be reduced by the Director?

Please advise.

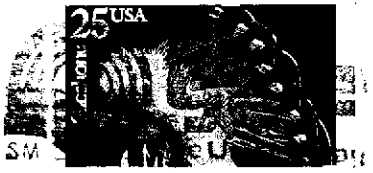
RECEIVED
FEB 17 1991

Regards,

Thom A. Townsend

Thomas Townsend
447 E 8th St
Moscow ID
83843

SPOKANE, WA 992
PM
24 OCT
1990



Mr. L. Glen Sexton
Chief, Water Allocation Bureau
Idaho Department of Water Resources
1301 N. Orchard Street
Statehouse Mail
Boise, Idaho 83720

RECEIVED
FEB 17 1995

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720 -(208) 327-7900

CECIL D. ANDRUS
GOVERNOR

R. KEITH HIGGINSON
DIRECTOR

October 16, 1990

Thomas A. Townsend
447 E. 8th St.
Moscow, ID 83843

RE: UNIVERSITY OF IDAHO WATER RIGHTS

Dear Mr. Townsend:

The Department has reviewed your October 1990 correspondence connection with the water rights of the University of Idaho (University).

The University has compiled and provided some information to the Department concerning its water rights of record. The water rights include 87-2005, 87-2014, 87-2017, 87-2018, 87-2031, 87-7012, 87-7026, 87-7135 and 87-7141. An initial review of the information has been made and I have asked Bob Haynes, manager of the Department's Coeur d'Alene office to work directly with the University to guide the development of information needed to determine if additional filings are needed or if changes are needed on present filings.

A review of the water right files including the examinations conducted in connection with the licenses suggest certain "general" uses of water within University buildings was occurring at the time of the examinations. While not termed "aquaculture" use, such use and other beneficial uses of water not then referred to by present day terminology likely were occurring. The Department will not require changes to existing rights for past uses which are reasonably included in existing water rights. If changes to any of the existing water rights are determined to be needed, however, the University has stated it intends to cooperate as needed.

It is the Department's intent and the University's stated intent to have the water rights of the University properly recorded with the Department. We appreciate your continuing interest in this matter.

Sincerely,

R. KEITH HIGGINSON
Director

c: IDWR - N. Region
John A. Rosholt
University of Idaho

RECEIVED
FEB 17 1995

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

October 9, 1990

RECEIVED
OCT 12 1990
Department of Water Resources

Mr. Kenneth A. Hall
Physical Plant Director
University of Idaho
Physical Plant Division
Moscow, Id. 83843

Re: Water Right Information

Dear Mr. Hall:

Thank you for your letter of October 3, 1990, enclosing the above information which our Department requested.

Upon review of the information the University of Idaho submitted, it was discovered that there were no attachments for Water Right No. 87-07035 (your Item No. 9, copy enclosed).

Could you please forward this information at your earliest convenience. Thank you for your cooperation.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms

Enclosure

RECEIVED
FEB 17 1993

Celebrate IDAHO
1890 · CENTENNIAL · 1990

October 3, 1990

University of Idaho
Physical Plant Division
Moscow, Idaho 83843

Idaho Department of Water Resources
4055 Government Way
Coeur d'Alene, Idaho 83814
ATTN: Bob Haynes

SUBJECT: Idaho Department of Water Resources Information

Attached is the information you requested. If you have any questions please call. I have added the state water right number where I have that information. I hope this information meets your needs.

Sincerely,

Donald R Huskey for
Kenneth A. Hall
Physical Plant Director

RECEIVED
OCT 0 5 1990
NORTHERN REGION
I D W R

cc: Ken White
Tom Sawyer
Don Huskey
Larry Kirkland
File: UI Water Rights

FEB 1 7 1995

Phone: (208) 885-6246 FAX: (208) 885-5748 E Mail: UOIPLANT @ UIDAHO

The University of Idaho is an equal opportunity/affirmative action employer and educational institution.

University of Idaho Water Rights Information

1. A. State Water Right Number: 87-02005
   B. Diversion Location: Well #2, Guy Wickes Field
   C. Type of Beneficial Use: Not used.
   D. Location Of Beneficial Use (See attached map): None
   E. Pump Size and Capacity: Not Applicable
   F. Estimated Amount Pumped 1989: None

RECEIVED
OCT 0 5 1990
DWR

RECEIVED
FEB 17 1995

License and Certificate of Water Right

Water License No. 22027 Amount 2.22 second feet

Water District No. Priority March 12, 1951

THIS IS TO CERTIFY that THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, Idaho, made application for a permit to appropriate the public waters of the State of Idaho, dated March 12, 1951; that Permit No. 22027 was issued under said application; that Certificate of Completion of works, with a carrying capacity of Five second feet, was issued thereunder on June 9, 1952, showing that said works were completed on the 2nd day of June, 1952; and that on the 18th day of July, 1952,

THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, State of Idaho, made proof to the satisfaction of the State Reclamation Engineer of Idaho, of the right to use the waters of a well, ~~a tributary of~~ (subterranean flow), for the purpose of domestic water supply, under Use Permit No. 22027 of the Department of Reclamation and that said right to the use of said waters has been perfected in accordance with the laws of Idaho, and is hereby confirmed by the State Reclamation Engineer of Idaho and entered of record in Volume 8 of Licenses at page 5026, on the 20th day of November, 1952;

The right hereby confirmed dates from March 12, 1951;

The Point of Diversion is located

In the SE ¼ SW ¼, Sec. 7, Tp. 39 N., R. 5 W., B.M. Latah County

That the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually needed and beneficially used for said purposes, and shall not exceed 2.22 cubic feet per second.

Description and location of use:

Twp.	Range	Sec.	Forty-acre Tract	No. Acres Described in Permit	No. Acres Actually Irrigated
			University Campus at Moscow, Idaho.		

The right to the use of the water aforesaid hereby confirmed is restricted to the lands or place of use herein described, as provided by the laws of Idaho.

WITNESS the seal and signature of the State Reclamation Engineer, affixed at Boise, Idaho, this 20th day of November, 1952.

E. N. Humphrey
Deputy *State Reclamation Engineer*

WELL # 2
522

FEB 17 1995

2.22 x 448 X 60 X 24 X 365 = 522,741,000 87 GAL.

2. A. State Water Right Number: 87-02014
   B. Diversion Location: Paradise Creek below Moscow water treatment plant outfall
   C. Type of Beneficial Use: Irrigation
   D. Location Of Beneficial Use (See attached map): White Pine Forest Nursery
   E. Pump Size and Capacity: Allowed use 120,089,000 gal/yr; 25 HP
   F. Estimated Amount Pumped 1989: 7,257,600 gal/yr

RECEIVED
OCT 0 5 1990
NORTHERN REGION
I D W R

FEB 1 7 1995

State of Idaho
License and Certificate of Water Right

Water License No. 25634 Amount .51 second foot

Water District No. Priority April 21, 1955

THIS IS TO CERTIFY that THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, Idaho, made application for a permit to appropriate the public waters of the State of Idaho, dated April 21, 19 55; that Permit No. 25634 was issued under said application; that Certificate of Completion of works, with a carrying capacity of 1.0 second foot, was issued thereunder on November 19 55, showing that said works were completed on the 23rd day of September, 19 55; and that on the 27th day of April, 19 56.

THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, State of Idaho, made proof to the satisfaction of the State Reclamation Engineer of Idaho, of the right to use the waters of Paradise Creek, a tributary of Palouse River, for the purpose of irrigation under Use Permit No. 25634 of the Department of Reclamation and that said right to the use of said waters has been perfected in accordance with the laws of Idaho, and is hereby confirmed by the State Reclamation Engineer of Idaho and entered of record in Volume 9 of Licenses at page 5846 on the 29th day of October, 19 56;

The right hereby confirmed dates from April 21, 19 55;

The Point of Diversion is located

in the SE ¼ SW ¼ Sec. 12 Tp. 39 N, R. 6 W., B. M. Latah County

That the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually needed and beneficially used for said purposes, and shall not exceed .51 cubic feet per second.

Description and location of use:

Twp.	Range	Sec.	Forty-acre Tract	No. Acres Described in Permit	No. Acres Actually Irrigated
39 N.	6 W.	12	SE¼SW¼ Lot 4 (SW¼SW¼)	25.5	26

The right to the use of the water aforesaid hereby confirmed is restricted to the lands or place of use herein described, as provided by the laws of Idaho.

WITNESS the seal and signature of the State Reclamation Engineer, affixed at Boise, Idaho, this 29th day of October, 19 56.

MARK R. KULP
State Reclamation Engineer.

(SEAL)

87 20147 1995

.51 X 448 X 60 X 24 X 365 = 120,089,000 gal/yr PARADISE CREEK

WHITMAN CO
LATAH CO
UNION
PACIFIC
BURLINGTON
NORTHERN
Sewage Disposal
Paradise
Creek
MOSCOW
UNIVERSITY OF IDAHO
Trailer Parks
Water Tank
Trailer Park
State Line
Palouse
River
South
Fork
Gravel Pit
Landing Strip

3. A. State Water Right Number: 87-02018
   B. Diversion Location: Paradise Creek below Moscow water treatment plant outfall
   C. Type of Beneficial Use: Irrigation
   D. Location Of Beneficial Use (See attached map): White Pine Forest Nursery
   E. Pump Size and Capacity: Allowed use 96,524,220 gal/yr; no pump
   F. Estimated Amount Pumped 1989: None

RECEIVED
OCT 0 5 1990
NORTHERN REGION
I D W R

APPROVED
FEB 17 1995

State of Idaho
License and Certificate of Water Right

Water License No. 26886 Amount .41 c.f.s.

Water District No. Priority May 7, 1957

THIS IS TO CERTIFY that THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, Idaho, made application for a permit to appropriate the public waters of the State of Idaho, dated May 7, 1957; that Permit No. 26886 was issued under said application; that Certificate of Completion of works, with a carrying capacity of 0.8 second feet, was issued thereunder on May 12, 1961, showing that said works were completed on the 9th day of May, 1961; and that on the 14th day of May, 1964,

THE REGENTS OF THE UNIVERSITY OF IDAHO

of Moscow, State of Idaho, made proof to the satisfaction of the State Reclamation Engineer of Idaho, of the right to use the waters of Paradise Creek, a tributary of Palouse River, for the purpose of irrigation under Use Permit No. 26886 of the Department of Reclamation and that said right to the use of said waters has been perfected in accordance with the laws of Idaho, and is hereby confirmed by the State Reclamation Engineer of Idaho and entered of record in Volume 13 of Licenses at page 7974, on the 1st day of September, 1964.

The right hereby confirmed dates from May 7, 1957.

The Point of Diversion is located in the SW ¼ SW ¼, Sec. 12, Tp. 37 N., R. 6 W., B. M. Latah County.

That the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually needed and beneficially used for said purposes, and shall not exceed .41 cubic feet per second.

Description and location of use:

Twp.	Range	Sec.	Forty-acre Tract	No. Acres Described in Permit	No. Acres Actually Irrigated
39 N.	6 W.	13	[illegible]	23	12.5
			[illegible] (Lot 1)	8.8	8.0
			Total number of acres to be irrigated:		20.5

This appears to be the White Pine Forest Water permit.

.41 cfs ⇒ .82 AF/day = 267,320 gpd = 50 x 10⁶ gal/6 mo

The right to the use of the water aforesaid hereby confirmed is restricted to of use herein described, as provided by the laws of Idaho.

WITNESS the seal and signature of the State Reclamation Engineer, affixed at Boise, Idaho, this 1st day of September, 1964.

(SEAL)

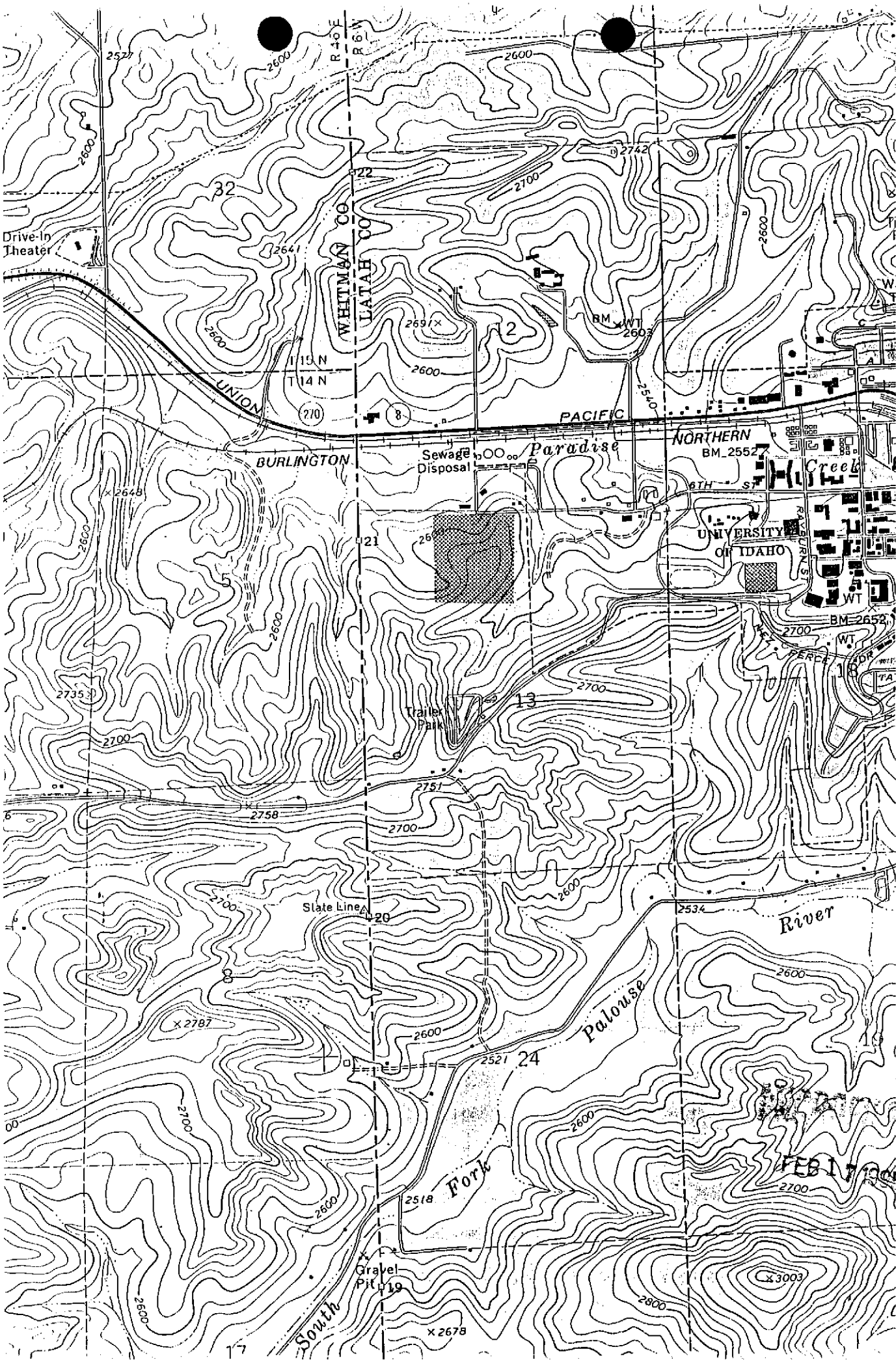
s/ RALPH W. THOMAS
Deputy State Reclamation Engineer.

FEB 17 1995

87 2018

.41 x 448 x 60 x 24 x 365 = 96,542,200

PARADISE CREEK



Drive-In Theater
WHITMAN CO
LATAH CO
T 15 N
T 14 N
UNION
PACIFIC
BURLINGTON
NORTHERN
Sewage Disposal
Paradise
Creek
6TH ST
UNIVERSITY OF IDAHO
RAYBURN ST
NEZ PERCE DR
Trailer Park
Slate Line
River
Palouse
Fork
South
Gravel Pit
BM 2552
BM 2652
WT
2600
2700
2800
2742
2641
2691
2603
2540
2648
2735
2751
2758
2534
2787
2521
2518
2678
3003
32
22
12
21
5
13
18
20
24
19
17

4. A. State Water Right Number: 87-02031
   B. Diversion Location: Main campus (Marked on attached map)
   C. Type of Beneficial Use: Domestic use and irrigation.
   D. Location Of Beneficial Use (See attached map): campus wide domestic water system
   E. Pump Size and Capacity:Allowed use 946,000,000 gal/yr; 400 HP, 1800 GPM
   F. Estimated Amount Pumped 1989: 156,000,000 gal/yr

RECEIVED
OCT 0 5 1990
NORTHERN REGION
IDWR

RECONVEYED
FEB 17 1995

State of Idaho
License and Certificate of Water Right

Water License No. G-32056 Amount 4.0 c.f.s.

Water District No. Priority August 31, 1964

THIS IS TO CERTIFY that The Regents of the University of Idaho of Moscow, Idaho, made application for a permit to appropriate the public waters of the State of Idaho, dated August 31, 1964; that Permit No. G-32056 was issued under said application; that Certificate of Completion of works, with a carrying capacity of 4.0 second feet, was issued thereunder on October 5, 1965, showing that said works were completed on the 24 day of November, 1964; and that on the 24th day of November, 1964. The Regents of the University of Idaho of Moscow, State of Idaho, made proof to the satisfaction of the State Reclamation Engineer of Idaho, of the right to use the waters of a well, a tributary of subterranean flow, for the purpose of domestic use and irrigation, under Use Permit No. G-32056 of the Department of Reclamation and that said right to the use of said waters has been perfected in accordance with the laws of Idaho, and is hereby confirmed by the State Reclamation Engineer of Idaho and entered of record in Volume 13 of Licenses at page 8302, on the 5 day of October, 1965;

The right hereby confirmed dates from August 31, 1964;

The Point of Diversion is located in the SW ¼ NW ¼, Sec 7, Tp. 39 N, R. 5 W, B. MLatah County

That the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually needed and beneficially used for said purposes, and shall not exceed 4.0 cubic feet per second.

Description and location of use.

Twp.	Range	Sec.	Forty-acre Tract	No. Acres Described in Permit	No. Acres Actually Irrigated
39 N	5 W	7	SW¼ SW¼	20	20
			SE¼ SW¼	20	20
		18	W½ NE¼	80	80
			NW¼	160	160
			Total number of acres to be irrigated: 280		
	NOTE:	2.0 c.f.s. for domestic use			
		2.0 c.f.s. for irrigation			

The right to the use of the water aforesaid hereby confirmed is restricted to the lands or place ie herein described, as provided by the laws of Idaho.

WITNESS the seal and signature of the State Reclamation Engineer, affixed at Boise, Idaho, this day of October, 1965.

/s/ RALPH W. THOMAS
Deputy State Reclamation Engineer.

Curried on the database as 87-02031

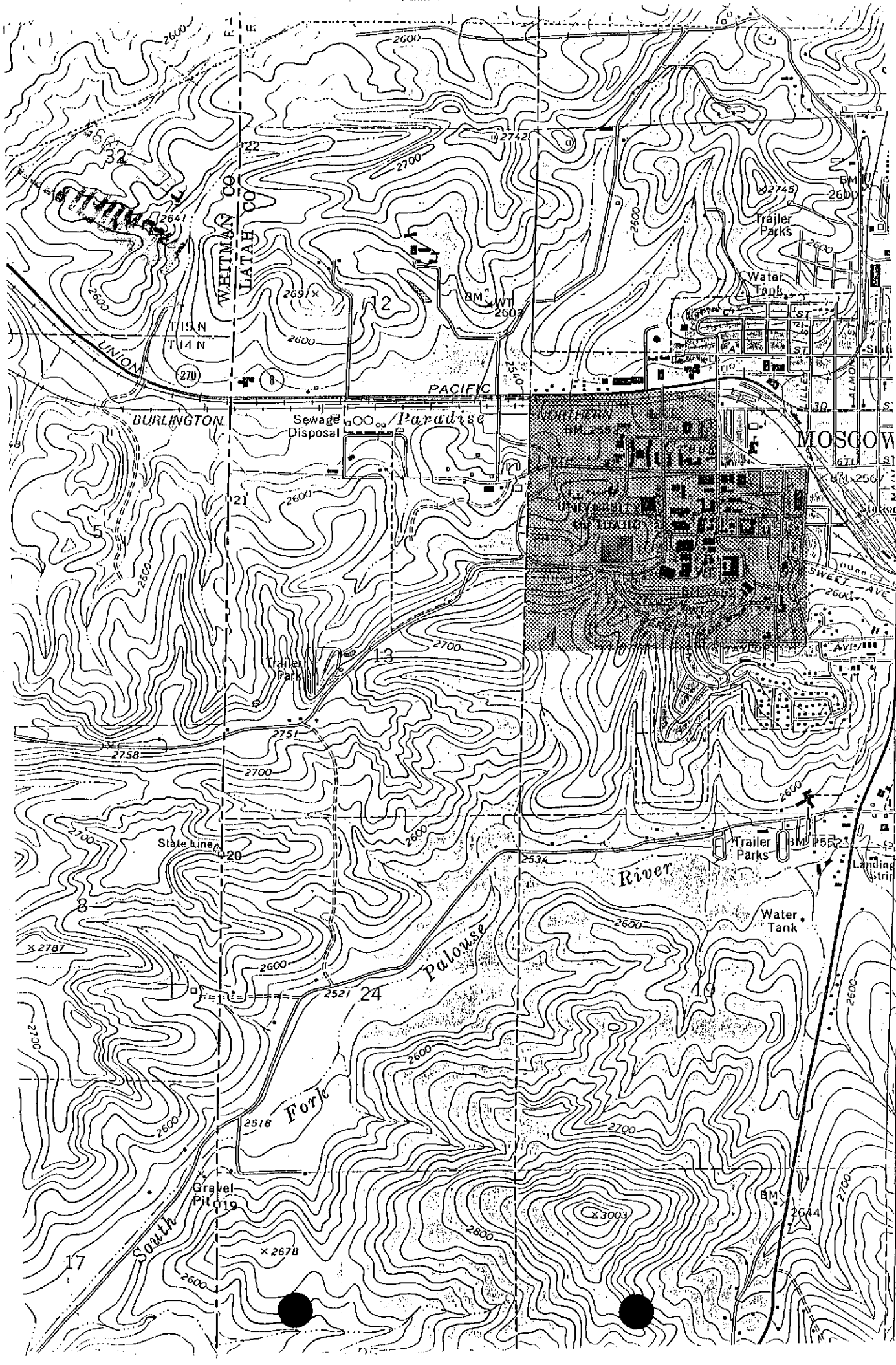
FEB 17 1995

Well # 3

86 2032

86-02032

4.0 x 448 x 60 x 24 x 365 = 941,875,000 gal/yr



WHITMAN CO
LATAH CO
UNION
PACIFIC
BURLINGTON
NORTHERN
Sewage Disposal
Paradise
Trailer Parks
Water Tank
MOSCOW
UNIVERSITY OF IDAHO
SWEET AVE
TAYLOR AVE
Trailer Park
State Line
Palouse River
South Fork
Gravel Pit
Landing Strip
T 15 N
T 14 N

5. A. State Water Right Number: 87-07012
   B. Diversion Location: Main campus-behind Palouse Empire Mall (marked on map)
   C. Type of Beneficial Use: Domestic water and irrigation.
   D. Location Of Beneficial Use (See attached map): Campus wide domestic water system
   E. Pump Size and Capacity: Allowed 970,131,000 gal/yr; 450 HP; 2000 GPM
   F. Estimated Amount Pumped 1989: 172,000,000 gal/yr

RECEIVED
OCT 0 5 1990
NORTHERN REGION
I D W R

FEB 1

State of Idaho

Department of Water Resources

WATER RIGHT LICENSE

License of Water Right No. 87-7012 Priority May 22, 1972 Amount 4.12 cfs

THIS IS TO CERTIFY, that THE REGENTS OF THE UNIVERSITY OF IDAHO

of Moscow, Idaho, has complied with the terms and conditions of Permit No. 87-7012 issued pursuant to Application for Permit dated May 22, 1972, and has submitted proof to the Department of Water Resources on May 13, 1977, that he has applied water to a beneficial use; an examination by the Department indicates that the works have a capacity for the diversion of 4.12 cfs of water from a groundwater source, tributary to _____, and that the permit holder has applied to a beneficial use an. established a right to use water as follows:

Beneficial Use	Period of Use	Rate of Diversion	Annual Volume
Irrigation	from April 1 to November 1	2.0 cfs and	708 acre feet
Domestic	from January 1 to December 31	2.12 cfs and	1,532 acre feet
	from _____ to _____ (both dates inclusive)	at _____ cfs and	

Subject, however, to the condition that no more than 4.12 cfs of water be diverted at any one time, and that the amount of water so diverted and to which such right is entitled and confirmed is for the purpose aforementioned and is limited to the amount which can actually be beneficially used and shall not exceed 2,240 acre feet per year, said waters to be diverted within the NE¼SE¼, Sec. 12, Twp. 39N, Rge. 6W, B.M. in the County of Latah

Description and location of place of use:

Twp.	Range	Sec.	NE¼ NE¼	NE¼ NW¼	NE¼ SW¼	NE¼ SE¼	NW¼ NE¼	NW¼ NW¼	NW¼ SW¼	NW¼ SE¼	SW¼ NE¼	SW¼ NW¼	SW¼ SW¼	SW¼ SE¼	SE¼ NE¼	SE¼ NW¼	SE¼ SW¼	SE¼ SE¼	Totals
39N	5W	7											15	30					45
		18		20	30		20	34	18	33	10	20							185
39N	6W	12																X 6	6
						X	Domestic Use												

Total number of acres irrigated 236

NOTE: Modifications to or variance from this license must be made within the limits of Section 42-222, Idaho Code, or the applicable Idaho Law. This right may be forfeited by five years of non-use.

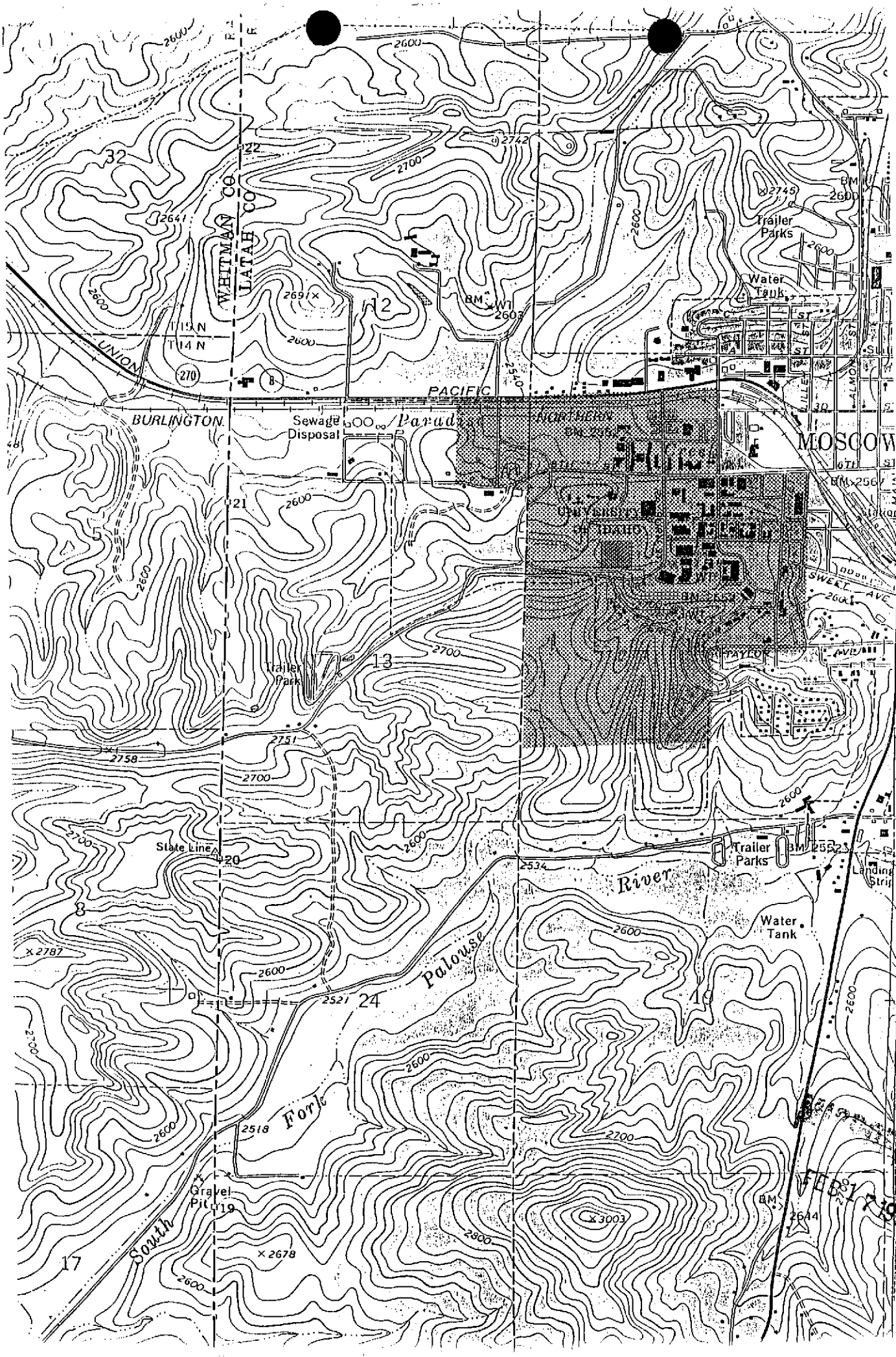
The right to the use of the water hereby confirmed is restricted and appurtenant to the lands or place of use herein described, as provided by the laws of Idaho.

Witness the seal and signature of the Director, affixed at Boise, Idaho, this 30 day of April, 19 80.

RECEIVED FEB 17 1995

87-7012

WELL #4 4.12 x 448 x 60 x 24 x 365 = 970,131,000 gal/yr



WHITMAN CO
LATAH CO
UNION
PACIFIC
BURLINGTON
NORTHERN
Sewage Disposal
Paradise
Creek
MOSCOW
UNIVERSITY OF IDAHO
Trailer Parks
Water Tank
Trailer Park
State Line
Palouse
River
South Fork
Gravel Pit
SWEET AVE
TAYLOR
Landing Strip
T 15 N
T 14 N
2600
2700
2800
2742
2745
2641
2691
2603
2540
2751
2758
2534
2787
2521
2518
2678
3003
2644
32
22
12
21
13
20
8
24
19
17

FEB 17 1995

6. A. State Water Right Number: 87-07026
B. Diversion Location: Effluent from Moscow Sewage Treatment Plant
C. Type of Beneficial Use: Irrigation
D. Location Of Beneficial Use (See attached map): Guy Wicks Field, ASUI Golf Course, Arboretum
E. Pump Size and Capacity: Allowed 227,031,000 gal/yr; 160 HP; 800 GPM
F. Estimated Amount Pumped 1989: 64,000,000 gal/yr

RECEIVED
OCT 05 1990
NORTHERN REGION
IDWR

FEB 17 1995

Identification No. 87-7026

Application No.

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPROVED

APPLICATION FOR PERMIT

To Appropriate the Public Waters of the State of Idaho
(TYPE OR PRINT IN INK)

1. Name of applicant The Regents of the University of Ida Phone: 885-6246
post office address Moscow, Idaho
2. Source of water supply Moscow City Sewage Treatment Plant which is a tributary of Paradise Creek
3. a. Location of point of diversion is SE ¼ of SW ¼ of Section 12 Township 39N Range 6 W B.M. Latah County; additional points of diversion if any: None

b. If water is not consumed, it will be discharged into N/A at a point in ¼ of ¼ of Section Township Range B.M.

4. Water will be used for the following purposes:
Amount 1.78 cfs (cfs or acre feet per annum) for irrigation purpose from April 1 to Oct. 15 (both dates inclusive)
Amount (cfs or acre feet per annum) for purpose from to (both dates inclusive)
Amount (cfs or acre feet per annum) for purpose from to (both dates inclusive)

5. Total quantity to be appropriated,
a. 1.78 cubic feet per second and/or
b. acre feet per annum.

6. Proposed diverting works:
a. Description of ditches, flumes, pumps, headgates, etc. A pumping station would be located at the point of diversion. The storage lagoon would be constructed south of that point. From the lagoon, the water would be pumped via underground mains to irrigate lawns and recreational facilities within the University of Idaho campus.
b. Height of storage dam 8 feet, active reservoir capacity 1.6 acre feet, total reservoir capacity 1.6 acre feet, materials used in storage dam earthfill.
Period of year during which storage will occur January 1 (mo. day) to December 31 (mo. day) inclusive.
c. Proposed well diameter is N/A inches; proposed depth of well is feet.

7. a. Time required for the completion of the works and application of the water to the proposed beneficial use is 2 years.
b. Estimated construction cost is $ 900,000

8. Description of proposed uses:
(1) If water is not for irrigation:
(1) Give the place of use of water N/A ¼ of ¼ of Section Township Range B.M.
(2) Amount of power to be generated hp under feet of head.
(3) List number of each kind of livestock to be watered
(4) Name of municipality to be served or number of families to be supplied with domestic water.
(5) If water is to be used for other purposes describe:

RECEIVED
FEB 17 1995

EFFLUENT 1.78 X 448 X 60 X 24 X 365 X 13/24 = 227,031,000 gal/yr

b. If water is for irrigation, indicate acreage in each subdivision in the location below:

TWP	RANGE	SEC	NE¼				NW¼				SW¼				SE¼				TOTALS
			NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	
39N	5W	7											X	X					20
																		X	20
		12																X	40
		13	X			X													80
		18		X	X		X	X	X	X		X							280

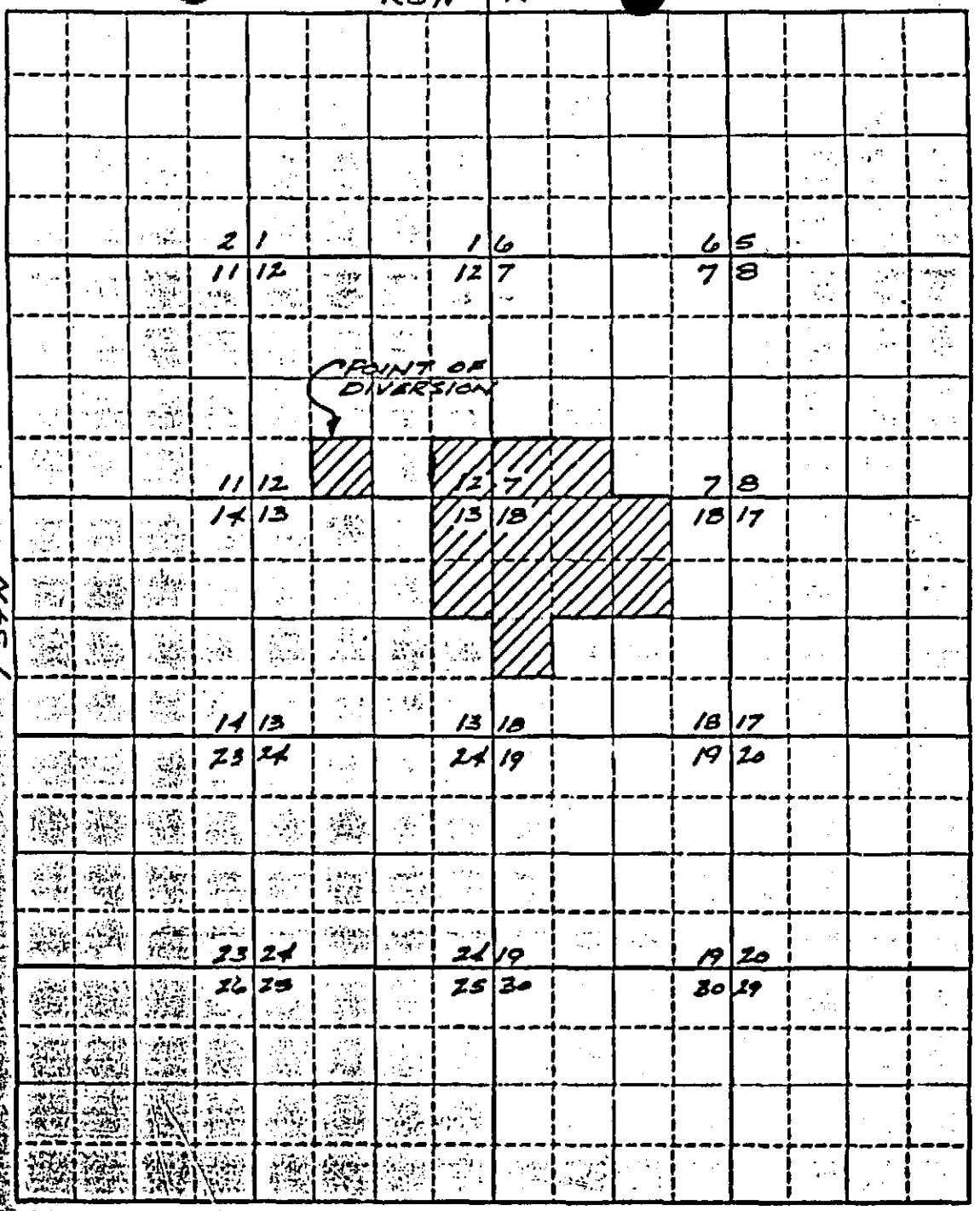
Total number of acres to be irrigated 440

c. Describe any other water rights used for the same purposes as described above. 2.0 cfs for domestic use and 2.0 cfs for irrigation from subterranean flow. Refer to water License No. 0-32056

9. a. Who owns the property at the point of diversion University of Idaho (long-term lease to City of Moscow.)
b. Who owns the land to be irrigated or place of use University of Idaho
c. If the property is owned by a person other than the applicant, describe the arrangement enabling the applicant to make this filing. Owned

10. Remarks A portion of the quantity of water requested in this permit is pumped by the University of Idaho from the underground water supply, and after use on the campus, is treated and discharged into Paradise Creek. Although it is impossible to determine the exact proportion, comparing average populations of the University to the city results in a ratio of 7,000/17,000 or 7/17. Allowing for industrial uses in the city, it should be safe to say that between one-fourth and one-third of the water herein requested was initially pumped by the University. This water permit request is for expanded use of water described above as well as for use of Moscow city waste water, both of which are discharged into Paradise Creek.

11. Map of proposed project: show clearly the proposed point of diversion, place of use, section number, township and range number.



Scale: 2 inches equal 1 mile

BE IT KNOWN that the undersigned hereby makes application for permit to appropriate the public waters of the State of Idaho as herein set forth.

Sherman Carter

(Applicant)

SHERMAN CARTER, Financial Vice President and Bursar, University of Idaho

July 9, 1976

FEB 17 1995

Proposed 8-02-76

Received by CP Date 7-12-76 Time 10:30 a.m. 11:00 a.m.

Preliminary check by PGH Fee $ 33.00

Receipted by cp Date 8-2-76 (Rec. #4335)

Publication prepared by cp Date 8-6-76

Published in Daily Idahonian

Publication dates 8-12 & 8-19-76

Publication approved ____ Date ____

Priority reduced to ____ Reason ____

Protests filed by: ____

Copies of protests forwarded by ____

Hearing held by ____ Date ____

Recommended for (approval) denial by [illegible]

CORRECTION NOTICE: 9-2 & 9-9-76

ACTION OF THE DIRECTOR, DEPARTMENT OF WATER RESOURCES

This is to certify that I have examined Application for Permit to appropriate the public waters of the State of Idaho No. 87-7026, and said application is hereby APPROVED.

1. Approval of said application is subject to the following limitations and conditions:

a. SUBJECT TO ALL PRIOR WATER RIGHTS.

b. Proof of construction of works and application of water to beneficial use shall be submitted on or before December 1, 1978.

c. Other: A measuring device of a type approved by the Director shall be permanently installed and maintained as part of the diverting works.

2. Denial of said application is for the following reasons: ____

Witness my hand this 6 day of November 1976.

R. Keith Higginson
Director

PRIOR WATER RIGHTS

FEB 17 1995

State of Idaho
DEPARTMENT OF HEALTH AND WELFARE
Division of Environmental Quality

450 W. State Street
Boise, Idaho 83720

CECIL D. ANDRUS
Governor
RICHARD P. DONOVAN
Director

RECEIVED
AUG 11 1989
PHYSICAL PLANT

August 4, 1989

Mr. Kenneth A. Hall
Physical Plant Director
University of Idaho
Moscow, Idaho 83843

Re: Wastewater-Land Application Permit No.: LA-000028
(U. of I. Wastewater Land Application System)

Dear Mr. Hall:

We are issuing the above referenced Wastewater-Land Application permit. The enclosed document is your official copy of the permit and demonstrates that you are authorized to operate the wastewater-land application facility subject to certain specified requirements.

The permit is effective the date of the Director's signature and will expire July 31, 1994.

Sincerely,

Al E. Murrey, P.E.
Chief, Water Quality Bureau

FILE - Joy
cc: Ken W ✓ 8-10-89
Butch F
Larry K/Tom S
Mike H
Joanne R

cc: Paul Jehn
Mark Von Lindern/George Dekan, LFO
Susan Burke

FEB 17 1995

Celebrate IDAHO
1890 • CENTENNIAL • 1990
Printed on Recycled Paper

GOLF COURSE
ARBORETUM
WEST FIELD
WICKS FIELD
NORTH FIELD
OUTDOOR TRACK
LAWN
N
UNIVERSITY OF IDAHO
LAND APPLICATIONS SYSTEM
7 1995

WHITMAN CO
LATAH CO
UNION
PACIFIC
BURLINGTON
NORTHERN
Sewage Disposal
Paradise
MOSCOW
Trailer Parks
Water Tank
Trailer Park
State Line
Palouse
River
South
Fork
Gravel Pit
SWEET AVE
TAYLOR
2600
2700
2800
2742
2745
2641
2691
2603
2540
2751
2758
2534
2787
2521
2518
2678
3003
32
22
12
13
21
20
8
24
19
17

FEB 17 1995

7. A. State Water Right Number: 87-07135
   B. Diversion Location: Arboretum Well
   C. Type of Beneficial Use: Irrigation
   D. Location Of Beneficial Use (See attached map): Arboretum
   E. Pump Size and Capacity: Allowed use 58,867,200 gal/yr; No Pump Installed
   F. Estimated Amount Pumped 1989: None

RECEIVED
OCT 05 1990
NORTHERN REGION
IDWR

FEB 17 1995

RECE... 1990

MAR 16 1990
...THERN REGION
IDWR

Form 202
6/85

Ident. No. 87-07135

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
APPLICATION FOR PERMIT

To appropriate the public waters of the State of Idaho

APPROVED

1. Name of applicant University of Idaho Phone _____

Post office address Moscow, Idaho

2. Source of water supply UNNAMED STREAM WHICH IS A TRIBUTARY OF PALOUSE RIVER ground water which is a tributary of N/A

3. Location of point of diversion is SE ¼ of SW ¼ of ~~¼, Govt. Lot~~

Sec. 18 Township T 39 N Range 5 W B.M. Latah County; additional

points of diversion if any: _____

PERI TEL/CON w/R.L. NASKALI

4. Water will be used for the following purposes:

Amount 0.25cfs for diversion to storage purposes from 1-1 to 12-31 (both dates inclusive
Amount 1.5 AF for storage for WILDLIFE purposes from 1-1 to 12-31 (both dates inclusive
Amount AF for _____ fm storage purposes from _____ to _____ (both dates inclusive
Amount cfs for _____ purposes from _____ to _____ (both dates inclusive
Amount 1.5 AF for storage for AESTHETICS purposes from 1-1 to 12-31 (both dates inclusive
Amount AF for _____ fm storage purposes from _____ to _____ (both dates inclusive
Amount cfs for _____ purposes from _____ to _____ (both dates inclusive
Amount AF for storage for _____ purposes from _____ to _____ (both dates inclusive
Amount AF for _____ fm storage purposes from _____ to _____ (both dates inclusive
Amount cfs for _____ purposes from _____ to _____ (both dates inclusive

5. Total Quantity to be appropriated is (a) .25 cfs cfs and/or 1.5 JK af/ann.

6. Proposed Diverting works:

a. Description of ditches, flumes, pumps, headgates, etc. Water will be pumped from well to two ponds with total surface area < .5 acre, about 6 ft deep. The water will be used to maintain the ponds

b. Height of storage dam ≈9.0 ft JK feet; active reservoir capacity 1.5 JK acre-feet; total reservoir capacity 1.5 JK acre-feet; period of year when water will be diverted to storage: _____ to _____ inclusive.

c. Proposed well diameter is 6 feet inches; proposed depth of well is 17.0 feet.
VERTICLE CMP JK

d. Is ground water with a temperature of greater than 90°F being sought? No

7. Time required for the completion of the works and application of the water to the proposed beneficial use is 1 year years (*minimum 1 year*).

FEB 17 1995

ARBORETUM WELL

.25 x 448 x 60 x 24 x 365 = 58,867,200

8. Description of proposed uses (*If irrigation only, go to item 9*):

a. Hydropower; show total feet of head and proposed capacity in KW. _____

b. Stockwatering; list number and kind of livestock. _____

c. Municipal; show name of municipality. _____

d. Domestic; show number of households. _____

e. Other; describe fully. Water will be used for maintaining pond and wetland for arboretum plantings.

9. Description of place of use:

a. If water is for irrigation, indicate acreage in each subdivision in the tabulation below.

b. If water is used for other purposes, place a symbol of the use (*example: D for Domestic*) in the corresponding place of use below. See instructions for standard symbols.

TWP	RANGE	SEC.	NE¼				NW¼				SW¼				SE¼				TOTALS
			NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	
39N	5W	18									W/J			W/J					

Total number of acres to be irrigated _____

10. Describe any other water rights used for the same purposes as described above. None

11. a. Who owns the property at the point of diversion? University of Idaho

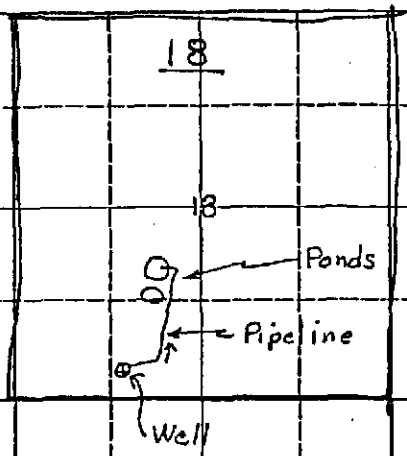
b. Who owns the land to be irrigated or place of use? University of Idaho

c. If the property is owned by a person other than the applicant, describe the arrangement enabling the applicant to make this filing. _____

12. Remarks: _____

FEB 17 1995

13. Map of proposed project: show clearly the proposed point of diversion, place of use, section number, township and range number.



Scale: 2 inches equal 1 mile.

BE IT KNOWN that the undersigned hereby makes application for permit to appropriate the public waters of the State of Idaho as herein set forth.

10/4/88
(Applicant)
FEE PAID
University of Idaho - Don A. Amos - Manager

Received by Ken Date 10/11/88 Time 2:00 p Preliminary check by TK

Fee $ 45.00 Receipted by TK # N1864 Date 10/13/88

Publication prepared by [signature] Date 10/26/88 Published in Illinois/Daily News 11/3 & 10/88

Publication approved [signature] Date 12/19/88

ACTION OF THE DIRECTOR, DEPARTMENT OF WATER RESOURCES

This is to certify that I have examined Application for Permit to appropriate the public waters of the State of Idaho No. 87-7135, and said application is hereby APPROVED.

1. Approval of said application is subject to the following limitations and conditions:

   a. SUBJECT TO ALL PRIOR WATER RIGHTS.

   b. Proof of construction of works and application of water to beneficial use shall be submitted on or before April 1, 19 90.

   c. The rate of diversion, if water is to be used for irrigation under this permit, when combined with all other water rights for the same land shall not exceed 0.02 cubic feet per second for each acre of land.

   d. The water right acquired under this permit if for hydropower purposes shall be junior and subordinate to all rights to the use of water, other than hydropower, within the State of Idaho that are initiated later in time than the priority of this permit and shall not give rise to any right or claim against any future rights to the use of water, other than hydropower, within the State of Idaho initiated later in time than the priority of this permit.

   e. Other:

   Permit holder shall comply with the drilling permit requirements of Section 42-235, Idaho Code.

   Witness my hand this 13th day of March, 1989.

L. Glen Saxton

FEB 17 1995

8. A. State Water Right Number: 87-2017
   B. Diversion Location: Parker Farm -East of campus
   C. Type of Beneficial Use: Irrigation and nursery stock.
   D. Location Of Beneficial Use (See attached map): Parker Farm
   E. Pump Size and Capacity: Allowed use 183,960,100 gal/yr; 30 HP
   F. Estimated Amount Pumped 1989: 1,000,000

FEB 17 1995

State of Idaho
License and Certificate of Water Right

Water License No. G-26879 Amount 0.78 c.f.s.

Water District No. Priority May 7, 1957

THIS IS TO CERTIFY that THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, Idaho, made application for a permit to appropriate the public waters of the State of Idaho, dated May 7, 1957; that Permit No. G-26879 was issued under said application; that Certificate of Completion of works, with a carrying capacity of 0.78 second feet, was issued thereunder on September 21, 1962, showing that said works were completed on the 10th day of May, 1962; and that on the 10th day of May, 1962

THE REGENTS OF THE UNIVERSITY OF IDAHO of Moscow, State of Idaho, made proof to the satisfaction of the State Reclamation Engineer of Idaho, of the right to use the waters of a well, a tributary of subterranean flow, for the purpose of irrigation - nursery stock, under Use Permit No. G-26879 of the Department of Reclamation and that said right to the use of said waters has been perfected in accordance with the laws of Idaho, and is hereby confirmed by the State Reclamation Engineer of Idaho and entered of record in Volume 12 of Licenses at page 7455, on the 21 day of September, 1962;

The right hereby confirmed dates from May 7, 1957;

The Point of Diversion is located in the SW ¼ NW ¼ Sec. 15, Tp. 39 N. R. 5 W., B. M. Latah County

That the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually needed and beneficially used for said purposes, and shall not exceed 0.78 cubic feet per second.

Description and location of use:

Twp.	Range	Sec.	Forty-acre Tract	No. Acres Described in Permit	No. Acres Actually Irrigated
39 N	5 W.	15	SE¼ NW¼	15	5
			SW¼ NW¼	30	40
		16	SE¼ NE¼	16	16
			Total number of acres to be irrigated:		61

Parker Farm

The right to the use of the water aforesaid hereby confirmed is restricted of use herein described, as provided by the laws of Idaho.

WITNESS the seal and signature of the State Reclamation Engineer, affixed at Boise, Idaho, this 21 day of September, 1962.

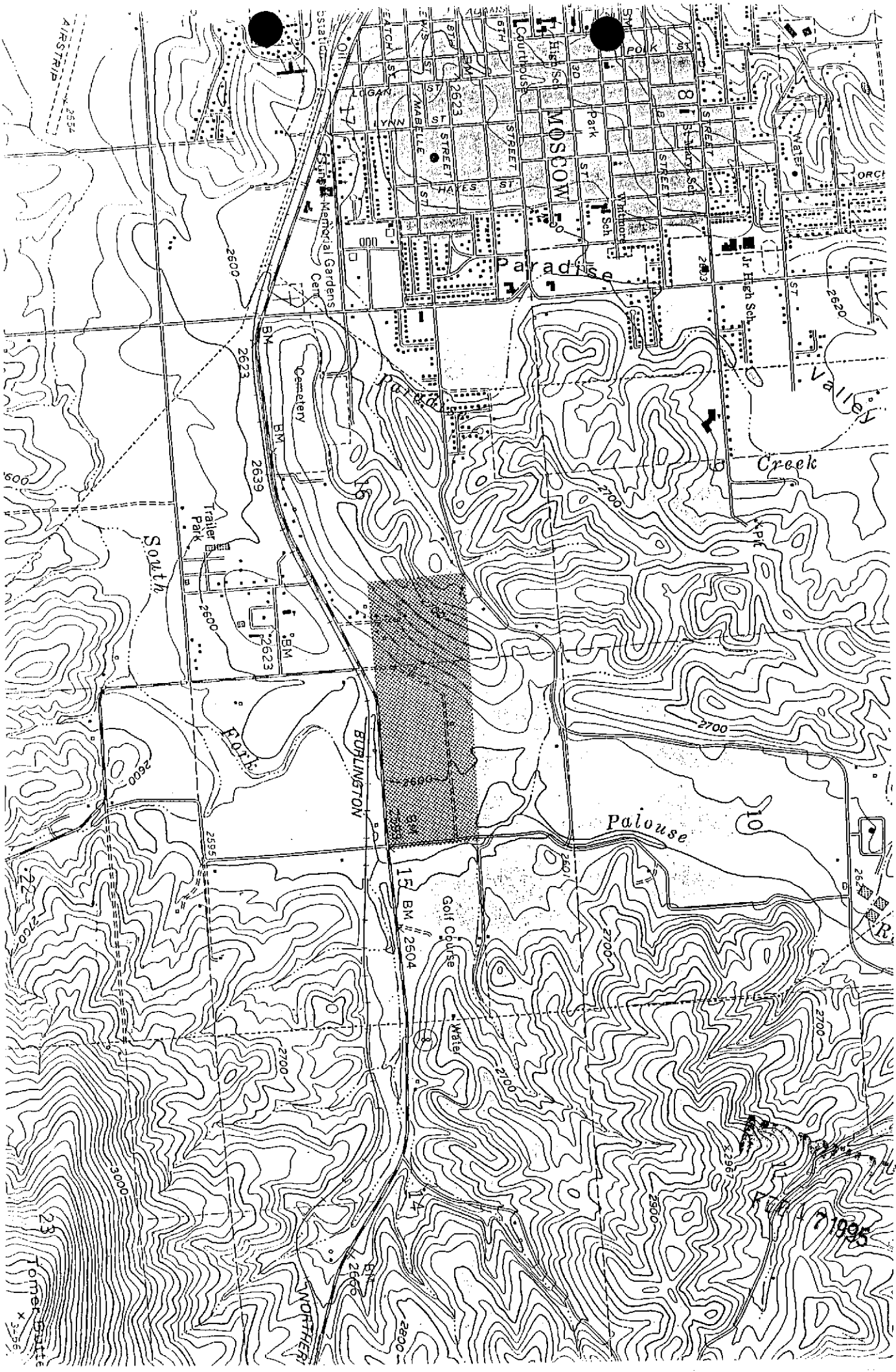
CARL E. TAPPAN
Assistant State Reclamation Engineer

(SEAL)

87 2017

FEB 17 1995

.78 x 448 x 60 x 24 x 365 = 183,666,000 gal/yr PARKER FARM



MOSCOW
Paradise
Valley
Creek
Palouse
South
Fork
Cemetery
Trailer Park
Memorial Gardens Cem
Courthouse
High Sch
Jr High Sch
Golf Course
BURLINGTON
NORTHERN
AIRSTRIP
Tomer Butte
2623
2639
2600
2700
2620
2595
2504
3000
2900
2800

87-402 City of Moscow 1952 1.67 cfs → 580c G.W. well

9. A. State Water Right Number:87-07035
B. Diversion Location: Well # 5, Aquaculture, West campus
C. Type of Beneficial Use: Research, Domestic water, and irrigation
D. Location Of Beneficial Use (See attached map): Aquaculture facility and same as #6 for the recycled water
E. Pump Size and Capacity: Allowed 54,000,000 gal/yr; No pump installed
F. Estimated Amount Pumped 1989: None

RECEIVED
OCT 05 1990
NORTHERN REGION
IDWR

No attachments received pmc 10/5/90

FEB 17 1995

9 Oct. 1990

Mr. Norman Young
Administrator, Resources Admin. Div.
Idaho Department of Water Resources
Statehouse Mail
Boise, Idaho 83720

RECEIVED
OCT 11 1990
Department of Water Resources

Re: University of Idaho Water Use Practices.

Dear Mr. Young,

You are no doubt aware of the recent problems that the University has had, still continuing, with water quality on campus.

Some salient points that derive from this issue that bear on my earlier complaints about non-permitted uses are as follow:

1. The University is utilizing so much of public resource in support of the Fish & Wildlife Resource wet lab - a non permitted use.
2. The University is having problems with coliform bacteria in its internal water system since no water in the campus system is chlorinated since the aquaculture fish lab draws upon this system. Some local news releases stories are enclosed.
3. The University to my knowledge is providing metered water service to several private society (fraternities/sororities) buildings along Nez Perce Drive on the south edge of campus. I believe a financial charge is being made for this service. If so, the University is presumed to be retailing water which is not a current permitted practice under existing permits.

Regards,

Thom A. Tammum

447 E. 8th St.
Moscow, Idaho 83843

FEB 17 1995

IDAHONIAN 10/4/90

Activist: UI dragging feet through water

By STEVE THOMPSON
Staff Writer

The University of Idaho is dragging its feet on a directive from an Idaho water agency to modify its water rights to cover uses not covered by existing permits, a Moscow citizen charges.

Frustrated by the delay, water activist Tom Townsend has filed a formal protest with the Idaho Department of Water Resources to force UI to clean up its act. UI has stalled because it doesn't want to do what Townsend calls its "administrative housekeeping" in public, he says.

"It's a cumbersome process, but it's also the law," Townsend says.

UI's annual use of about 380 million gallons of water does not exceed its total permitted draw. But Townsend says that UI does not use the water for the purposes specified on the permits.

The UI water permits in question, primarily granted during the 1950s and 1960s, allow the use of Palouse deep aquifer water for irrigation and domestic use. UI needs to change the use categories because it also uses water for research, stock watering and heating and cooling systems, Townsend says.

Last January, Idaho officials notified UI that it wants to keep closer tabs on how the university uses its water. UI may need to modify its water permits to conform with more recent laws, they told UI officials. In any case, the water department directed UI to detail its water uses.

Since then, the department has softened its position. UI and Idaho officials say it's still not clear whether any formal changes need to be made.

"Since I can't point to something that has to be changed, I'm satisfied as long as they're making a good faith effort to provide information," said Bob Haynes of the water resources department.

Last January, Haynes was particularly concerned that UI water was being used for commercial purposes at the Palouse Empire Mall, which sits on university land. That is not the case, he has since discovered. The mall is served by Moscow city water.

Norm Young, a water resources administrator in Boise, said the department is not sure how to respond to Townsend's unusual protest, which it received this week. "It's not a routine matter. We're not sure quite how to handle it, because normally we get a protest only if some decision is pending." He said the department is taking the matter seriously.

Since January, UI has been gathering the information requested by the state, says acting Financial Vice President Jerry Wallace. He acknowledged that two deadlines for resolving the matter, timetables that were suggested by UI, have passed unmet. He said that is because of shifting duties following the resignation of former Financial Vice President Joe Geiger in June.

UI water must be boiled or treated

MOSCOW — Water on the University of Idaho campus should be boiled for at least five minutes or two drops of chlorine bleach added to a quart, according to the Idaho Department of Health and Welfare, because of unacceptable coliform bacteria tests.

The UI water was found unacceptable for the second time in six weeks. Routine water tests earlier in the week did not pass the standard.

UI officials are preparing an emergency request to the Idaho Division of Public Works to spend up to $130,000 to fix the problem. The problem happens in the I tank on the southwest side of campus. When the water table dips too low, it stirs up a sediment layer, according Terry K. Maurer, UI director of media relations.

A similar problem occurred in August.

To fix the problem, the UI wants $50,000 to clean the tank on Nez Perce Drive and another $60,000 to $80,000 to replace the control system.

The UI is unable to use chlorine in its water because of research on fish that could be damaged by chemical contamination.

IDAHONIAN 10/4/90

WHEAT & CHAFF

The Latah County state senate campaign, hottest political race of the season, has a few familiar names lining up as advisers to the three candidates.... Moscow auto dealer and GOP patriarch Jimmy Anderson and former University of Idaho financial vice president Joe Geiger are co-chairing Republican Gary Scott's campaign.... Retiring Sen. Don Mackin and Nobby Inn owner Tom Mayburry are directing the campaign of Democrat Craig Mosman.... And CPA Andrea Beckett is leading the charge for independent Andy Schwam. But Schwam, the pro-abortion rights candidate, also landed a defection from the Democratic Party ranks: Marilyn Francis, until recently the coordinator of the party's headquarters on Jackson Street, is a consultant and assistant to Schwam.

FEB 1995

UI may boil water 'til Homecoming

By STEVE THOMPSON 10/8/90
Staff Writer

The University of Idaho is a nice place to visit, but don't drink the water.

That may be the message that greets UI alumni this week when they return to Moscow for annual homecoming celebrations and Saturday's football game.

UI officials learned today that its water supply, which has been contaminated with bacteria since early last week, is still unsafe for drinking. UI water should be boiled five minutes or sterilized with two drops of chlorine bleach per quart.

The problem could get worse before it gets better. A "boil water" order will be in effect at least until Wednesday, and possibly into the weekend, an Idaho Department of Health and Welfare official said today.

The source of the contamination, UI officials believe, is sedimentation in the water tank along Nez Perce Drive. Water levels in the tank became too low last week due to faulty controls. The water level fluctuation swirls sediments and bacteria into the water system.

UI today put in an emergency request to the Idaho Division of Public Works to scour and clean the 500,000 gallon water tank immediately. But that could prolong the problem because UI officials aren't sure how to do that. Water pumped from the Palouse deep aquifer goes directly into the tank, and UI engineers this morning were still searching for a way to bypass the tank for cleaning.

The system has not flushed itself as quickly as physical plant director Ken Hall would like because water use has declined

Please see **WATER** back page

FEB 17 1995

WATER

From Page 1A

since the boil order was issued.

Hall says cleaning the tank before homecoming is UI's top priority, but engineers don't know yet how to do so without turning off the university's entire water system. Once the technical problems are solved, UI can clean the tank — a two-day, $50,000 project — with its own crews, Hall said.

The water scare underscores serious design flaws and maintenance defects in the university's infrastructure. UI needs to replace sections of pipe, fix broken controls and devise a system to isolate the water tower for cleaning.

UI received $400,000 from the 1989 Idaho Legislature to identify and fix some of those problems. Some of that money has not yet been released by the Division of Public Works. That includes the $130,000 that Hall wants for immediate repairs. Meanwhile, the Idaho Board of Education has requested another $565,000 this year to upgrade the water system.

George Dekan of the Idaho Department of Health and Welfare said UI's water contamination "has proven to be a much more difficult problem than we usually deal with."

Donald Chin, director of UI's Student Health Services, said UI officials haven't detected any increase in diarrhea or stomach ailments that could be related to the bad water. UI's system apparently was contaminated three days before test results were confirmed and UI officials notified the campus community about the problem.

Coliform is a common and easily detected bacteria that, although not necessarily harmful, indicates the possible contamination of water by other health-threatening bugs.

Jerry Curtis, director of Marriott dining services on campus, said bad water is not a major problem. Marriott is boiling or chlorinating its water, and has had to stop selling soda drinks.

"We turned off our pop machines and (students) are drinking milk. It's an inconvenience, but it's something we can live through," Curtis said. If the water is contaminated into the weekend, Curtis says he'll have to assign additional people to work the football game at the ASUI Kibbie Dome.

The only campus buildings unaffected are the Student Union Building and Greek houses along Elm Street, which are on city water.

Researchers who require a clean water source in their laboratories also appear to be adjusting to the inconvenience. Most labs that require quality water have their own filtration systems, says fish researcher Christine Moffett. The main problem, she says, is the need to continually clean sediments out of the filters.

University of Idaho
Office of Financial Affairs
Moscow, Idaho 83843
208-885-6174
FAX 208-885-5752

RECEIVED
OCT 0 3 1990
NORTHERN REGION
I D W R

October 1, 1990

Mr. Robert G. Haynes, P.E.
Regional Manager, Northern Division
Idaho Department of Water Resources
1910 Northwest Boulevard
Coeur d'Alene, Idaho 83814

Dear Mr. Haynes:

Having recently become the Acting Financial Vice President at the University of Idaho, I find myself just now reminded of an agreement the university made to provide information regarding our water permits by September 1, 1990.

Obviously, we have not yet complied with that request and I apologize for any inconvenience this may have caused. I have asked that the necessary information be summarized as soon as possible. As you may have anticipated, we need some time to prepare the information in the format you have required. As soon as I can determine when we can finalize the data, I will call to discuss our timeframe.

Again, I apologize for any inconvenience. Your patience and understanding will be most appreciated.

Sincerely,

Jerry Wallace
Acting Financial Vice President

FEB 1 7 1995

The University of Idaho is an equal opportunity/affirmative action employer and educational institution

University of Idaho
Office of Financial Affairs
Moscow, Idaho 83843
208-885-6174
FAX 208-885-5752

RECEIVED
OCT 0 9 1990

October 1, 1990

Mr. Thomas A. Townsend
447 East Eight Street
Moscow, Idaho 83843

Dear Mr. Townsend:

As noted in my phone conversation with you on September 28, the University of Idaho is developing the appropriate information to respond to the request of the Idaho Department of Water Resources. Further information provided by the university will be as required by the Idaho Department of Water Resources in our effort to clarify the university's water permit status.

Sincerely,

Jerry Wallace
Acting Financial Vice President

cc: Robert G. Haynes, P.E.
President Elisabeth A. Zinser

FEB 17 1993

The University of Idaho is an equal opportunity/affirmative action employer and educational institution.

1 OCTOBER 1990

Mr. Norman Young
Administrator, Resources Administration Div.
Idaho Department of Water Resources
1301 N. Orchard Avenue, Statehouse Mail
Boise, Idaho 83720

RECEIVED
OCT 3 1990
Department of Water Resources

Dear Mr. Young

This letter constitutes a public and formal charge that the University of Idaho and the Board of Regents of the University of Idaho are knowingly applying public waters of the State of Idaho to uses not in compliance/conformance with the conditions of existing valid water rights held by those parties.

The water rights of the University/Board of Regents on record and established prior to 19 January 1990 specifically authorized usage of public ground water for the sole purposes of domestic and irrigation use.

The reality of the situation is that the license holders actually use the public resource for purposes such as space heating, space cooling, stock watering, scientific research projects and aquaculture support — in addition to the allowed usages.

This usage of the public resource for purposes outside the conditions of a valid water right is clearly known of by the policy making leadership of the institution and is seemingly condoned as demonstrated by their reluctance to rectify the situation.

Director Higginson in his letter of 27 July 1989 to President Zinser noted that IDWR had "researched the university's water right records and has not found an existing water right authorizing the proposed aquaculture use." The option was noted "If there is no existing water right, an application to make an appropriation of water or to modify an existing right must be submitted to the department." The University chose to make a new application which resulted in issuance of WR-87-7141 following a contested hearing.

This action had no effect on the continuing problem of non-conforming usage. IDWR was aware that the University

RECEIVED
FEB 17 1995

was then currently, and for some period in the past, utilizing 80 million gallons per year of public water for aquaculture research purposes in the then existing FWR wet lab.

This was a matter of public record derived from University furnished materials and was made known to Mr. Young in my letter of 8 August 1989.

It has been my hope over the past fourteen months that the University would take the necessary action to modify and amend their existing licensed rights to reflect actual usages. I have repeatedly attempted to convince the University to make these necessary amendments to the public water record of Idaho with no success to date. A detailed record of these efforts is noted in the enclosed letter with appendix of 20 September 1990 to President Zinser.

Given that Director Higginson, Mr. Norman Young, and Mr. Robert Haynes have all made official representations with the University on the matter of non-conforming use it seems to this citizen that enough time has elapsed for the University to take the necessary remedial action.

From my perspective I do not believe the University is acting in good faith. They may in fact be conducting on-campus studies of what current uses they have and the magnitude of these usages. They are also taking an inordinate period of time in so doing.

The University, in my opinion, is absolutely unwilling to modify or amend their water rights in a manner according to existing law that would expose said rights to public review.

That is; however, the law and I expect the laws of Idaho to be upheld by the regulatory agency and the judicial system should that be necessary. It is not my intent to single out the University for scrutiny. The issue of non-conformance came to light as a result of their new demands for water for a new aquaculture facility.

The University of Idaho in not alone in being subject to oversight - witness the Snake River Basin Adjudication program. That judicial action is intended to result in a

FEB 17 1995

"technically correct ad legally sufficient - -- water right."

The provisions of Idaho Code, section 42-351 are the crux of the issue in general. The specific non-conforming uses have already been mentioned and can be easily verified. The magnitude of these uses, with the exception of the FWR wet lab noted earlier, are unknown to me. The University probably doesn't know that data themselves lacking a distribution metering/monitoring system.

I am historically aware of how these matters come to pass and the growing sophistication of the regulatory oversight process. The rules have changed and the permittee also has to change to keep pace or fore the punitive consequences. A sophisticated entity such as the University of Idaho is certainly expected by the public to do no less.

The University has the known options of modifying the existing rights or by filing new applications for the unpermitted uses. The consequences of not so doing are very clear and require imposition of further dalliance is demonstrated.

I trust this problem can be speedily resolved in accordance with the Idaho Code and in the public arena with public participation.

Regards,

Thom A. Tammi

441 E 8th Street
Moscow, Idaho 83843

CC: Mr. Robert Haynes, Cd'A Regional Mgr.
Mr. Jerry Wellere, Actim VP, Finance; UI w/o enclosure
Mr. Gene Gray, Chmn. IWRB

FEB 1 9

447 East Eighth Street
Moscow, Idaho 83843
September 20, 1990

President Elisabeth Zinser
Office of the President
University of Idaho
Moscow, Idaho 83843

Dear President Zinser:

Over a year ago the issue of unpermitted uses of public water by the University arose and remains unresolved to this day. My concerns about the problem have been made repeatedly to Dr. Joseph Geiger, Dr. Ernest Brannen, and Mr. John Rosholt, either by letter or by personal contact; however, without resolution. Copies of some of my correspondence were made available to you as well.

The University's permits and licenses of record in 1989 from the State of Idaho indicated the University had been allowed use of public water at the Moscow site for domestic and irrigation purposes only.

Director Higginson, Idaho Department of Water Resources (IDWR), in his letter to you of 27 July 1989 made note of the fact that they "had not found an existing water right authorizing the proposed aquaculture use." He went on to state, "If there is no existing water right, an application to make an appropriation of water or to modify an existing right must be submitted to the department."

The University chose to proceed with a new application for appropriation which eventually led to the contested hearing before the Director on 30 November 1989.

This action did nothing to modify the continued use of the public water resource for unauthorized purposes by the University of Idaho.

Section 42-351 of the Idaho Code seems very much to the crux of the matter. "The University needs to bring the written record of their water rights into line with what is actually on the ground, either by modifying the existing rights or by filing new applications for those unpermitted uses"--as Mr. Haynes of IDWR already told Dr. Geiger eight months ago.

It is my intention to file a formal protest with the State of Idaho Department of Water Resources to the effect that the University of Idaho is applying water not in conformance with the conditions of a valid water right and has done so for some period of time.

FEB 17 1995

Such protest will go forward on 1 October 1990. Should you care to discuss this matter with me before that time I would be glad to meet with you.

Appendix A is attached as a brief summary of the prior communications and commentary on the elements of the issue.

Regards,

Thomas A. Townsend

TAT:alc

Enclosures

FEB 17 1995

APPENDIX A TO PRESIDENT ZINSER LETTER OF 20 SEPTEMBER 1990

The genesis of the probe into the status of existing University of Idaho water rights and permitted usages came as a result of the sudden announcement in June, 1989, by the University of Idaho to construct an on-campus aquaculture facility and to divert additional public water resources to this project.

The question of the unpermitted uses of water by the University became one element in the negotiations between myself and Dr. Geiger, representing the University of Idaho, regarding the wider issues of the aquaculture program.

In my letter of 8 August 1989 to Mr. Norman Young, Idaho Department of Water Resources (copy to Dr. Ernest Brannon) I noted the University already was using 80 million gallons per year for research purposes in the existing FWR wet lab and that such usage was not specifically authorized by the State of Idaho and presumed to be contrary to the Idaho Code.

On 31 October 1989 I met with Dr. Geiger to discuss some possible solutions that would be amenable to both parties. On 6 November 1989 I sent Dr. Geiger a letter that formally outlined some mitigating actions that I believed were relevant to the overall water use problem with the Moscow-Pullman aquifer. These actions if undertaken by the University would satisfy my immediate concerns and in return I would withdraw my protest. Among these mitigating actions requested was item F that the University would make a good faith effort to correct its water rights record to correctly reflect actual usage.

The University, in a draft document dated 16 November 1989, prepared by John Rosholt and to be issued by Dr. Geiger, made six paragraph style responses to my proposals. Paragraph C noted that the "University of Idaho would discuss with the Idaho Department of Water Resources (IDWR) available procedures to obtain a redesignation of water uses to the appropriate labels for the beneficial purposes recognized as appropriate by IDWR without in any way exposing said rights."

I responded by letter to John Rosholt on 18 November 1989 concerning the draft proposal for negotiation. In a portion of that response I said, "Redesignation of water uses is conceded to be a mess. Exposure of existing rights to amend these rights is an unnecessary problem. It is desirable that redesignation be accomplished; however, not at the risk of singular exposure. Concur with paragraph C."

I made that comment because I understood the Idaho Code made it difficult to modify an existing water right without opening up the issue to a public hearing process. This is, however, the law in the matter and not some hurdle I personally was imposing on the University.

The negotiations continued to work and Mr. Rosholt came back on 22 November 1989 with a Fax letter that addressed some of my concerns to the actions outlined in the University proposal of 16 November.

FEB 17 1995

The negotiation phase came to an end at this point since my primary concerns about reduction in pumpage and stabilization of pumping at a prior level were not relieved. However, as far as the usage designation issue was concerned, we were of the same general opinion--that a redesignation of water uses for the existing University of Idaho water rights was in order. The process of amending the existing water rights without exposing those rights to undue critical scrutiny seemed to be the stumbling block for the University.

No action was taken by the University to seek a redesignation process for several months. On 17 January 1990 Mr. Robert Haynes, Regional Manager, IDWR, Northern Division, wrote Dr. Geiger noting the uses of water by the University not authorized by the IDWR and asking the intentions of the University.

The University's attorney, Mr. Rosholt, responded on March 7, 1990, noting the University staff and Dr. Geiger were gathering data as to water use/reuse. Mr. Rosholt was hopeful that the matter could be put to rest by 1 July 1990.

On 6 July 1990 I wrote Mr. Rosholt, with a copy to President Zinser, asking "at what point in time will the University be prepared to bring forth their solution to this problem for discussion and final resolution?"

No answer to this inquiry to Mr. Rosholt has been received to date from either Mr. Rosholt or President Zinser.

FEB 17 1995

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720 - (208) 327-7900

CECIL D. ANDRUS
GOVERNOR
R. KEITH HIGGINSON
DIRECTOR

July 27, 1989

Elizabeth Zinser, President
University of Idaho
Moscow, ID 83843

RE: AQUACULTURE LABORATORY

Dear Ms. Zinser:

Several articles have recently been published in the Idaho Statesman relative to the University of Idaho's plans to build an aquaculture center on the university campus. Associated with these articles has been a concern expressed to the department by existing water users that the ground water resources in the Moscow-Pullman area are rapidly being depleted and that there is insufficient water for major new uses such as the proposed aquaculture laboratory.

The Department of Water Resources has researched the university's water rights records and has not found an existing water right authorizing the proposed aquaculture use. A listing of those water rights is enclosed. Please advise us if there is a right which you believe authorizes the use which the department has overlooked.

If there is no existing water right, an application to make an appropriation of water or to modify an existing right must be submitted to the department. Given the concerns about the adequacy of the water supplies in the basin that resulted in formation of the local water committee, it is likely that such an application will be protested. If protested, the department will conduct an administrative hearing relative to the merits of each party's argument and will issue a decision accordingly.

I would like to emphasize that this matter needs to be addressed soon and before construction starts on any new facilities.

Sincerely,

R. KEITH HIGGINSON
Director

Encl: Abstract

c: N. Region
IWRB
Chairman, Pullman Moscow Water Resource Committee
George Blumsburg, Water Resource Research Institute
George Krill, Washington Dept. of Ecology

FEB 17 1995

1st July 1990

Norm –

This is not a criticism of Bob Haynes. He laid the problem out very clearly to the University some time ago and has been waiting patiently for them to clear up the problem.

Rosholt said he'd get it squared away by 1 July then come back in (to Haynes) and asked for more time.

How much more time UI needs is unknown. How serious they are working on it is also unknown.

My concern is the issue be resolved in the very near future. I think the Idaho Code is very clear on what options the UI has and what options the Director has to resolve such situations.

RECEIVED
JUL 23 1990
Department of Water Resources

MICROFILMED
FEB 07 1995

MAJ. T. A. TOWNSEND. USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

17 July 1990

RECEIVED
JUL 23 1990
Department of Water Resources

Mr. Robert Haynes, P.E.
Regional Manager, Northern Division
Idaho Department of Water Resources
1910 Northwest Boulevard
Coeur d' Alene, Idaho 83814

Re: University of Idaho Water Rights (Usage Designation)

Dear Bob,

The resolution of the water usage issue with the University seems to drag on even though section 42-351 of the Idaho Code is quite clear as to the definition of the problem and provides a solution as to relief.

Injunctive relief or an order by the Director are possibilities; however, I would hope the University would rather solve the problem in a less draconian manner.

The University has been aware of this concern for nearly a year now and your letter of 17 January 1990 laid out the issues very clearly to Dr. Geiger.

John Rosholt in March 1990 said, on behalf of the University that the matter would be put to rest by 1 July 1990. That date has come and gone without action and my personal letter to John of 6 July has not been responded to at the time of this writing.

I suspect Rosholt is more involved in other major Idaho water issues on behalf of irrigator clients and is letting this one slide as far as possible. I say this because I see newspaper reports of John's activities all over the N.W. on other water issues

FEB 17 1995

I would like to see the issue out in the open and

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

See how the University intends to comply with the provisions of the Idaho Code

I understand how this situation arose, what I do not understand is why it is allowed to drag on as it has.

Many of the current uses are "ungermitted" and as you noted there are two methods of resolution. Certainly the University can make a decision on two variables and move onward.

Would appreciate whatever you can do to move the program forward to completion.

Regads,
Tom Townsend

CC: President Zinser
Mr. Norm Young; IDWR, Boise

RECEIVED
FEB 17 1995

T. Townsend
447 E 8th St.
Moscow, Idaho 83843

SPOKANE, WA 992
PM
19 JUL
1990

U.S. POSTAGE
OFFICIAL SE
1992 OLYMPI

WEST QUODDY HEAD MAINE

Mr. Norman Young
Idaho Department of Water Resources
Statehouse Mail
Boise, Idaho 83720

FEB 17 1995

Keith
File 87-7141

RECEIVED
MAY 29 1990
Department of Water Resources

447 East Eighth Street
Moscow, Idaho 83843
May 23, 1990

Mr. Robert G. Haynes, P.E.
Regional Manager, Northern Division
Idaho Department of Water Resources
1910 Northwest Boulevard
Coeur d'Alene, Idaho 83814

RE: University of Idaho Water Rights (Usage Designation)

Dear Mr. Haynes:

One of the supplemental issues raised concerning the recent water right application by the University of Idaho was the lack of specific information concerning the actual use of appropriated water by the University. All prior water rights were designated as either "domestic" or "irrigation." Obviously "domestic" does not adequately describe the various uses of public water by a large state educational institution.

In my letter of December 11, 1989, I noted the existing fish laboratory at the University of Idaho utilizes 80 MGF of deep aquifer resource. This utilization, in my view, is neither domestic nor irrigation oriented usage and constitutes the utilization of public waters for purposes other than authorized.

This matter has been discussed with the University and the March 7, 1990, letter of John Rosholt indicates they are aware of the problem. To what extent they are pursuing the rectification of this problem I don't know.

The issue goes beyond semantics. The water used by the University is a public resources which is controlled by the IDWR. In authorizing water rights the applicant is expected to disclose what the resource will be utilized for and the location of its intended beneficial use. The public has the right to know for what purpose the public resource is being assigned. If water is being utilized for stock watering, air conditioning, or fish farming then that designation should be utilized and so noted in the public water records.

As I have noted before, I am not interested in placing existing University of Idaho water rights in jeopardy, that is in having the allocations reduced as a result of use designation error. I am interested in having all existing water right allocations correctly reflect the use to which they are put.

MICROFILMED
FEB 17 1995

RECEIVED
MAY 29 1990
Department of Water Resources

The July 1, 1990, date proposed by Mr. Rosholt is appropriate. However, I view it as a deadline that should be insisted upon. This housekeeping chore is long overdue and deserves prompt remedial action on the part of the University and the Department.

I would appreciate being kept informed as to the status of this issue.

Regards,

Tom Townsend

TAT:alc

cc: Mr. Norm Young, IDWR
Mr. Wayne Haas, IDWR
Dr. J. Geiger, UI
Mr. John Rosholt

RECEIVED
FEB 17 1995

RECEIVED
MAY 29 1990
Department of Water Resources

447 East Eighth Street
Moscow, Idaho 83843
May 23, 1990

Mr. R. Keith Higginson, Director
Idaho Department of Water Resources
Statehouse Mail
Boise, Idaho 83720

RE: University of Idaho Permit 87-7141
Mr. John A. Rosholt Letter of March 28, 1990, Same Subject
My Letter of 2 April 1990, Same Subject

Dear Director Higginson:

Would you please advise me of your reply to the inquiry of Mr. Rosholt regarding the utilization of aquaculture facility effluent for irrigation purposes without prior waste water treatment?

As indicated in my letter I believe the determination of issues concerning the use of effluent for land application (irrigation) is more the province of the Department of Health and Welfare/DEQ than IDWR.

Paragraph 3 of your Order seems clear enough to me--the rediversion of the 48 M/G/A, allowed by the permit, as effluent for new irrigation purposes is allowed after adequate treatment. Whether that treatment is at the Moscow sewage treatment plant or at a new treatment plant constructed by the University is not critical. The treatment of the effluent prior to irrigation usage is, in my view, the critical issue.

The University, as you know, already has permission from DEQ to utilize 72 M/G/A of final effluent from the Moscow plant for irrigation purposes. Since the effluent from the aquaculture facility is waste water with public health concerns, I read the 48 M/G/A allowed by your order as being an integral part of the limits and conditions of the DEQ permit.

Treatment of effluent prior to irrigation is a critical part of the DEQ permitting process. I do not believe the Order should be modified to allow any effluent rediversion to irrigation without final treatment taking place.

If the University cannot provide its own treatment of the resource after use in the aquaculture facility and does not choose to redivert from the Moscow treatment plant for irrigation purposes, I would suggest they not be allowed the 48 M/G/A irrigation allocation now established.

Regards,

Thom A. Townsend

Thomas A. Townsend

TAT:alc

MICROFILMED
FEB 17 1995

RECEIVED
APR 4 1990
Department of Water Resources

University of Idaho
Trust and Investment Office
Administration Annex
Moscow, Idaho 83843
208-885-6174
FAX: 208-885-5752

April 2, 1990

Mr. R. Keith Higginson, Director
Idaho Department of Water Resources
1301 N. Orchard
Statehouse Mail
Boise, Idaho 83720

Dear Mr. Higginson:

RE: University of Idaho 87-7141

By this time you will have received a March 28, 1990, letter from our attorney John Rosholt regarding a letter of clarification. I hope you agree that Mr. Rosholt's suggestion is appropriate.

According to the language, on the second page, last sentence, the reader might be left with the impression that the University has already decided it will seek additional diversion authority under this permit "in a couple of years."

With the risk of something too sensitive, please be advised that, although the possibility of such a future request exists, the university has not made any decision at this time.

Sincerely,

Joseph J. Geiger
Financial Vice President

JJG/kf

cc: John Rosholt

FEB 17 1995

The University of Idaho is an equal opportunity/affirmative action employer and educational institution.

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER
Chartered
ATTORNEYS AT LAW

THOMAS G. NELSON
JOHN A. ROSHOLT
J. EVAN ROBERTSON
STEVEN K. TOLMAN
JAMES C. TUCKER
TERRY R. McDANIEL
GARY D. SLETTE
F. BRUCE COVINGTON
JERRY JENSEN
CAROLYN M. MINDER
BRUCE M. SMITH
G. RICHARD BEVAN
GARY L. QUIGLEY
TIM J. WILLIAMS
SHARON F. DUNKIN
JUSTIN R. SEAMONS

142 3rd AVENUE NORTH
P.O. BOX 1906
TWIN FALLS, IDAHO 83303-1906
TELEPHONE (208) 734-0700
FAX (208) 736-0041

Boise Office
1020 MAIN ST., SUITE 400
P.O. BOX 2139
BOISE, IDAHO 83701-2139
TELEPHONE (208) 336-0700
FAX (208) 344-6034

RECEIVED
MAR 29 1990
Department of Water Resources

March 28, 1990

R. Keith Higginson, Director
Idaho Department of Water Resources
1301 N. Orchard
Statehouse Mail
Boise ID 83720

RE: University of Idaho -- 87-7141

Dear Mr. Higginson:

After review of your Memorandum Decision and Order dated January 19, 1990, in the above entitled matter, my client seeks clarification of Paragraph 3 of the Order. That paragraph reads as follows:

> 3. The amount of water rediverted by the university for irrigation purposes under this permit from the Moscow City sewage lagoons shall not exceed the rate of flow and volume of water being diverted under this permit for the university's aquaculture research facility and thereafter treated and discharged into the sewage lagoons.

The question is whether the water diverted and used in the aquaculture facility must be discharged back to Moscow City sewage system before it can be used for irrigation. While we understand the University is limited to 48 m/g/a under the permit, it is expected that the water would be of good enough quality for irrigation use without treatment in the Moscow plant.

If you agree, would an amendment to the Order be appropriate? I think the point is basic enough that a letter of clarification would be adequate. Perhaps in the letter you would be willing to indicate that the total amount directly applied for irrigation (after use in the aquaculture facility) or rediverted from the Moscow sewage lagoons under permit

FEB 17 1995

No. 87-7141 shall not exceed a diversion of 1.5 cfs to a total of 48 million gallons per year.

I hope you will agree that it is unnecessary to have to amend this permit, and that a letter of clarification would be adequate. We can ask for correction in the Order in a couple of years when the University requests additional diversion authority under this permit.

Respectfully submitted,

NELSON, ROSHOLT, ROBERTSON,
TOLMAN & TUCKER, CHARTERED

By: John A. Rosholt
JOHN A. ROSHOLT
Attorney for University of Idaho

JAR:dcb
49291

cc: Bob Haynes
Dr. Joseph Geiger
Larry Kirkland
John Stegner
Tom Townsend

FEB 17 1995

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER
ATTORNEYS AT LAW
142 3RD AVE. N.
P.O. BOX 1906
TWIN FALLS, IDAHO 83301
(208) 734-0700

RMA
Norm NCY
Phil PJZ
Your comments please

DATE: 3/15/90

TO: Keith Higginson

Looks okay to me.
NCY

RE: U. of I. – Permit – 87-7141

Dear Keith,

Inclosed is a draft letter along the lines of our previous conversation. If it looks like an idea that is workable, please call me and I'll officially mail the letter to you. If you're not comfortable, we should talk.

Thanks,

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER

BY Tom Rosholt

FEB - 7 1990

Keith, 3/26/90

I don't think an amendment is necessary. The purpose of the FP is to prohibit the use of more water than is authorized under the permit whether it's used directly from the research facility or from the treatment plant. There plans called for retrieval from the treatment plant. Paul

NORM— PHIL RSZ

I CALLED POSHOLT'S OFFICE 3/28 AND TOLD HIS SECRETARY THE LETTER LOOKS OK — SO THEY WILL SEND IT.

NORM, 3/29 RKA

I'd be happy to review the draft letter or this if someone else drafts it. Paul

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER
Chartered
ATTORNEYS AT LAW

THOMAS G. NELSON
JOHN A. ROSHOLT
J. EVAN ROBERTSON
STEVEN K. TOLMAN
JAMES C. TUCKER
TERRY R. McDANIEL
GARY D. SLETTE
F. BRUCE COVINGTON
JERRY JENSEN
CAROLYN M. MINDER
BRUCE M. SMITH
G. RICHARD BEVAN
GARY L. QUIGLEY
TIM J. WILLIAMS
SHARON F. DUNKIN
JUSTIN R. SEAMONS

142 3rd AVENUE NORTH
P.O. BOX 1906
TWIN FALLS, IDAHO 83303-1906
TELEPHONE (208) 734-0700
FAX (208) 736-0041

Boise Office
1020 MAIN ST., SUITE 400
P.O. BOX 2139
BOISE, IDAHO 83701-2139
TELEPHONE (208) 336-0700
FAX (208) 344-6034

Draft

March 15, 1990

R. Keith Higginson, Director
Idaho Department of Water Resources
1301 N. Orchard
Statehouse Mail
Boise ID 83720

RE: University of Idaho -- 87-7141

Dear Mr. Higginson:

After review of your Memorandum Decision and Order dated January 19, 1990, in the above entitled matter, my client seeks clarification of Paragraph 3 of the Order. That paragraph reads as follows:

> 3. The amount of water rediverted by the university for irrigation purposes under this permit from the Moscow City sewage lagoons shall not exceed the rate of flow and volume of water being diverted under this permit for the university's aquaculture research facility and thereafter treated and discharged into the sewage lagoons.

The question is whether the water diverted and used in the aquaculture facility must be discharged back to Moscow City sewage system before it can be used for irrigation. While we understand the University is limited to 48 m/g/a under the permit, it is expected that the water would be of good enough quality for irrigation use without treatment in the Moscow plant.

If you agree, would an amendment to the Order be appropriate? I think the point is basic enough that a letter of clarification would be adequate. Perhaps in the letter you would be willing to indicate that the total amount directly applied for irrigation (after use in the aquaculture facility) or rediverted from the Moscow sewage lagoons under Permit

MICROFILMED
FEB 17 1995

No. 87-7141 shall not exceed a diversion of 1.5 cfs to a total of 48 million gallons per year.

I hope you will agree that it is unnecessary to have to amend this permit, and that a letter of clarification would be adequate. We can ask for correction in the Order in a couple of years when the University requests additional diversion authority under this permit.

Respectfully submitted,

NELSON, ROSHOLT, ROBERTSON,
TOLMAN & TUCKER, CHARTERED

By: _____
JOHN A. ROSHOLT
Attorney for University of Idaho

JAR:dcb
49291

cc: Larry Kirkland
Tom Townsend
John Stegner
Bob Haynes

MICROFILMED
FEB 17 1995

87-7141

Wayne FYI

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

6 July 1990

Mr. John Rosholt
Nelson, Rosholt, Robertson, Tolmen and Tucker
P.O. Box 1906
Twin Falls, Idaho 83303-1906

RECEIVED
JUL 9 1990
Department of Water Resources

Re: University of Idaho Water Rights (Usage Designation)

Dear Mr. Rosholt,

Prior to the recent hearing on the new UI water right I noted my concern with the fact that the University was using water for purposes other than allowed on existing permits and licenses. The terms "domestic" and "irrigation" do not adequately reflect the actual usage the resource is put to and I have suggested, on a number of occasions, that this matter be clarified by the University as soon as possible.

IDWR made a formal request of the University in January 1990 to move upon this matter and you, in your capacity as attorney for the University, indicated that "proper steps (would be) taken to put the matter to rest by July 1, 1990."

This response was made in March 1990. In May 1990, in a letter to Bob Haynes, IDWR northern Division manager, I noted the July 1 date as being appropriate; however, that in view of the long overdue solution I viewed that date as a deadline, not some unilateral goal.

FEB 17 1995

The July 1, 1990 date for resolution has come and gone and there is nothing at hand to indicate the University

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

has entered the world of multiple use and proper/ accurate designators for the public waters it uses.

The utilization of public waters for purposes other than specifically authorized by legal authority makes a sham of the regulatory system and deprives the Idaho public of the right to know for what purposes their water resource is being allocated in their name.

At what point in time will the University be prepared to bring forth their solution to this problem for discussion and final resolution?

Regards,
Tom Townsend

cc: President Elizabeth Zinser
Mr. Norm Young, IDWR, Boise
Mr. Bob Haynes, IDWR, C d'A

MICROFILMED
FEB 17 1995

MINUTES
(Approved 6/7/90)

PULLMAN-MOSCOW WATER RESOURCES COMMITTEE
April 12, 1990
McCluskey Building, 1:30 pm

MEMBERS PRESENT: Mardi Baron, Ken Abbey, Gary Presol, Ken Hall, Larry Kirkland, George Bloomsburg, Craig Benjamin (for Joe Spoonemore), Jim Hudak, Maggie McGreavy, Jim Nebel, and Pam Peterson

VISITORS: Kathleen Warnick, Cal Warnick, Tom Townsend, and Jeff Filler

The minutes of the meeting of February 8, 1990, were approved as sent out.

Ken Abbey asked Jim Hudak for a report on the proposal that was submitted for Washington Centennial funding. Hudak said there was nothing to report.

The next topic was the Ground Water Management Plan. Ken Abbey turned the discussion over to Ken Hall, the Chairman of the subcommittee which has been responsible for developing the plan. Hall stated that the philosophy of the subcommittee in developing the plan was that all entity viewpoints were represented, but we are aware that there will be other viewpoints presented in the committee. After the committee has reviewed the plan, there will be wider distribution and more viewpoints added. The details of how goals will be achieved are not spelled out in the plan; it is not a regulatory document since the Water Resource Committee is not a regulatory body. After the committee has reviewed the plan, the entities and state agencies will review it. The review should take place between now and September. In September or October a public workshop is planned; in November or December a public hearing is planned with adoption by the various entities shortly after the 1st of 1991.

Ken Abbey stated these were good comments and that we feel the plan describes what the committee should do in the future.

Ken Abbey suggested that the plan be reviewed page by page. Larry Kirkland first suggested that perhaps the title should read "Water Management Plan" or "Water Supply Management Plan" rather than specifying ground water, because he felt that the plan does consider all aspects of water.

Gary Presol felt that this was too broad, that ground water is the main impetus behind the plan and that it should stay in.

Jeff Filler stated that if the term ground water is taken out, then we will have to go over the plan very carefully to be sure that the text recognizes that we are talking about all sources of water.

Ken Hall stated that he felt ground water in the title was all right as long as we are not restricted to ground water in our actual discussion of other options.

Moscow WFD
FEB 17 1995

The consensus of the committee seemed to be that there should be a paragraph in the first chapter speaking to these points that the title be left as is. The first chapter should point out that the plan is really broader than consideration of only ground water.

Jim Nebel suggested that ground water should be defined as drinking water because all the ground water here must be of drinking water standards. Jeff Filler stated that paragraphs one, two and three may be redundant with later statements in later chapters, but Ken Abbey felt that some redundancy is necessary for clarity. Ken Hall suggested that the goals written in sections 1, 3, 4.2 and 6.2 should be reviewed rather carefully to be sure that they are consistent, not necessarily that they say the same thing, but at least they should be similar. It was pointed out by several people that the one goal of the plan is to satisfy the state agencies because IDWR's concerns with ground water are the main reason that the committee was formed.

Larry Kirkland suggested that on page 3 there should be a mention of the importance of interbeds in the aquifers at least in the Moscow area, and perhaps there should be revisions of some of the maps. It was decided that such emphasis should be added.

Ken Hall suggested that on page 7 the uses of water should be clarified. It should also be pointed out that there are few trees and little forested area in most of the basin.

There was next discussion on the historical pumping rates and the cost of water in Moscow and Pullman. Both Jim Hudak and Gary Presol stated that studies in the two states show that Pullman and Moscow have lower water costs than the average of cities in the two states. There should also be some cost data relative to the incremental cost of water.

? Ken Hall again pointed out that the plan is not proposing solutions. Ken Abbey said that the concept should not get connected with any particular solution because this had been detrimental to the committee when they got too closely related to the Corps of Engineers Pump Storage Plan several years ago.

? Tom Townsend asked whether the entities may need help in knowing how to attain the goals if these goals are just going to be outlined in the plan. It was pointed out that there are suggestions in later chapters about how the various goals may be attained.

There was next discussion on whether we should segregate the two aquifers and attempt to get the state to recognize that there are two aquifers. It seemed to be the consensus that this is a good idea because it may make it easier to develop a management plan in which the two aquifers are operated in different ways.

At this time Ken Abbey stated that he had to leave for another meeting, so it was agreed that the meeting should be recessed until Thursday, April 26, 1990 at 1:30 pm.

McDonell WRD
FEB 17 1995

MINUTES
(Approved 6/7/90)

Continuation of Meeting of April 12, 1990
MOSCOW-PULLMAN WATER RESOURCES COMMITTEE
Thursday, April 26, 1990
McCluskey Hall, 1:30 pm

MEMBERS PRESENT:	Ken Abbey, Larry Kirkland, Jim Hudak, Craig Benjamin (for Joe Spoonemore), Nancy Johansen, Pam Peterson, Maggie McGreavy, Mardi Baron, Gary Presol, and George Bloomsburg
VISITORS:	Tom Townsend, Cal Warnick, and Jeff Filler

Ken Abbey stated that according to his records, we were starting on page 22, Section 5, General Basin Characteristics.

Larry Kirkland suggested that Figure 5 should have some interbeds indicated on it to give greater emphasis to the importance of the interbeds, particularly in the Moscow area. He also stated that Figure 6 should be more explicit as to what we are trying to depict. Ken Abbey stated that on page 27 there should be some footnotes or reference to Dale Ralston's studies relative to the importance of recharge from excess surface water in the basin. Several changes to the plan were simply made in the text.

In Section 6 on the Duties of the Committee, Gary Presol feels that there should be mention of the possibility of having an interstate compact relative to interstate transfer of water. In other words, he feels that sometime in the future Moscow may wish to drill wells across the state line as this may be the most efficient way for Moscow to obtain their water. This item had been discussed previously and Gary feels that it should be spelled out rather carefully in the Management Plan that this could be done. He feels that there should be a definite statement about the development of an interstate compact relative to transfer of water. After much discussion a statement was added as 6.3.6.3 to review and make recommendations relative to the development of an interstate compact for interstate water transfers.

There also was considerable discussion on 6.3.6.1 concerning the term "cross-pollination." This term was finally changed to "information exchange."

Section 6.4.2 next was discussed relative to incentives that could be offered by the entities to encourage water conservation. It was agreed that cities could offer incentives to private water users but universities could not unless particular buildings were metered. After much discussion the reference to incentives was removed.

Jeff Filler and George Bloomsburg agreed to get a clean copy of the revised plan to the entities and state agencies.

The meeting was adjourned at 3:30 pm.

MICROFILMED
FEB 17 1995

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

SPOKANE WA 992

U.S. POSTAL SERV
OFFICIAL SPONS
1992 OLYMPIC GA

Mr. Norman Young
Administrator, Resources Admin. Div.
Idaho Department of Water Resources
Statehouse Mail
Boise, Idaho 83720

FEB 17 1995

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

2 July 1990

Mr. Wayne Haas
Administrator, Resource Analysis Division norm Young
Idaho Department of Water Resources
Statehouse Mail,
Boise, Idaho 83720

RECEIVED
JUL 5 1990
Department of Water Resources

Re: Draft Pullman-Moscow Ground Water Management Plan -

Dear Wayne, norm

The plan(?) noted above has been sent to your department for review and comment.

The document, while an interesting compendium of local ground water data, is in no way a plan that provides protection to the existing sole source aquifer nor much of an outline of management strategies.

A plan charts the accomplishment of desired outcomes which can be expressed as objectives and goals. These are to be achieved through various actions on the part of various participants. A plan involves action verbs — what is to be done, who does it, how is it to be done etc.

This document fails to mention the actions the public workshop elicited — which actions I think were well considered. This document doesn't even suggest carrying out the suggestion of the USGS study that pumpage be stabilized at 1981-1985 average rates.

FEB 17 1995

I find it difficult to understand a group of local leaders that are unable to comprehend their mission, pays a large sum to an inexperienced graduate student to ignore such a document and consistently ignores the professional advice of experts commissioned to make recommendations.

Nan –
sent copy of my letter to
Bloomberg. See it yet?

Wayne

Wayne –

Let's discuss.

WM

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

The document is not a plan and does not address the details of how the local aquifer will be managed by local interests. It's a fuzzy, academic style product of many words that doesn't lay it on the line as to who does what and how.

I've been involved with operational plans as a marine since 1949, written them and marched to them and there was never any question as to what needed to be done - who, what, where, why, when et al -

There are many specific glitches I have noted, but it not worth the time to nit-pick them. Except one. On page 37, last sentence " As the figures indicate, pumping withdrawals have generally stabilized for both communities over the last 15 years." That is not valid. The pumpage increases annually about 1-2% - a factor that needs to be considered part of the problem -

Im disappointed that the P-MWRC would send out such a product for outsiders to see. There was some good, well-reasoned material in earlier drafts; however, reason was obviously overcome in the process -

I have no idea what to suggest except this pitiful piece of fluff should be returned to the authors for re-work - It simply doesn't provide the controls that are necessary -

The possibility strikes me that perhaps a federal sole source aquifer designation is in order since the local governments to include the Imperial Universities can't seem to get their act together. Are you prepared to talk about this? Not a new idea. Ive been thinking about it for a long time

FEB 17 1995

Regards
Tom Townsend

MR THOMAS TOWNSEND
447 E 8TH ST
MOSCOW ID 83843

Mr. Norm Young
Administrator, Resources Administration Div.
Idaho Department of Water Resources
1301 N. Orchard St.
Statehouse Mail
Boise, Idaho 83720

Form 238-7
4/92

ENT'D

RECEIVED
MAY 24 1993
Water Resources

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

USE TYPEWRITER OR BALLPOINT PEN

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name UNIVERSITY OF IDAHO

Address MOSCOW IDAHO 83843

Drilling Permit No. 87-92-N-44

Water Right Permit No. 87-07141

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase ☐ Modification
☐ Abandoned (describe abandonment or modification procedures such as liners, screen, materials, plug depths, etc. in lithologic log, section 9.)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Monitor
☒ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Auger ☐ Reverse rotary
☐ Cable ☐ Mud ☐ Other _____ (backhoe, hydraulic, etc.)

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Pulled	Thickness	Diameter	From	To
	.250 inches	8 inches	+ 2 feet	62 feet
	.250 inches	6 inches	2 feet	+314.5 feet
	_____ inches	_____ inches	_____ feet	_____ feet

Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☒ Yes ☐ No 2-5" K Pakers
Perforated? ☐ Yes ☒ No
How perforated? ☐ Factory ☐ Knife ☐ Torch ☐ Gun
Size of perforation? _____ inches by _____ inches

Number		From	To
_____	perforations	_____ feet	_____ feet
_____	perforations	_____ feet	_____ feet
_____	perforations	_____ feet	_____ feet

Well screen installed? ☒ Yes ☐ No
Manufacturer _____ Type Stainless Steel
Top Packer or Headpipe 309' to 315.9
Bottom of Tailpipe 342 to 348

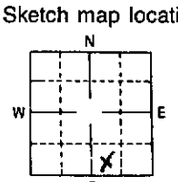
Diameter 5 Slot size 20 Set from 315 feet to 342 feet
Diameter _____ Slot size _____ Set from _____ feet to _____ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet

Surface seal depth 80 Material used in seal: ☐ Cement grout
☒ Bentonite ☒ Puddling clay ☐ _____
Sealing procedure used: ☒ Slurry pit
☒ Temp. surface casing ☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded
☐ Solvent Weld ☐ Cemented between strata

Describe access port _____

6. LOCATION OF WELL

Sketch map location **must** agree with written location.



Subdivision Name _____
West 6th Street
Lot No. _____ Block No. _____
County Latah
Address of Well Site Agriculture Resaerch Facility
(give at least name of road)
T. 39 N ☒ or S ☐
SW ¼ SE ¼ Sec. 12, R. 6 E ☐ or W ☒

7. WATER LEVEL

Static water level 148' feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature _____ °F. Quality _____
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
200+		

9. LITHOLOGIC LOG

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
10	0	62	Silty Clay, Brn		X
8	62	73	Basalt Dark Brn Weathered		X
8	73	77	Basalt light brn w/clay		X
8	77	85	Basalt Drk/Brn Med. Hard		X
8	85	94	Basalt lght Brn Fractured		X
8	94	120	Basalt Blk Hard		X
8	120	145	Baslat Lght Brn fractured		
			W/Water apx 30 to 40 gpm	X	
8	145	235	Baslat Blk Hard		X
8	235	250	Basalt Blk Fractured		X
8	250	270	Silty Sand Brn	X	
8	270	279	Silty Sand w Weed	X	
8	279	288	Sand Course W/Water	X	
8	288	305	Sand Finer w/Water	X	
8	305	342	Sand w/some Gravel W/Water	X	
8	342	351	Silty Sand hard Packed		X

RECEIVED
FEB 22 1993
NORTHERN REGION
IDWR

FEB 17 1995

10.

Work started 1/18/93 finished 2/5/93

11. DRILLER'S CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H2O WELL SERVICE Firm No. 448
Address HAYDEN LAKE, ID Date 2-11-93
Signed by Drilling Supervisor _____
and
(Operator) _____ *(if different than the Drilling Supervisor)*

2 April 1990

RKH
NORM
PHIL

R. Keith Higginson, Director
Idaho Department of Water Resources
1301 N. Orchard
Statehouse Mail
Boise, Idaho 83720

Re: University of Idaho Permit 87-7141

Dear Director Higginson,

The 28 March 1990 letter from John Rosholt, attorney for the Univesity, requesting clarification and amendment of your Memorandum Decision and Order raises some questions in my mind.

The University during the hearing made known its intention to re-utilize the water being requested for irrigation of some 566 acres overall. The Order permitted diversion of 48 million gallons annually and paragraph 3 of the Order limited the re-diversion of water for irrigation purposes to that amount (1) being used in the aquaculture research facility and (2) after being treated and discharged into the sewage lagoons at the Moscow sewage treatment plant.

I assume the University intended to use the allocated 48 m/g/a in the aquaculture facility although the application for water right spreads out their possibilities for use between irrigation, research, and domestic purposes.

I don't, at the moment, concur with Mr. Rosholt that the water used in the aquaculture facility would be acceptable for secondary irrigation use without further treatment. At the moment that treatment is being provided by the Moscow sewage treatment plant.

If the University were to establish a post-treatment facility of their own it would be unnecessary to move the effluent from the aquaculture center [illegible] the Moscow plant prior to re-use for irrigation.

FEB 17 1995

At one time I understood the University intended to do that however there is nothing at present to indicate such action is planned. This effluent treatment facility, if of sufficient quality, could treat the aquaculture effluent so that the water could be used again in the aquaculture facility on a continuing basis. Very little water then would be passed on to irrigation should that on-site treatment be available.

The University is currently allowed to apply up to 72 m/g/a of the Moscow Sewage Treatment Plant final effluent over 500 acres under permit LA-000028, Idaho Department of Health and Welfare. Since the effluent from the aquaculture facility is wastewater with public health concerns I read the 48 m/g/a allowed by your order as being part of the limits and conditions of the Health and Welfare permit.

If the University wishes to bypass the Moscow sewage treatment plant in re-utilization of aquaculture facility effluent I believe the Department of Health and Welfare/Division of Environmental Quality should be involved in the process.

I support the maximum re-utilization of all ground water. If the University can develop a post-treatment facility that can re-cycle the aquaculture effluent back into the rearing tanks for as many times as possible I would support that. If, at some point in time, the effluent must go on to irrigation then I would expect that use to be controlled under public health standards.

The University doesn't currently divert it's allocation from the Moscow sewer treatment plant of 72 m/g/a. To irrigate the acreage designated for wastewater application will require a considerable infrastructure addition.

All these considerations cause me to wonder why Rosholt poses these matters at this time.

RECEIVED
FEB 17 1995

Respectfully Submitted,

John A. Iannuzzi

MR. THOMAS A. TOWNSEND
447 E. 6TH STREET
MOSCOW ID 83843

Hemingway

Mr. R. Keith Higginson
Director, Idaho Department of Water Resources
Statehouse Mail
Boise, Idaho 83720

FEB 17 1995

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER
Chartered
ATTORNEYS AT LAW

THOMAS G. NELSON
JOHN A. ROSHOLT
J. EVAN ROBERTSON
STEVEN K. TOLMAN
JAMES C. TUCKER
TERRY R. McDANIEL
GARY D. SLETTE
F. BRUCE COVINGTON
JERRY JENSEN
CAROLYN M. MINDER
BRUCE M. SMITH
G. RICHARD BEVAN
GARY L. QUIGLEY
TIM J. WILLIAMS
SHARON F. DUNKIN
JUSTIN R. SEAMONS

142 3rd AVENUE NORTH
P.O. BOX 1906
TWIN FALLS, IDAHO 83303-1906
TELEPHONE (208) 734-0700
FAX (208) 736-0041

Boise Office
1020 MAIN ST., SUITE 400
P.O. BOX 2139
BOISE, IDAHO 83701-2139
TELEPHONE (208) 336-0700
FAX (208) 344-6034

Keith

RECEIVED
MAR 8 1990
Department of Water Resources

March 7, 1990

Robert G. Haynes, P.E.
Regional Manager, Northern Division
Idaho Department of Water Resources
1910 Northwest Boulevard
Coeur d'Alene, Idaho 83814

87-7135
87-7141

RE: University of Idaho Water Rights -

Dear Mr. Haynes:

Dr. Geiger referred to me your letter of January 17, 1990, to prepare a proper response for the University. My recent schedule is the reason for the delay in the answer.

As you point out in your letter, at the time the University obtained its water rights, the nomenclature of "domestic" was generally used by the Department to cover all uses for State institutions. As our State system has become more sophisticated over the last few years, the Department now offers many diverse designations to a water rights applicant. It is my opinion that the rights are valid and perfected under the uses authorized in the permits and licenses. However, I have been directed by the University to cooperate in properly designating beneficial uses to reflect the Department's present terminology, so long as no rights are jeopardized.

I have asked Dr. Geiger and University staff to supply me with all of the records they have as to water use and reuse. Upon receipt, I will confer with you as to procedure.

I am hopeful that the information can be obtained and proper steps taken to put the matter to rest by July 1, 1990. Please advise if this schedule does not meet your approval.

MICROFILMED
FEB 17 1995

It is the University's intent to do all things necessary to protect their water rights and comply with your Department's mandates.

Respectfully,

John A. Rosholt

JAR:smw
39641/47961

cc: Mr. Norm Young
Dr. Joseph J. Geiger
Mr. Tom Townsend

MICROFILMED
FEB 17 1995

January 23, 1990

Steve Thompson
Daily Idahonian
409 S. Jackson
Moscow, ID 83843

Dear Mr. Thompson:

Re: Application for Permit No. 87-7141
UNIVERSITY OF IDAHO

Enclosed is a copy of the Memorandum Decision and Order issued for the above referenced matter. I believe you wanted a copy.

Sincerely,

RITA I. FLECK
Secretary/Records Manager

Enclosure

MICROFILMED
MAR 19 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720 -(208) 327-7900

CECIL D. ANDRUS
GOVERNOR
R. KEITH HIGGINSON
DIRECTOR

January 23, 1990

University of Idaho
c/o Larry Kirkland
Physical Plant
Moscow, ID 83843

Gentlemen:

Re: Application for Permit No. 87-7141

Enclosed is a copy of the approved Application for Permit No. 87-7141 along with a copy of the Memorandum Decision and Order. Please note the conditions of approval as set forth in the decision.

Condition of Approval No. 9 requires the university to install a flow measurement port or measuring device to provide for the installation of measuring equipment by the department. Enclosed please find a list of measuring device options and specifications for the installation of the flow measurement port.

Also, read the enclosed "Instructions for Proof of Beneficial Use" carefully since you must eventually take further action to develop this permit into a license. The proof due date is indicated last page of the permit.

Any person who does not agree with the decision of the director may request a rehearing within 20 days or may appeal directly to the district court within 30 days of the date the decision is mailed.

Sincerely,

L. GLEN SAXTON, Chief
Water Allocation Bureau

Enclosures

c: John A. Rosholt, Esq.
Mr. Thomas A. Townsend

MICROFILMED
MAR 19 1990

RECEIVED
DEC 13 1989
Department of Water Resources

University of Idaho
Office of Financial Affairs
Moscow, Idaho 83843
208-885-6174
FAX 208-885-5752

December 8, 1989

RECEIVED
DEC 18 1989
Department of Water Resources

Mr. R. Keith Higginson, Director
Idaho Department of Water Resources
450 West State Street
Boise, Idaho 83720

Dear Mr. Higginson:

At the suggestion of University of Idaho attorney John Rosholt, I would like to reaffirm the university's commitment to expend a minimum of $100,000 during FY90-91 to upgrade the campus effluent irrigation system. The source of funds is the University Facilities account, which is created each year from the cash resources of the campus. The account has been budgeted well in excess of $1.0 million annually for the past several years. The State Board of Education recognizes this account (and similar accounts at other higher education campuses) each year as part of its budget approval process.

Thus, President Zinser's pledge to expand the effluent system is backed up by a funding source which is in hand. I hope this clarifies the University of Idaho's commitments. I would be pleased to answer any additional questions you may have.

Sincerely,

Joseph J. Geiger
Financial Vice President

vn
cc: John Rosholt

MICROFILMED
MAR 19 1990

The University of Idaho is an equal opportunity/affirmative action employer and educational institution.

RKH
NCY
LGS

447 East Eighth Street
Moscow, Idaho 83843
December 11, 1989

RECEIVED
DEC 14 1989
Department of Water Resources

Mr. Robert Haynes, P.E.
Regional Manager, Northern Region
Idaho Department of Water Resources
1910 Northwest Boulevard, Suite 210
Coeur d'Alene, Idaho 83814

Dear Mr. Haynes:

In my letter of protest of 16 October 1989 to the University of Idaho Application for Permit 87-07141 I noted that the University is currently using 80 MGY of deep aquifer resource in the existing College of Forestry, Wildlife and Range Sciences fisheries laboratory. This use is a matter of public record and is included in some of the materials submitted as exhibits in the recent hearing.

This utilization for research purposes is not in line with existing allocations to the University which are designated for either irrigation or domestic use. This functional utilization does not fit in either category and in my view places the University in the position of utilizing the public waters of the State of Idaho for purposes other than authorized by law.

This issue was peripheral to the matters discussed in thehearing on the Application for Permit for shallow aquifer appropriation and was not mentioned by this writer since it seemed outside of the scope of the hearing.

The problem still exists and is one that seems difficult to resolve given the lack of amendment procedures that do not expose the applicant to additional public scrutiny. As much as I dislike the University using appropriated water for purposes other than that designated by IDWR, I do not believe the University should be required to start the application process all over again with the attendant disadvantages that could accrue.

At the same time I believe continued substantial use of public water for research purposes and livestock watering, although beneficial in nature, when it is not so specifically authorized by the administrative authority is illegal. Section 42-201 notes, "No person shall divert any water from a natural watercourse or apply water to land without having obtained a valid water right to do so, or apply it to purposes for which no valid water right exists."

MICROFILMED
MAR 19 1990

The water right licenses of the University/Board of Regents state the water use as either irrigation or domestic or some combination thereof.

The problem is passed to you for appropriate action.

Regards,

Tom Townsend

TT:alc

cc: Mr. Wayne Haas, Idaho Department of Water Resources

MICROFILMED

MAR 19 1990

447 East Eighth Street
Moscow, Idaho 83843
December 11, 1989

RECEIVED
DEC 14 1989
Department of Water Resources

Dr. Joseph J. Geiger
Financial Vice President
Office of Financial Affairs
University of Idaho
Moscow, Idaho 83843

Dear Dr. Geiger:

Back in August I suggested a modest change in the research objectives of the Aquaculture Program to include a demonstration project on the feasibility of a viable commercial fish culture operation using the effluent from a high-quality municipal sewage treatment plant.

The major constraints in the aquaculture industry are: lack of sufficient good water for rearing and the high cost of transportation to market of fish products.

There is no lack of water resource from the Moscow Sewage Treatment Plant. Every day from two to four million gallons of treated resource flows into Paradise Creek where it slowly seeps into the soil, evaporates, or flows westward towards the Pacific. Basically a lost opportunity that could serve the needs of mankind on a higher level if harnessed properly.

Additional treatment, tertiary level perhaps, may be required. That is one of the tasks the demonstration project would determine. That requirement, if necessary, may still be less expensive than the pre-treatment of the shallow aquifer water now being planned.

Research and operation of a facility that could successfully rear fish using municipal effluent would, in my view, be a giant step forward toward solution of worldwide food shortages. Major population centers throughout the world have sewage treatment facilities that could in time become the resource base for fish rearing facilities and the creation of inexpensive protein production.

This proposed facet of research would not be in place of existing planned projects, but hopefully would be in addition to them.

I believe it merits consideration and would ask that these comments be passed along to the aquaculture industry Policy Advisory Committee for their consideration.

MICROFILMED
MAR 19 1990

The Aquaculture Program has many good features. The initial laboratory project concerning treatment of BKD in chinook salmon is of benefit to the regionwide, BPA funded, fish mitigation project. My objections to that project relate solely to the water use planning and site location.

Regards,

Tom Townsend

TT:alc

cc: President Elisabeth Zinser, University of Idaho
Dr. Ernest Brannon, Director, Aquaculture Program, University of Idaho
Dean John Hendee, College of Forestry, Wildlife and Range Sciences
Dean Larry Branen, College of Agriculture
Mr. Wayne Haas, Idaho Department of Water Resources, Boise

MICROFILMED
MAR 19 1990

RECEIVED
DEC 14 1989
Department of Water Resources

447 East Eighth Street
Moscow, Idaho 83843
December 11, 1989

TO: Chairman Abbey and Members, Pullman-Moscow Water Resources Committee

SUBJECT: Proposal for Consideration

It seems obvious that additional work must be accomplished in a number of areas to provide a demonstrable data base upon which the Committee can rely in the development of a viable aquifer protection and management plan. Some of these requirements are outlined in Executive Secretary Bloomsburg's memorandum to the Committee dated June 8, 1988. Other programs have been suggested to the Committee in the past by Dr. Dale Ralston and Mr. Wayne Haas of the Idaho Department of Water Resources.

The projects in the main have not been accomplished because funding has not been available. This proposal addresses the funding issue.

The proposal is that the major water users of the shared resource base create a funding base for future water related demands through the imposition of a resource fee upon all waters pumped from the local aquifer(s). Details as follow:

(1) A fee of _____ mills per gallon pumped would be assessed to each major pumping entity--both universities and the two cities. Such fee to be established by the Committee.

(2) Fees would be collected on a monthly basis computed on the basis of pumpage records and would be merged in a collective fund established by the Committee. Such a fund might be separated on a state basis if necessary; however, would be available to support projects approved of by the Committee as a whole.

(3) Collected funds would be protected under appropriate fiscal safeguards as each state may require: audits, counter-signatures, periodic statements, etc. Funds could be invested as accumulated in prudent, conservative investments such as are available to the municipalities and educational institutions.

(4) Funds so collected would be controlled by the PMWRC membership presumably with the consent of the constituencies represented on the Committee. The expenditure of these funds for Committee approved projects may require the adoption of some internal rules regarding voting procedures, super majority concerns, etc.

MICROFILMED
MAR 19 1990

The magnitude of the fund would depend on the fee established and the contingencies that may arise. If further investigations determine that alternative water sources may be necessary then it might be appropriate to design the fund to cover part or all of the capital costs previously detailed by the Corps of Engineers to the Committee.

From a parochial viewpoint I would suggest that the current summer surcharge for water in Moscow would have to be revoked since the resource fee and surcharge would fall only on Moscow ratepayers.

County participation in this proposal is limited by the fact that they are not water providers. The Committee I presume could establish a reasonable level of financial contribution from the two counties.

On a related issue I would like to make a comment. The public involvement workshop data included an alternative water source proposal and asked, "Is $50 a month an acceptable family water fee?" The announcement went on to say, "These costs would be paid by the citizens of the six entities, which would significantly raise water usage fees."

Obviously the introduction of a new $50 million capital improvement project would raise ratepayer fees. But there aren't ratepayers in the six entities. Only the cities of Moscow and Pullman have municipal water ratepayers. The universities pay only the cost of pumping and distribution and citizens in the counties would not be beneficiaries of the alternative water supply. The cities I don't believe meter the water they use in the parks and swimming pools so there is no record of municipal usage.

The point is that I don't believe the commercial and private ratepayers in Pullman and Moscow should be expected to be responsible for all the costs alone. All the universities and cities would benefit and would be expected to share the costs on some rational common basis.

Respectfully submitted,

Thomas A. Townsend

TT:alc

cc: Mr. Wayne Haas, Idaho Department of Water Resources
Mr. Ken Hungerford, IWRB

MICROFILMED

MAR 19 1990

Form No. 202a.
4/87-8/89 n

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
APPROPRIATION APPLICATION ANALYSIS SHEET

INITIAL REVIEW BY: IDK DATE: 9/25/89 APPLICATION: 87-07141

APPLICANT: U of I

REQUIRED INFORMATION

(1). ___ Name & Address: (If applicant is a corporation or partnership, names must be provided for the director,officers, and other partners.)
(2). ✓ Source: (See USGS Quad for names of water sources)
(3). ✓ Point of Diversion including county: (10 acres for spring, lot & block descriptions for Subdivisions, local name)
(4). ✓ Quantity: (flow and/or volume)
✓ Nature of proposed use: (Include description of use)
✓ Period of use:
(5). ✓ Total Quantity: (flow and/or volume)
(6). ✓ Description of diverting works:
(7). ✓ Time required for beneficial use of water:
(8). ___ Proposed uses
(9). ✓ Place of use or acres irrigated:
(10). ✓ Other Water Rights
(11). ✓ Ownership
(13). ___ Map:
✓ Signature: (If applicant is corp., partnership, or municipality title of signator is required)
✓ Fee amount, receipt number and date recorded on application:
✓ Acknowledgement Letter sent
✓ Overlap Review: (Describe source & relationship to present application in remarks.)

ADDITIONAL INFORMATION

YES	NO	
___	___	Field check required: Field check by: _____
___	___	Field report attached:
___	___	Critical groundwater area:
___	___	Groundwater management area:
___	___	Send dam safety information:
___	___	Send power requirement letter:
___	___	Send fish farm requirement letter:
___	___	Power residency affidavit:
___	___	Power efficiency form:
___	___	Within trust water boundry: (If yes, attach Trust Water Supplementary Analysis Sheet.)
___	___	Diversion greater than 5 cfs or 500 af: (If yes, attach Large Diversion supplementary analysis sheet.)

FOLLOWING INFORMATION REQUESTED FROM APPLICANT

Item	Date Requested
(8) PD NWNE SEC 18 NOT ON MAP	9/25/89
(3) PD SWSE SEC 7 ON MAP	

PROCESSING

YES NO

___ ___ In form for advertising:
___ ___ Statewide advertising:

Send Copies To

YES	NO		YES	NO	
___	___	I.D. Health and Welfare	___	___	U.S. BLM
___	___	I.D. Fish and Game	___	___	U.S. Forest Svc.
___	___	I.D. Lands	___	___	Water District #_____
___	___	Adjudication Bureau	___	___	Other _____

FINAL REGIONAL PROCESSING REVIEW

YES NO

___ ___ Affidavit of publication received:
___ ___ Application published correctly: If not, record action taken.

_____

_____

_____

___ ___ Publication dates and paper recorded on application:
___ ___ Protests received, Final date for protest 10/23/87
___ ___ Protests, dates, resolution of protest recorded on application:
___ ___ Recommendations attached:
___ ___ Measuring device required:
___ ___ Measuring port required:
___ ___ Water delivered by water master? District #_____
___ ___ Special conditions of approval or cover letter: (see additional info. below)
___ ___ See Below For Additional Information

Recomended Date of Priority _____

Recomended by: _____ Date _____

STATE OFFICE REVIEW _____

_____

_____

___See remarks for additional information. By _____ Date _____

REMARKS

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

87-07141

UNIVERSITY OF IDAHO
C/O LARRY KIRKLAND
PHYSICAL PLANT
MOSCOW, ID 83843

Source: GROUNDWATER (SHALLOW AQUIFER)

Diversion Pt:

SESW	Sec 7	T 39N	R 05W	
~~NWNE~~	~~Sec 18~~	~~T 39N~~	~~R 05W~~	
SESW	Sec 12	T 39N	R 06W	
SWSE	Sec 12	T 39N	R 06W	
SESE	Sec 12	T 39N	R 06W	
SWSE	Sec. 7	T 39N	R 05W	

Use: IRRIGATION (1.500 CFS)
RESEARCH (1.500 CFS)
DOMESTIC (1.500 CFS)

Shown as research in advertising so as not to confused anyone. But it was data entered as commercial since that was the closest use.
← Added P/D because of map. per RGH's instructions. Also corrected on computer. [illegible] 9/27/89

Date Filed: 9/18/1989

In: T39N R05W S07	SWSW	SESW		
S18	NWNE	SWNE	NENW	NWNW
	SWNW	SENW	NESW	NWSW
	SWSW	SESW		
R06W S12	SESW	SWSE	SESE	
S13	NENE	SENE	NESE	SESE

566.0 ACRES TOTAL

Deleted P/D on computer & newspaper will delete. [illegible] 9/28/89

MICROFILMED
MAR 19 1990

SENDER: Complete items 1 and 2 when additional services are desired, and complete items 3 and 4.

Put your address [illegible] "RETURN TO" space on the reverse side. Failure [illegible] this will prevent this card from being returned to you. The return receipt fee will provide you th[illegible]me of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for additional service(s) requested.

1. ☐ Show to whom delivered, date, and addressee's address.
2. ☐ Restricted Delivery.

3. Article Addressed to:

Mr. Thomas A. Town[illegible]
447 E. 8th St.
Moscow, Id. 83843

87-7141

MICROFILMED
MAR 19 19[illegible]

[illegible]ticle Number
[illegible]781

Type of Service:

☐ Registered ☐ Insured
☒ Certified ☐ COD
☐ Express Mail

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature — Addressee
X Thom A Townsend

6. Signature — Agent
X

7. Date of Delivery
BB 11-7-89

8. Addressee's Address *(ONLY if requested and fee paid)*

PS Form 3811, Feb. 1986

DOMESTIC RETURN RECEIPT

UNITED STATES POSTAL SERVICE

OFFICIAL BUSINESS

SENDER INSTRUCTIONS

Print your name, address, and ZIP Code in the space below.

- Complete items 1, 2, 3, and 4 on the reverse.
- Attach to front of article if space permits, otherwise affix to back of article.
- Endorse article "Return Receipt Requested" adjacent to number.

RETURN TO

MICROFILMED
MAR 19 1990

U.S.MAIL

PENALTY FOR PRIVATE USE, $300

Print Sender's name, address, and ZIP Code in the space below.

DEPARTMENT OF WATER RESOURCES
1910 NORTHWEST BLVD. - SUITE 210
COEUR D'ALENE, IDAHO 83814

NAME AND ADDRESS OF SENDER: DEPARTMENT OF WATER RESOURCES
1910 NORTHWEST BLVD. - SUITE 210
COEUR D'ALENE, IDAHO 83814

Indicate type of mail
☐ Registered
☐ Insured
☐ COD
☒ Certified

I certify that we have
☐ Commercial Insurance
☐ A deductible clause of $

Affix stamp here if issued as certificate of mailing or for additional copies of this bill.
POSTMARK AND DATE OF RECEIPT

LINE	NUMBER OF ARTICLE	NAME OF ADDRESSEE, STREET, AND POST-OFFICE ADDRESS	POSTAGE	FEE	Handling Charge	Actual Value (If Registered)	DUE SENDER IF C.O.D.	R. R. FEE	S.D. FEE	S. H. FEE	REST. DEL. FEE / REMARKS
1	14780	University of Idaho, c/o Mr. Larry Kirkland Physical Plant, Moscow, Id. 83843	25¢	85¢				90¢			87-7141
2	14781	Mr. Thomas A. Townsend 447 E. 8th St., Moscow, Id. 83843	"	"				"			"
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

COEUR D'ALENE, ID 83814 USPS NOV 6 1989

MICROFILMED MAR 19 1990

TOTAL NUMBER OF PIECES LISTED BY SENDER	TOTAL NUMBER OF PIECES RECEIVED AT POST OFFICE	*POSTMASTER, PER (Name of receiving employee)*
2		

The full declaration of value is required on all domestic and international registered mail. Commercial Insurance—Payment of the full registry fee is required on articles valued up to $1,000 or the full amount of the deductible if the deductible exceeds $1,000. The maximum indemnity payable is $25,000 for registered mail, $400 for COD and $400 for insured mail. Special handling charges apply only to third- and fourth-class parcels. Special delivery service also includes special handling service.

FORM MUST BE COMPLETED BY TYPEWRITER, INK OR BALL POINT PEN

* U.S. GOVERNMENT PRINTING OFFICE: 1978 270-037

PS Form 3877, July 1978

ACCEPTANCE OF REGISTERED, INSURED, C.O.D. AND CERTIFIED MAIL

BEFORE THE DEPARTMENT OF WATER RESOURCES

OF THE

STATE OF IDAHO

IN THE MATTER OF A PROTEST AGAINST	)	
APPROVAL OF APPLICATION FOR PERMIT	)	NOTICE OF HEARING
NO. 87-7141 IN THE NAME OF THE	)	AND/OR CONFERENCE
UNIVERSITY OF IDAHO.	)	

On September 18, 1989, the University of Idaho filed with the Department of Water Resources an application to appropriate the public waters of the State of Idaho. On October 17, 1989, the Department received a protest against approval of said application from Thomas A. Townsend.

The Department has set the matter of protest for a hearing &/or conference for Thursday, November 30, 1989, at 9:30 AM, in the Appalousa Room of the Student Union Building of the University of Idaho, Moscow, Idaho. The hearing will be held in accordance with provisions of Chapters 2 and 17, Title 42 and Chapter 52, Title 67, of the Idaho Code, the adopted Rules of Practice and Procedure of the Department of Water Resources, and Rules 4 and 5 of the adopted Rules and Regulations of Water Appropriation of the Department of Water Resources.

The following issues are involved in the consideration of the application and protest(s):

1. Will the proposed use reduce the quantity of water under existing water rights?
2. Is the proposed water supply insufficient for the purpose intended?
3. Is the application made in good faith or for delay tive purposes?

MICROFILMED
MAR 19 1990

4. Has the applicant sufficient financial resources with which to complete the project?

5. Will the proposed use conflict with the local public interest?

Opportunity shall be afforded all parties to respond and present evidence and argument on all issues involved.

Dated this 6th day of November, 1989.

Robert G. Haynes

ROBERT G. HAYNES, P! E.
REGIONAL MANAGER

I hereby certify that on the 6th day of November, 1989, I mailed a true and correct copy, postage prepaid, of this document to the applicant(s) and protestant(s) listed:

Patricia M. Stypa

Patricia M. Stypa
Secretary/Office Coordinator

CERTIFIED MAIL

University of Idaho
c/o Mr. Larry Kirkland
Physical Plant
Moscow, Id. 83843

Mr. Thomas A. Townsend
447 E. 8th St.
Moscow, Id. 83843

- -

NON-CERTIFIED MAIL

Mr. Frank Hitchcock
Nelson-Rosholt
P. O. Box 1906
Twin Falls, Id. 83303-1706

MICROFILMED

MAR 19 1990

CONFERENCE AND HEARING INFORMATION
IN THE MATTER OF APPROVAL OF AN APPLICATION FOR PERMIT

In accordance with Idaho Code, Section 42-203, the following issues are involved in the consideration of the application and protest(s):

1. Will the proposed use reduce the quantity of water under existing water rights?
2. Is the proposed water supply insufficient for the purposes intended?
3. Is the application made in good faith or for delay or speculative purposes?
4. Has the applicant sufficient financial resources with which to complete the project?
5. Will the proposed use conflict with the local public interest?

Any party may request in writing five (5) days before any hearing that the oral proceedings thereof be taken in the form of stenographic notes at the expense of the requesting party. Any party may have such stenographic notes of the oral proceedings, or part thereof, transcribed at his own expense. A taped record of the proceedings will be maintained for the appeal period.

If the hearing is conducted by a hearing officer appointed by the Director, rather than the Director himself, a proposed decision will be submitted to the parties and the parties may be afforded an opportunity to file exceptions to the proposed decision and present briefs and oral arguments to the Director prior to the issuance of a final decision by the Director. This procedure is required by Idaho Code, Section 42-1701A.

The parties, by written stipulation may waive their right to a proposed decision, however, the failure of either party to waive a proposed decision will not prejudice the Director's review of a party's evidence and arguments. However, such a waiver will shorten the decision-making process and may expedite substantially the issuance of a final decision. Whether compliance with Section 42-1701A is waived will not affect a party's right to petition for a rehearing of the final decision pursuant to Rule 11 of the Department's Rules of Practice and Procedure or affect a party's right to appeal the final decision to the district court.

Under the provisions of Idaho Code, Sections 42-1701A and 67-5215, any court review of the Department's decision on appeal shall be confined to the record created before the Department.

Failure to appear at the time and place set for hearing by the applicant or protestant(s) may allow the Department to dismiss without prejudice the protest(s) or the application. Any and all cost incurred by reason of such non-appearance may be assessed against such non-appearing parties.

MICROFILMED
MAR 19 1990

November 15, 1989

Mr. Thomas A. Townsend
447 East Eighth Street
Moscow, ID 83843

Re: Application for Permit 87-07141

Dear Mr. Townsend:

In reply to your letter of November 9th, please be advised that the date for a conference and/or hearing was set at the request of the University of Idaho. That we have scheduled a conference and/or hearing does not alter our recommendation that you and the University of Idaho continue your efforts to resolve the protest. Idaho Code 42-203A governs the department's actions in regard to the scheduling of hearings for protested water right applications. It requires that we must provide at least ten days notice of a hearing to both the applicant and protestant. We, as a matter of practice, provide as much notice as possible to allow the parties to prepare.

We encourage a dialogue between parties in contested water right matters because it has been our experience that many can be settled amicably by the parties. Many contested water rights matters involve neighbors and the imposition of a decision by department may result in strained relations among neighbors. However, there is no legal requirement to wait twenty days after the acknowledge letters are sent to schedule a hearing.

Your assessment of what we would expect to occur at a "conference" and a "hearing" are accurate. At the conference we would informally discuss the facts surrounding the matter. In many cases settlement of protests occurs because the department representative is able to act as a mediator. Because of your discussions with the University, that may not be likely in this case.

In the October 25th acknowledge letter, and also in the November 6th hearing notice, five criteria that the director must consider in his decision were cited. If a hearing is necessary, we first hold a conference to discuss the application and protest. At that conference we would hope to identify those of the five items that are at issue. Hopefully, in this way we can shorten the time necessary for the hearing itself.

MICROFILMED

MAR 19 1990

Both a conference and hearing have been scheduled for November 30th. The conduct of hearing, including the issuance of a decision, is governed by the those provisions of Idaho law cited in the hearing notice.

I hope this satisfactorily answers your questions. If not, please let me know.

Sincerely,

Robert G. Haynes, P.E.
Regional Manager

cc: Dr. Joseph J. Geiger, University of Idaho
R. Keith Higginson

MICROFILMED
MAR 19 1990

447 East Eighth Street
Moscow, Idaho 83843
9 November 1989

Mr. Robert G. Haynes, P.E.
Regional Manager, Northern Region
Idaho Department of Water Resources
1910 Northwest Boulevard, Suite 210
Coeur d'Alene, Idaho 83814

RECEIVED
NOV 13 1989
NORTHERN REGION
IDWR

Re: Application for Permit 87-07141

Dear Mr. Haynes:

Your letter of 25 October, 1989, and Notice of Hearing and/or Conference dated 6 November, 1989, have been received.

It was my impression from your letter of 25 October that the University of Idaho and myself were being urged to discuss the issues inherent in their application in an attempt to resolve the protest without the need for a hearing.

The 25 October letter goes on to state, "If you do not advise us within twenty (20) days that the protest has been resolved, the matter will be scheduled for conference and/or hearing." The 25 October letter, mailed 26 October, and received on either the 27th or 28th of October presumably would allow a period of contact extending until about the 16th of November to effect resolution.

The certified mail notice received 7 November, long before the end of the resolution period, establishes a hearing and/or conference for 30 November, 1989.

As you are aware, efforts are underway to attempt to resolve the protest by the undersigned. I met with Dr. Joseph Geiger and other University officials on 31 October, 1989, and my letter/memorandum of record of 6 November, 1989, copy furnished to you, outlines the mitigating actions I recommended at that meeting for their consideration.

The formal notice of hearing and/or conference setting a date certain seems premature to this protestant. The twenty-day resolution period has not elapsed, the resolution process is underway, the University of Idaho is presumably considering my recommendations, and I have not advised the Idaho Department of Water Resources that the protest is either resolved or unresolved.

The issue of resolution is still very much open and I am awaiting a reply from the University of Idaho at this time. Should resolution not be possible, I would of course inform you by the 16th in accordance with your earlier directive.

MICROFILMED
MAR 19 1990

The term "hearing and/or conference" is confusing to this writer. Conferences to me mean an informal exchange of ideas and information between individuals. Consensus to desirable courses of action may be sought, but are not directed by a superior authority. A hearing is a more formal exchange of information operating under specific rules of law and evidence, taking place before a legally appointed hearing officer having authority to make a decision about a contested issue.

What form of gathering does the notice of 6 November imply? Is the meeting of 30 November a conference of IDWR, the University of Idaho, and myself to find resolution on a consensual basis? Or is it the formal process outlined in Section 42-203A of the Idaho Code and other authorities?

I am prepared to go either way; however, would prefer to focus my efforts and preparation for the specific event prescribed. Responses to the specific five issues outlined in both of your communications are significantly different than mitigating actions I have already proposed toward resolution of my protest.

Your prompt response to the questions noted above would be greatly appreciated.

Regards,

Thomas A. Townsend

TAT:alc

cc: Dr. Joseph J. Geiger, University of Idaho
Mr. Wayne Haas, IDWR

MICROFILMED
MAR 19 1990

447 East Eighth Street
Moscow, Idaho 83843
6 November 1989

RECEIVED
NOV 8 1989
Department of Water Resources

Mr. Joseph J. Geiger
Financial Vice President
Office of Financial Affairs
University of Idaho
Moscow, Idaho 83843

Dear Mr. Geiger:

This letter is intended to serve two purposes. The first is to confirm our meeting of 31 October 1989 which the University requested to assist in resolution of my protest to your Application for Permit, No. 87-07141 of 18 September 1989.

The second, and most important purpose, is to place in formal context those recommendations that I informally discussed with you and your staff at the 31 October meeting. Those recommendations represent mitigating actions that I believe the University of Idaho, as applicant, must effect as pre-conditions before I can, in good conscience, withdraw my protest.

The mitigating actions are as follow:

A. That the University of Idaho agrees to reduction of pumpage from the deep aquifer and that such pumpage is stabilized at an amount/volume not to exceed the average pumped volume of the University (less effluent pumpage volume) for the period 1981-1985. Such action to be effective commencing 1 January 1990.

B. That the University of Idaho agrees: (1) no water drawn from the deep aquifer levels will be used for any form of irrigation by the University and (2) that all future University irrigation requirements will be met from totally effluent derived sources, primarily the Moscow Sewage Treatment Plant. See exception in paragraph E. Implementation of this action will require some infrastructure addition, such costs to be borne by the University, and to be completed at a time certain, such time to be determined by mutual consent.

C. That the University of Idaho agrees to legally abandon/revert its existing Idaho water rights for irrigation purposes to a level not to exceed 1,698 feet per annum with that volume to be derived solely from effluent sources. See paragraph E for a restriction on the use of effluent from the Aquaculture Project tank system. These proposed reductions would apply to existing water rights: WR 87-02017, WR 87-02031, WR 87-07012, and WR 87-07026.

MICROFILMED
MAR 19 1990

D. That the University of Idaho agrees that no water appropriated from the shallow aquifer under the provisions of the proposed Application for Permit will be utilized in direct first-use application for irrigation purposes. Direct first-use of shallow aquifer derived water is not a beneficial use considering the ready availability of treated effluent from the Moscow Sewage Treatment Plant and possibly a lesser amount available from the Aquaculture Project effluent.

E. That the University of Idaho agrees to implement maximum reuse of the effluent from the proposed holding and rearing tanks of the Aquaculture Project. This effluent, after treatment, should be the major source of make-up or pass through water, depending on the project design, and should be returned to the tank system for reuse. Only if the aquaculture fish tank system effluent volume exceeds system demand (make-up/pass through) or qualitative imperatives dictate should the effluent discharged be allocated for irrigation purposes.

This action would reduce the load on the upper aquifer levels by restricting uses to other than the Aquaculture Program.

F. That the University of Idaho agrees to make a good faith effort to correct its water rights record in coordination with the Idaho Department of Water Resources. This is necessary so as to clean up ambiguities and/or errors in that record. Current records reflect water usage in two functional areas: domestic and irrigation whereas in reality the University uses its water allocations not only for those purposes, but also for research, stock watering, and possibly others.

G. That the University of Idaho agrees to take remedial action in clearing the status of WR 87-02005. Those rights were granted by the State of Idaho in 1951, used until 1966, and since 1966 not been exercised. These rights have been unused for twenty-three years yet remain on IDWR records as a valid license to appropriate. Reversionary action seems appropriate so that those waters can again be subject to appropriation by other Idaho parties.

H. That the University of Idaho agrees to establish a monitoring/recording system on the shallow aquifer to verify changes in water table levels following commencement of water appropriations requested by the University in their Application for Permit, No. 87-07141. The extent of the physical area around the diversion point to be monitored may well be very large and even extend into Whitman County, Washington. Determination of the physical boundaries of the monitored area/system design parameters would be reviewed and approved by the Idaho Department of Water Resources and the Washington Department of Ecology.

MICROFILMED
MAR 19 1990

Should the proposed new use by the University of the shallow aquifer cause water table elevation declines inconsistent with historical data of shallow aquifer use by the City of Moscow there would be cause for reconsideration by all parties. The risk side of the presumed beneficial use attending to the appropriation might require reevaluation. It is assumed that protection of existing and senior water rights is a paramount concern.

I. That the University of Idaho consider the formation of a community environmental advisory committee, consisting of citizens from within our local area: Latah and Whitman Counties, that could provide University of Idaho planners and administrators with early on, grass roots perspective and evaluation of proposed University of Idaho projects in the area. Such projects may or may not have impacts; however, it is the perceptions of local citizens that drive community reactions. Total reliance on the views of economic development groups, elected officials, and other groups with special or pecuniary interests does not always provide reliable planning information.

In closing I would note the University has already made significant strides towards reduction of deep aquifer resource utilization. Hopefully it can do even more.

I realize the City of Moscow does use shallow aquifer resources from three wells. Moscow's usage of the shallow aquifer, based on a cursory review of city pumping data, is much smaller in acre feet volume than that requested by the University from the same shallow source.

Shallow water resource used by Moscow accounted for less than 6% of total consumption in 1988. Carry this comparison a bit further. Current pumping by the University, according to Aquaculture Program data, is 1,157.05 acre feet per annum. The current request for new shallow resource is 1,085 acre feet per annum. This would place the University in the position of being the major user of the shallow aquifer with over 48% of its total consumption being derived from shallow aquifer resource.

The shallow aquifer already has a history of being mined. It was exploited from the 1880's to the early 1960's, given a partial recovery period for the past thirty years, and is today only at the level of year 1900 A.D. How it will respond to new demands remains to be seen.

The planning shift to reutilize the shallow/upper aquifer is neither risk free nor the optimum solution by itself. Hence this letter and the recommended mitigation actions therein.

Respectfully submitted,

Thomas A. Townsend

TAT:alc

cc: Mr. Robert G. Haynes, IDWR, Coeur d'Alene
Mr. Wayne Haas, IDWR, Boise
Councilwoman Mardi Baron, City of Moscow

MICROFILMED
MAR 19 1990

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER
Chartered
ATTORNEYS AT LAW
142 3rd AVENUE NORTH
P.O. BOX 1906
TWIN FALLS, IDAHO 83303-1906
TELEPHONE (208) 734-0700
FAX (208) 736-0041

Boise Office
1020 MAIN ST., SUITE 400
P.O. BOX 2139
BOISE, IDAHO 83701-2139
TELEPHONE (208) 336-0700
FAX (208) 344-6034

THOMAS G. NELSON
JOHN A. ROSHOLT
J. EVAN ROBERTSON
STEVEN K. TOLMAN
JAMES C. TUCKER
TERRY R. McDANIEL
GARY D. SLETTE
F. BRUCE COVINGTON
JERRY JENSEN
CAROLYN M. MINDER
BRUCE M. SMITH
G. RICHARD BEVAN
BRAD M. PURDY
GARY L. QUIGLEY
TIM J. WILLIAMS
SHARON F. DUNKIN

October 25, 1989

RECEIVED
OCT 26 1989
Department of Water Resources

R. Keith Higginson, Director
Idaho Department of Water Resources
1301 N. Orchard
Statehouse Mail
Boise ID 83720

RE: University of Idaho
Application No. 87-07141

Dear Keith:

The above referenced filing has apparently been protested.

The University has asked that due to the time constraints and the sensitivity of the matter that I request that the Director serve as the hearing officer and that the hearing be set as soon as possible.

Thank you for your consideration of this matter.

Respectfully submitted,

NELSON, ROSHOLT, ROBERTSON,
TOLMAN & TUCKER, CHARTERED

By: John A. Rosholt
JOHN A. ROSHOLT
Attorneys for University
of Idaho

JAR:dcb
36471

cc: Bob Haynes
Dr. Joseph Geiger
Thomas Townsend

MICROFILMED
MAR 19 1990

New app.
87-7141

MEMORANDUM

RECEIVED
OCT 30 1989
NORTHERN REGION
IDWR

TO: Bob Haynes

FROM: Norman C. Young

RE: Tom Townsend - U of I Application

DATE: October 3, 1989

Please provide Tom Townsend with a copy of the University of Idaho's application and the publication and protest dates.

MICROFILMED
MAR 19 1990

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

28 SEPT 1989

Mr. Norman Young
Administrator, Resources Admin. Div.
Idaho Department of Water Resources
Statehouse Mail
Boise, Idaho 83720

OCT 02 1989

Department of Water Resources
RECEIVED
OCT 30 1989
NORTHERN REGION
IDWR

Dear Mr. Young,

The U of I, I understand, has filed an application to appropriate 354 million gallons per year from the sole source Pullman-Moscow aquifer. The legal notice of this application has not yet appeared in local newspapers of record and I was wondering when such notice will be made and the time period for posing objections will be established.

I am assuming the quantity requested is for the new appropriation to support the proposed aquaculture project as well as the existing source currently being utilized in the FWR wet lab.

As I plan to object to this massive drawdown I would appreciate receiving a copy of the UI application when it can be publicly released.

Regards,
Tom Townsend

MICROFILMED
MAR 19 1990

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER
Chartered
ATTORNEYS AT LAW

THOMAS G. NELSON
JOHN A. ROSHOLT
J. EVAN ROBERTSON
STEVEN K. TOLMAN
JAMES C. TUCKER
TERRY R. McDANIEL
GARY D. SLETTE
F. BRUCE COVINGTON
JERRY JENSEN
CAROLYN M. MINDER
BRUCE M. SMITH
G. RICHARD BEVAN
BRAD M. PURDY
GARY L. QUIGLEY
TIM J. WILLIAMS
SHARON F. DUNKIN

142 3rd AVENUE NORTH
P.O. BOX 1906
TWIN FALLS, IDAHO 83303-1906
TELEPHONE (208) 734-0700
FAX (208) 736-0041

Boise Office
1020 MAIN ST., SUITE 400
P.O. BOX 2139
BOISE, IDAHO 83701-2139
TELEPHONE (208) 336-0700
FAX (208) 344-6034

October 25, 1989

R. Keith Higginson, Director
Idaho Department of Water Resources
1301 N. Orchard
Statehouse Mail
Boise ID 83720

RECEIVED
OCT 27 1989
NORTHERN REGION
IDWR

RE: University of Idaho
Application No. 87-07141

Dear Keith:

The above referenced filing has apparently been protested.

The University has asked that due to the time constraints and the sensitivity of the matter that I request that the Director serve as the hearing officer and that the hearing be set as soon as possible.

Thank you for your consideration of this matter.

Respectfully submitted,

NELSON, ROSHOLT, ROBERTSON,
TOLMAN & TUCKER, CHARTERED

By: John A. Rosholt
JOHN A. ROSHOLT
Attorneys for University
of Idaho

JAR:dcb
36471

cc: Bob Haynes
Dr. Joseph Geiger
Thomas Townsend

MICROFILMED
MAR 19 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

October 25, 1989

Mr. Thomas A. Townsend
447 E. 8th St.
Moscow, Id. 83843

Re: 87-07141

Dear Mr. Townsend:

Your protest against the approval of the above-referenced application has been received and a copy has been sent to the applicant. The Department suggests that you contact the applicant directly in an effort to determine what is proposed by the application and to attempt to resolve the protest.

If you do not advise us within twenty (20) days that the protest has been resolved, the matter will be scheduled for conference and/or hearing. At such a conference and/or hearing, the following are the principle items the Department can consider in either approving or denying the application for permit (Section 42-203, Idaho Code):

1. Will the proposed use reduce the quantity of water under existing water rights?

2. Is the proposed water supply insufficient for the purpose intended?

3. Is the application made in good faith or for delay or speculation?

4. Has the applicant sufficient financial resources with which to complete the project?

5. Will the proposed use conflict with the local public interest?

You will be notified at a later date of the time and place of the conference and/or hearing. If we can be of any assistance, please contact us.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms

MICROFILMED
MAR 19 1990

Celebrate IDAHO 1890-CENTENNIAL-1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

October 25, 1989

University of Idaho
c/o Mr. Larry Kirkland
Physical Plant
Moscow, Id. 83843

Gentlemen:

Enclosed is a copy of a protest filed against the approval of the above-referenced application for permit to appropriate the public waters of the State of Idaho. The Department suggests you contact the protestants directly in an effort to determine the nature of the protest and attempt to resolve the protest.

If you do not advise us within twenty (20) days that the protest has been resolved, the matter will be scheduled for conference and/or hearing. At such a conference and/or hearing, the following are the principle items the Department can consider in either approving or denying the application for permit (Section 42-203, Idaho Code):

1. Will the proposed use reduce the quantity of water under existing water rights?

2. Is the proposed water supply insufficient for the purpose intended?

3. Is the application made in good faith or for delay or speculation?

4. Has the applicant sufficient financial resources with which to complete the project?

5. Will the proposed use conflict with the local public interest?

You will be notified at a later date of the time and place of the conference and/or hearing. If we can be of any assistance, please contact us.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms
Enclosure
cc: Mr. Frank Hitchcock, Nelson-Rosholt

Celebrate IDAHO 1890-CENTENNIAL-1990

MICROFILMED
MAR 19 1990

18 OCT 1989

Director, Idaho Department of Water Resources
c/o Mr. Robert G. Haynes, Northern Regional Manager
1910 Northwest Boulevard, Suite 210
Coeur d'Alene, Idaho 83814

RECEIVED
OCT 19 1989
NORTHERN REGION
DWR

Subj: Addendum to Water Right Protest, Permit Application 87-07141 of 18 Sept. 1989

Dear Mr. Haynes,

The University of Idaho released an Executive Summary of the UI Aquaculture Project yesterday which has a bearing on their pending application before IDWR. A copy of this material is attached and I have some additional observations, comments and objections that I would like to add as an addendum to my earlier letter of protest.

New material is keyed to the UI summary. Paragraph entitled Aquifer Management/Recharge Initative. The Pullman Moscow Water Resource Committee on 9 June 1988 granted $ 4,210 to Professor Dale Ralston, Professor of Hydrology UI, for continued research at the Ground Water Research site on campus. The research involved degree of recharge of the shallow basalt aquifer from stream flows. No report of work accomplished has ever been released to date although I did request same of the Committee in September 1989. There have been previous investigations in this area in the past, the UI has irrigated for years using sewage plant effluent and yet another new study is being done to justify the use of additional public waters.

MICROFILMED
MAR 19 1990

Engineering Plan for Facility and Water Recharge. Discussion of a shallow well, water to be pre-treated, used by fish labs, treated as effluent and recycled into campus irrigation system. Exhibit II gives a schematic diagram of the process. This diagram indicates 48 MGY being utilized before mixing to the Moscow sewage trickling filter treatment plant and the adjacent UI holding lagoons/surge ponds. Several observations apply: (1) The 48 MGY shown in Exhibit II is vastly reduced from the 240 MGY of shallow well resource depicted in the earlier UI exhibit entitled FUTURE to support the new fish lab and the existing FWR fish lab.

(2) The earlier plan showed a total fish related demand requirement of 320 MGY with 80 MGY of deep well resource and 240 MGY of new shallow well resource. The deep well resource usage for fish is currently 80 MGY so no change in that resource under that concept.

(3) If 320 MGY is the demand side (as UI once said it was) the exhibit II concept of supply is: (a) 48 MGY of shallow well resource (b) 272 MGY deep well resource — an increase of deep well pumping of 192 MGY over the current 80 MGY used in the existing FWR tank. This does not square with the comment in the fourth (4th) subparagraph of the Summary section entitled "General". "This project is based upon the development of a design and project strategy that minimizes negative impact upon the Paluxe Aquifer system---" 192 MGY of new deep aquifer exploitation is not minimal negative impact on a questionable primary water source!

(4) If the UI needs only 48 MGY shallow well resource (Exhibit II) I cannot understand their proposed appropriation of 1085 AF/annum - seven times what they now claim they will use. The other uses beside research - domestic and irrigation certainly don't need it.

Exhibit III has data on financial assumptions. My earlier letter discussed in detail the lack of funding for necessary infrastructure. The supporting projects listing seem unfunded at the moment yet these projects are necessary to make the scheme work. Missing are the programmed costs for the pre and post treatment installations which must be in place if the shallow well resource is used and if fish lab effluent is to be used for irrigation and be compatible with the provisions of DEQ Permit LA-000028.

MICROFILMED

It should be noted that the storage lagoon/[illegible] owned by the UI as part of their current effluent irrigation project have been subject to eutrofication due to extended storage times - this with a smaller irrigation load than is being proposed. Since much stress is being placed on the benefits of recycling the aquaculture effluent it may be prudent for IDWR to coordinate with the Department of Health and Welfare (DEQ) to insure their monitoring and reporting requirements are being met and that compliance conditions and schedules are up to date. Schedules A, B, and C of Permit LA-000028 apply -

Thomas A Tammany

Keith Kirk
Nancy

University of Idaho
Office of Financial Affairs
Moscow, Idaho 83843
208-885-6174
FAX 208-885-5752

October 17, 1989

Members of the Pullman-Moscow Water Resources Committee:

Ken Abbey
Mardi Baron
George Bloomsburg
Ken Hall
Jim Hudak
Nancy Johansen
Nora Mae Keifer
Larry Kirkland
Maggie McGreevy
Grant Morton
Gary Presol
Joe Spoonemore
Craig Ward

Dear Committee Members:

SUBJECT: University of Idaho Aquaculture Project

Attached please find an "Executive Summary" of the project as described by President Zinser at a press conference today. The final product is the result of considerable input from many individuals associated in one way or another with the water resources group. I hope the major emphasis upon water management (recharge, etc.) is responsive to general community concerns.

The monitoring project to be established at the onset of the operation of the Moscow facility will assist all parties in reviewing aquifer impact caused by the facility as well as the overall use patterns in the immediate region.

If you have any questions, please do not hesitate to call me at 885-6176 (work) or 883-3384 (home).

Sincerely,

Joseph J. Geiger
Financial Vice President

JJG/cw
Attachment
cc: President Elisabeth A. Zinser

MICROFILMED
MAR 19 1990

EXECUTIVE SUMMARY
UNIVERSITY OF IDAHO AQUACULTURE
RESEARCH AND DEVELOPMENT INITIATIVE

General

Following many weeks of discussions, analysis, and program refinement, the University of Idaho will proceed with plans for an aquaculture and fisheries research and development initiative encompassing a small research laboratory on the Moscow campus and a larger research and development laboratory in an area near Twin Falls, Idaho.

The Moscow facility will focus upon basic research and graduate education related to aquaculture, fish disease, water resources, and aquifer management. It will involve multidisciplinary teams of scholars located in Moscow.

The Twin Falls area facility will focus upon research and development related to the specific needs of the Idaho trout farming industry. It will involve University of Idaho faculty, local industry, and the College of Southern Idaho.

The project is based upon the development of a design and project strategy that minimizes negative impact upon the Palouse aquifer system and promotes the use of the immediate campus area as an aquifer research/monitoring entity. Work on the Moscow laboratory will commence as soon as final water diversion authority is issued by the Department of Water Resources.

With the support of the southern Idaho-based Aquaculture Advisory Committee, planning for the Twin Falls facility will begin immediately according to the appropriate state board approval processes.

Programmatic Values

The Moscow campus laboratory will serve as an education and a research facility. The education program will offer graduate studies in Aquaculture Science (genetics, nutrition, pathology, husbandry), Aquaculture Engineering (facility design, waste management, fish processing), and Aquaculture Business/Marketing (marketing, production operations management). The research emphasis at the campus laboratory will be on basic research to benefit the fish culture needs of Idaho, including both the commercial farms and the conservation hatcheries in the state. Research projects, therefore, will address issues from drug certification for use in hatcheries, to molecular engineering, to problems that affect the sport fishing industry. The initial research grant is from the Bonneville Power Authority in the amount of $1.22 million.

The Twin Falls area facility will serve as the center for applied research in the commercial industry, student training, and as the diagnostic center for fish disease in commercial hatcheries. Research projects will be directed at production needs of commercial aquaculture and distributed to industry through the extension network. Applied training for students from the College of Southern Idaho and the University of Idaho in fish husbandry, water quality, and diagnostics, will be conducted at the laboratory in concert with facilities at the College of Southern Idaho. It is also envisioned that programmatic cooperation in research will include faculty from BSU and ISU.

MICROFILMED

MAR 1 5 1990

To accomplish the program goals at both facilities, research teams will be developed from members of faculty and industry to undertake specific tasks. Examples of such tasks will be oxygen recharge and water reuse in fish farms to improve efficiency, developing the proper application of fish waste as fertilizer for croplands, identifying alternative protein sources for fish feed, culturing new species for industry and the sport fishery, and researching needs related to steelhead and chinook salmon production on the Columbia River.

Aquifer Management/Recharge Initiative

A major effort will be mounted to use the University of Idaho campus as a "test bed" for aquifer management and recharge research. As an initial effort, the university has authorized a seed grant of $10,000 to begin evaluation of the irrigation recharge strategy. The research project will involve analysis of groundwater levels and quality in an area presently irrigated with treated effluent. The work will be done in conjunction with on-going investigations at the University of Idaho Ground Water Research site on the west side of campus. The university's goal is to use the recharge strategy to provide increasingly clear base-line information for economic and population planning in the Palouse region (see Exhibit I for initial research plan prospectus).

Engineering Plan For Facility and Water Recharge

The Moscow facility is shown in Exhibit II. The basic water supply will come from a well drawing from the shallow aquifer. The water will be treated, used by the lab, treated again, and recycled into the campus irrigation system. Campus land currently watered from "deep aquifer" wells will be irrigated with the treated effluent from the laboratory. In this manner, use of the deep aquifer for irrigation will be reduced. Effluent water from the treatment plant will be applied on the campus, where a portion of the water will work its way down through the soil and strata to recharge the shallow aquifer. Procedures to be used to treat the effluent before recharge will be designed to ensure safe water and to exceed standards applied in most labs of this kind. Because water rights for using the sewage treatment plant effluent exceed both current irrigation usage and the maximum flow from the aquaculture lab, additional volumes will be added to the irrigation program until meaningful recharge of the shallow aquifer is achieved.

Water Rights Issue

Early questions about the university's rights to draw from Palouse wells for research (including aquaculture) appear to be resolved. The university has applied for the necessary change in the diversion point (i.e., new well location) along with the associated water right, which replaces the old shallow well near the dorms. The review of the application, which is to reinstitute prior water rights, is proceeding normally and approval is expected in November 1989.

MICROFILMED

MAR 19 1990

Construction Costs And Scheduling

Exhibit III summarizes the program, budget, and schedule for the campus-based facility. The lab will cost approximately $500,000 and be paid for from the proceeds of the Centennial Campaign. Ancillary projects, including the expansion of the irrigation system, will add to the project cost and be paid for out of grant and university facility funds. The irrigation system upgrade will follow the operational start-up of the laboratory.

Planning for the Twin Falls area facility will commence immediately with fundraising efforts (private, federal, and state appropriation), beginning in the summer of 1990.

MICROFILMED
MAR 19 1990

Frequently Discussed Points

- Approval of the campus-based initial facility is based upon the following policy parameters:
    - Lab must be built and operated without any net increase in the use of the deep aquifer water resource.
    - The effluent irrigation system must be expanded to cover areas currently being irrigated with deep aquifer water.
    - The new shallow aquifer water is to be the primary resource for the new lab.
    - An amount equal to the shallow aquifer pumpage must be recharged with properly treated effluent via the expanded irrigation system.
    - The effluent irrigation system must be operated in concert with a research program in aquifer management.
- The two-facility aquaculture strategy is designed to maintain the critical mix of skills at the University of Idaho campus for graduate education and research while creating a full scale R&D and training facility at Twin Falls, in the midst of the Idaho trout industry. Also, disease research conducted in Moscow will be isolated from production R&D at Twin Falls.
- Palouse shallow aquifer water, when properly treated, can serve as a primary water source for the University of Idaho campus lab. Current studies indicate that the costs will not be extra-ordinary for pre-treatment of shallow aquifer water.
- Pre-treatment of shallow aquifer water to be used by the lab will be designed in final form following analysis of the actual water drawn from the new well. However, treatment will include removal of elements such as iron from the water, chlorine oxidation, neutralization with $KmNO_4$, chlorine removal with coal, and mineral filtration with green sand.
- Post-treatment procedures to be used in treating the discharge from the laboratory will meet or exceed standards employed in most labs of this type.
- The shallow Palouse aquifer is recharged annually; there may be a link between the shallow and deep aquifer as well. Recharging the aquifers through irrigation is a proven technology.
- It is critical to provide R&D support for the Idaho trout industry which is facing increasing national and international competition.
- No new degree programs are necessary. Undergraduate aquaculture is already in place. The graduate programs exist in the appropriate colleges (Letters and Science; Forestry, Wildlife, and Range Sciences; and Agriculture). The MS/PhD studies will be related to fish.
- The University of Idaho is a leader in the field of education and research on aquifer management.
- Expansion of the initial University of Idaho campus facility will not occur until the impact upon the total aquifer system has been analyzed and found to be acceptable.

MICROFILMED
MAR 19 1990

- Future growth at Moscow will depend first upon aquifer impact analyses and second, upon successfully competing for new research grants.

- Facilities development in the Twin Falls area depends largely upon federal and private support, as well as state construction appropriations.

- Building only the initial facility at the University of Idaho campus is justified because it alone would constitute a significant upgrade and high quality laboratory environment for existing fish research needed in current programs.

- The ability to create a campus-sized "test bed" for aquifer studies--through the campus-based Idaho Water Resources Research Institute and other agencies--is viewed by campus administration as just as important as the aquaculture research itself.

101789
UI

MICROFILMED
MAR 19 1990

EXHIBIT I

Where Tradition Meets the Future
1889-1989
University of Idaho

PRELIMINARY EVALUATION OF GROUND WATER IMPACTS ASSOCIATED WITH IRRIGATION WITH TREATED EFFLUENT ON THE UNIVERSITY OF IDAHO CAMPUS

Idaho Water Resources
Research Institute

Morrill Hall 106
University of Idaho
Moscow, Idaho
83843

208-885-6429

Dr. Dale R. Ralston
Professor, Hydrogeology

Dr. George L. Bloomsburg
Professor, Agricultural Engineering

Dr. John E. Hammel
Associate Professor, Soil Physics

WATER for IDAHO

Purpose

The purpose of this project is to aid in the development of artificial recharge as a ground water management tool within the Pullman-Moscow basin.

Objectives

The general objective of this project is to evaluate water level and water quality impacts on the shallow ground water system associated with irrigation of portions of campus with treated effluent from the Moscow sewage treatment plant.

The specific objectives are as follows:

1) *select a research site from areas presently irrigated using treated effluent;*

2) *install a monitor well network at the site to allow collection of water level and water quality information from the shallow ground water system;*

3) *install instrumentation to allow collection of water quality samples from the unsaturated zone above the shallow ground water table;*

4) *install necessary valves and flow meter(s) in the effluent application system to allow controlled application of effluent to the research site;*

5) *collect water level and water quality data from the research site during both the non-irrigation season of 1989-90 and the irrigation season of 1990;*

6) *analyze the research results and prepare a reports of findings.*

MICROFILMED
MAR 19 1990

Description of the Research

The probable research site is located on the extreme west side of the playing fields next to Perimeter Drive. This area is near the University of Idaho Ground Water Research Site and is presently irrigated using treated effluent. The depth of the water table in this area is about 5 to 10 feet, which will minimize drilling expenses.

The monitoring network would be constructed using a commercial drilling rig. All monitor sites would be completed with steel surface casing and locking caps that would extend about .5 feet above land surface.

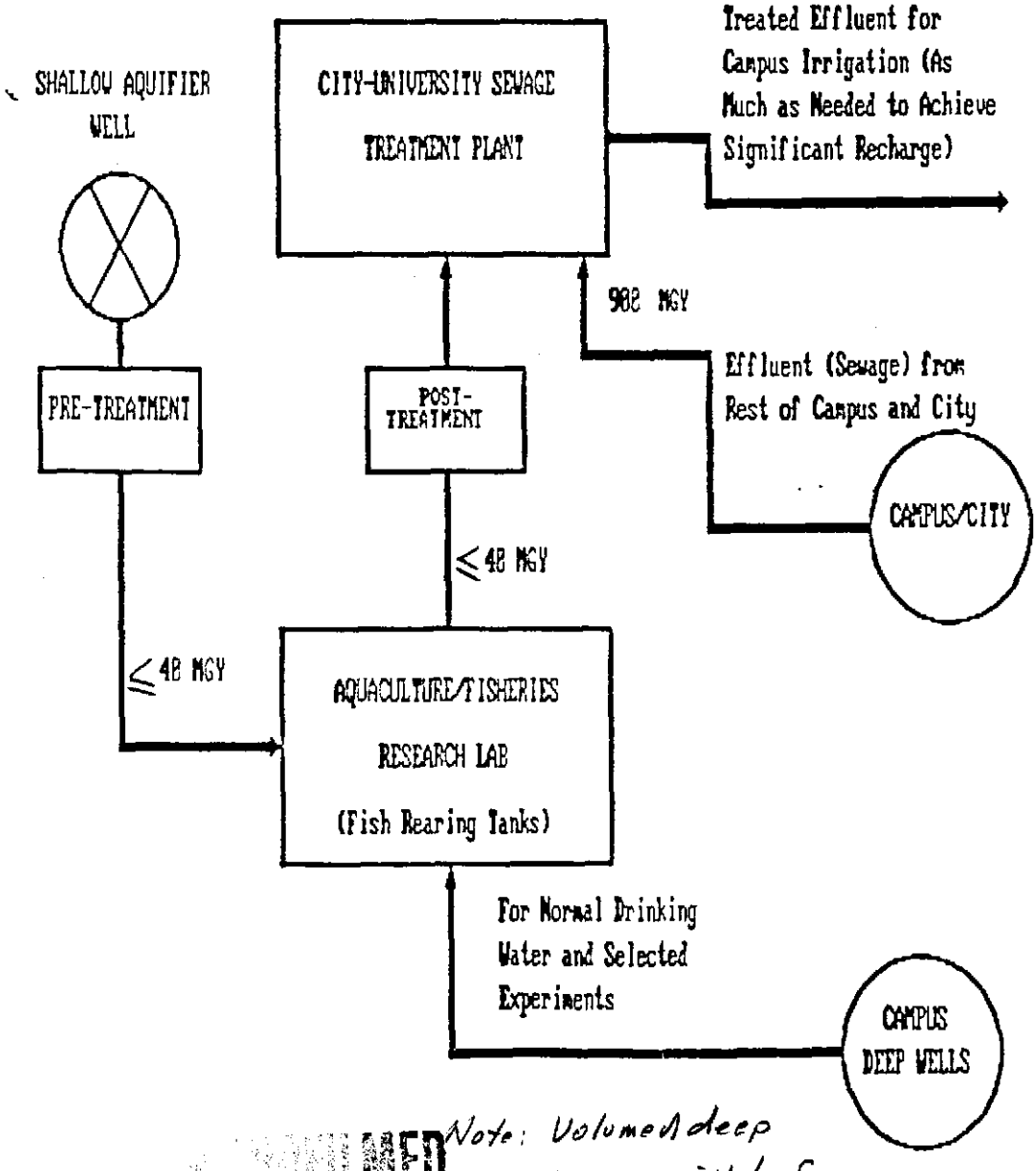
Field data collection would be done by a graduate student on appointment. Analysis of water samples would be conducted by the graduate student on campus using available equipment. University provided support would include: 1) furnishing laboratory space and equipment for laboratory analyses; 2) furnishing and installing valves and meter(s) as may be required for controlling and monitoring effluent application; 3) additional costs required to effect specific effluent application rates during specific test periods; and 4) additional costs required for lawn maintenance because of the presence of monitoring sites.

Budget

Salaries	
Graduate Assistant (.25 FTE)	$4,000
Irregular Help ($5.00/HR x 100 HRS)	500
Operating Expenses	
Contract Drilling	2,500
Chemical, Soil & Water Analyses	1,000
Field and Lab Supplies	1,000
Report Preparation	483
Fringe Benefits	
Rate: 11.5%	517
TOTAL	$10,000

MICROFILMED
MAR 19 1990

SCHEMATIC DIAGRAM OF UI CAMPUS AQUACULTURE/FISHERIES RESEARCH FACILITY



RECLAIMED
MAR 19 1990

Note: Volume of deep aquifer use will be far less than the drop in water saved by expand effluent irrigation

EXHIBIT III

University of Idaho

Department of Facility Planning

Aquaculture Center, Phase One
Project Assumptions

PROGRAM:

Construct an approximately 5,400 square foot research lab for the first phase of the University Aquaculture/Fisheries Research Laboratory. The research lab will house fourteen (14) twelve foot diameter fish rearing tanks. A single shallow aquifer well will provide water for the lab. The initial research project will require 40 mgy of high quality make-up water to be delivered to the lab; total water required in the recycling system will be 560 gpm.

The method for expanding and extending the irrigation system will be designed as part of the $100,000-$250,000 project listed in the budget.

BUDGET:

The budget assumptions that follow include all expenses associated with the sitework, building, and equipment, with the exceptions noted below.

	University Facility*	College Equipment	Total
Programming/Master Plan	$ 8,385		$ 8,385
Basic A/E Fees	51,985		51,985
Construction	278,380		278,380
Equipment (existing and donated)		113,730	113,730
Overhead/Contingency	41,760	19,110	68,660
Totals	$388,510	$132,840	$513,350

* Primarily centennial donation

Supporting Projects:

- Power failure alarm and back-up system ($15,000)
- Shallow well connection to the main university system ($10,000)
- Walk-in freezer for fish carcass storage ($10,000)
- Effluent irrigation system extensions ($100,000 to $250,000)
- Steps for aquifer recharge implementation (part of new research)

SCHEDULE:

Programming Complete	August 23, 1989
Found. Design Docs Complete	October 16, 1989
Found. Bid Opening (contingent upon water rights permit)	November 7, 1989
Receive water permit	November 15, 1989
Foundation Construction Start	November 15, 1989
Building Design Docs. Complete	November 17, 1989
Building Bid Opening	December 12, 1989
Building Construction Begin	December 19, 1989
Occupancy	March-April, 1990
Effluent Irrigation System	Fiscal Year 1991
Recharge Monitoring/Research	Commence FY 1990
Magic Valley Facility Planning	Oct. 89 - June 90
Magic Valley Design/Construction	Funds Available basis

MICROFILMED
MAR 19 1990

(1)

16 OCT 1989

Director, Idaho Department of Water Resources
C/o Mr. Robert G. Haynes, Northern Regional Manager
1910 Northwest Boulevard, Suite 210
Coeur d' Alene, Idaho 83814

RECEIVED
OCT 17 1989
NORTHERN REGION
IDWR

Dear Mr. Haynes,

This letter constitutes a record of protest to the Application For Permit 87-07141 filed by the University of Idaho on September 18, 1989 and is filed in the provisions of the legal notice published 10/05/89 and 10/12/89.

A. The published legal notice (Notice of Application For Water Right) and the more detailed Application For Permit to Appropriate the Public Waters of the State of Idaho further identified as #87-07141 dated 18 September 1989 notes five (5) points of diversion of ground water from the shallow portion of the Moscow-Pullman aquifer.

Paragraph 6 of the Application For Permit (Form 202, 6/88) notes "Drill well in shallow aquifer ...." This signifies to this observer that one (1) new well is anticipated. Paragraph 10 of the application asks the applicant "Describe any other water rights used for the same purposes as described above." The applicant lists other existing water rights used for the purposes desired as: WR 87-02031, WR 87-07012, and WR 87-07026. The applicant, in remarks in paragraph 12, notes that existing water right WR 87-02005 has not been used for over twenty three years (1966) and that all the University water needs have been supplied by the three water rights noted directly above.

Chart I describes the currently authorized water rights of the UI by WR identification and diversion point location. The chart, on the right, lists the proposed points of diversion.

MICROFILMED
MAR 19 1990

When trying to compare the proposed work with existing facilities several problems arise:

(1) the additional diversion point 39N-05W 7 SESW coincides in location with existing WR 87-02005; however, the University

(2) stated earlier in Remarks (Para. 12) the water quality at that site was unsatisfactory and hasn't used that site/pump for over twenty three years. Depending on the intended use, which is vague in the application, it seems odd that this is the chosen site of an additional diversion point since the aquifer quality has not improved since the original well was taken out of service in 1966. It concerns me also that the Regents of the University of Idaho have held on to the water rights to 2.2 CFS when they have not used the resource for twenty three years. It seems to this citizen that if an institution does not utilize a public resource that it has asked to use that it should forfeit that authorization promptly when conditions change.

(2) The primary diversion point noted in the Application for Permit is described as 39N 06W 12 SWSE which matches the location (presumed) of existing WR 87-07026 which is a pumping system for waste water effluent derived from the Moscow sewage treatment plant. Since this location is close to the proposed Aquaculture Project research facility it is possible that a new well could be drilled in this general area as well.

If this is so I fail to understand the application for the three additional diversion points that do not coincide with existing water rights/diversion points. Are these three intended as new wells or does the one new well assumption hold?

The applicant describes three water rights as serving all current needs, noted as active in chart 1, yet does not utilize two of of these authorized wells as diversion points under the proposed application. Does the applicant intend to relinquish water rights inherent in WR 87-02031 and WR 87-07012 since they don't seem to be a part of the new permit application

B. The applicant in paragraph 4 of the Application For Permit describes potential water use, if allocated, as being distributed between: (a) domestic, (b) research and [illegible] not to exceed 1.5 CFS or 1085 AF/A.

MICROFILMED
MAR 19 1990

The inclusion of research as a requested and designated functional use is new and stems in part from the fact that for years the applicant has been using a large percentage of its allocations for research purposes whereas all the authorizations of the period have been limited to either domestic or irrigation.

(3) This oversight or mis-interpretation of the word "domestic" was made known by this writer to Gary Spackman, Water Rights Permit Section, IDWR in late June 1989 after I found the UI planned a massive drawdown on the aquifer to support their proposed Aquaculture Program. At that time I received a listing/details of existing UI water rights and found no research authorization existed or that the state knew of how much water was being used for research.

It is difficult to estimate the exact amount of water dedicated to research purposes; however, I do know that the UI uses about 22% of it's annual pumpage to support the existing FWR (Fish & Wildlife Resources) Wet Lab. It is obvious that the research portion has a minimum of 22% and may reach 40% or higher - yet this use has never before been defined and requested by the user or authorized by the Department of Water Resources.

Several dissections derive from the information derived from paragraph 4. The applicant already has water diversion rights equivalent to 13.15 CFS at diversion volume (not available/specified for all rights) of 2241.5 AF/A. The newest water right, WR 87-07026, doesn't reflect a diversion volume nor do allocations WR-87-02031, WR 87-02017 and WR 87-02005. Data from the Division of Environmental Quality, Idaho Department of Health and Welfare (Wastewater-Land Application Permit No. LA-000028) authorizes application of 72 million gallons of final effluent to treat 500 acres of UI land.

The new allocation request of 1.5 CFS / 1085 AF/A is an unnecessary addition to water rights already authorized. The UI presently uses 377 million gallons/year from all sources (pumpage records) which I compute as equivalent to 1159.7 AF/annum.

The amount of actual current usage as compared to current authorized usage of 2241.5 AF/A is about 52%. This percentage would be of even less magnitude if all existing water rights had authorized diversion volumes to compare with. Since there is a current average of authorized, but unused allocation, it seems in a general sense inappropriate to allow an additional allocation as requested.

This is, I realize, not an unusual situation for municipal/institutional users to have a greater allocation than actually needed/used; however, I believe the differential (Δ) should be reduced, not increased.

MICROFILMED
MAR 19 1990

(4) The proposed allocation of the resource by the applicant is deliberately vague as to intended utilization. It lists a maximum diversion rate of 1.5 CFS for three separate functional purposes yet requests a total/maximum appropriation of 1.5 CFS/1085 AF/A overall. The probable, but unstated, intended use of a major portion of the requested water from the shallow saturated levels of the aquifer is to provide water to the existing FWR Fish Lab (wet Lab) and the new fish research lab which is part of the proposed Aquaculture Program. Secondary uses of this water, according to data earlier provided by the applicant, would be irrigation, ground water recharge and recycled back to the fish labs. Copies of current and future plans developed by UI are attached.

In a specific sense the applicant is asking for a greater appropriation than is needed. The latest UI data provided reflects a new research requirement for 240 million gallons per year of shallow well water yet the applicant requests 352.7 MGY.

What is the difference for? There is already an abundance of final effluent available from Moscow for irrigation purposes and aquifer recharge is a concept that needs to be tested.

The applicant has considered recycling a portion of the requested appropriation to a ground water injection well recharge system. There is, I would note, no authority by several regulatory agencies to do this. I would note also that the infrastructure to irrigate the 566 acres mentioned in paragraph 9 Application For Permit is not now totally in being. As mentioned earlier the UI has DEQ permission to use 72 MGY to irrigate 500 acres whereas the IDWR application reflects an area of 566 acres and plans for use of 80 MGY for irrigation. Point is not the discrepancy between numbers but that the current irrigation system cannot handle the programmed load and the UI budget submissions for future capital improvements for the system have a low present priority.

MICROFILMED
MAR 19 1990

The same weak infrastructure comment can be made about the proposed use of shallow aquifer water to support the fish research projects. The water has a high iron content and a high content of other dissolved solids which will require extensive treatment prior to the use either in research or domestic areas. Presumably it could be used directly for irrigation, but that seems

(5) Counterproductive since sewage effluents available in quantity at lower cost.

The effluent from the fish labs will certainly require extensive treatment, especially with the use of powerful antibiotics in conjunction with diseased fish, even before being considered suitable for recharge or surface irrigation purposes. The infrastructure to accomplish these tasks seems not to be present or on the future horizon.

A major objection to new water appropriations from the upper aquifer levels is the possibility of re-mining. The upper levels are now reported at elevations that existed in the year 1900. That portion of the aquifer was exploited from the 1880's to around 1960, been basically unused for almost thirty years, and now has recharged only to the level of 1900 A.D.

From my perspective I am not convinced that drawing 1085 AF/A from an already shaky stratum is good public policy. It may be less offensive than exploiting the lower aquifer levels; however, as a non-geologist I find it difficult to conceive of future low level recharge occurring without percolation through the upper layers. To over burden the initial source of recharge seems like robbing Peter to pay Paul.

A long held philosophical/scientific objection to the UI application hinges on the findings of the USGS report on the Moscow-Pullman aquifer. Specific in mind is the conclusion that the "Cities and universities can rely on the existing ground water resource without extensive water level declines if pumpage rates are stabilized and held constant." The study makes other comments that indicate "stabilization of water levels can occur at pumpage rates significantly higher than 1985"; however, doesn't make clear at what elevation this stabilization takes place or whether we can economically pump from that elevation. Even the parameters of "extensive" are left in darkness.

MICROFILMED
MAR 1 9 1990

Until there is less hedging on how the aquifer functions I ought to accept the concept of rate stabilization holds constant.

The application for appropriation of public waters flies in the face of the study conclusions. The UI already uses 377 MGY. It now wants an additional 352.7 MGY resource allocation — all of this for an institution that already has resource allocations

⑥ that far exceed demonstrated needs. This is neither reduced purpose nor stabilization! Besides being environmentally unsound it sets a bad example for the other users.

All of the current major users have authorizations that far exceed demonstrated need. Any one of them could increase purpose from existing wells with little legal recourse.

A comment regards ownership of existing water rights. The majority of the WR authorizations are to the owners of record: Board of Regents, UI. The Application For Permit is from the University of Idaho as applicant. The University of Idaho as an entity is not the same as the Board of Regents to my knowledge. There is nothing with the Application For Permit that indicates approval of the request by the Board concerning their specifically designated water rights. Does Idaho law permit one party unilaterally to adjust/modify the water rights of another party?

My recommendations re: this application are:

(1) Deny the application for any/all of the reasons noted.

(2) By negotiation reduce the differential between current authorized WR allocations and actual demonstrated use

(3) Require the University to justify it's current use of public waters for research purposes without prior approval of IDWR.

a. Allow UI to continue operation of FWR wet Lab on a temporary, conditional use basis pending receipt of justification submittal - Same for other obvious research applications -

b. Assuming research is a necessary element of such an institution allocate a minimum of 80 MGY from current water right authorizations to the existing fish research function (FWR Lab) with the proviso that an additional amount could be authorized on request (to be taken from the current 13.15 CFS diversion rate) for other on-campus research functions. This would not include the proposed new fish labs in Aquaculture Project.

(4) Establish maximum authorized diversion volumes for all existing UI water rights that exist in connection with recommendation (2) above.

MICROFILMED
MAR 19 1990

(5) Establish a system for future applications that will determine, in advance, the ability of the applicant to make effective, appropriate use of the requested resource, ie: engineering plans, financial

(7) Capability et al. The current system allows applicants to propose diversion of public waters to projects that may or may not be feesible in actuality. If approved, missing necessary comparative data, the water right could be "locked up" in a project that won't happen and deprive another applicant of the resource.

Please keep me informed as to on-going review of this application.

Submitted,

Thomas A. Townsend

Thomas A. Townsend
447 E 8th Street
Moscow, Idaho 83843

MICROFILMED
MAR 19 1990

AUTHORIZED WELLS/Diversions	CURRENT DIVERSION POINT				STATUS	PROPOSED IN Application for Permit				
(1) WR 87-02005	39N	05W	7	SESW	Inactive (2)	39N	05W	7	SESW (5)	
(2) WR 87-02017	39N	05W	15	SWNW	unknown					
(3) WR 87-02031	39N	05W	7	SWNW	Active (2)					
(4) WR 87-07135	39N	05W	18	SESW	unknown					
(5) WR 87-07012	39N	06W	12	NESE	Active (2)					
(6) WR 87-07026	39N	06W	12	SWSE (1)	Active (2)	39N	06W	12	SWSE (1)	Primary Diversion Point
						39N	06W	12	SESW (2)	
						39N	06W	12	SESE (3)	
						39N	05W	7	SWSE (4)	

RECEIVED
MAR 19 1990
MICROFILMED

Footnotes
(1) Presumed location from map examinations.
(2) Status from Part 12 Remarks, Application for Permit

O Permit Sequence

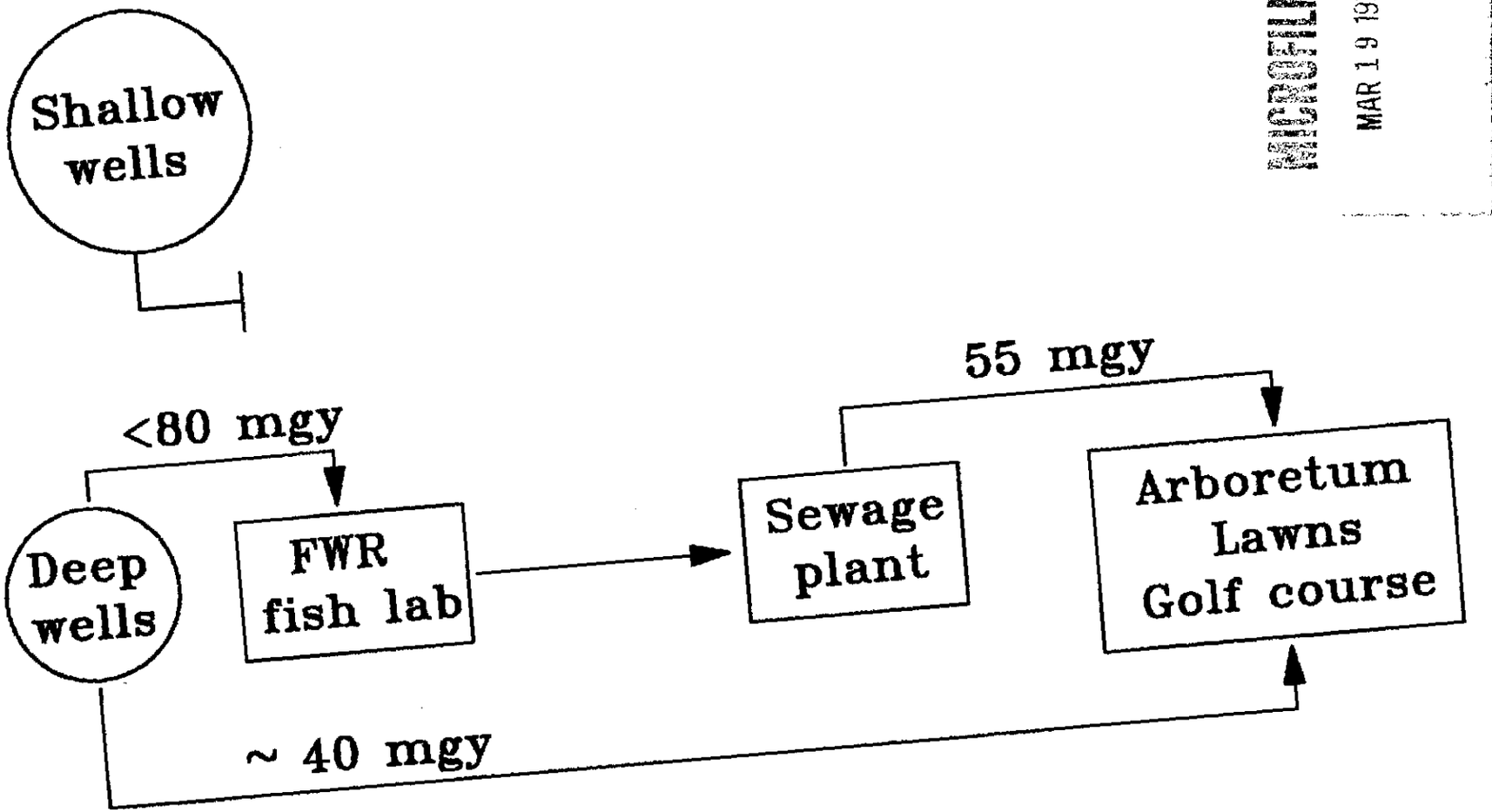
CHART I

U of I Aquaculture Program

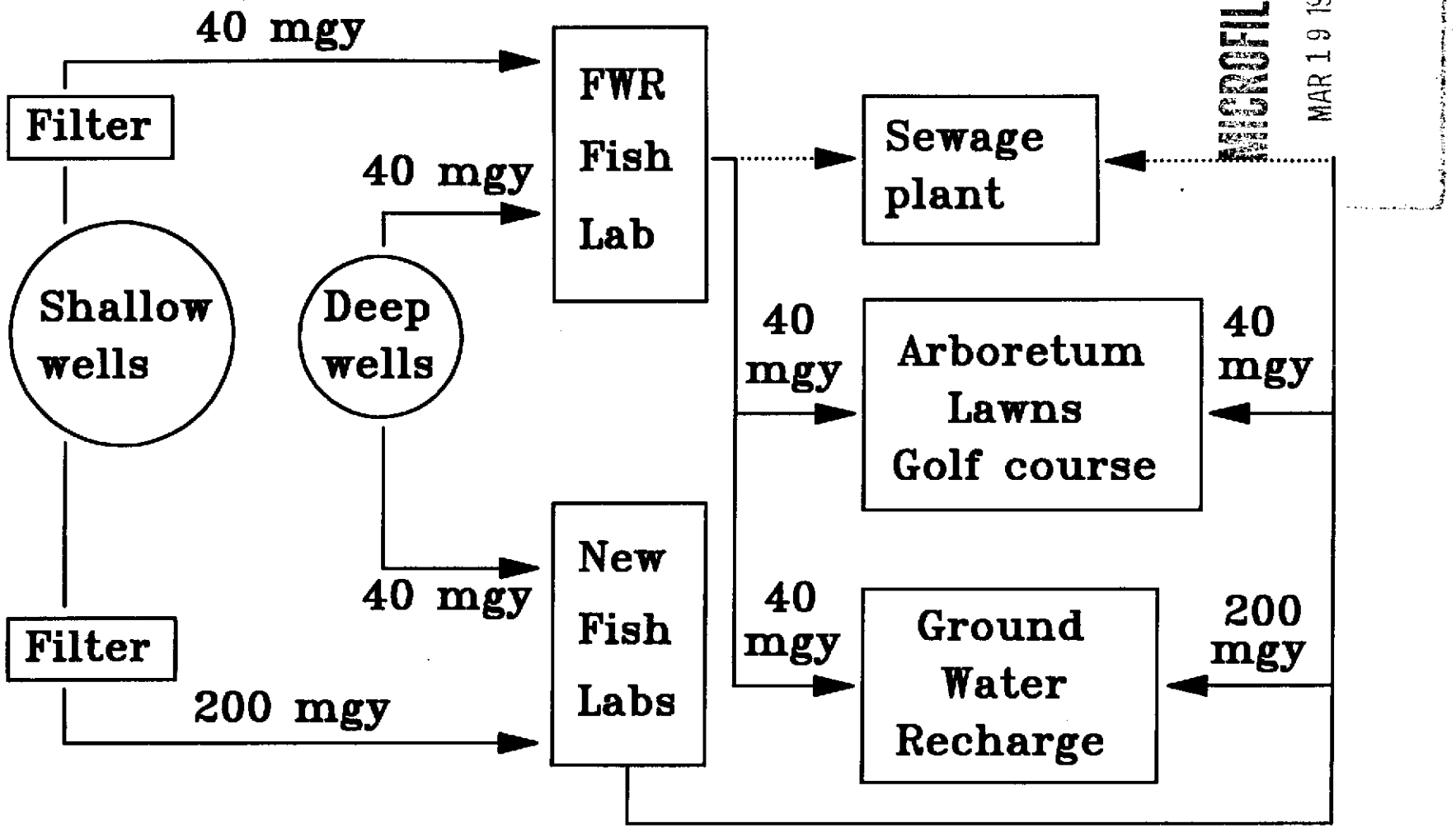
MICROFILMED
MAR 19 1990

Present:

MICROFILMED
MAR 19 1990



Future:



MICROFILMED
MAR 19 1990

Treated Waste Water Irrigation Use on Campus

MICROFILMED
MAR 19 1990

Present:

- Arboretum
- Golf course
- Guy–Wicks field
- Hartung lawn
- Football practice
- I – tank lawn

Future:

- East section Guy–Wicks field
- Expansion of Arboretum, Phase 2
- Performing Arts expansion
- N.W. side outdoor track
- Administration lawn
- Band field
- Info Center lawn
- Ghormley Park (City)
- Central quad (Library–FWR)

Proposed Steps for Water Conservation at U of I

Short Term: Years 1–3

- Use entire 150 gpm waste water from new facility Apr–Sep in present irrigation system.

Mid Term: Years 2–5

- Expand waste water irrigation system to displace present use of deep aquifer for irrigation.
- Begin use of shallow aquifer for some of Aquaculture/fish research needs.

Long Term: Years 5+

- Use shallow aquifer for most of aquaculture needs.
- Use waste water exclusively for all irrigation needs.
- Begin aquifer recharge with waste water from Aquaculture/fish research.

RECEIVED
MAR 19 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720 - (208) 327-7900

CECIL D. ANDRUS
GOVERNOR
R. KEITH HIGGINSON
DIRECTOR

RECEIVED
OCT 0 6 1989
NORTHERN REGION
IDWR

MEMORANDUM

TO: Bob Haynes

FROM: Norman C. Young NCY (wcy)

RE: Tom Townsend - U of I Application

DATE: October 3, 1989

Please provide Tom Townsend with a copy of the University of Idaho's application and the publication and protest dates.

Done

MICROFILMED
MAR 1 5 1990

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

28 SEPT 1989

OCT 02 1989
Department of Water Resources

Mr. Norman Young
Administrator, Resources Admm. Div.
Idaho Department of Water Resources
Statehouse Mail
Boise, Idaho 83720

Dear Mr. Young,

The UofI, I understand, has filed an application to appropriate 354 million gallons per year from the sole source Pullman-Moscow aquifer. The legal notice of this application has not yet appeared in local newspapers of record and I was wondering when such notice will be made and the time period for posing objections will be established.

I am assuming the quantity requested is for the new appropriation to support the proposed aquaculture project as well as the existing 80 mgy currently being utilized in the FWR wet lab.

As I plan to object to this massive drawdown I would appreciate receiving a copy of the UI application when it can be publicly released.

Regards,
Tom Townsend

MICROFILMED
MAR 19 1990

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

30 Sept. 1989

Mr. Robert G. Haynes
Regional Manager, Northern Region
Idaho Department of Water Resources
Suite 210
1910 N.W. Boulevard
Coeur D' Alene, Idaho 83814

RECEIVED
OCT 02 1989
NORTHERN REGION
IDWR

Dear Mr. Haynes,

Thank you for the information on the U of I application for a ground water permit.

The diversion points specified in the application, with the exception of WR 87-02005, don't seem to match the descriptions in the IDWR water Rights Report dated 6/29/89 I received from Boise.

The fifth (5th) proposed diversion point reflects tract SWSE whereas existing WR# 87-02031 shows tract SWNW. Is that an error or a new proposed well site? The proposed diversions in 39N, R06W, sec. 12 don't match with existing data I have — are they all new wells?

The ownership of existing wells show, with one exception, the Regents as being owner of record whereas the application is from the University of Idaho and shows no approval by the Board of Regents.

Does this application mean the Board of Regents has surrendered ownership rights to WR 87-02005 which is the only existing well that I can identify clearly on the new application? I fail to see how the University of Idaho physical plant/administration can ask for changes to water rights owned by a different body, the Board of Regents in this case.

RECEIVED
MAR 15 1990

MAJ. T. A. TOWNSEND, USMC (RET.)
447 E. 8TH STREET
MOSCOW, IDAHO 83843

This letter started out as a simple thank you, but I started to make the comparisons and ran into problems. Could your staff take a look at the UI application, particularly the proposed diversion points, and identify which are already existing wells? My listing shows five existing approved diversion points; however, can only identify one on the new proposed list. If new wells please so note.

The application is not clear as to individual well diversion rate or diversion volume, simply a distribution between three functional uses. Is this information available?

I do plan to object to the magnitude of the proposed appropriation; however, the application data seems to be somewhat suspect as well and deserving of further scrutiny.

Please try to get back with the information requested as time is relatively short.

Regards,
Tom Townsend

MICROFILMED
MAR 1 9 1990

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
Northern Region Office

1910 Northwest Blvd. * Suite 210 * Coeur d'Alene, Id. * 83814 * (208) 765-4639

Cecil D. Andrus
Governor

R. Keith Higginson
Director

October 2, 1989

University of Idaho
% Mr Larry Kirkland
Physical Plant
Moscow, Id. 83843

Re: Water Appropriation Application # 94-07324

Dear Applicant:

This department acknowledges receipt of your Application For Permit To Appropriate The Public Waters Of The State Of Idaho and your filing fee in the amount of $65.00 for which your Receipt #C011681 is enclosed.

Your appropriation application has been assigned the above referenced number, to assist us in providing you with prompt, accurate service, please refer to this number in all future correspondence.

Your application is currently being prepared for advertising in the county newspaper. This advertisement will be published for two consecutive weeks followed by a waiting period of ten days to allow for the submittal of protests.

If the application is protested during this waiting period, you will be sent a copy of the protest and instructions to aid you in resolving the protest without a hearing. However all protests must be resolved before approval of the application can be made, so if the protestant does not voluntarily withdraw the protest, this department will conduct a conference and/or hearing on the matter.

If the application is not protested it will be forwarded to Boise, where departmental staff will conduct a more in depth review of the application, to determine if there is a need for further information that will facilitate the Directors decision on the application. You will be notified by mail of this decision.

Unless you are using a well that was constructed prior to July 1, 1987, it will be necessary for you to apply for a well drilling permit upon approval of the appropriation application. Well drilling permits can be issued by this office only to holders of approved appropriation permits.

If you have any questions or if I can be of any assistance please feel free to contact me at this office.

Sincerely,

Tom D. King
Sr. Water Resource Agent

Enc: Receipt

MICROFILMED
MAR 1 9 1990

Form 202
6/85

RECEIVED
SEP 18 1989
Department of Water Resources

Ident. No. 87-07141

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
APPLICATION FOR PERMIT

To appropriate the public waters of the State of Idaho

1. Name of applicant UNIVERSITY OF IDAHO c/o LARRY KIRKLAND Phone 208-885-6222

   Post office address PHYSICAL PLANT, MOSCOW, IDAHO 83843

2. Source of water supply GROUNDWATER which is a tributary of _____

3. Location of point of diversion is SW ¼ of SE ¼ of _____ ¼, Govt. Lot _____

   Sec. 12 Township 39N Range 6W B.M. LATAH County; additional points of diversion if any: SESW SESE OF SECTION 12, T. 39 N., R. 6 W.; SWSE AND SESW OF SECTION 7, and ~~NWNE OF SECTION 18~~, T. 39 N., R. 5 W., ALL IN LATAH COUNTY, IDAHO. - per telcon. with Larry Kirkland--pms 9/28/89

4. Water will be used for the following purposes:

   Amount 1.5 (cfs or acre-feet per annum) for DOMESTIC purposes from Jan 1 to Dec 31 (both dates inclusive)

   Amount 1.5 (cfs or acre-feet per annum) for RESEARCH purposes from JAN 1 to Dec 31 (both dates inclusive)

   Amount 1.5 (cfs or acre-feet per annum) for IRRIGATION purposes from March 15 to Nov 15 (both dates inclusive)

   Amount _____ (cfs or acre-feet per annum) for _____ purposes from _____ to _____ (both dates inclusive)

5. Total quantity to be appropriated is (a) 1.5 cubic feet per second and/or (b) 1085 acre feet per annum

6. Proposed diverting works:

   a. Description of ditches, flumes, pumps, headgates, etc. DRILL WELL IN SHALLOW AQUIFER. INSTALL PUMP, MOTOR, PANEL AND PIPELINES TO CONNECT TO EXISTING UNIVERSITY SYSTEM SO TO FACILITATE WATER USES FOR ABOVE LISTED PURPOSES.

   b. Height of storage dam _____ feet; active reservoir capacity _____ acre-feet; total reservoir capacity _____ acre-feet; period of year when water will be diverted to storage: _____ to _____ inclusive.

   c. Proposed well diameter is 16 inches; proposed depth of well is 300 feet.

   d. Is ground water with a temperature of greater than 90°F being sought? NO

7. Time required for the completion of the works and application of the water to the proposed beneficial use is 5 years (*minimum 1 year*).

MICROFILMED
MAR 1 5 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

September 28, 1989

City of Moscow
City Hall
Moscow, Id. 83843

Gentlemen:

Enclosed is a Notice of Application for Appropriation of the Public Waters of the State of Idaho.

We felt it might be of interest to you.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms

Enclosure

MICROFILMED
MAR 19 1990

Celebrate IDAHO
1890 • CENTENNIAL • 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

September 28, 1989

Mr. Tom Townsend
447 E. 8th St.
Moscow, Id. 83843

Dear Mr. Townsend:

Enclosed is a Notice of Application for Appropriation of the Public Waters of the State of Idaho.

We felt it might be of interest to you.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms

Enclosure

MICROFILMED
MAR 19 1990

Celebrate IDAHO
1890-CENTENNIAL-1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

September 28, 1989

City of Pullman
City Hall
Pullman, Wa. 99163

Gentlemen:

Enclosed is a Notice of Application for Appropriation of the Public Waters of the State of Idaho.

We felt it might be of interest to you.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms

Enclosure

MICROFILMED
MAR 19 1990

Celebrate IDAHO
1890 · CENTENNIAL · 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

September 28, 1989

Mr. Ted Olson
Washington Dept. of Ecology
N. 4601 Monroe, #100
Spokane, Wa. 99205-1295

Dear Mr. Olson:

Enclosed is a Notice of Application for Appropriation of the Public Waters of the State of Idaho.

We felt it might be of interest to you.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms

Enclosure

MICROFILMED
MAR 1 9 1990

Celebrate IDAHO
1890 · CENTENNIAL · 1990

State of Idaho
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION, Suite 210 • 1910 Northwest Blvd. • Coeur d'Alene, Idaho 83814 • (208) 765-4639

CECIL D. ANDRUS
Governor

R. KEITH HIGGINSON
Director

September 28, 1989

Mr. Ken Abbey, Chairman
Pullman-Moscow Resources Committee
Washington State University
French Administration Building
Pullman, Wa. 99164-1045

Gentlemen:

Enclosed is a Notice of Application for Appropriation of the Public Waters of the State of Idaho.

We felt it might be of interest to you.

Sincerely,

ROBERT G. HAYNES, P.E.
Regional Manager

RGH/pms

Enclosure

Celebrate IDAHO 1890 · CENTENNIAL · 1990

MICROFILMED
MAR 19 1990

NOTICE OF APPLICATION FOR WATER RIGHT

The Following application(s) have been filed to appropriate the public waters of the State of Idaho:

87-07141

UNIVERSITY OF IDAHO
C/O LARRY KIRKLAND
PHYSICAL PLANT
MOSCOW, ID 83843

Source: GROUNDWATER (SHALLOW AQUIFER)

Diversion Pt:	SESW	Sec 7 T 39N R 05W	
	SESW	Sec 12 T 39N R 06W	
	SWSE	Sec 12 T 39N R 06W	
	SESE	Sec 12 T 39N R 06W	
	SWSE	Sec 7 T 39N R 05W	
Use: IRRIGATION		(1.500 CFS)	
RESEARCH		(1.500 CFS)	
DOMESTIC		(1.500 CFS)	

Date Filed: 9/18/1989

In: T39N R05W S07	SWSW	SESW		
S18	NWNE	SWNE	NENW	NWNW
	SWNW	SENW	NESW	NWSW
	SWSW	SESW		
R06W S12	SESW	SWSE	SESE	
S13	NENE	SENE	NESE	SESE

566.0 ACRES TOTAL

For additional information concerning the property location, call the Northern Regional Office at 765-4639.

The permit(s) will be subject to all prior water rights. Protests must be filed with the Director, Dept. of Water Resources, Northern Region, 1910 Northwest Blvd., Suite 210, Coeur d' Alene, Idaho 83814 on or before OCTOBER 23, 1989.

MICROFILMED
MAR 19 1990

R. KEITH HIGGINSON, Director

Published 10/05/1989 & 10/12/1989

University of Idaho
Budget and Planning
Moscow, Idaho
83843 U.S.A.

Budget Office, 208-885-7044
Business Management/Real Estate, 208-885-7044
Facility Planning, 208-885-6671

RECEIVED
SEP 18 1989

September 14, 1989

Department of Water Resources
RECEIVED
SEP 25 1989
NORTHERN REGION
IDWR

State of Idaho
Department of Water Resources
1301 North Orchard
Statehouse Mail
Boise, Idaho 83720

Gentlemen:

Enclosed for your consideration and processing are the University of Idaho's application and $65.00 filing fee for a permit to appropriate state of Idaho public waters.

The university would like to drill a well to the shallow aquifer, and install a pump and pipelines to connect with existing university water systems to facilitate water use for domestic, research, and irrigation purposes.

Your early processing would be greatly appreciated. Thank you for your consideration of this water rights permit application.

Sincerely,

Don A. Amos
Business Manager

ks
cc: Ken Hall, Director, Physical Plant
enclosures

MICROFILMED
MAR 19 1990

The University of Idaho is an equal opportunity/affirmative action employer and educational institution.

NELSON, ROSHOLT, ROBERTSON, TOLMAN & TUCKER
Chartered
ATTORNEYS AT LAW

THOMAS G. NELSON
JOHN A. ROSHOLT
J. EVAN ROBERTSON
STEVEN K. TOLMAN
JAMES C. TUCKER
TERRY T. UHLING
TERRY R. McDANIEL
F. BRUCE COVINGTON
JERRY JENSEN
GARY D. SLETTE
CAROLYN M. MINDER
BRUCE M. SMITH
G. RICHARD BEVAN
BRAD M. PURDY
GARY L. QUIGLEY
TIM J. WILLIAMS

142 3rd AVENUE NORTH
P.O. BOX 1906
TWIN FALLS, IDAHO 83303-1906
TELEPHONE (208) 734-0700
FAX (208) 736-0041

Boise Office
1020 MAIN ST., SUITE 400
P.O. BOX 2139
BOISE, IDAHO 83701-2139
TELEPHONE (208) 336-0700
FAX (208) 344-6034

September 19, 1989

RECEIVED
SEP 20 1989
Department of Water Resources

Norman Young
Idaho Department of Water Resources
1301 N. Orchard
Statehouse Mail
Boise ID 83720

RE: University of Idaho -- Application for Water from Shallow Aquifer

Dear Norm:

I have been advised by the University of Idaho that they have sent the Application for Permit directly to the Boise office for processing. As of this date, I have not yet received a copy of the Application as executed and filed.

As I understand, it is identical in form to the one we informally discussed.

The purpose of this letter is to request expedited handling of this matter by the Department to the extent that is possible.

Thanks in advance for your help.

Respectfully submitted,

John A. Rosholt

JOHN A. ROSHOLT

JAR:dcb
33391

MICROFILMED
MAR 19 1990

Name: University of Idaho
File: 87-07141
Place: Appalousa Rm, Student Union Bldg., University of Idaho
Date: Thursday, November 30, 1989, 9:30 AM.

ROSTER OF ATTENDANCE

Name	Address	Representing
Tom Townsend	447 E. 8th ST, Moscow	Protestant
Tonia M. Roshold	P.O. 1906 Twin Falls, Id	Applicant-UI
ERNEST L. BRANDOW	U of I Moscow	U of I
William E. Lum III U.S. Geological Survey	1201 Pacific Ave suite 600 Tacoma WA 98401	U.S. Geological Survey
LARRY KIRKLAND U of Idaho Physical Plant	Physical Plant	U of Idaho
Ken Hungerford	Moscow, Ida	Idaho Water Res Board
THOMAS R. SAWYER	PHYSICAL PLANT	UNIV. OF IDAHO
Andrew Rose	PO BX 12, VIOLA 83872	self
Garrett Brown	P.O. Box 3294 Moscow, Id. 83843	self.
Robert C. Haynes	103 N. Blaine, Moscow, ID 83843	Self.
Hal P. Demuth	323 S. Roosevelt Moscow, ID	self
JAMES BECKER	813 INDIAN HILLS MOSCOW	EDC.
DALE RALSTON	GEOLOGY & GEOLOGICAL ENGINEERING	U OF I
ERNEST D. ABLES	Fish & Wildlife Dept, U. of I.	UI
Theodore C. Bjornn	" " "	"
Larry Brancn	U of I Moscow	U of I
Al Linss	College of Ag., Moscow	U of I

MICROFILMED
MAR 1 9 1990

Application No. 87-7141

SPECIAL NOTE: _____

_____

PROTEST INFORMATION SHEET

Protestant(s)

	NAME	ADDRESS	
1	Mr. Thomas A. Townsend	447 E. 8th St., Moscow, Id.83843	10/17/89
2			
3			
4			
5			
6			
7			
8			
9			
10			

ATTORNEY NAME ADDRESS

Date Filed: 10/17/89 Protest Due Date: 10/23/89

Issues: Protestant feels U of I is allotting more water than it can use.

Applicant

ATTORNEY NAME ADDRESS

Mr. Frank Hitchcock, Nelson-Rosholt P.O. Box 1906, Twin Falls, Id. 83303-1706

	DATE
Protest Date Entered on Computer	10/24/89
Acknowledgement Letters Sent	10/25/89
Hearing Date	
	(Other Dates)

Other Information: _____

MICROFILMED
MAR 1 9 1990

Protest information submitted to computer (following hearing): _____

STATEMENT OF THOMAS A. TOWNSEND IN PROTEST
OF APPLICATION FOR PERMIT TO APPROPRIATE THE PUBLIC
WATERS OF THE STATE OF IDAHO, NUMBER 87-07141, BY
THE UNIVERSITY OF IDAHO

GIVEN BEFORE AN IDAHO DEPARTMENT OF WATER RESOURCES
HEARING CONDUCTED NOVEMBER 30, 1989, AT MOSCOW, IDAHO

Thomas A. Townsend
447 East Eighth Street
Moscow, Idaho 83843

MICROFILMED
MAR 1 3 1990

Protestants Exhibit
Admitted #1

OPENING STATEMENT

It is important to understand that the contested application for water rights by the University of Idaho is not taking place within a vacuum. The proposed Aquaculture Program is not a singular event that has no connections to other water users within the Pullman-Moscow aquifer basin. These users range from private individuals in both the states of Washington and Idaho to the cities of Moscow and Pullman and the Washington State University.

All water right applications have potential detrimental impacts on the existing rights of other users. It is a system of competition for a natural resource. If supply exceeds demand it is not difficult to make an equitable allocation for beneficial use. If supply does not exceed demand the equitable allocation becomes a real problem.

The issue of water availability in the region has been a concern, albeit low-key, for nearly seventy years. During the 1920's the President of the University of Idaho expressed concern and inquired about possible use of surface sources in lieu of shallow ground water sources.

Between 1920 and 1987, where I wish to focus your attention, there were plenty of meetings held and studies conducted, but no significant changes on the continued increasing demands on the resource base.

In 1987 this attitude began to shift. Washington State University made application in April of that year for water rights of 2,500 GPM in connection with a new deep well to be located on campus. This request, if allocated by the Washington State Department of Ecology, would have been equivalent to 52% of all water pumpage by the other three major municipal and institutional users on the aquifer.

MICROFILMED
MAR 1 5 1990

Concerns about this new intrusion were made to the Idaho Department of Water Resources by this protestant. The location of the new well in Washington

seemed to imply to IDWR that it was not their problem; however, I tried to make the point that increased pumpage from that new well, especially at capacity volume, could be most detrimental to an aquifer already in decline and a state of non-equilibrium. Were Idaho users to be sacrificed to the demands of a cross line user without comment?

At the time I was President of the Clearwater Resource Conservation and Development Area Council, a five county organization with representatives from about twenty-five political jurisdictions. That group considered the problem and decided to formally oppose the application proposal. A formal protest was filed with the Department of Ecology on 14 May 1987. The IDWR after wavering for a month also submitted a formal protest the next day, a move that began to signal a new philosophy of aquifer oversight.

In addition to the formal protest then Director Kenneth Dunn proposed to DOE Director Rimker that the two departments "meet to see if we can develop an action program to address this problem. A memorandum of understanding between the two agencies could be developed. . . ."

New winds were beginning to blow. In August, 1987, the two state agencies and the local using entities met in Moscow to develop a strategy. The moribund Pullman-Moscow Water Resources Committee (P-MWRC), on which I had previously served from 1982 through 1985, was resurrected to take a role in aquifer planning. It was then expanded to include the county governments of Latah and Whitman Counties.

The P-MWRC did not get off to a fast start. By August, 1988, a year later, it had formally worked out the legalities of formation and was involved in the development of a Resolution of Understanding and a long-range management plan. After numerous discussions and draft versions the Resolution of Understanding between the six parties was finally agreed to on 30 May 1989.

UNDERLINED
MAR 1 9 1990

The ROU confirmed the will of the signatory entities to move forward in management and protection efforts for the aquifer. One section said it would "serve to avert the overuse of quality ground water resources within the basin."

As the ROU went through its formative stages a subcommittee of the P-MWRC was developing a draft Master Plan for Resource Management. In early April, 1989, the subcommittee draft plan commented, "All plans for expansion of existing systems for UI, WSU, Moscow, and Pullman cities will be ~~renewed~~ reviewed by the P-MWRC and public hearings conducted by the requesting agency."

What was the University of Idaho doing all this time? They obviously had representation on the P-MWRC so they were involved in the ROU development and the draft Master Plan for Resource Management.

From my perspective not what one would expect given the thrust of events and comforting phrases of the ROU and P-MWRC announcements.

Sometime in 1988, or possibly even earlier, the University of Idaho began planning for its Aquaculture Program. Perhaps not the whole University but definitely the Idaho Cooperative Fish and Wildlife Research Unit; the College of Forestry, Wildlife and Range Sciences; and senior administrative personnel to include Vice Presidents Bell and Geiger.

The initial key element of the larger program was a Bonneville Power Administration (BPA) funded research grant solicitation entitled "Approved Registration of Erythromycin for Treatment of Bacterial Kidney Disease (BKD) in Juvenile and Adult Chinook Salmon." This solicitation for bids was published by BPA in late 1988 with proposals due 12 January 1989. The University, the lone applicant, submitted its proposal on 10 January 1989.

During the ensuing evaluation of the UI proposal BPA requested additional information regarding the UI's plan. The University made it clear in February,

MICROFILMED
MAR 1 9 1990

1989, correspondence that they planned to do major portions of the work in a proposed aquaculture facility to be constructed on-campus in three phases over a period of years. These phases were installation of (1) holding facility, (2) administrative facility, and (3) rearing facility. The University in the correspondence assured BPA that 242 AF (150 GPM) of water was available to the holding facility and that 2,420 AF (1,500 GPM) was available for the rearing units.

The essence of this historical narrative is not that BPA funded the grant application for a five-year span worth about $750,000 to the University. The point is that all of this planning for an Aquaculture Program with massive demands for new water was being simultaneously developed while the P-MWRC and the two state water agencies were seeking solutions to avert the overuse of a possibly marginal resource in the basin. I find that disturbing and indicative of a lack of awareness or concern on the part of the University.

The demand for new water, as reflected by the Application for Permit, is itself a non-imperative requirement. The University in correspondence with BPA (14 February 1989) noted that should the holding area portion of the program not come on line by 1990 that it had other location options identified: Lyons Ferry Hatchery in Washington and Hayden Creek Research Station near Lemhi which was already under lease to the UI Cooperative Fish and Wildlife Research Unit. Some of the initial work would be accomplished in the existing FWR fish laboratory which already uses 21% of the total water utilized on-campus by the University.

Not only was the new demand for water being developed simultaneously with regional planning efforts to manage existing resources more effectively, it was being done in a closed, almost covert, fashion.

MICROFILMED
MAR 19 1990

It was not until 8 June 1989, barely a week after the ROU had been signed by all parties, that the University revealed its plans to a stunned P-MWRC. Estimates of water consumption ranged from 242 AF (150 GPM) for the initial phases to 1,129 AF-1,290 AF (700-800 GPM). By July these maximum estimates were reduced to 968 AF (600 GPM).

Since July there have been all kinds of planning variations on several themes: deep water, shallow water, mixed waters, maximum use of fish tank effluent, maximum irrigation (2-2.5X), recharge by injection wells, recharge through maximum irrigation practices, more use of Moscow Sewage Treatment Plant effluent, use of treated effluent from Aquaculture Program for re-cycling into holding tanks, maximum use of treated sewage plant effluent as a basic source in lieu of either shallow/deep pumpage, and others I am sure.

The final upshot is the University request for 1,085 acre-feet of new shallow aquifer resource, a proposal with which I cannot agree and the subject of this hearing.

As I began this statement I noted this contested application is not a singular event standing alone. Apart from the merit or lack of merit of the application, I find the route at which the University arrives at this hearing today to be one of carelessness at best and deceit and hypocrisy at worst.

At a time when ground water management and aquifer protection issues were out in the open heading for solutions the University chose to do it their way: no consultation, no listening to other than captive "yes" voices. The University has not consulted with the P-MWRC, it tells them on occasion what the University has already done and what it intends to do--after the decision has been made.

Lastly I would note that despite the planning efforts of the P-MWRC there will be no policy guidelines in place before the middle of 1991 and that is optimistic at best.

MICROFILMED
MAR 1 9 1990

There is nothing in place today to protect the local aquifer and the citizens that depend upon it from additional demands except for the existing regulations for water right applications. This system has merit when new wells must be developed. It does nothing if an existing water right holder chooses to maximize consumption for whatever reason. All of the major users of the basin hold water right allocations greatly in excess of demonstrated needs. We, locally, are in an arms race scenario, everyone has more weapons/ rights than are needed.

How can we develop a consensual plan when every player has the legal ability to bankrupt the system by unilateral action? In the past two years two educational institutions, two of our neighbors, have come like vandals to claim a major portion of a community shared resource.

In these past eleven minutes or so I have tried to explain why this hearing is necessary and why I am here to outline my objections to the University's request. As you note I am here alone, that is by choice. I am not alone in my opposition to the program and its water demands.

I am prepared now to move on to justification of my position relative to the five principal items that the Department can consider in either approving or denying the application for permit.

Thank you Director Higginson for my opportunity to testify today and for your presence here in Moscow as the Hearing Officer in this instance.

DISAPPROVED

MAR 19 1990

STATEMENT AS TO ISSUES: Re: Application for Permit 87-07141, University of Idaho, before an IDWR Hearing conducted November 30, 1989, at Moscow, Idaho

ITEM 1. Will the proposed use reduce the quality of water under existing water rights?

Yes. I believe the University, if allowed the use of this water, will substantially reduce the quantity of water available to existing and senior water right holders, both public and private. Substantial reductions in consumption of this shallow aquifer resource over the past years, particularly by the City of Moscow, have enabled the resource to return to a reasonably stable situation. To now reverse course and return to large withdrawals and jeopardize what has already been gained is not a prudent action in my view.

The University in its September Application for Permit No. 87-07141 has requested permission to appropriate 1.5 cubic feet per second or 1,085 acre-feet per annum of public waters of the State of Idaho from the shallow or upper level aquifer(s) underlying the City of Moscow

The intended utilization of this resource is listed as being a combination of domestic, research, and irrigation purposes. It is reasonably obvious that the major portion of this resource will be utilized under the "research" category for the operation of the proposed fish research facilities within the new Aquaculture Program. A secondary re-use for irrigation purposes from the holding facility effluent or for re-use as make-up water, after treatment, in the holding facility is probable as well. Given the quality of the shallow aquifer water under Moscow, it is unlikely that it would be utilized for so-called domestic purposes. The City of Moscow pumps very modest amounts from that source and continues to get complaints about the taste/smell of dissolved solids.

MICROFILMED

MAR 19 1990

The shallow aquifer from which the University proposes to withdraw its 1,085 AF has been utilized privately since early settlement in the late 1800's and by the City of Moscow since 1900 for municipal and industrial purposes. Records do exist on some aspects of early usage; however, they are incomplete and many informational gaps occur.

Information I have found suggests that upper level/shallow aquifer water levels were about sixty feet (60') below ground surface when the initial wells were drilled. This is somewhat confirmed by existing City of Moscow wells when there is no pumpage for an extended period of time and there is an opportunity for the recharge process to be demonstrated.

Recharge does seem to take place on this particular aquifer; however, the volume of this recharge does not always keep ahead of the demand and this leads to a deficit situation.

This deficit situation has been termed by some as mining and is not in keeping with the intent of Policy 1G of the Idaho State Water Plan.

The aquifer which the University proposes to utilize is a fragile one at best and its current reasonable good health is due in large part to the fact that it has been pampered by non-usage or restricted usage over a long period of time.

The City of Moscow has three working wells in this strata which they identify as "drilled public-supply artesian wells in the upper basalts and upper inter-beds of the upper artesian zone." These wells, #2, #3, and "Cemetery," provide some history since 1925 when well #2 was drilled. In 1938 the depth to water below top of well #2 was 62.9 feet, basically the year 1900 level. By 1952 it was down 82 feet below ground surface after 300.5 MGY drawdown that year. By 1963 the water levels in well #2 averaged 116.4

MICROFILMED
MAR 19 1990

feet below the top of the well. Since that time the water levels have gradually risen back to the elevations common before heavy usage was prevalent.

Large pumped volumes were common from well #2 from the early 1950's until about 1966 when they were substantially reduced from the volumes of the earlier period. Volumes in the heavy use period ranged from 300.5 MGY to a low of 28.2 MGY. Since 1966 the highest use occurred in 1980 with an annual use of 170.4 MGY down to a total non-use in 1972. With the low point reached in 1963 at well #2 it might be noted that top of the enclosed pump was only fifty feet further down and elevation drops of three feet per year were not uncommon. It was a time for concern yet heavy pumping continued for another two years. At the same time the data suggests the water table began to rise and has continued that same trend.

That suggests a correlation between pumpage and the elevation of the water table, a glitch here and there that I cannot fathom, but generally that elevations rise as pumpage decreases.

Well #3 seems to march to a different drummer at times. Its low point arrived in 1964 when it sank 138.7 feet below the top of the well. At that time the water table was about seven feet below the top of the pump encased in well #3. Heavy pumpage had occurred in well #3 since 1947 and became considerably more moderate commencing in 1959 (398 MGY → 69 MGY). Between 1959 and 1960 the water table dropped about twenty-one (21) feet even though the consumption was reduced by almost 39% in that year. Consumption remained light to moderate and the water table elevations rose even more quickly than well #2. In 1977, a year of low consumption, the elevation returned to about sixty feet below the well head, to the basic 1900 year level. Since that time it has declined in general and now is seemingly stable, but considerably lower than its highest levels and below the levels of well #2.

RECEIVED
MAR 19 1990

The drawdown has been very light since 1977 and well #3 has not been used in years 1986, 1987, and 1988. It seems to have reached a stable plateau; however, with no use one could expect it to rise to its best elevation.

Data on the "cemetery" well is incomplete to the point of uselessness. The point of this background is that the upper aquifer has a history of exploitation over a long period of time, that discharge exceeded recharge, and the only reason the downward spiral has been reversed has been the reduction in consumption by the major user, the City of Moscow. The use by the City since 1981 has been minuscule to moderate. The maximum consumption, through all three wells noted, has been 143.8 MGY in 1981 down to 8 MGY in 1987.

Now comes the University requesting authority to withdraw 353.5 million gallons from the same source on the presumption of non-impact. In the 1963/1964 period when the ebb point was reached, the average consumption was ~~287~~ 143.8 MGY, a ~~28%~~ 54% lesser usage than being requested by the University today.

The City of Moscow uses this water to replace more valuable deep aquifer consumption and generally pumps the majority of this water during the irrigation season. If this usage must be curtailed/reduced to protect the water levels in the City wells as a result of a junior holder's requirement I would contend the junior applicant is impinging on senior existing rights. The same philosophy would apply to private water right holders as well.

It could be argued, "Let's try it and find out what happens." That assumes the status quo is operative, i.e., the City does not increase its usage which is very small now, but has the right to be expanded considerably at any future time.

MICROFILMED
MAR 19 1990

As far as I am concerned the testing has already been accomplished and the bottom line is that consumption has to be reduced and held stable if the

water table is not to have a severe fall-off. We are in a state of equilibrium now: demand equals supply. Another new user changes the demand equation by diminishing the rights of existing users, assuming equilibrium is desired. Which I believe it is!

ITEM 2. Is the proposed water supply insufficient for the purpose intended:

Yes and basically for the reasons I have already stated. The upper aquifer is not a source of indefinite magnitude. It can be depleted under heavy consumption as history has already shown. The new University requirement of 1,085 acre-feet per year is a heavy demand, even heavier than former consumption demands of the City of Moscow.

The low point in 1964 on well #3 when the water table was below the top of the submerged pump is indicative to me that the exploitation phase was pushing its outer limits. Was that as low as the water table could drop? I do not have that answer, but if heavy pumping had continued much longer the water levels would have dropped below the intake screens and the answer would be moot.

Today the system is in a state of equilibrium: demand has been reduced where it now equals supply. Another new user, especially a large user, will upset this equilibrium equation by placing new demands.

The supply side is not likely to increase greatly, especially to the magnitude required to maintain the balance. The University says it will mitigate this supply problem by expanding its effluent irrigation system on-campus from 200+ acres to 566 acres under irrigation. This effluent will percolate through soil and strata and recharge the shallow aquifer, so says the applicant.

Replacement of 1,085 acre-feet requires a substantial infrastructure to support such distribution, a system which I think is a long way off--more on that later.

RECEIVED
MAR 19 1990

Recharge seems a natural part of the system, but is not a massive recharge. Elevations in well #2 have been relatively constant since 1981. The consumption/pumpage from that well from 1981-1988 was 338 million gallons for the period. I view that consumption as having an equivalent recharge volume since the system remained stable.

That recharge volume on an annual basis is only 12% of what the applicant desires to appropriate annually.

A new demand of 1,085 acre-feet per year (353.5 MGY) on the proposed source that has limited recharge can only cause the resource, now stabilized, to go one way: downward.

That strikes me as a case of withdrawals exceeding recharge which is contrary to the already established policy (Policy 1G) of the Idaho State Water Plan.

This shallow aquifer has been heavily exploited since settlers arrived in the area. It has been the subject of sporadic concern, but little action.

It is now relatively stable since we have reached the point of wisdom that mankind cannot push mother nature too far. Push too hard and the water levels drop below the intake screens.

The University request is not of an imperative nature since the Aquaculture Program can be conducted in other optional sites.

From my perspective the requirement for 353.5 MGY from the proposed source will have a deleterious effect on existing water right holders and that the source aquifer is insufficient to carry the new proposed burden.

MICROFILMED
MAR 19 1990

ITEM 3. Is the application made in good faith or for delay or for speculation?

From my perspective the application of September 18, 1989, by the University of Idaho was not made in good faith. The University was a signatory to the Resolution of Understanding between the Pullman-Moscow Water Resources Committee, the Idaho Department of Water Resources, and the Washington Department of Ecology. This understanding, signed by Dr. Joseph Geiger on May 25, 1989, for the University, affirmed that the group and its individual members would work together so as to "avert the overuse of the ground water resources in the basin."

On June 8, 1989, University representatives revealed the planning efforts for the proposed Aquaculture Program which by that time had been underway since the end of 1988. That was the same period the P-MWRC was creating the draft Resolution of Understanding which certainly did not point to expanding use of water resources.

On July 13, 1989, I wrote Dean John Hendee, College of Forestry, Wildlife and Range Sciences, outlining my concerns about the project and noted very clearly the variance between the goals of the recently signed Resolution of Understanding and the University plans for the increased use of local water resources within the Aquaculture Program. This letter was also sent to then President Dr. Gibb, the incoming Dr. Zinser, assorted deans, and Mr. Wayne Haas, IDRW.

Two weeks later, on 27 July 1989, the University was notified by Director Higginson, Idaho Department of Water Resources, that the University did not have existing water rights authorizing such proposed aquaculture use. That fact was already known to me by the end of June, following a review of existing University of Idaho water rights and I mentioned the same to Mr. Haas and Mr. Ken Hungerford, Idaho Water Resource Board member, in a letter of 7 July 1989.

By the time the University filed its application it was quite clear that the University was off on a course of action that was demonstrably consumptive in nature rather than one of conservation orientation. All of the plans developed by the University to allay concerns about the new proposed usage are mitigating in nature only. They have requested 1,085 acre-feet per year and have attempted to make that usage less unpalatable through a myriad of mitigation efforts that may or may not be effective and may or may not ever be put into place.

None of the mitigation efforts put forth to date would be necessary if the underlying facilities of the Aquaculture Program, holding and rearing tanks, etc. were located elsewhere, a situation discussed earlier.

Is the application of a speculative nature? My definition of speculation is "an engagement in business transactions involving considerable risk but offering the chance of large gains."

Using that definition as a baseline I would assert the application for new water rights from the shallow aquifer is of a speculative nature.

The existence of the planned facilities is the driving force behind the need for additional water rights from the shallow aquifer. The University already has ample water rights in the deep aquifer for this work; however, I assume they are aware that utilization would bring considerable condemnation if it were attempted.

The Aquaculture Program with its planned phases and facilities are all leveraged toward some expansionist goal which the University characterizes as an "area of excellence." The scientific cooperative research project funded by the Bonneville Power Administration provides the initial start-up monies for the first year work projects: salaries, travel costs, overhead,

RECEIVED
MAR 1 9 1980

and operating costs. A minor amount is provided for actual facilities which initially are the research laboratory and its fourteen fish holding tanks.

As research work goals are met the project rolls forward. The next facility phase is justified and funded and comes on-line until at some point in the future the second wet laboratory identified in early University of Idaho documents as "wet lab-phase 2 with reservoir and rearing ponds" comes into being or is so planned.

The total water requirements for this fully implemented, phased three part system were developed by the University and amounted to 240 MGY according to their handout of July 6, 1989.

By November, 1989, and following the arrival of a new University President, the project was scaled back to only the initial fourteen fish holding tanks and a 5,400 square foot research laboratory (University Aquaculture/Fisheries Research Laboratory). This change was reported in the Executive Summary University of Idaho Aquaculture Research and Development Initiative with three exhibits.

The water requirement for this initial facility was estimated at 40 MGY of high-quality make-up water within a recycling system.

The University Administration has made it very clear publicly that the institution is supporting only this first phased facility of the older three-part phased Aquaculture Program on campus. President Zinser, during an October 17 news conference, is quoted as saying, "That's all we're authorizing right now, and we're making absolutely no commitment to develop other phases at this time."

The problem is that the September application for water by the University exceeds the requirement of the now limited single facility as defined October and November.

FILMED
MAR 19 1990

It is my belief that the additional water allocations in the now pending request are to support the now "on-hold" reservoir/rearing ponds facility.

This understanding has been confirmed by a knowledgeable University source after the University of Idaho application became public. At the time I was wondering if the proposed allocation covered all near-future planned projects or would new demands arise again.

If these assumptions are correct, then I believe the University is indeed attempting to obtain additional water resources at this time over their defined current needs. This additional allocation to support a planned, but currently dormant, three-part system is speculation in my view.

ITEM 4. Has the applicant sufficient financial resources with which to complete the project?

The answer to this depends in part on how the project is defined, its magnitude, and the time allowed. The construction of only the University Aquaculture/Fisheries Research Laboratory, the 5,400 square foot research laboratory with fourteen holding tanks, is funded.

The supporting infrastructure financial support is not as financially viable. The mitigating conditions proposed by the University such as increased use of treated effluent for irrigation, development of irrigation recharge strategies, and expansion of existing effluent irrigation systems on-campus or new ones are not only expensive but take time to develop or install.

Beneficial use of the shallow aquifer resource does not accrue simply by distribution from the well head to the holding tanks. Beneficial use, assuming no other injurious effects are present, takes place when the resource is utilized to the maximum degree possible. This would be multiple passes through the holding tanks followed by irrigation use and finally by recharge of the supplying aquifer.

RECEIVED
MAR 19 1990

The University currently irrigates about 200 acres with effluent derived from the treated product of the Moscow Sewage Treatment Plant. The University effluent system was installed in 1977/1978 at a cost of about $393,000. The University in its application specifies the area to be irrigated using the newly authorized resource to be 566 acres, a substantial expansion.

In addition to expanding the system the University needs to improve the existing lagoons adjacent to the Sewer Treatment Plant so as to control bacterial growth and provide a better sludge disposal system. The University has been directed by the Idaho Department of Health and Welfare to install a permanent system for disposal of pond sludge by July 2, 1994, and a temporary system by May 1, 1990. In 1988 the estimated cost of this work was between $100,000 and $200,000. The University in public budget documents and project assumption materials does not seem to have the money programmed in either 1990 or 1991 to do all the things required.

I do not know the details of the engineering to accomplish these tasks nor do I know if the budget submissions of the University will be approved and granted by the Legislature. There is a commitment on the part of the University to work on irrigation system upgrade following "the operational start-up of the laboratory."

The University in a public document stated, "Ancillary projects, including the expansion of the irrigation system, will add to the project cost and be paid out of grant and University facility funds." I would doubt that the grant source (BPA) would provide funding for a permanently emplaced capital improvement of that nature.

The total cost of the so-called supporting or ancillary projects is substantial. If it took $393,000 to fund the first 200 acres at [illegible] costs, it will be a substantially larger sum to expand the system to 566 acres

DISTRIBUTED MICROFILMED
MAR 19 1990

for irrigation. Add in the lagoon costs, etc., and the true costs of project completion are developed.

The facility structure may be funded, but the supporting infrastructure that supports the mitigating conditions is not.

I do not think the project passes the financial resources test.

ITEM 5. Will the proposed use conflict with the local public interest?

Community understanding and awareness of water-related issues is growing in this basin and that movement I try to encourage and support.

In a local survey done several years ago, 25% of the respondents questioned did not know the source of their public water supply. That awareness level is not encouraging, but it is improving with education and time.

The proposed use of the shallow aquifer resource is obviously supported by its proponents in the College of Forestry, Wildlife and Range Sciences, the Idaho Cooperative Fish and Wildlife Research Unit, and key senior administrative officials of the University. It no doubt enjoys the support of some academics at Washington State University involved in the current research project for which they receive $105,000 during this first year. The University of Idaho contingent receiving $189,000 in the same period.

The University Administration places the value of the underlying BPA grant at $1.22 million over a five-year period. That certainly colors how they view their proposed use as contrasted to local public interest where no financial incentives exist.

The project does not enjoy demonstrable positive support from any elected governmental body in the area. The principal researcher, Dr. Moffitt, and colleagues have briefed the City Councils of Moscow and Pullman as well as the joint Pullman-Moscow Water Resources Committee. Neither council made a

MICROFILMED
MAR 19 1990

public statement either endorsing or rejecting the project. The Pullman-Moscow Water Resources Committee in a letter to Dr. Ernest Brannon, Director of the Aquaculture Program, said it takes no official position on the matter.

University President Zinser at a news conference held on 17 October 1989 is reported to have said, "UI Financial Vice President Joseph Geiger has spent considerable time in large-scale informal discussion with officials about the project. He said they have unofficially signed off on the idea."

Individual elected officials may indeed privately support the project and that is their prerogative. However, as elected representatives of the people, those elected officials reflect the public interest in statements of policy arrived at in public session and duly voted upon and recorded. This did not occur.

President Zinser at the same news conference is reported to have "noted that the Moscow-Latah Economic Development Council wrote a letter supporting the project." A letter was indeed sent; however, members of that group have indicated that it was couched in conditional statements that placed it in a neutral state.

A large number of interested citizens in the area believe the proposed use conflicts with the local public interest. Many of them are employed by the University or are affiliated with the University in some fashion. For these particular individuals to publicly speak out on the issue places them in a difficult situation. Others, not in that situation, are aware of the problems I have outlined but for reasons of their own choose not to advertise publicly their beliefs.

I find it disappointing that the Pullman-Moscow Water Resources Committee could not or would not carefully investigate the proposed project and provide an advisory opinion to the respective sponsoring entities. That would have

brought the issue to four governmental bodies where the democratic processes of government would take over and an up or down vote would have been possible.

That did not happen, even though I had suggested the process, because the Committee did not feel it was in a position to review all proposed water use plans in the area. This approach to a new major water requirement even as their own subcommittee was suggesting such peer review in the future continues to bother me.

The turnout of about one hundred citizens last month in Pullman to attend a workshop on basin water issues should indicate that citizens are aware and concerned about future water supplies, consumption, and a host of other related considerations. Many of those attending were fr m Moscow; a majority I was told.

The workshop, conducted by the P-MWRC, was intended for long-range planning purposes and the aquaculture issue was deliberately down-played so no insights came from that forum.

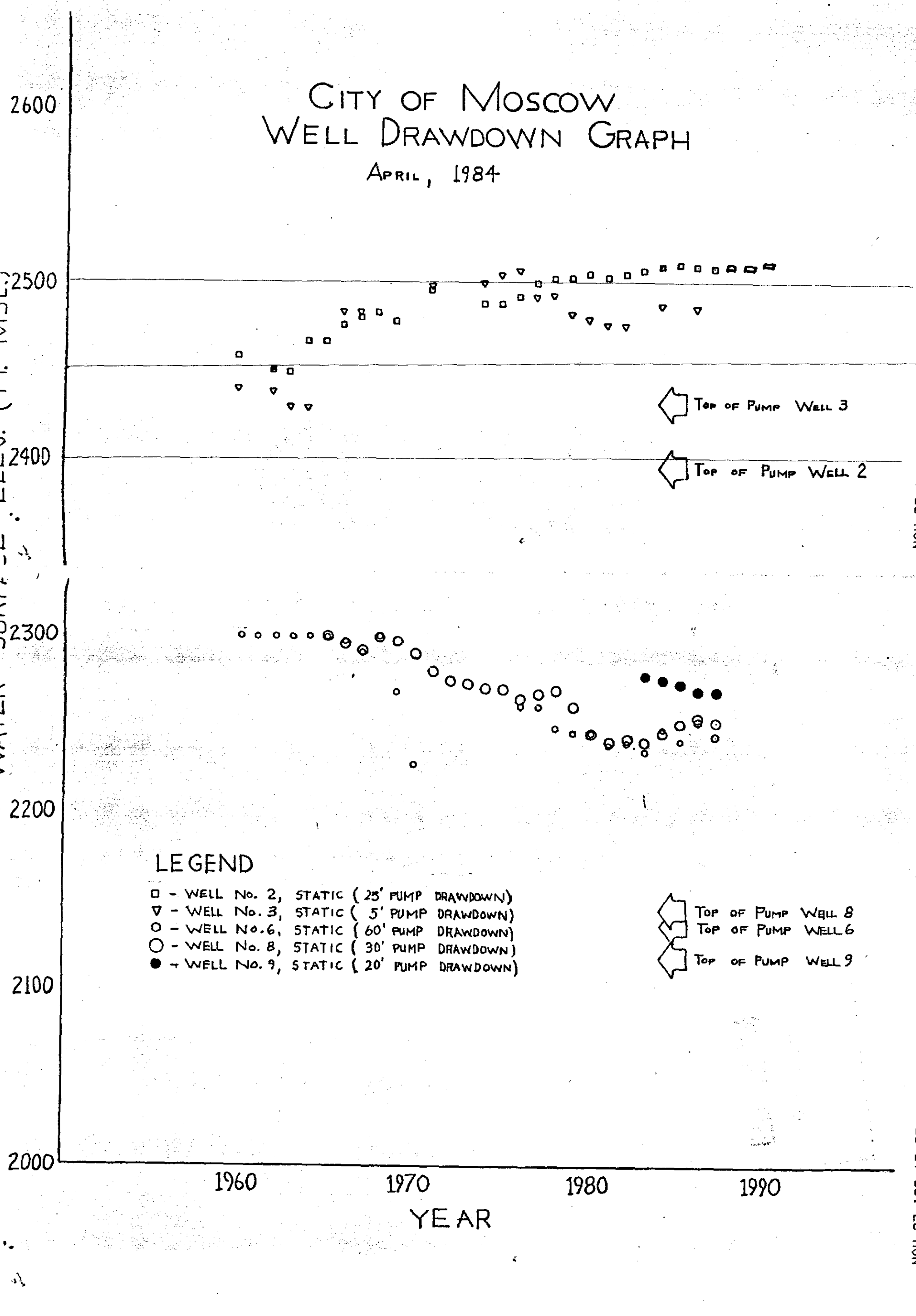
Short of a vote or signed petition by concerned citizens, I cannot prove exactly where the public interest lies. Even those measures cannot accurately gauge the interests of all citizens as evidenced by voter participation levels.

The demonstrated lack of positive support by the local governments makes a statement that the State of Idaho should not overlook.

DIGITIZED
MAR 19 1990

2088855752 PAGE.003

CITY OF MOSCOW
WELL DRAWDOWN GRAPH
APRIL, 1984



NOV 27 '89 17:24

2088855752 PAGE.004

NOV 27 '89 17:24

Applicants Exhibit # Admitted

EXECUTIVE SUMMARY
UNIVERSITY OF IDAHO AQUACULTURE RESEARCH AND DEVELOPMENT INITIATIVE

General

Following many weeks of discussions, analysis, and program refinement, the University of Idaho will proceed with plans for an aquaculture and fisheries research and development initiative encompassing a small research laboratory on the Moscow campus and a larger research and development laboratory in an area near Twin Falls, Idaho.

The Moscow facility will focus upon basic research and graduate education related to aquaculture, fish disease, water resources, and aquifer management. It will involve multidisciplinary teams of scholars located in Moscow.

The Twin Falls area facility will focus upon research and development related to the specific needs of the Idaho trout farming industry. It will involve University of Idaho faculty, local industry, and the College of Southern Idaho.

The project is based upon the development of a design and project strategy that minimizes negative impact upon the Palouse aquifer system and promotes the use of the immediate campus area as an aquifer research/monitoring entity. Work on the Moscow laboratory will commence as soon as final water diversion authority is issued by the Department of Water Resources.

With the support of the southern Idaho-based Aquaculture Advisory Committee, planning for the Twin Falls facility will begin immediately according to the appropriate state board approval processes.

Programmatic Values

The Moscow campus laboratory will serve as an education and a research facility. The education program will offer graduate studies in Aquaculture Science (genetics, nutrition, pathology, husbandry), Aquaculture Engineering (facility design, waste management, fish processing), and Aquaculture Business/Marketing (marketing, production operations management). The research emphasis at the campus laboratory will be on basic research to benefit the fish culture needs of Idaho, including both the commercial farms and the conservation hatcheries in the state. Research projects, therefore, will address issues from drug certification for use in hatcheries, to molecular engineering, to problems that affect the sport fishing industry. The initial research grant is from the Bonneville Power Authority in the amount of $1.22 million.

The Twin Falls area facility will serve as the center for applied research in the commercial industry, student training, and as the diagnostic center for fish disease in commercial hatcheries. Research projects will be directed at production needs of commercial aquaculture and distributed to industry through the extension network. Applied training for students from the College of Southern Idaho and the University of Idaho in fish husbandry, water quality, and diagnostics, will be conducted at the laboratory in concert with facilities at the College of Southern Idaho. It is also envisioned that programmatic cooperation in research will include faculty from BSU and ISU.

MICROFILMED

MAR 1 9 1990

OCT-26-89 THU 11:12 UNIV OF IDAHO RISK MGMT. P.04

To accomplish the program goals at both facilities, research teams will be developed from members of faculty and industry to undertake specific tasks. Examples of such tasks will be oxygen recharge and water reuse in fish farms to improve efficiency, developing the proper application of fish waste as fertilizer for croplands, identifying alternative protein sources for fish feed, culturing new species for industry and the sport fishery, and researching needs related to steelhead and chinook salmon production on the Columbia River.

Aquifer Management/Recharge Initiative

A major effort will be mounted to use the University of Idaho campus as a "test bed" for aquifer management and recharge research. As an initial effort, the university has authorized a seed grant of $10,000 to begin evaluation of the irrigation recharge strategy. The research project will involve analysis of groundwater levels and quality in an area presently irrigated with treated effluent. The work will be done in conjunction with on-going investigations at the University of Idaho Ground Water Research site on the west side of campus. The university's goal is to use the recharge strategy to provide increasingly clear base-line information for economic and population planning in the Palouse region (see Exhibit I for initial research plan prospectus).

Engineering Plan For Facility and Water Recharge

The Moscow facility is shown in Exhibit II. The basic water supply will come from a well drawing from the shallow aquifer. The water will be treated, used by the lab, treated again, and recycled into the campus irrigation system. Campus land currently watered from "deep aquifer" wells will be irrigated with the treated effluent from the laboratory. In this manner, use of the deep aquifer for irrigation will be reduced. Effluent water from the treatment plant will be applied on the campus, where a portion of the water will work its way down through the soil and strata to recharge the shallow aquifer. Procedures to be used to treat the effluent before recharge will be designed to ensure safe water and to exceed standards applied in most labs of this kind. Because water rights for using the sewage treatment plant effluent exceed both current irrigation usage and the maximum flow from the aquaculture lab, additional volumes will be added to the irrigation program until meaningful recharge of the shallow aquifer is achieved.

Water Rights Issue

Early questions about the university's rights to draw from Palouse wells for research (including aquaculture) appear to be resolved. The university has applied for the necessary change in the diversion point (i.e., new well location) along with the associated water right, which replaces the old shallow well near the dorms. The review of the application, which is to reinstitute prior water rights, is proceeding normally and approval is expected in November 1989.

FILMED
MAR 1 9 1990

OCT-26-89 THU 11:13 UNIV of IDAHO RISK MGMT. P.05

Construction Costs And Scheduling

Exhibit III summarizes the program, budget, and schedule for the campus-based facility. The lab will cost approximately $500,000 and be paid for from the proceeds of the Centennial Campaign. Ancillary projects, including the expansion of the irrigation system, will add to the project cost and be paid for out of grant and university facility funds. The irrigation system upgrade will follow the operational start-up of the laboratory.

Planning for the Twin Falls area facility will commence immediately with fundraising efforts (private, federal, and state appropriation), beginning in the summer of 1990.

MICROFILMED
MAR 19 1990

OCT-26-89 THU 11:14 UNIV OF IDAHO RISK MGMT. P.06

Frequently Discussed Points

- Approval of the campus-based initial facility is based upon the following policy parameters:
  - Lab must be built and operated without any net increase in the use of the deep aquifer water resource.
  - The effluent irrigation system must be expanded to cover areas currently being irrigated with deep aquifer water.
  - The new shallow aquifer water is to be the primary resource for the new lab.
  - An amount equal to the shallow aquifer pumpage must be recharged with properly treated effluent via the expanded irrigation system.
  - The effluent irrigation system must be operated in concert with a research program in aquifer management.
- The two-facility aquaculture strategy is designed to maintain the critical mix of skills at the University of Idaho campus for graduate education and research while creating a full scale R&D and training facility at Twin Falls, in the midst of the Idaho trout industry. Also, disease research conducted in Moscow will be isolated from production R&D at Twin Falls.
- Palouse shallow aquifer water, when properly treated, can serve as a primary water source for the University of Idaho campus lab. Current studies indicate that the costs will not be extra-ordinary for pre-treatment of shallow aquifer water.
- Pre-treatment of shallow aquifer water to be used by the lab will be designed in final form following analysis of the actual water drawn from the new well. However, treatment will include removal of elements such as iron from the water, chlorine oxidation, neutralization with $KmNO_4$, chlorine removal with coal, and mineral filtration with green sand.
- Post-treatment procedures to be used in treating the discharge from the laboratory will meet or exceed standards employed in most labs of this type.
- The shallow Palouse aquifer is recharged annually; there may be a link between the shallow and deep aquifer as well. Recharging the aquifers through irrigation is a proven technology.
- It is critical to provide R&D support for the Idaho trout industry which is facing increasing national and international competition.
- No new degree programs are necessary. Undergraduate aquaculture is already in place. The graduate programs exist in the appropriate colleges (Letters and Science; Forestry, Wildlife, and Range Sciences; and Agriculture). The MS/PhD studies will be related to fish.
- The University of Idaho is a leader in the field of education and research on aquifer management.
- Expansion of the initial University of Idaho campus facility will not occur until the impact upon the total aquifer system has been analyzed and found to be acceptable.

FILMED

- Future growth at Moscow will depend first upon aquifer impact analyses and second, upon successfully competing for new research grants.

- Facilities development in the Twin Falls area depends largely upon federal and private support, as well as state construction appropriations.

- Building only the initial facility at the University of Idaho campus is justified because it alone would constitute a significant upgrade and high quality laboratory environment for existing fish research needed in current programs.

- The ability to create a campus-sized "test bed" for aquifer studies--through the campus-based Idaho Water Resources Research Institute and other agencies--is viewed by campus administration as just as important as the aquaculture research itself.

101789
UI

MICROFILMED
MAR 19 1990

OCT-26-89 THU 11:15 UNIV OF IDAHO RISK MGMT. P.08

Where Tradition Meets the Future 1889-1989
University of Idaho

PRELIMINARY EVALUATION OF GROUND WATER IMPACTS ASSOCIATED WITH IRRIGATION WITH TREATED EFFLUENT ON THE UNIVERSITY OF IDAHO CAMPUS

Idaho Water Resources
Research Institute

Morrill Hall 106
University of Idaho
Moscow, Idaho
83843

208-885-6429

Dr. Dale R. Ralston
Professor, Hydrogeology

Dr. George L. Bloomsburg
Professor, Agricultural Engineering

Dr. John E. Hammel
Associate Professor, Soil Physics

WATER for IDAHO

Purpose

The purpose of this project is to aid in the development of artificial recharge as a ground water management tool within the Pullman-Moscow basin.

Objectives

The general objective of this project is to evaluate water level and water quality impacts on the shallow ground water system associated with irrigation of portions of campus with treated effluent from the Moscow sewage treatment plant.

The specific objectives are as follows:

1) *select a research site from areas presently irrigated using treated effluent;*

2) *install a monitor well network at the site to allow collection of water level and water quality information from the shallow ground water system;*

3) *install instrumentation to allow collection of water quality samples from the unsaturated zone above the shallow ground water table;*

4) *install necessary valves and flow meter(s) in the effluent application system to allow controlled application of effluent to the research site;*

5) *collect water level and water quality data from the research site during both the non-irrigation season of 1989-90 and the irrigation season of 1990;*

6) *analyze the research results and prepare a reports of findings.*

RECEIVED
MAR 19 1990

OCT-26-89 THU 11:16 UNIV OF IDAHO RISK MGMT. P.09

Description of the Research

The probable research site is located on the extreme west side of the playing fields next to Perimeter Drive. This area is near the University of Idaho Ground Water Research Site and is presently irrigated using treated effluent. The depth of the water table in this area is about 5 to 10 feet, which will minimize drilling expenses.

The monitoring network would be constructed using a commercial drilling rig. All monitor sites would be completed with steel surface casing and locking caps that would extend about .5 feet above land surface.

Field data collection would be done by a graduate student on appointment. Analysis of water samples would be conducted by the graduate student on campus using available equipment. University provided support would include: 1) furnishing laboratory space and equipment for laboratory analyses; 2) furnishing and installing valves and meter(s) as may be required for controlling and monitoring effluent application; 3) additional costs required to effect specific effluent application rates during specific test periods; and 4) additional costs required for lawn maintenance because of the presence of monitoring sites.

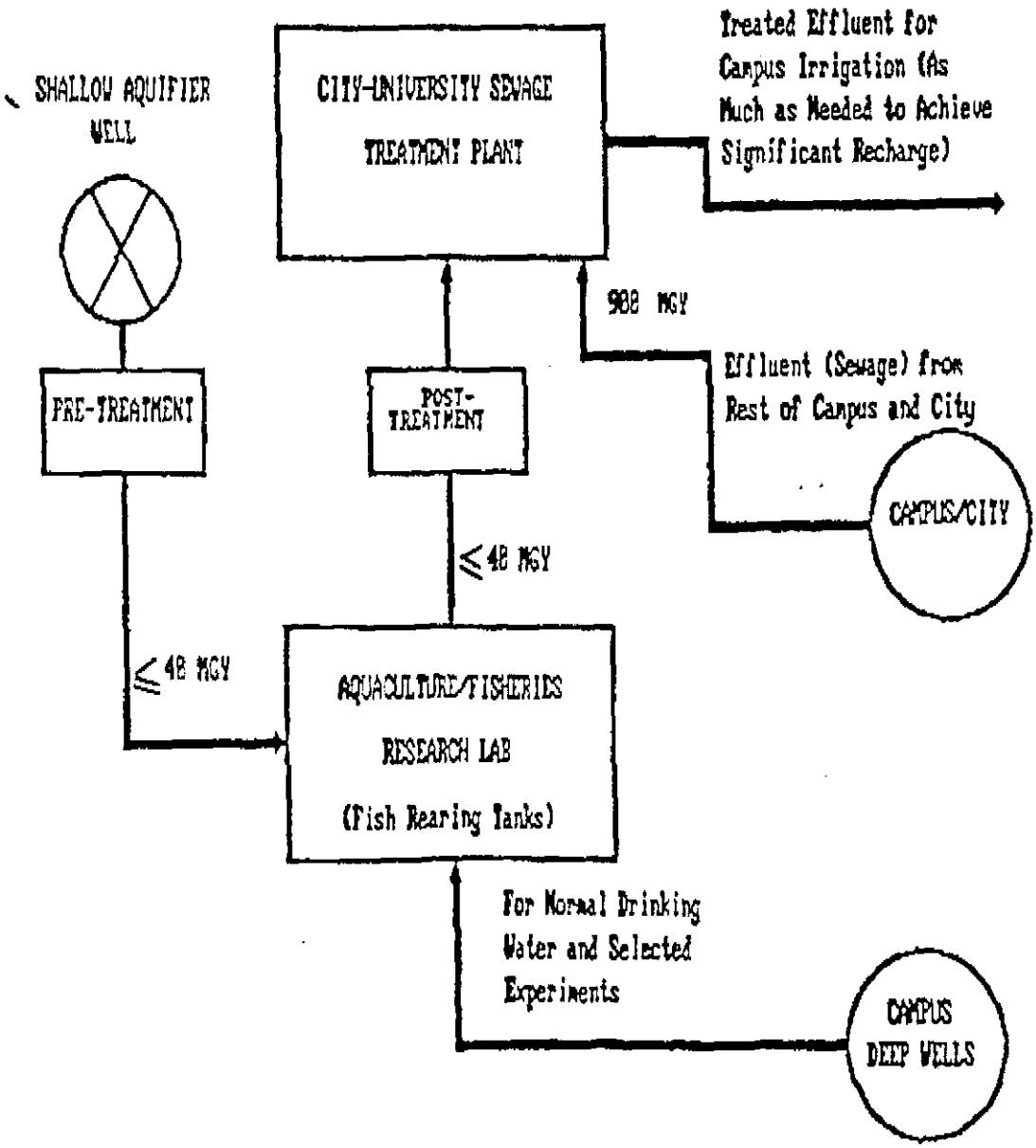
Budget

Salaries	
Graduate Assistant (.25 FTE)	$4,000
Irregular Help ($5.00/HR x 100 HRS)	500
Operating Expenses	
Contract Drilling	2,500
Chemical, Soil & Water Analyses	1,000
Field and Lab Supplies	1,000
Report Preparation	483
Fringe Benefits	
Rate: 11.5%	517
TOTAL	$10,000

MICROFILMED
MAR 19 1990

OCT-26-89 THU 11:16 UNIV OF IDAHO RISK MGMT. P.10

SCHEMATIC DIAGRAM OF UI CAMPUS AQUACULTURE/FISHERIES RESEARCH FACILITY



MICROFILMED
MAR 19 1990

OCT-26-89 THU 11:17 UNIV OF IDAHO RISK MGMT. P.11

University of Idaho

Department of Facility Planning

Aquaculture Center, Phase One
Project Assumptions

PROGRAM:

Construct an approximately 5,400 square foot research lab for the first phase of the University Aquaculture/Fisheries Research Laboratory. The research lab will house fourteen (14) twelve foot diameter fish rearing tanks. A single shallow aquifer well will provide water for the lab. The initial research project will require 40 mgy of high quality make-up water to be delivered to the lab; total water required in the recycling system will be 560 gpm.

The method for expanding and extending the irrigation system will be designed as part of the $100,000-$250,000 project listed in the budget.

BUDGET:

The budget assumptions that follow include all expenses associated with the sitework, building, and equipment, with the exceptions noted below.

	University Facility*	College Equipment	Total
Programming/Master Plan	$ 8,385		$ 8,385
Basic A/E Fees	51,985		51,985
Construction	278,380		278,380
Equipment (existing and donated)		113,730	113,730
Overhead/Contingency	41,760	19,110	68,660
Totals	$388,510	$132,840	$513,350

* Primarily centennial donation

Supporting Projects:

- Power failure alarm and back-up system ($15,000)
- Shallow well connection to the main university system ($10,000)
- Walk-in freezer for fish carcass storage ($10,000)
- Effluent irrigation system extensions ($100,000 to $250,000)
- Steps for aquifer recharge implementation (part of new research)

SCHEDULE:

Programming Complete	August 23, 1989
Found. Design Docs Complete	October 16, 1989
Found. Bid Opening (contingent upon water rights permit)	November 7, 1989
Receive water permit	November 15, 1989
Foundation Construction Start	November 15, 1989
Building Design Docs. Complete	November 17, 1989
Building Bid Opening	December 12, 1989
Building Construction Begin	December 19, 1989
Occupancy	March-April, 1990
Effluent Irrigation System	Fiscal Year 1991
Recharge Monitoring/Research	Commence FY 1990
Magic Valley Facility Planning	Oct. 89 - June 90
Magic Valley Design/Construction	Funds Available basis

RECEIVED
MAR 19 1990

OCT-26-89 THU 11:17 UNIV OF IDAHO RISK MGMT. P.12

87-07141 - UNIVERSITY OF IDAHO - 11/30/89
JOHN ROSHOLT -
TOWNSEND - OPENING STATEMENT

DR ERNEST ~~[illegible]~~ BRANNON - DIR. NEW AQUICULTURE PROGRAM
AQUICULTURE LAB - PREFERRED SITE - WEST SIDE OF CAMPUS

U EXH #1 MAP OF CAMPUS - ADMITTED
U EXH #2 AQUICULTURE PLAN - ADMITTED
U EXH #3 U OF I AQUACULTURE PROGRAM - ADMITTED
USE WOULD BE A PHASED PLAN STARTING A 4DMG/YEAR INITIALLY - DOES NOT CONTEMPLATE CONTINUOUS USE OF 1.5 CFS - STATE OF ART REUSE FACILITY - PLAN TO REPLACE USE OF PART OF DEEP AQUIFER WITH SHALLOW SOURCE
COST OF FACILITY - $500,000 - HAVE LOOKED AT POTENTIAL OFF-CAMPUS FACILITY - TROUT INDUSTRY HAS STATE VALUE OF $60/M/YEAR
PLANNING A TWIN FALLS FACILITY ALSO
USE WILL REQUIRE PRE-TREATMENT - IRON MUST BE REMOVED - USING EXISTING TECHNOLOGY - EFFLUENT FROM LAB WILL BE "ENRICHED" AMONIA & NITRATES WILL BE TREATED AND USED FOR IRRIGATION OR WATER SPREADING ON PASTURE LAND. - GOOD FAITH -
X REQUIREMENT 4DMG/YEAR + 70,000
TREATMENT FACILITY - $15 - 50,000

DR LARRY KIRKLAND -
4 ENTITIES
U OF I 320,000,000
MOSCOW 700,000,000
WSU 200,000,000
PULLMAN 850,000,000

MICROFILMED
MAR 19 1990

Ex #4 - Wells used by U - Admitted
Stopped pumping in 1966 from Shallow Aquifer
Ex #5 - - Admitted
Sewage use of both City & University effluent
Presently irrig 250 AC with both eff & deep water
About 200 of that from effluent
Project should allow reduction in demand on deep aquifer
Well #1 and 2 shallow
Well #3 and 4 deep 1700' 750'

Dr. Dale Ralston - Prof of Hydrogeology
Palouse Aquifer - Granitic Basement
Basalt sequence - Grande Ronde - Deep Aquifer (Sewage mi. east of town)
Wanapum - Shallow Aquifer
Sediments - Sands, Gravel, Silts
Loess - Rolling Hills

Studies of GW resources in area - water budget
3.3" to loess
1.9" to basalt from loess
Ex 6 - Hydrogeology Report - Admitted
Ex 7 -
Rate of water movement - Age dating - 5000 yrs Shallow
" " 30,000 yrs - Deep
Ex 6-P 65 - Rates of recharge
63 cfs in estimated recharge to upper aquifer - should
easily support 1.5 cfs - will be water level decline
but not nearly to level when City and U were both
pumping - will result in decrease in deep
aquifer - GW Research Facility - Water level measurements
Part of Ex #2 - memo from Ralston, et al
Recharge - Reinjection - has not been evaluated
Adequate water supply for development

MICROFILMED
MAR 19 1990

X 63X2 = 126 X 365 = ~~[illegible]~~/YEAR

~~B~~ WILLIAM E. LUM, II - HYDROLOGIST - USGS, TACOMA
Ex 8 - USGS REPORT ON PULLMAN MOSCOW AREA -
CONCLUSIONS
1) AQUIFERS ARE CONNECTED
2) THICKNESS 0 TO 3000'
3) Recharge - 140 CFS OVER 500 SQ MILES
4) WATER LEVELS WILL DECLINE IF USE INCREASES
5) USE WILL RESULT IN DECLINE - WILL NOT EXCEED RECHARGE
6) Report SUPPORTS RALSTON REPORT - USE OF 1.5 CFS
X DRAWDOWN WILL RESULT IN DECLINE

THOMAS A. TOWNSEND

JOHN ROSHOLT
- IN EXPERT OPINION - WATER SUPPLY IS SUFFICIENT
- CONSTITUTIONAL RIGHT TO APPROPRIATE
- NO RIGHT HOLDERS IMPACTED
- GOOD FAITH - FINANCIAL RESOURCES
- PUBLIC INTEREST - EVIDENCE OF NON APPEARANCE

TOWNSEND
- INCESTUOUS RELATIONSHIPS

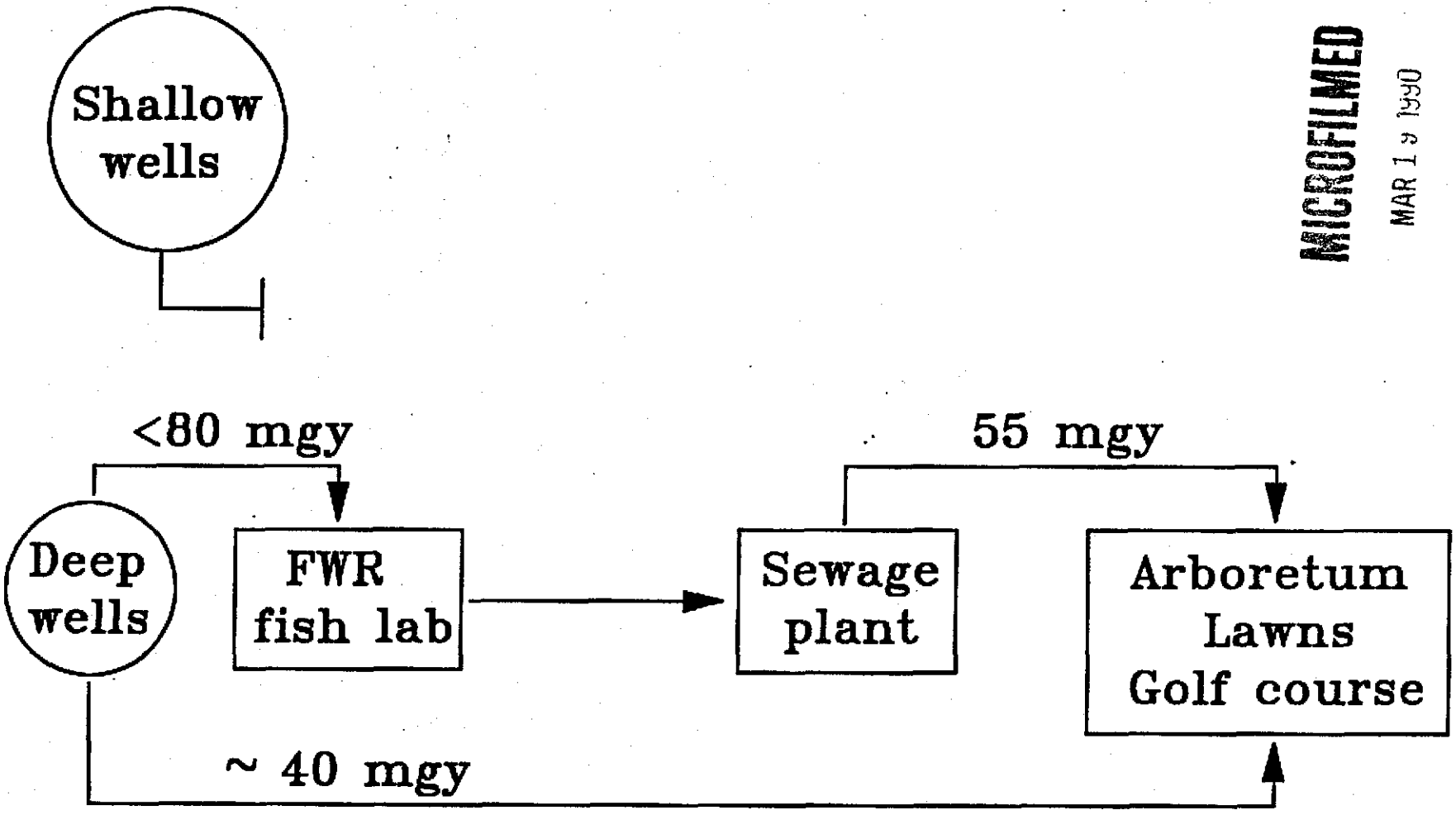
MICROFILMED
MAR 19 1990

Applicants Exhibit
#3
Admitted

U of I Aquaculture Program

MICROFILMED
MAR 1 5 1990

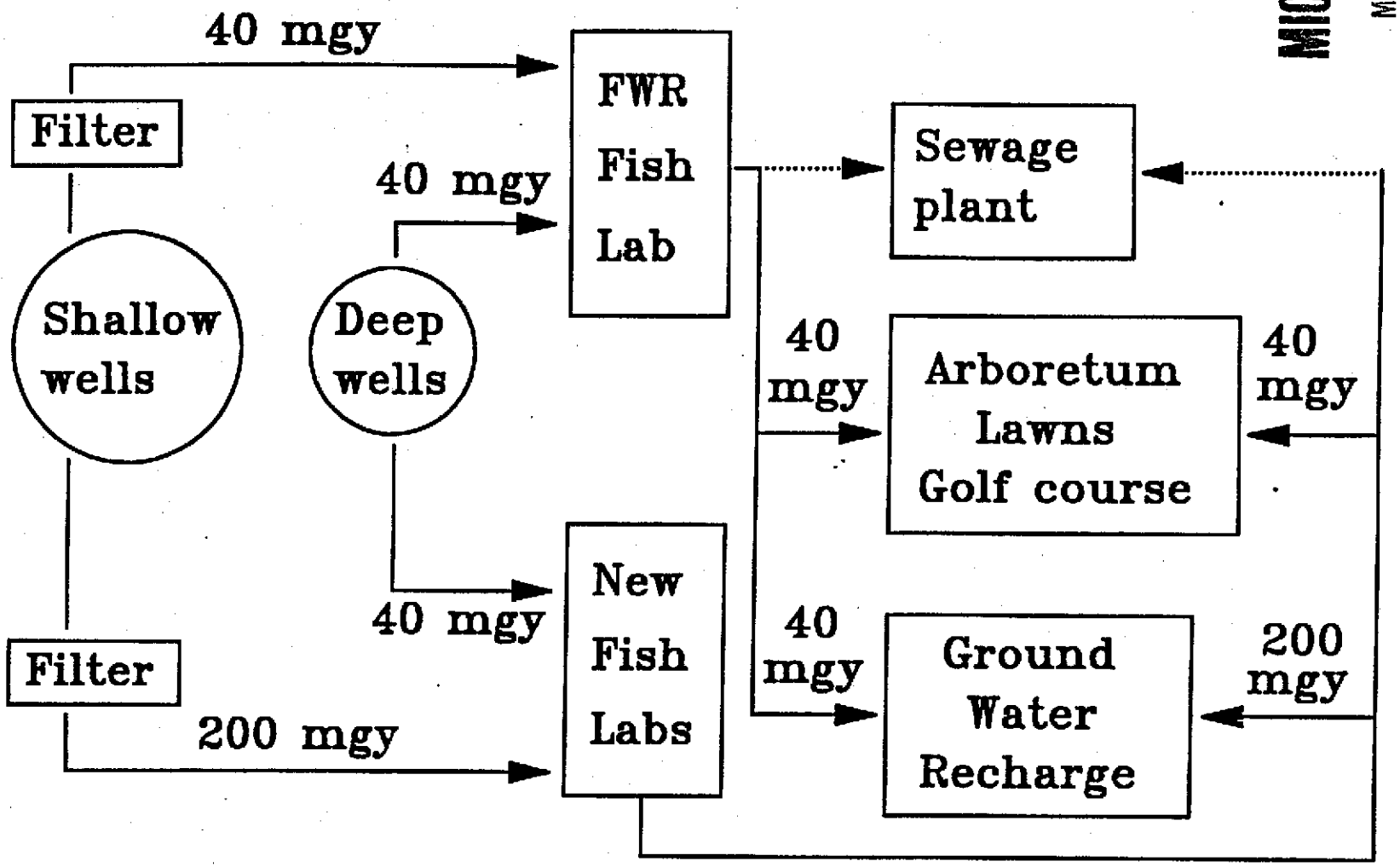
Present:



MICROFILMED
MAR 1 9 1990

MICROFILMED
MAR 19 1990

Future:



Treated Waste Water Irrigation Use on Campus

Present:

- Arboretum
- Golf course
- Guy–Wicks field
- Hartung lawn
- Football practice
- I – tank lawn

Future:

- East section Guy–Wicks field
- Expansion of Arboretum, Phase 2
- Performing Arts expansion
- N.W. side outdoor track
- Administration lawn
- Band field
- Info Center lawn
- Ghormley Park (City)
- Central quad (Library–FWR)

MICROFILMED
MAR 1 9 1990

Proposed Steps for Water Conservation at U of I

Short Term: Years 1–3

- Use entire 150 gpm waste water from new facility Apr–Sep in present irrigation system.

Mid Term: Years 2–5

- Expand waste water irrigation system to displace present use of deep aquifer for irrigation.
- Begin use of shallow aquifer for some of Aquaculture/fish research needs.

Long Term: Years 5+

- Use shallow aquifer for most of aquaculture needs.
- Use waste water exclusively for all irrigation needs.
- Begin aquifer recharge with waste water from Aquaculture/fish research.

MICROFILMED
MAR 1 9 1990

RESOLUTION OF UNDERSTANDING
between
PULLMAN-MOSCOW WATER RESOURCES COMMITTEE
IDAHO DEPARTMENT OF WATER RESOURCES
WASHINGTON DEPARTMENT OF ECOLOGY
1989

WHEREAS, the Pullman-Moscow Water Resources Committee composed of representatives of Pullman, Moscow, University of Idaho, Washington State University, Whitman County and Latah County has an interest in the protection and management of the ground water resources of the Pullman-Moscow basin; and

WHEREAS, the Idaho Department of Water Resources and Washington Department of Ecology have the legal authority and the technical expertise to administer and regulate water law in their respective states, and the responsibility and desire to participate and assist in the management of the ground water resources; and

WHEREAS, there is evidence to show that the potential exists for the overuse of quality ground water resources within the basin; and

WHEREAS, a ground water management plan developed and implemented in concert with public needs and interests and in accordance with state and local laws, rules and regulations can serve to avert the overuse of the ground water resources in the basin; and

WHEREAS, the parties to this Resolution are desirous of developing and implementing such a ground water management plan; and

WHEREAS, the parties hereto are authorized to enter into this Resolution of Understanding for the purposes stated herein.

NOW, THEREFORE BE IT RESOLVED that the parties to this Resolution do agree to the following:

The Idaho Department of Water Resources (IDWR) and Washington Department of Ecology (WDE) agree to commit sufficient staff time to assist in the completion of such tasks as may be appropriate. IDWR and WDE further agree to pursue the implementation of a coordinated Washington-Idaho ground water management plan for the Pullman-Moscow basin in accordance with their respective state law and policies.

The Pullman-Moscow Water Resources Committee (PMWRC) agrees to work with the state agencies and to serve as the forum for input from local governments, interest groups and private citizens.

Specific obligations of the Committee are as follows:

1. PMWRC will pursue and administer funding to conduct and promote studies and research relative to improving knowledge of the water resources of the basin.

2. PMWRC will prepare a management plan for the basin in cooperation with the two state agency parties (IDWR and WDE), which will address both water quantity and water quality concerns.

3. PMWRC will prepare as an initial step in the development of the management plan a principal workplan and time schedule which will outline the concerns and issues to be studied. This workplan shall indicate the party or parties with responsibilities for each task and an estimated schedule for completion of each task.

4. PMWRC will encourage public involvement in the development of the water management plan through public hearings and education programs.

5. PMWRC will facilitate the implementation of the ground water management plan in concert with the member entities of the Committee.

BE IT FURTHER RESOLVED, this Resolution shall be effective upon execution by all parties and accomplishment of the filing requirements and approvals as may be necessary. This Resolution shall remain in effect until the completion of the ground water management plan or until any party to the agreement terminates its participation by written notice of termination to the other parties.

This Resolution can be amended at any time by written notice to all parties, except that action by the Committee at a regularly scheduled meeting and notice to IDWR and WDE shall satisfy the written notice for PMWRC or Committee members.

Carole A. Helm	5-30-89	Mardi Baum	5.30.89
Pullman	Date	Moscow	Date
Kenneth E. Ahlney	5/30/89	Joseph L. Geiger	5-25-89
Washington State University	Date	University of Idaho	Date
John Henley Jr.	5-30-89	Nancy Johansen	5-30-89
Whitman County	Date	Latah County	Date
Fred Olson	5-30-89	Wayne Haas	5/30/89
Washington Department of Ecology	Date	Idaho Department of Water Resources	Date

pmc147
4/13/89

UNIVERSITY OF IDAHO WELL DATA

ABBREVIATIONS: GPM = GALLONS PER MINUTE; [redacted] = GALLONS PER YEAR; SS => SAND

	WELL 1	WELL 2	WELL 3	WELL 4	PARKER FARM	EFFLUENT
AQUIFER	SHALLOW	SHALLOW	DEEP	DEEP	SHALLOW	
YEAR DRILLED	1900+-	1952	1964	1976-78	1957	1977
DEPTH DRILLED	?	240 FT	1337 FT	747 FT	493 FT	SURFACE
DEPTH TO WATER						SYSTEM
1960	-- 154.00	125.00			<75 FT	WATER
1964			258.00			FROM
1970	50.00	92.00	270.00		<75 FT	CITY
1975			276.00			OF
1980			281.00	271.00	<75 FT	MOSCOW
1985			296.00	283.00		SEWAGE
1989		50.00	301.00	288.00	<75 FT	TREATMENT
						PLANT.
CAPACITY	N.A.	<1000 GPM SS	>2000 GPM	>2000 GPM	1000+ GPM	1400 GPM
PUMP SIZE	CAPPED	860 GPM	1600 GPM	1600 GPM	350 GPM	1200 GPM
WATER RIGHT	NONE	1000 GPM	1800 GPM	500 MGY	0.78 CFS = 350 GPM	72 MGY
INSTANTANEOUS	N.A.	1000 GPM	1800 GPM	2000 GPM	SAME	NO LIMIT
AVERAGE/MINUTE/YR	N.A.	1000 GPM	1800 GPM	963 GPM	SAME	415/4 MON.S
PRESENT USE	0	0	305 GPM	360 GPM		
PURPOSE ON WATER RT	N.A.	DOMESTIC	IRRIGATION/DOMESTIC ====>		IRRIGATION - NURSERY STOCK	WASTEWATER
AQUIFER	SHALLOW	SHALLOW	DEEP	DEEP	SHALLOW	LAND
						APPLICATION

ANNUAL PUMPAGE

YEAR	WELL 1	WELL 2	WELL 3	WELL 4	TOTAL PUMPAGE	PARKER FARM
1955	83,307,050	76,506,273			159,813,323	NO
1956	104,031,600	39,261,694			143,293,294	RECORD
1957	125,256,825	65,930,924			191,187,749	OF
1958	54,930,450	135,433,939			190,364,389	ACTUAL
1959	864,000	178,007,048			178,871,048	PUMPING.
1960	7,137,000	160,979,954			168,116,954	USE
1961	21,522,460	112,368,587			133,891,047	WELL
1962	9,412,245	190,687,367			200,099,612	AS
1963	3,096,750	188,573,060			191,669,810	NEEDED
1964	32,852,245	96,561,083	19,141,378		148,554,706	FOR
1965		2,856,000	161,799,596		164,655,596	IRRIGATION
1966	"shut down" ==========>		176,519,290		176,519,290	AND
1967			189,561,400		189,561,400	DOMESTIC
1968			175,706,900		175,706,900	WATER
1969			326,696,200		326,696,200	NEEDS
1970	"Well #3 down for 12 days."		205,846,101		205,846,101	
1971	"Well #3 down Aug.1 - Oct. 5."		178,141,610		178,141,610	
1972			264,006,599		264,006,599	
1973			318,276,459		318,276,459	
1974			295,929,780		295,929,780	
1975			263,200,701		263,200,701	
1976			276,358,560		276,358,560	
1977			388,898,870		388,898,870	
1978			269,829,874		269,829,874	COMMENCED
1979			89,260,950	194,572,050	283,833,000	EFFLUENT
1980			59,588,930	269,554,577	329,143,507	IRRIGATION
1981			175,837,250	151,531,850	327,369,100	ON
1982			25,339,800	285,717,300	311,057,100	UI
1983			40,827,460	218,832,858	259,660,318	CAMPUS
1984			138,749,000	144,031,100	363,627,800	1978
1985			93,322,200	226,878,800	251,415,100	
1986			155,457,895	158,092,900	313,550,795	
1987			178,140,450	199,124,150	377,264,600	
1988			182,798,850	183,182,200	365,981,050	

MICROFILMED
MAR 1 9 1990

Applicants Exhibit #4 Admitted

PUMPING FROM CITY OF MOSCOW AND UNIVERSITY OF IDAHO SHALLOW WELLS

YEAR	WELL #2	WELL #3	TOTAL CITY	TOTAL UI	GRAND TOTAL	COMMENTS
1947	42,844,500	232,422,000	275,266,500	?	275,266,500	
1948	15,943,500	327,708,000	343,651,500	?	343,651,500	
1949	59,697,000	398,198,000	457,895,000	?	457,895,000	
1950	127,188,000	298,512,000	425,700,000	?	425,700,000	
1951	195,870,000	271,440,000	467,310,000	?	467,310,000	
1952	300,466,500	82,812,600	383,279,100	?	383,279,100	
1953	250,904,250	130,504,800	381,409,050	?	381,409,050	
1954	333,701,925	64,863,705	398,565,630	?	398,565,630	
1955	283,440,125	247,437,451	530,877,576	159,813,323	690,690,899	
1956	103,762,900	187,648,100	291,411,000	143,293,294	434,704,294	
1957	86,913,300	264,572,200	351,485,500	191,187,749	542,673,249	
1958	138,713,000	233,326,900	372,039,900	190,364,389	562,404,289	
1959	354,280,500	69,041,000	423,321,500	178,871,048	602,192,548	<= CITY DEEP WELL #6 BROUGHT ON LINE
1960	269,479,270	42,323,120	311,802,390	168,116,954	479,919,344	
1961	175,452,800	33,068,900	208,521,700	133,891,047	342,412,747	
1962	276,290,400	10,826,900	287,117,300	200,099,612	487,216,912	
1963	272,692,300	89,021,500	361,713,800	191,669,810	553,383,610	UI DEEP WELL #3
1964	191,359,300	22,269,900	213,629,200	129,413,328	343,042,528	<= BROUGHT ON LINE
1965	167,974,490	12,070,700	180,045,190	2,856,000	182,901,190	<= CITY DEEP WELL #8
1966	28,293,900	338,600	28,632,500	0	28,632,500	BROUGHT ON LINE
1967	22,221,200	421,900	22,643,100	0	22,643,100	
1968	39,758,000	5,272,600	45,030,600	0	45,030,600	
1969	35,783,500	1,164,600	36,948,100	0	36,948,100	
1970	858,800	7,398,188	8,256,988	0	8,256,988	
1971	941,800	0	941,800	0	941,800	
1972	0	36,857,500	36,857,500	0	36,857,500	
1973	82,432,000	8,002,000	90,434,000	0	90,434,000	
1974	118,407,200	11,997,600	130,404,800	0	130,404,800	
1975	122,454,900	113,876,800	236,331,700	0	236,331,700	
1976	66,440,900	9,632,300	76,073,200	0	76,073,200	
1977	75,665,200	13,889,079	89,554,279	0	89,554,279	
1978	113,819,400	26,703,400	140,522,800	0	140,522,800	
1979	144,240,200	32,110,700	176,350,900	0	176,350,900	
1980	170,485,700	17,912,800	188,398,500	0	188,398,500	
1981	85,282,900	47,567,100	132,850,000	0	132,850,000	
1982	73,462,100	24,515,000	97,977,100	0	97,977,100	<= CITY DEEP WELL #9 BROUGHT ON LINE
1983	30,042,000	60,000	30,102,000	0	30,102,000	
1984	34,244,000	2,256,000	36,500,000	0	36,500,000	
1985	58,110,000	778,000	58,888,000	0	58,888,000	
1986	17,257,000	0	17,257,000	0	17,257,000	
1987	5,747,000	0	5,747,000	0	5,747,000	
1988	34,714,000	0	34,714,000	0	34,714,000	
1989	65,000,000	0	65,000,000	0	65,000,000	

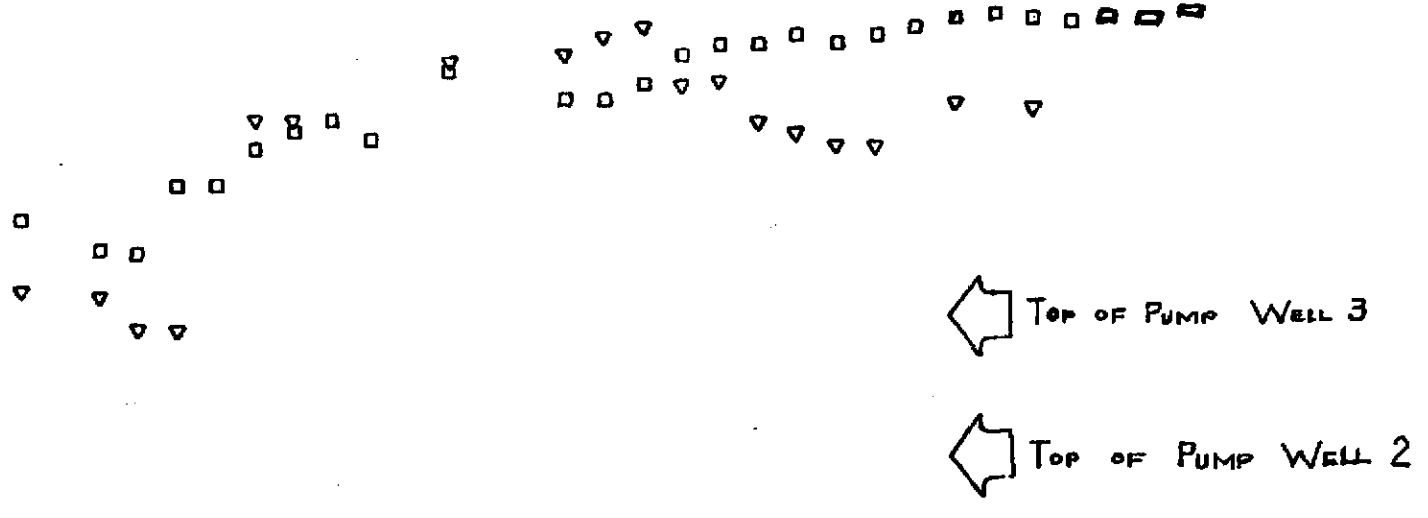
MICROFILMED
MAR 1 9 1990

Admitted

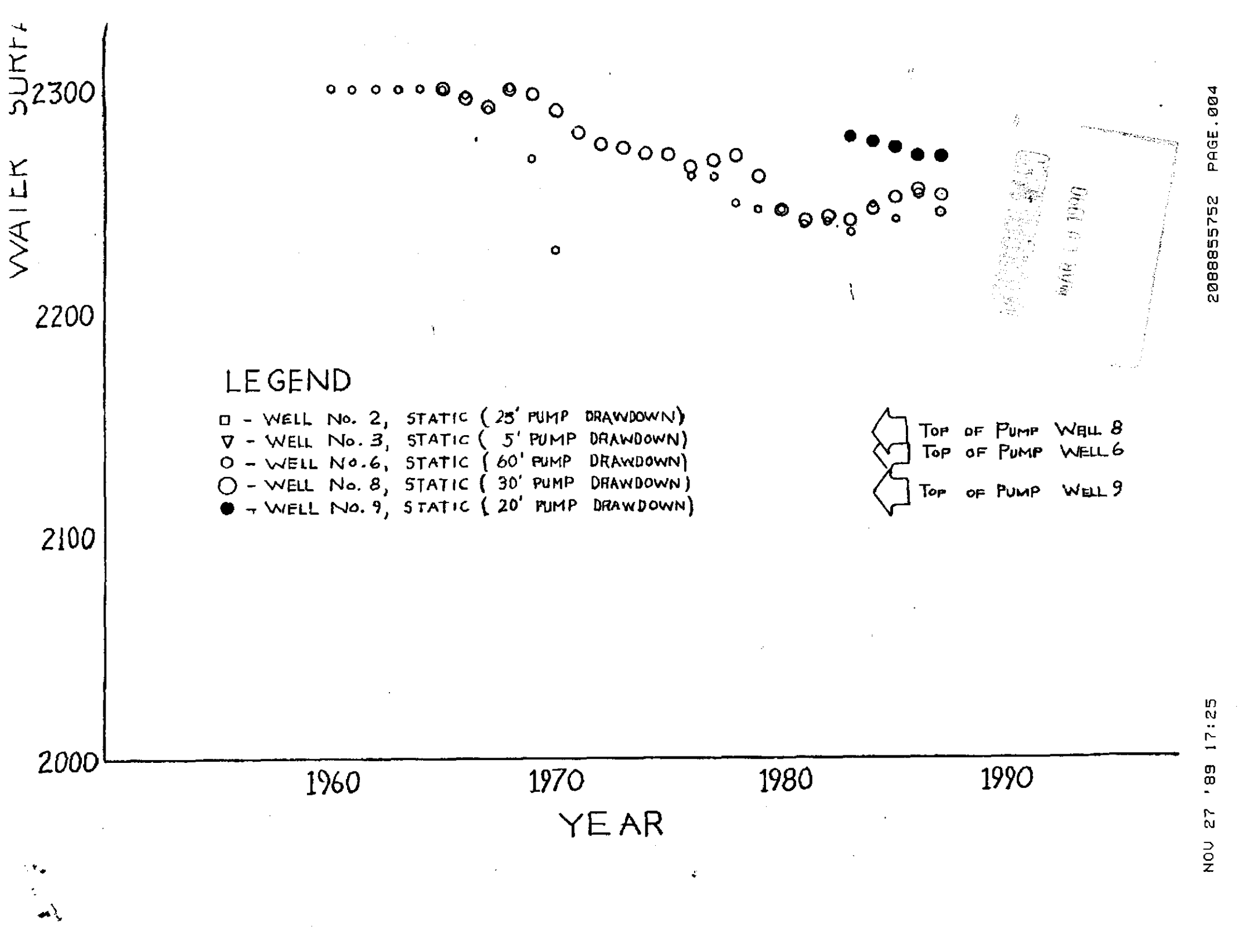
2088855752 PAGE.003

DISAPPROVED
MAR 19 1990

CITY OF MOSCOW
WELL DRAWDOWN GRAPH
APRIL, 1984



NOV 27 '89 17:24



2088855752 PAGE.004
NOV 27 '89 17:25

ANALYSIS OF GROUND WATER RECHARGE FROM PARADISE CREEK AT THE UNIVERSITY OF IDAHO GROUND WATER RESEARCH SITE: PART I

by

Dale R. Ralston
Professor
Geology and Geological Engineering
University of Idaho

Tong Li
Graduate Assistant
Geology and Geological Engineering
University of Idaho

Prepared for the Pullman-Moscow Water Resources Committee

MICROFILMED
MAR 1 9 1990

November, 1989

Applicants Exhibit #6
Admitted

NOV 9 '89 18:25 2088855752 PAGE.003

TABLE OF CONTENTS

I. Introduction 1

Purpose and Objectives 1

Location and Initial Development of the UI Ground Water Research Site (GRS) 1

II. General Geology and Hydrogeology 3

Geology 3

Site Stratigraphy and Hydrogeology 4

III. Water Level Data Analysis 8

Ground Water Hydrograph 8

Ground Water Recharge and Discharge 14

IV. Conclusions and Recommendations 16

Conclusions 16

Recommendations 16

References 17

I. INTRODUCTION

Purpose and Objectives

The purpose of this report is to increase the understanding of ground water recharge to basalt aquifers in Pullman-Moscow basin. The general objective is to utilize wells at the University of Idaho Ground Water Research Site to study the interrelationship between Paradise Creek and shallow alluvial and basalt aquifers. The specific objectives are as follows:

1) *monitor ground water levels and surface flow discharge in the Paradise Creek at the UI Ground Water Research site.*
2) *analyze the water level and surface flow data with respect to site hydrogeology.*
3) *describe the controls for recharge of shallow aquifers from streams in the area.*

Location and Initial Development of the UI Ground Water Research Site (GRS)

The GRS is located at western edge of University of Idaho campus. Five drilled wells were constructed at the site in 1987. The site is in triangular shape (figure 1) with Paradise Creek along its northern boundary, Perimeter Drive as its eastern boundary and a moderate hill as its southwestern boundary.

Paradise Creek is a tributary of south fork of the Palouse River, originated from Moscow Mountain. The discharge of the creek varied from 0.3 cfs to 50 cfs in 1988. The peak daily discharge usually occurs during snowmelt periods in the spring time. A U.S. Geological Survey gaging station on Paradise Creek is located about 100 feet cross Perimeter Drive from the northeastern corner of the site.

The test wells, named 1-A, 1-B, 1-C, 1-D and 1-E, were constructed with depths of 70, 100, 140, 146 and 80 feet, respectively. All the wells were completed within the Wanapum basalt of Yakima Subgroup of Columbia River Basalt Group with about 10 to 20 feet overburden at ground surface. The water yield of the test wells varies from 5 to 50 gpm. Two piezometers were set up within the overburden to depths of 10 to 12 feet for monitoring water level fluctuations in the shallow alluvial aquifer.

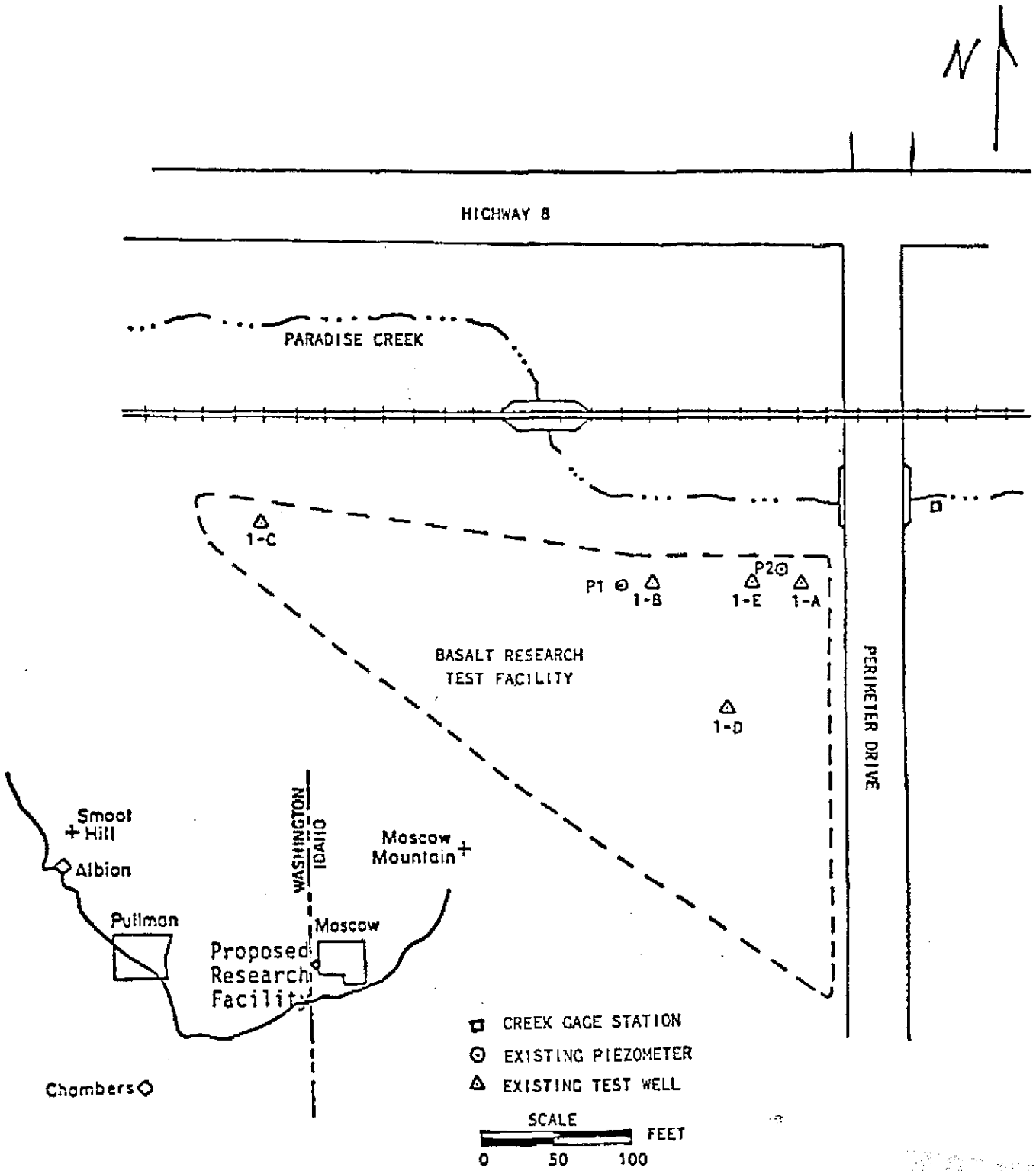


Figure 1. Plan View of Ground Water Research Site

II. GENERAL GEOLOGY AND HYDROGEOLOGY

Geology

Pullman-Moscow Basin lies near the eastern edge of Columbia Plateau within the Palouse Region. The basin base consists of Pre-Tertiary crystalline rocks which are overlain by the Columbia River Basalt with an irregular buried contact surface. The crystalline rocks are primarily granites that are Cretaceous in age and appear to be related to the Idaho Batholith. Some metamorphic rocks occur in the northern part of the Basin (Smoot and Ralston, 1987).

Miocene basalts interbedded with sediments overlie the basement of the crystalline rocks. The total thickness of basalt sequence is as great as 1,500 feet in Moscow and more than 2,200 feet in Pullman. The basalt sequence is classified into the Wanapum and Grande Ronde Formations of Yakima Basalt Subgroup of Columbia River Basalt Group (Swanson et al., 1979). The basalt in the basin is composed of individual flows or layers that were produced by a series eruptions of basalt lava. The thickness of the individual flow range from a few feet up to 200 feet with most flows ranging from 40-100 feet.

Three sets of cooling fractures or joints are generally observed within individual basalt flows. Columnar hexagonal joints that form columns 0.5 to 0.6 feet in width and blocky joints about 0.5 feet in diameter occur in the vertical direction. Platy fractures occur in the horizontal direction (Smoot and Ralston, 1987). The greatest hydraulic conductivity in the basalt sequence occurs at contact zones between individual flows. The outcrops of Wanapum basalt exposed along the Pullman-Moscow Highway illustrate the complexity of the fracture systems (Bush, 1988).

The numerous sedimentary layers that are composed of clay silt, sand and gravel, as well as claystone and siltstone were interbedded with the basalt. Much of the sediments appear to have been deposited in lakes or dammed streams that were formed by eruptions of the basalt lava. The interbeds tend to be thinner in layer thickness and finer in grain size to the west.

The Wanapum and Grande Ronde are two major formations of the basalt in the Basin. They may be differentiated geochemically by the magnesium, titanium and phosphorus concentrations. Wanapum basalt appears to be high in titanium and phosphorus and low in magnesium, whereas Grande Ronde basalt

tends to have high magnesium concentrations and low titanium and phosphorus concentrations. The different percentage of concentrations of TiO_2 and P_2O_5 for the two formations is shown in figure 2 (modified from Wood, 1987). The Wanapum basalt is separated stratigraphically from the Grande Ronde basalt by Vantage member of the Ellensburg Formation, which is composed of siltstone, claystone and tuffaceous rocks (Swanson et al. 1979).

Surface of the Wanapum basalt is covered by Pleistocene loess in most part of the Pullman-Moscow Basin. The thickness of loess varies from zero to several hundred feet.

Site Stratigraphy and Hydrology

Understanding of site stratigraphy and aquifer characteristics is based on the drilling cutting logs and borehole geophysical logs as well as water level data and pumping test data. Borehole geophysical logging was conducted on the five test wells using the Washington State University logging unit. Nine logging sondes were used in the study: caliper log, flow meter log, fluid temperature log, fluid resistivity log, natural gamma log, neutron gamma log, gamma-gamma log, neutron-neutron log and spontaneous potential/resistivity log.

The principal findings from the geological, hydrogeological and borehole geophysical investigations of the GRS are as follows:

(1) Five stratigraphic units have been identified at the Ground Water Research site (figure 3). From top to bottom, unit 1 consists of about 6 to 10 feet loam soil and silty clay. Alluvial sand and gravel deposits about 3 to 6 feet thick is considered as unit 2. A broken basalt zone, generally composed of basalt rubbles and highly fractured basalt rock with various thickness of 6 to 16 feet is recognized as unit 3. Unit 4 includes 45 to 110 feet of black, dense basalt with several soft or fractured zones. This unit is the interior of a basalt flow. Underlying the hard basalt is a flow contact zone with thickness of 1 to 5 feet. The flow contact zone, unit 5, is a major water-producing layer on the site.

(2) The sand and gravel layer (unit 2) has a relatively high hydraulic conductivity and appears to be connected hydraulically with the weathered and broken basalt (unit 3). These two layers act as a single aquifer and probably are hydraulically connected with Paradise Creek. Units 2 and 3 form the upper aquifer. The bottom of the upper aquifer occurs at a depth of

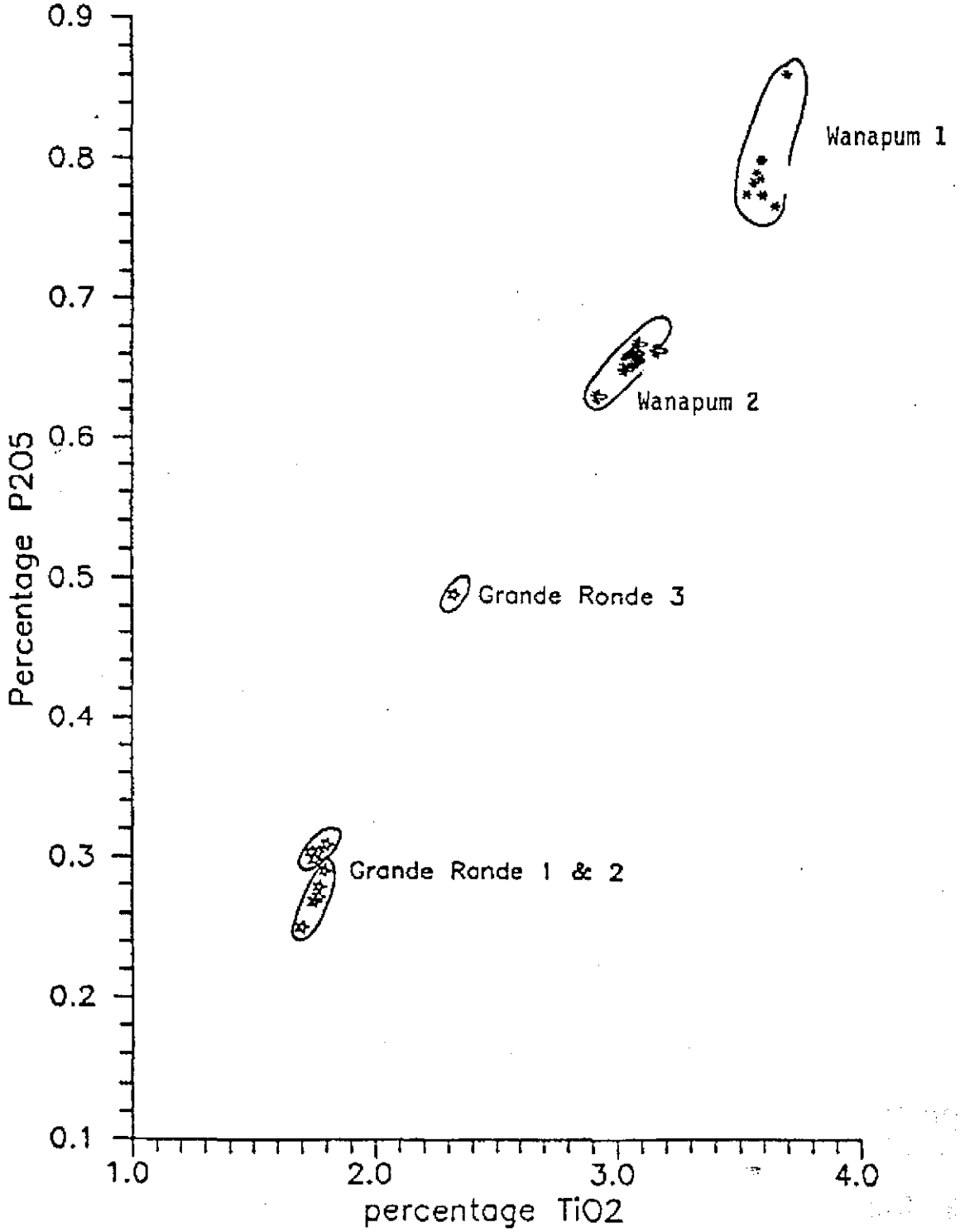


Figure 2. Basalt Chemistry, Percentage of TiO_2 and P_2O_5 of Wanapum and Grande Ronde Formations (modified from Wood, 1987)

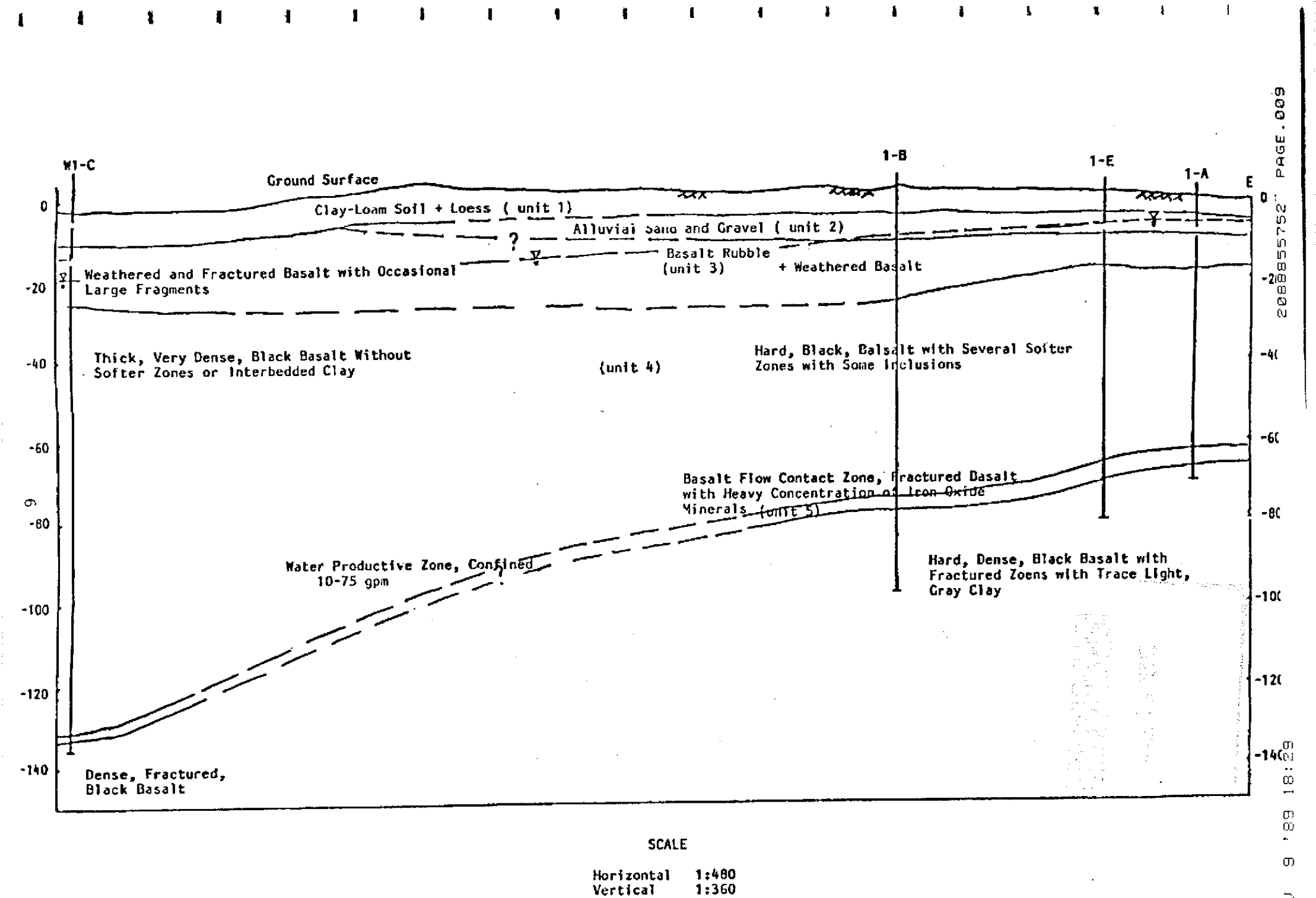


Figure 3. Cross-Section of Ground Water Research Site (GRS)

about 30 feet below ground surface. The lateral distribution of this aquifer limited to the east part of the GRS. The grain size and total thickness of the aquifer tend to decrease toward to the southwest. The aquifer disappears at the west end of the site, where well 1-C is located.

(3) The basalt flow contact zone (unit 5) forms the lower aquifer at the GRS. The aquifer lies at depths of 65 to 130 feet from ground surface and is approximately 1 to 5 feet in thickness. The lower aquifer is obviously confined with the hard basalt above it as the confining layer. The aquifer appears to dip to the southwest in an angle less than 10 degree.

(4) Both upper and lower aquifers are very heterogeneous and anisotropic due to complex fracture pattern of the basalt. Based on preliminary analysis of the pumping test data, transmissivity and storitivity of the aquifers generally decrease from the northeast to southwest.

(5) The basalt flow interior (unit 4) that forms the aquitard between the upper and lower aquifers contains 3 to 4 fracture zones. These fracture zones have low hydraulic conductivity but do hydraulically interconnected the upper and lower aquifers. The results of several pumping tests show that a leaky effect exists between the two aquifers. This vertical leaky condition plays an important role in recharge of the lower aquifers. However, these fracture zones do not appear to extend laterally in a great distance and were not logged within the hard basalt at the west end of the site.

III. WATER LEVEL DATA ANALYSIS

Ground Water Hydrograph

Ground water level has been continuously monitored at the five test wells since Dec. 28, 1987 and the two piezometers since April 15, 1988. Relative static water levels of the test wells and piezometers in the different seasons are shown in figure 4. The static water levels shown on the test wells 1-A, 1-B, 1-D and 1-E are average water levels of upper and lower aquifers. These wells are presently open to both aquifers. Piezometers P-1 and P-2 represent the unconfined aquifer which is directly available for recharge from downward infiltration from precipitation or from stream losses.

Well 1-C has the lowest static water level at all times of the year (figure 4). Two possible explanations are that: (a) static water level in well 1-C represents only the lower confined aquifer; or (b) ground water flow at the research site has a significant gradient to the west. Relative water levels from all the wells show that ground water flows generally from the northeast to southwest, which is consistent with the regional flow direction. However, 10 to 15 foot drop of water head in a horizontal distance of about 400 feet is probably too high for the natural ground water gradient in the basalt aquifers.

Figure 4 also shows that the water table of upper aquifer (piezometers) and static water levels in the test wells at the east part of site are lower than the water elevation of Paradise Creek throughout the year. The water level in well 1-C is significantly lower than the Creek elevation.

The changes of static water levels with time in the wells and piezometers are shown in figure 5, 6 and 7. Figure 5 shows static water level hydrographs of four test wells from Jan. 1988 to May 1989. The stage of Paradise Creek at the USGS station is also presented. Figure 6 shows the hydrograph for well 1-C. The hydrographs for the two piezometers are presented on figure 7. A semi-log plot of stream discharge versus time is presented in figure 8 for the period of January-September, 1988.

The basic characteristics of the hydrographs are:

(a) static water levels in the eastern part of the site (all the wells except 1-C) tend to have similar fluctuation patterns; the water level in the west end of the site (well 1-C) is about 10 to 15 feet lower than that in the east end for all period of the year.

(b) water levels in wells 1-A, 1-B, 1-D, and 1-E appear to increase amplitude of fluctuation in the

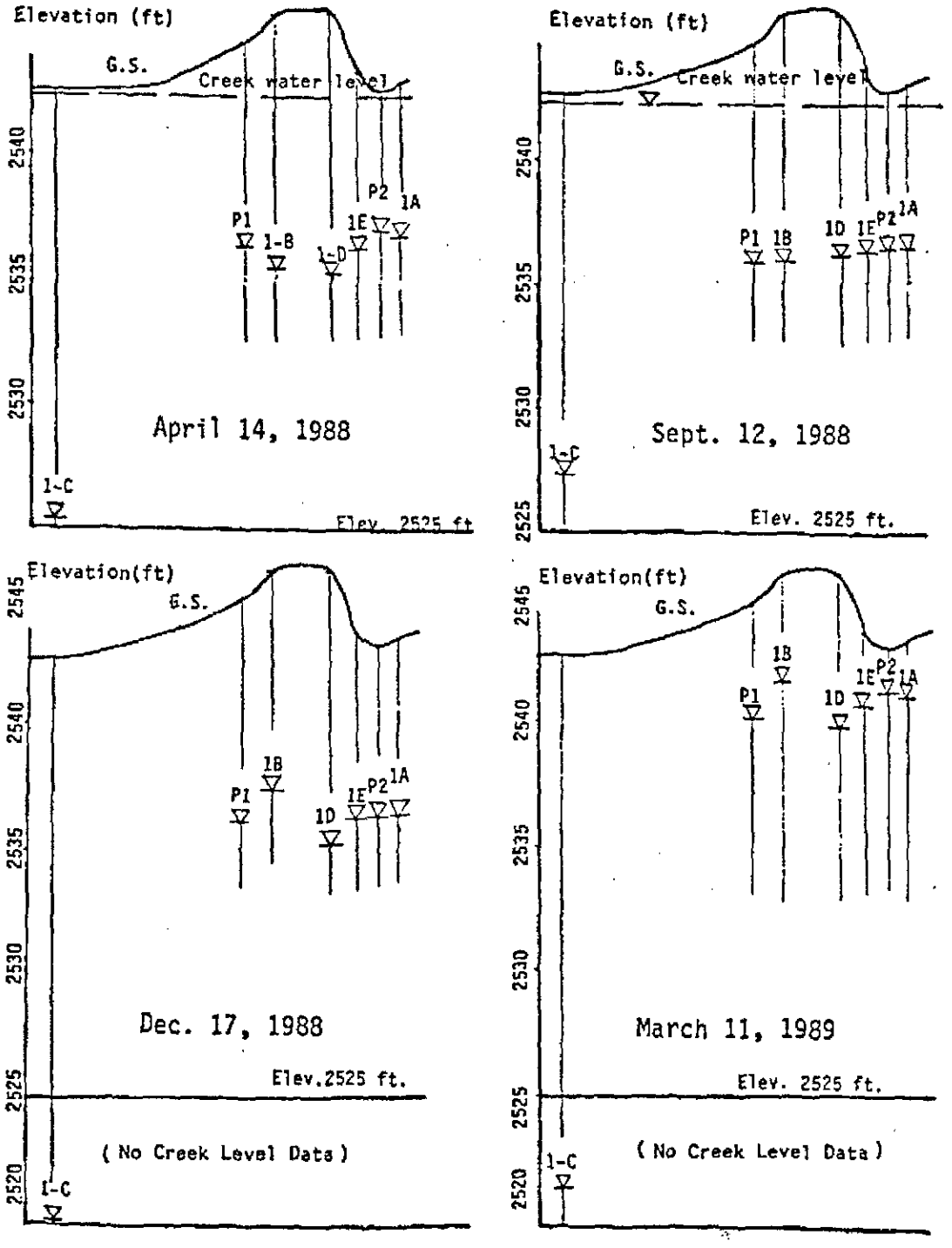


Figure 4. Relative Static Water Levels of Test Wells, Piezometers and Paradise Creek

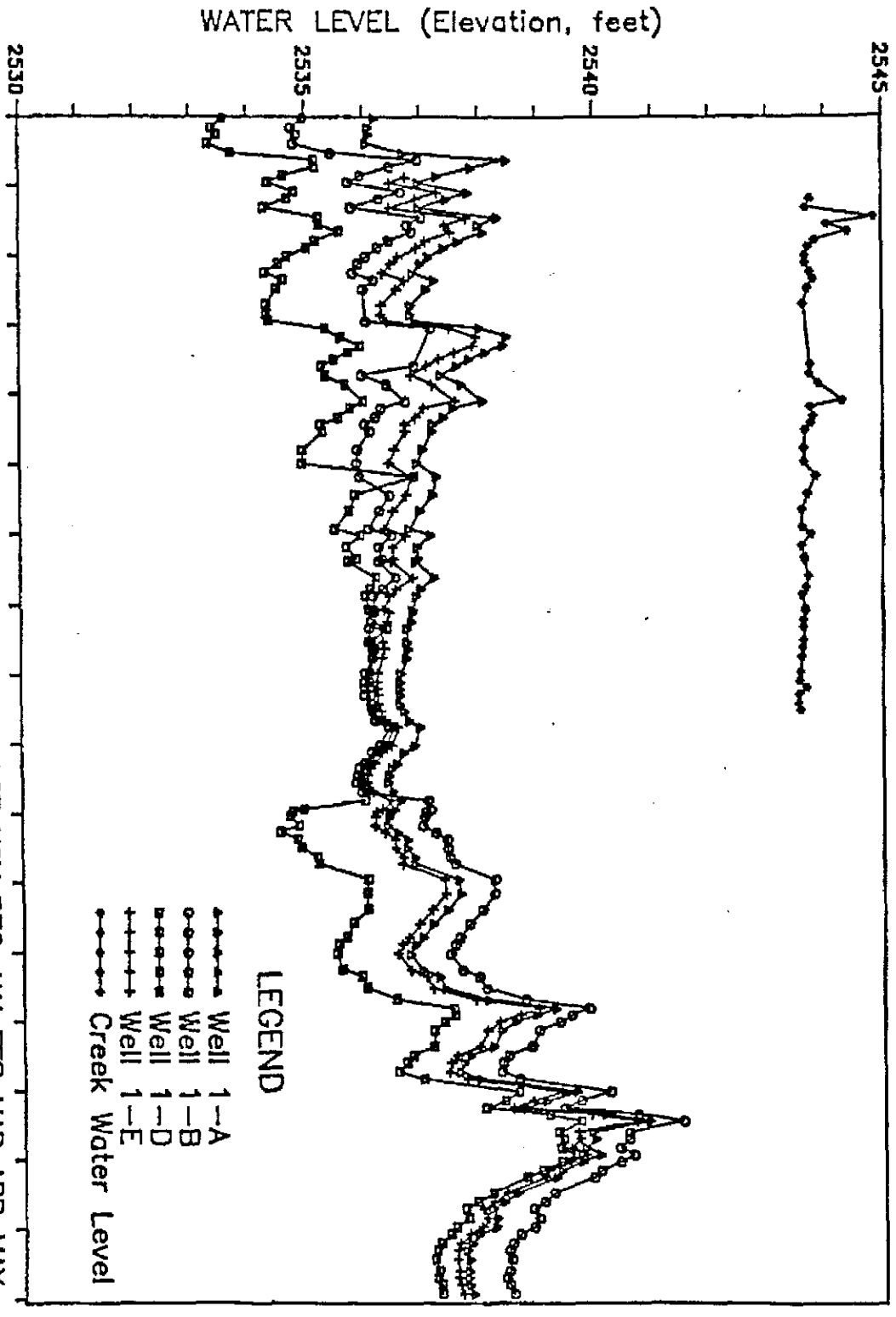


Figure 5. Water Level Records for Wells 1-A, 1-B, 1-D and 1-E Plus the Stage of Paradise Creek, GRS

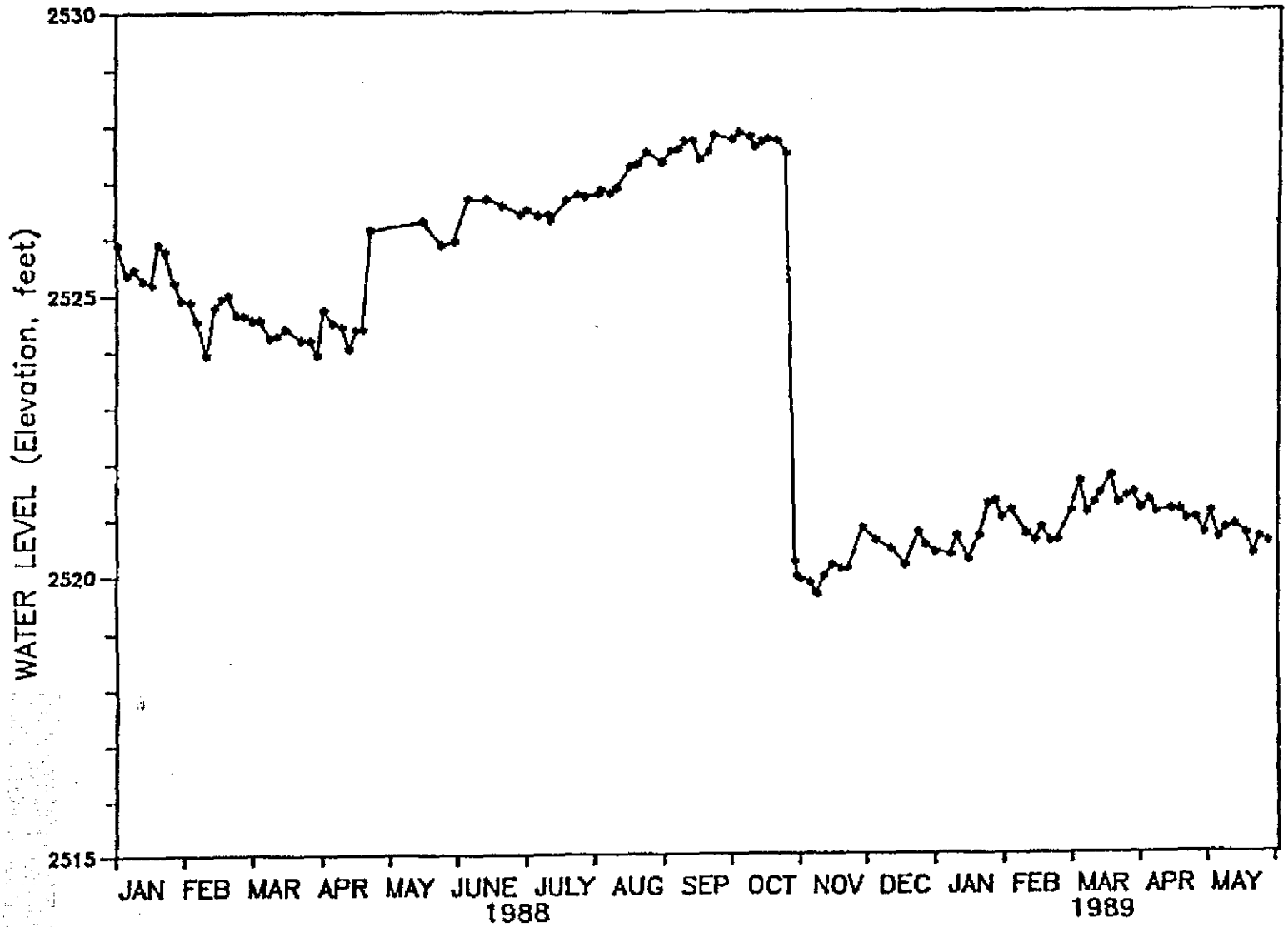


Figure 6. Water Level Record for Well 1-C, GRS

2088855752 PAGE.014
NOV 9 '89 10:32

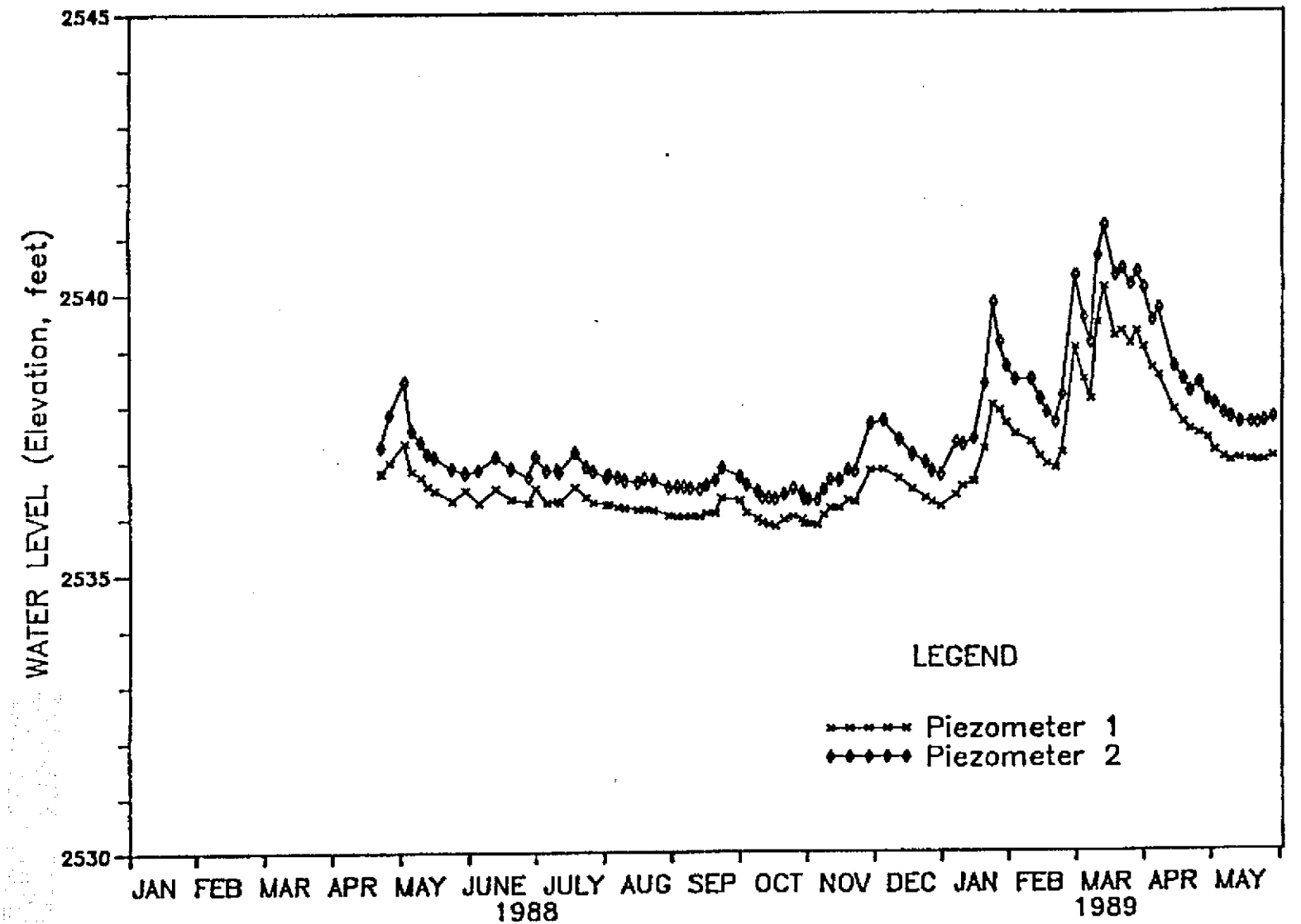


Figure 7. Water Level Records for Piezometer 1 and 2, GRS

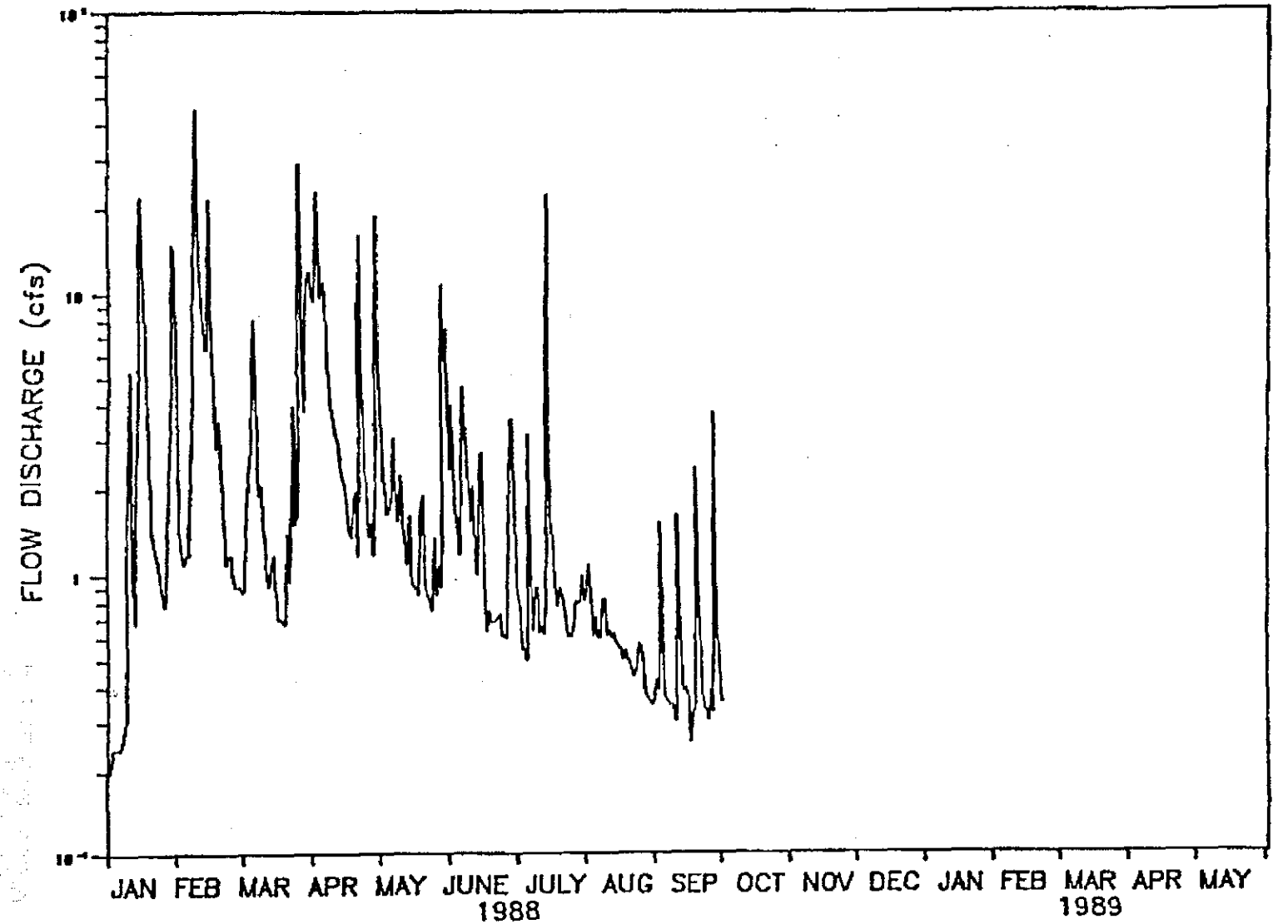


Figure 8. Semi-log Plot of Discharge versus Time for Paradise Creek at GRS, January-September, 1988

spring and to stabilize in the summer and fall without obvious decline;

(c) the hydrograph of well 1-C is significantly different from the other wells; the water level in well 1-C is quite stable during the winter, declines slightly in the spring, and keeps to be stable or slightly rises in the summer and fall; it shows 4 to 6 month time delay as compared to the other wells;

(d) static water levels within well 1-C are generally within 2 feet year around (except two abrupt rise and drop due to the pumping test and well construction); The water levels in other wells have the fluctuations of 3 to 5 feet during the period of record.

The water table levels from the piezometers follow each other very closely (figure 7). The general pattern of these hydrographs is similar to that of the test wells at the eastern part of the site. The piezometer hydrographs are closely correlated to precipitation of the palouse area and the flow of Paradise Creek. The hydrographs for the test wells located at the eastern part of the site similarly correspond with precipitation and streamflow.

Figures 5 and 6 show that there is a discontinuity in the hydrographs of wells 1-B, 1-D and 1-C on October 22, 1988. On this date, the water level of well 1-B rose abruptly about 1 foot while water levels of wells 1-D and 1-C dropped unexpectedly about 1 foot and 7 feet respectively. This was caused by the completion of well 1-B on October 21, 1988. Well 1-B was packed up from bottom to about 80 feet from ground surface with pea gravel, fine sand and bentonite chips in order to install the PVC liner to the open hole. It appears that backfill of lower part of well 1-B sealed part of fractures and reduced the direct connection between the upper and lower aquifers.

Ground Water Recharge and Discharge

Recharge and discharge of the aquifers can be understood from the water level hydrographs (figures 5, 6 and 7). Water levels in wells 1-A, 1-B and 1-E and two piezometers respond to rainfall and snowmelt events with a short time delay of several hours. Well 1-C generally has its water level change several days later. The range of water level change of well 1-C is significantly smaller than that in other wells. The upper aquifer obtains recharge directly from infiltration through the soil during the spring and from stream loss. Rainfall during the other seasons probably does not infiltrate through 6 to 10 feet soil profile to recharge the ground water system.

The lower basalt aquifer appears to get most of its recharge from downward leakage from the upper aquifer. The recharge from leakage is controlled by leaky condition of aquitards and water head difference of two aquifers.

The water level in the upper aquifer is lower than Paradise Creek throughout the year. Most of the stream recharge to the upper aquifer occurs during the peak flow period in the spring.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Basalt stratigraphy and hydrogeology are quite complicated at the GRS. Two aquifers have been identified. The upper aquifer, composed of sand, gravel and weathered basalt, is likely unconfined with a total thickness of 10 to 22 feet. The aquifer is directly below the loam soil and silty clay with its bottom at less than 30 feet from ground surface. It plays an important role in ground water recharge and has a close relation with the Paradise Creek. A basalt flow contact zone forms the lower aquifer. The aquifer is at depth of 65 to 130 feet with a thickness ranging from 1 to 5 feet. It is characterized with great heterogeneity and anisotropy. There are several horizontally extended fractures within the basalt flow interiors above the lower aquifer. These fractures may interconnect the two aquifers.

Hydrographs of the upper aquifer correspond closely with precipitation and with Paradise Creek; the lower aquifer also responds to recharge events. Recharge to the upper aquifer is mainly from infiltration of precipitation and leakage from Paradise Creek, primarily during the spring runoff. Discharge from the upper aquifer probably is to the lower aquifer. Recharge to the lower aquifer is from the upper aquifer.

Recommendations

(1) Hydrologic data collecting should continue at GRS. A longer data record will allow quantitative evaluation of well hydrographs as compared to streamflow.

(2) More hydraulic tests need to be conducted at the GRS for detailed characterization of the aquifer system in the site. Tracer tests should be conducted for understanding of solute transport characteristics of the aquifers.

(3) Completion of existing test wells is very important for further study and confirmation of hydrogeological models. Several of the existing wells interconnect the two aquifers.

REFERENCES

Bush, J. H., 1988, Personal Communication, Department of Geology, University of Idaho, Moscow, Idaho.

Freeze, R. A. and Cherry, J. A., 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, N. J., 604p.

Lohman, S. W., 1972, Groundwater Hydraulics, USGS. Professional Paper 708, 70p.

Smoot, J. L. and Ralston, D. R., 1987, Hydrogeology and A Mathematical Model of Groundwater Flow in the Pullman-Moscow Region, Washington and Idaho, Idaho Water Resources Research Institute Report, University of Idaho, Moscow, Idaho, 118p.

Swanson, D. A., Wright, T. L, Hooper, P. R., and Bentley, R. D., 1979, Revisions in Stratigraphic Nomenclature of the Columbia River Basalt Group, USGS Bulletin 1457-G, 59p.

Wood, T. R., 1987, The Hydrogeology of the Wanapum Basalt, Creston Study Area, Lincoln County, Washington., M. S. Thesis, Washington State University, Pullman, Washington, 166p.

HYDROGEOLOGY AND A MATHEMATICAL MODEL OF GROUND-WATER FLOW IN THE PULLMAN-MOSCOW REGION, WASHINGTON AND IDAHO

by

John Leach Smoot
Dale R. Ralston

Department of Geology

MICROFILMED
MAR 1 1988

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho 83843

April, 1987

Contents of this publication do not necessarily reflect the views and policies of the Idaho Water Resources Research Institute nor does mention of trade names or commercial products constitute their endorsement by the Idaho Water Resources Research Institute.

HYDROGEOLOGY AND A MATHEMATICAL MODEL OF GROUND-WATER FLOW IN THE PULLMAN-MOSCOW REGION, WASHINGTON AND IDAHO

by

John Leach Smoot
Dale R. Ralston

Department of Geology

In cooperation with:

Cities of Moscow, Idaho and Pullman, Washington
University of Idaho
Washington State University

U.S. Geological Survey
Water Resources Division
Tacoma, Washington

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho 83843

April, 1987

ABSTRACT

Increasing pumpage rates and declining ground-water levels in the Columbia River Basalts of the Pullman-Moscow area of Washington and Idaho indicate a need for ground-water management. A three-dimensional numerical computer model of ground-water flow is constructed to guide this management. Basalt aquifer thicknesses of 0 to 3500 feet are determined by a magnetotelluric geophysical survey in support of the study.

The model incorporates a Grande Ronde Basalt layer, a Wanapum Basalt layer, and an overlying surficial loess layer. A recharge rate of 139 cubic feet per second to the upper layer of the ground-water flow model is calculated using a recharge model developed by the U.S. Geological Survey. Ground-water discharge is modeled as stream inflow and seepage where a layer is incised by a river. Cross-sectional models distributed across the domain of the three-dimensional model along flow lines provide an efficient means of obtaining hydraulic coefficient input for the three-dimensional model. The three-dimensional model is calibrated using the time-average method and evaluated through a history match procedure. The model incorporates numerous assumptions and simplifications; model predictions therefore are indicative only of general trends for the future.

The model suggests that it is possible for ground-water levels to stabilize if ground-water pumpage stabilizes at a constant level. Ground-water level declines will continue into the foreseeable future as long as ground-water pumpage continues to increase.

SEP 19 1990

TABLE OF CONTENTS

	Page
ABSTRACT	ii
LIST OF FIGURES	v
LIST OF TABLES	vii
CHAPTER I. INTRODUCTION	1
Statement of the Problem	1
Purpose and Objectives	2
Geographic Setting	3
Location	3
Surface Water	3
Precipitation	5
Land Use	5
Previous Investigations	6
Barker Ground-Water Flow Model	7
CHAPTER II. HYDROGEOLOGY	10
Introduction	10
Geology	10
Water-Bearing Characteristics of Geologic Units	13
Ground-Water Flow System	15
Definition of Hydrostratigraphic Units	15
Recharge	21
Ground-Water Flow	21
Discharge	23
Ground-Water Pumpage	24
Water Level Declines	27
CHAPTER III. MODEL CONSTRUCTION	31
Introduction	31
Discretization of Space	32
Hydrostratigraphic Units	32
Boundary Conditions	35
Data Inputs	38
Hydraulic Properties of Hydrostratigraphic Units	38
Recharge Model	41
Hydraulic Connection of Ground Water With Rivers	45
Seepage Faces	46
Cross-Sectional Model Construction	47

MAR 18 1985

CHAPTER IV. MODEL CALIBRATION 52

Introduction 52
Cross-Sectional Model Calibration 53
Time-Averaged Three-Dimensional Model Calibration 57
Hydraulic Coefficients 58
Hydraulic Head Distribution 58
Water Budget Analysis of Time-Average Model 63
Evaluation of Time-Average Calibration 66

CHAPTER V. PREDICTIVE SCENARIOS 69

Introduction 69
Constant Pumpage Scenarios 70
Pumpage at 100 Percent of 1985 Level 70
Pumpage at 125 Percent of 1985 Level 72
Pumpage at 200 Percent of 1985 Level 73
Increasing Pumpage Rate Scenarios 73
Pumpage Increase at 1 Percent Per Year 73
Pumpage Increase at 2 Percent Per Year 74
Pumpage Increase at 3 Percent Per Year 74
Limitations of Model Predictions 75
Implications of Findings on Ground Water as a Resource Base 76

CHAPTER VI. CONCLUSIONS AND RECOMMENDATIONS 78

Conclusions 78
Recommendations 79

REFERENCES CITED 81

APPENDIX A. THREE-DIMENSIONAL MODEL INPUT AND OUTPUT PROCESSOR SOFTWARE 86

APPENDIX B. WELL NUMBERING SYSTEMS OF WASHINGTON AND IDAHO 110

APPENDIX C. WELL DATA AND MASS WATER LEVEL MEASUREMENTS 113

LIST OF FIGURES

Figure		Page
1	Location of Pullman-Moscow region	4
2	Location of the previous ground-water flow model by Barker	8
3	Stratigraphy and water bearing characteristics of the geologic units in the Pullman-Moscow region	14
4	Structural contour map of the top of the Wanapum Basalt Formation	16
5	Structural contour map of the top of the Grande Ronde Basalt Formation	17
6	Thickness of the basalt	19
7	Structural contour map of the top of the crystalline basement rocks	20
8	Three-dimensional perspective of the layered aquifer system	22
9	Streamflow measurements, October, 1984	25
10	Plot of five-year averages of total pumpage for major wells operated by Pullman, Moscow, Washington State University, and the University of Idaho	26
11	Hydrographs of recent ground-water level declines at Moscow and Pullman	28
12	Water level decline in the Grande Ronde Basalt Formation, 1974-85	29
13	Location and orientation of the model grid	33
14	Idealized cross-section through the Pullman-Moscow area	34
15	Boundary conditions imposed on the basalt hydrostratigraphic units of the three-dimensional model	36

16 Areal distribution of recharge to the upper layer of the three-dimensional ground-water flow model 44

17 Location of cross-sectional models in the domain of the three-dimensional model 49

18 Construction of cross-sectional models: a) layering, b) zonation 50

19 Calibrated cross-sectional model B-B': a) calibrated hydraulic conductivity distribution, b) calibrated hydraulic head distribution 55

20 Grande Ronde Basalt Formation horizontal hydraulic conductivity distribution that honors the cross-sectional model calibration and the time-average three-dimensional model calibration 59

21 Calibrated distribution of hydraulic head for the Wanapum Basalt Formation 60

22 Calibrated distribution of hydraulic head for the Grande Ronde Basalt Formation 62

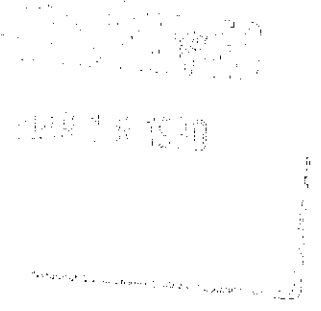
23 Layer fluxes in the three-dimensional model 65

24 History match evaluation of the calibrated model results for the Grande Ronde Basalt Formation 68

25 Future ground-water level projections for Pullman and Moscow 71

LIST OF TABLES

Table		Page
1	Average Monthly Precipitation for Moscow and Pullman	5
2	Hydraulic Coefficients	40
3	Water Budget of Time-Average Model	64
4	Discharge From Model to Rivers	66
5	Pumpage Projection Scenarios for 1990 and 2000	70



CHAPTER I

INTRODUCTION

Statement of the Problem

The Pullman-Moscow area of northern Idaho and eastern Washington depends on ground water as the principal source of water. Primary pumpage occurs from the Miocene Grande Ronde Formation of the Yakima Basalt Subgroup and associated interbedded sediments. Water levels in wells in the deeper basalts have declined slowly but steadily since the wells were first drilled. The presence of the cities of Moscow, Idaho and Pullman, Washington, as well as the University of Idaho and Washington State University, implies a steady demand for ground water in the future.

The water supply in the region has long been a concern. The trend in recent years has been toward the development of mathematical models to simulate the ground-water system. These efforts began with the image well model of Jones and Ross (1969). Later modeling was conducted by Barker (1979). Barker's model underpredicted water level declines in the area; Barker's water levels predicted for the year 2000 were reached in 1985.

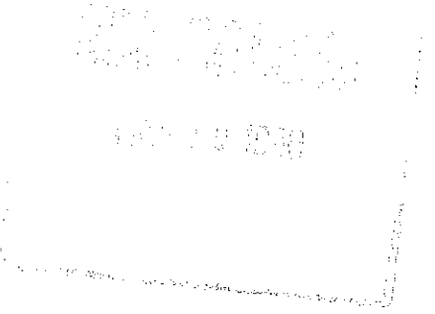
Representatives of the two universities, the two cities, the Washington State Department of Ecology, and the United States Geological Survey met in 1984 to discuss the area's water problems. The group acknowledged the deficiency in knowledge of the system and the need for a predictive tool to guide future management decisions. As a result, municipal and university officials entered into an agreement with the

United States Geological Survey to help support the present effort to construct a new model of the Pullman-Moscow area. The study plan included the collection of additional hydrogeologic data. A critical part of the study was a magnetotelluric geophysical survey to delineate the thickness of the basalt aquifer in the basin. Hydrogeologic data were input into an updated version of the U.S. Geological Survey modular model that was applied to the basin. The model was used to predict future water level behavior under various pumping scenarios. This report presents the details of field data collection, model construction, model operation, and an analysis of results.

Purpose and Objectives

The purpose of this study is to develop and construct a numerical ground-water model to be utilized to guide ground-water management in the Pullman-Moscow region. The general approach was to construct, calibrate, and operate a numerical model of the ground-water system in the Pullman-Moscow basin. Specific objectives include:

1) Discuss the hydrogeology of the Pullman-Moscow area.
2) Define data needs and collect of data for the digital model.
3) Construct and calibrate the digital model.
4) Operate the model under various management plans, evaluate their impacts, and evaluate the potential for future ground-water use and development based on model results.



Geographic Setting

Location

The Pullman-Moscow region is located in Whitman County, Washington and Latah County, Idaho (fig. 1). The area is located near the edge of the Columbia Plateau within the Palouse subprovince. The city of Pullman, Washington is about 85 miles south of Spokane, Washington.

Surface Water

The Snake River is the main surface water body in the region. No other large surface water bodies exist within the basin. The U.S. Army Corps of Engineers operates Lower Granite Lock and Dam southwest of Pullman. Pool elevation upstream from the dam is 740 feet above sea level. Average annual discharge through the dam for the years 1978 to 1984 was 57,500 cubic feet per second (Blazs, personal communication, 1986). The Palouse River is the only other major river; its average annual discharge at Colfax, Washington for the period 1964 to 1984 was 394 cubic feet per second (Blazs, personal communication, 1986).

Several perennial streams drain the area in addition to the Snake and Palouse Rivers. These include the South Fork of the Palouse River, Paradise Creek, Fourmile Creek, and Union Flat Creek (fig. 1). Streamflow measurements indicate that these streams gain or lose water from the ground-water system, depending on location and stream stage. A small amount of lawn and pasture irrigation is derived from these streams. The upper reaches of these streams flow on the loessial soils of the basin, whereas the lower reaches are incised into the basalt bedrock.

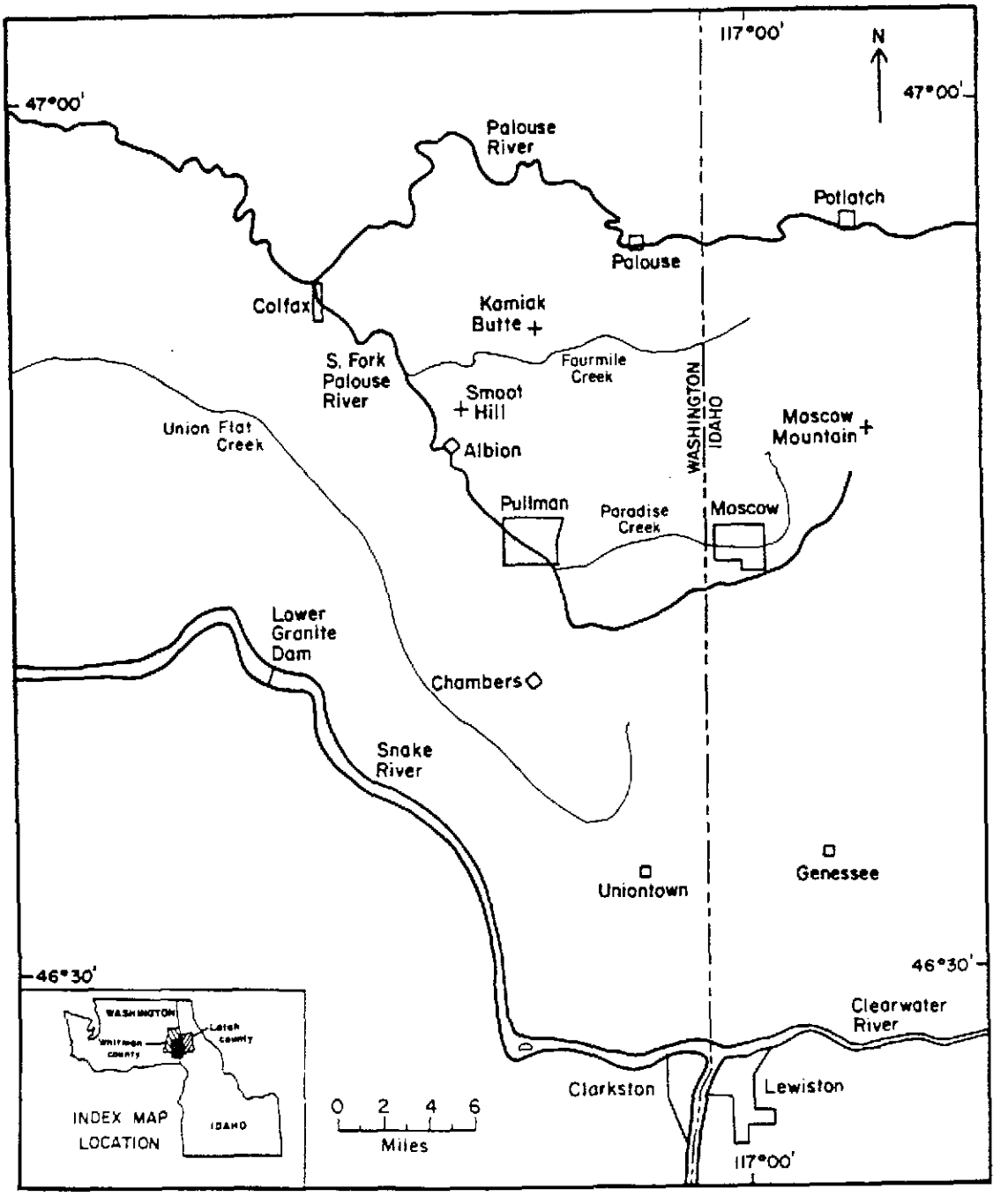


Figure 1. Location of Pullman-Moscow region.

Precipitation

Long term records indicate an average annual precipitation of 24 inches in Moscow and 22 inches in Pullman (HISARS, 1986). Precipitation may be more than double this amount in the highlands east of Moscow because of orographic effects. Precipitation falling on the basin generally is low intensity and seasonal. About 65% of the precipitation falls during the months of November through April followed by dry conditions during the summer. Table 1 shows long-term average monthly conditions for Pullman and Moscow.

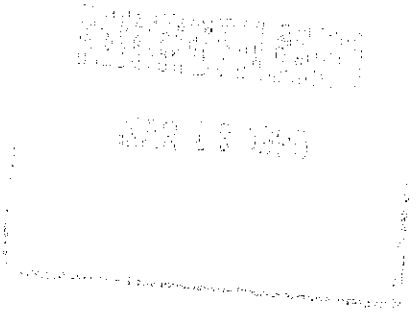
Table 1. Average Monthly Precipitation for Moscow and Pullman (Inches).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Moscow+	3.2	2.1	2.0	2.0	2.0	1.7	0.7	1.1	1.1	1.8	3.0	3.3
Pullman*	3.1	2.1	2.1	1.6	1.5	1.6	0.5	1.0	1.1	1.7	2.8	3.1

+1951-1980. (HISARS, 1986)
*1956-1977.

Land Use

Dryland farming constitutes the major land use within the basin. The primary crops are wheat, peas and lentils. Rainfall is ample for the crops because the large soil moisture storage capacity carries the crops through the dry summer; no irrigated agriculture exists. The urban areas of Moscow and Pullman account for only a few percent of the land use within the basin.



Previous Investigations

Eyck and Warnick (1984) provide a comprehensive listing of documents that deal with ground water and water supply in the Pullman-Moscow area. Ground-water investigations in the Pullman-Moscow region began in the late 1800's. Russell (1897) makes the initial hydrogeologic reconnaissance of the area. DeMotte and Miles (1933) incorrectly postulate the independence of the Moscow and Pullman aquifer systems. Foxworthy and Washburn (1963) and Walters and Glancy (1969) constitute two of the most significant works on the basic hydrogeology of the area.

Foxworthy and Washburn (1963), Ross (1965), Ringe (1968), Brown (1976), and Cotton (1982) provide discussions of the geology of the area. Swanson and others (1979) discuss the stratigraphy and geology of the Columbia River Basalt Group. Swanson and others (1980) and Hooper and Webster (1982) provide surficial geologic maps of the area. Ross (1965), Jones and Ross (1972), Crosthwaite (1975), and Barker (1979) provide information on wells and water levels in the basin. Bauer and others (1985) show the regional ground-water levels in the basalt. Williams and Allman (1969) discuss mechanisms for recharge and infiltration in the surficial loessial soils. Jones and Ross (1972) and Barker (1979) conducted the previous ground-water modeling studies.

The theory of the magnetotelluric geophysical technique used in this study is described by Vozoff (1972). Instrumentation and field procedures are described by Stanley and Frederick (1979) and Stanley and Tinkler (1982). Klein and Sneddon (1985) discuss the preliminary results of the magnetotelluric survey; Klein and others (1987) prepared the final report on the magnetotelluric investigation. Bockius (1985) conducts a

magnetic geophysical survey to better delineate the buried basalt-granite contact in the Idaho portion of the basin.

Barker Ground-Water Flow Model

Barker (1979) models the basalt aquifer in the region under the support of the United States Geological Survey. A computer program written by Pinder (1971) constitutes the basis for his two-dimensional, finite-difference model of the basalt aquifer. The model covers an area within a radius of about 8 miles of Pullman (fig. 2). The edge of the basalt flows form much of the model boundary, with Union Flat Creek forming the western boundary.

Barker's modeled aquifer consists of what he termed the "primary aquifer system". This corresponds to what has since been termed the Grande Ronde Basalt Formation. The Grande Ronde Basalt constitutes most of the basalt in the model area and is the primary supplier of water to wells. The much thinner overlying Wanapum Basalt Formation is not included as part of Barker's "primary aquifer system".

Barker (1979, p. 105) lists several problems with his model. He notes that inaccurate pumpage records could lead to inaccurate predictions of drawdown, because water level declines are related directly to pumpage rates. Barker questions the accuracy of his pumpage information. He also indicates the possibility of inaccuracy in his storativity value of 5×10^{-3}, particularly with respect to the potential change from confined to unconfined storativity in the future.

Recent water level records indicate that Barker's model is not a good tool for water level predictions. The model predicts declining

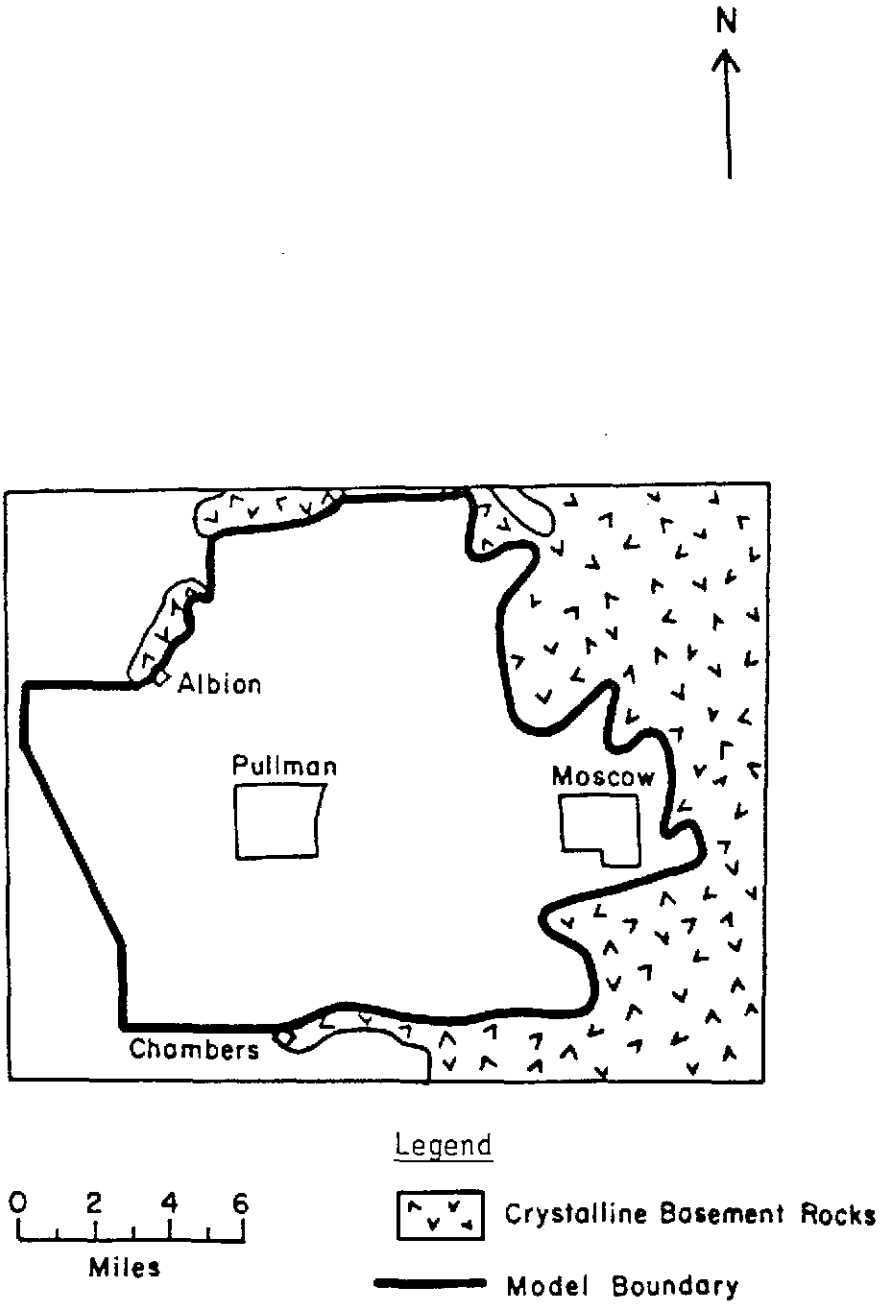


Figure 2. Location of the previous ground-water flow model by Barker (modified from Barker, 1979).

water levels in the deep Grande Ronde Basalt aquifer through the year 2000. By 1985, actual water levels in Moscow and Pullman had dropped below levels predicted for the year 2000. This error may be explained partially by Barker's perceived inaccuracies of pumpage and storativity; however, the discrepancy may be more the result of problems with his conceptual model of the ground-water flow system.

Barker uses local water level information to assume that Union Flat Creek west of Pullman is a hydrogeologic boundary. This assumption implies that the stream channel fully penetrates the aquifer and can be replaced in the mathematical model by a constant head boundary. Barker's results indicate that the flux from this constant head boundary is the major source of water for pumpage in the model. Data collected since Barker's work indicate that the Snake River rather than Union Flat Creek is the regional hydrogeologic boundary on the southwestern side of the region.

MICROFILMED
MAR 19 1990

CHAPTER II

HYDROGEOLOGY

Introduction

The occurrence and movement of ground water in the Pullman-Moscow region is dependent on the hydrogeology of the region, including the nature of the geologic units and their water bearing characteristics, as well as recharge to and discharge from the ground-water system. The development of a conceptual model that integrates all hydrogeologic information is an essential step in understanding the basin. The impacts of pumpage in a ground-water basin can be investigated through an understanding of the hydrogeologic framework of the system. The hydrogeologic framework is the integration of geologic and hydrologic information that describes water flow within the subsurface.

Geology

The Pullman-Moscow area consists of an irregular buried surface of pre-Tertiary crystalline rocks overlain by Columbia River basalts and interbeds that are capped by Pleistocene loess. The crystalline basement rocks primarily are granites, although some metamorphic rocks occur in the northern part of the basin. The granites are Cretaceous in age and appear to be related to the Idaho Batholith.

Miocene basalts interbedded with sediments overlie the crystalline rocks. Basaltic lava was extruded from fissures located near Pullman and elsewhere in southeastern Washington and northeastern Oregon (Bush, personal communication, 1987). A series of eruptions over millions of

MICROFILMED

MAR 19 1990

Note microfilmed # Sel file #

Retain rest of applicants Exhibit #1

years produced the layers that make up the existing basalt sequence. The thickness of the layers or flows averages 40 to 80 feet, although layers 200 feet thick have been observed.

Basalt flows fracture at the surface as they cool from the molten state. Three sets of joints commonly occur; two are in the vertical direction and one is in the horizontal direction. Columnar hexagonal joints that form columns 0.5 to 6 feet in width and blocky joints about 0.5 feet in diameter occur in the vertical direction (Newcomb, 1965, p. 19). Platy fractures occur in the horizontal direction. In addition, regional fractures hundreds or thousands of feet long may intersect several flows.

The basalt flows in the Pullman-Moscow basin are classified into the Wanapum and Grande Ronde Formations of the Yakima Basalt Subgroup of the Columbia River Basalt Group (Swanson and others, 1979). Wanapum and Grande Ronde Basalt may be differentiated geochemically by their magnesium and titanium concentrations. Wanapum Basalt tends to be high in titanium and low in magnesium concentrations, whereas Grande Ronde Basalt tends to have high magnesium concentrations and low titanium concentrations. The Wanapum Basalt is separated from the Grande Ronde Basalt by the Vantage Member (interbed) of the Ellensburg Formation. The Vantage Member is composed of siltstone, claystone, and tuffaceous rocks (Swanson and others, 1979, p. 25).

Numerous sedimentary interbeds like the Vantage Member commonly are mixed with the basalt, particularly near the margins of the Columbia Plateau. Basalt flows are known to have dammed streams that existed during the eruption process. The dams produced lakes where sediment

deposition occurred. Soils also may have formed on the interbeds or on the basalt surfaces. Subsequent lava flows may have covered the sediments and created new lakes.

Interbeds commonly are encountered during well drilling near Moscow and Pullman. Lithologies include clays, sands, and gravels. Laterally the interbeds tend to thin and become finer to the west, but their spatial distribution has not been mapped adequately. Some driller's logs for wells east of Moscow report hundreds of feet of clay. Examination of the clays reveals both lateritic and swelling clays. Lateritic clays probably derive from soils whereas swelling clays probably derive from lake bed deposits.

Little structural deformation of the basalt flows has been detected in the Pullman-Moscow area. Foxworthy and Washburn (1963) note the possibility of broad flexures in the basalt. Some subsidence appears to have occurred to the west (Brown, 1976). The basalts generally dip a few degrees to the northwest. Cross-sections by Brown do not reveal any structure other than the regional dip. The dip increases northwest of Pullman (Walters and Glancy, 1969). This increase may be the result of greater subsidence in that area. The basalts dip in the reverse direction in the Idaho portion of the basin. This reversal may be the result of compaction of clay interbeds due to loading by overlying basalt flows.

Pleistocene loess covers the relatively flat surface of the Wanapum Basalt Formation. The loess originated in the Pasco Basin of Washington. Loess deposition occurred as large dunes which form the present topography. Thicknesses of the loess range from several hundred feet to

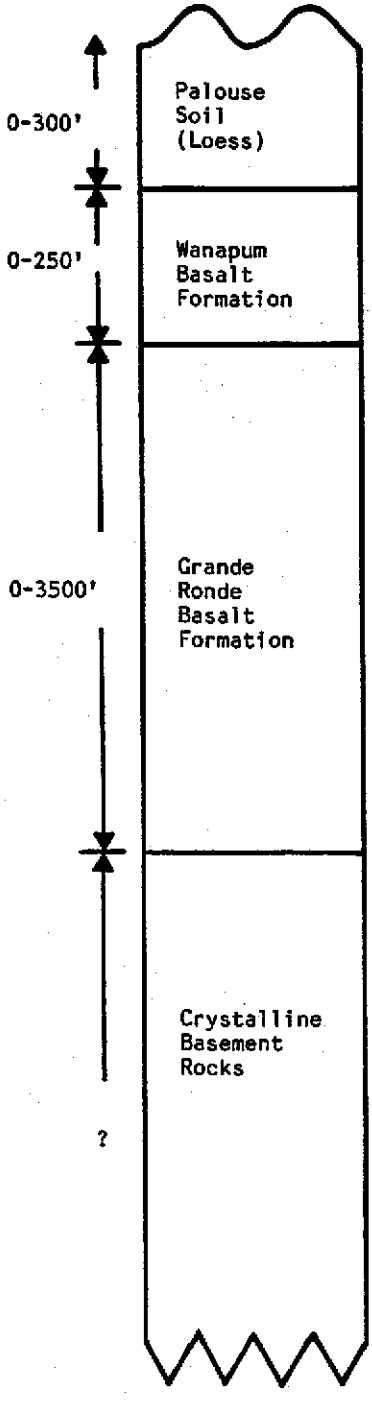
zero where streams penetrate through to the underlying basalt. Large thicknesses correspond to the crests of the loessial dunes. The loess is fine-grained and contains a well-developed silt-loam soil that plays a major role in subsequent discussion of ground-water recharge and discharge.

Water-Bearing Characteristics of Geologic Units

The loess, basalt, crystalline, and metamorphic rocks all contain sufficient saturated permeable material to yield water to wells and springs (fig. 3). The loess has a high water holding capacity. Unconfined ground water occurs in the loess with the water table conforming roughly to the topography (Williams and Allman, 1969). Water levels fluctuate in response to the annual wet and dry cycle of precipitation. Water availability within the loess is sufficient for stock and domestic purposes. Small springs are common in the loess, particularly along stream valleys at the contact of the loess and underlying Wanapum basalt.

Basalts constitute the major producing aquifers in the basin. Most of the water occurs in the fractured zones between the basalt flows. Wells that penetrate one or more of these zones are the best producers. The deepest wells are at Moscow; they fully penetrate the basalt flows into the underlying crystalline rocks. Near Moscow, sandy interbeds can be a significant source of water.

The crystalline and metamorphic rocks underlying the basalt can be assumed to have negligible permeability. They generally yield small quantities of water for domestic use and for stock watering along the



WATER BEARING CHARACTERISTICS

Local stock and domestic supplies via wells and springs (less than 30 gallons per minute).

Most rural domestic wells; older municipal wells (less than 1500 gallons per minute).

Major municipal supplier (less than 3000 gallons per minute).

Local domestic supplies from wells (less than 20 gallons per minute).

Figure 3. Stratigraphy and water bearing characteristics of the geologic units in the Pullman-Moscow region.

eastern margin of the basin; however a few prolific wells do exist in these rocks.

Ground-Water Flow System

Definition of Hydrostratigraphic Units

Three hydrostratigraphic units are delineated based on the correlation of hydrogeologic properties with mappable geologic units. The eolian Palouse soil overlies unconformably the Wanapum Basalt. The contact between the Wanapum Basalt Formation and the Grande Ronde Basalt Formation was determined from borehole sample geochemistry and maps of surface exposures. The large thickness of Grande Ronde Basalt was not subdivided for several reasons. First, a logical division that could be mapped does not exist in the Grande Ronde Basalt; the available field data simply do not support more detailed hydrostratigraphy. Second, the inclusion of four or more layers is not believed to be justifiable for this study.

Structural contour maps that describe the topography of the top surface of the Wanapum Basalt Formation and Grande Ronde Basalt Formation are shown in figures 4 and 5. These maps incorporate available literature, surface outcrop, and borehole geochemistry data. Both maps reveal the regional dip of the basalts to the northwest.

A magnetotelluric investigation of the Pullman-Moscow area (Klein and others, 1987) was done in support of the modeling effort in order to help define the hydrogeologic framework. This geophysical technique identifies the depth to electrical basement, which is considered to be the contact between the Grande Ronde Basalt and crystalline rocks at

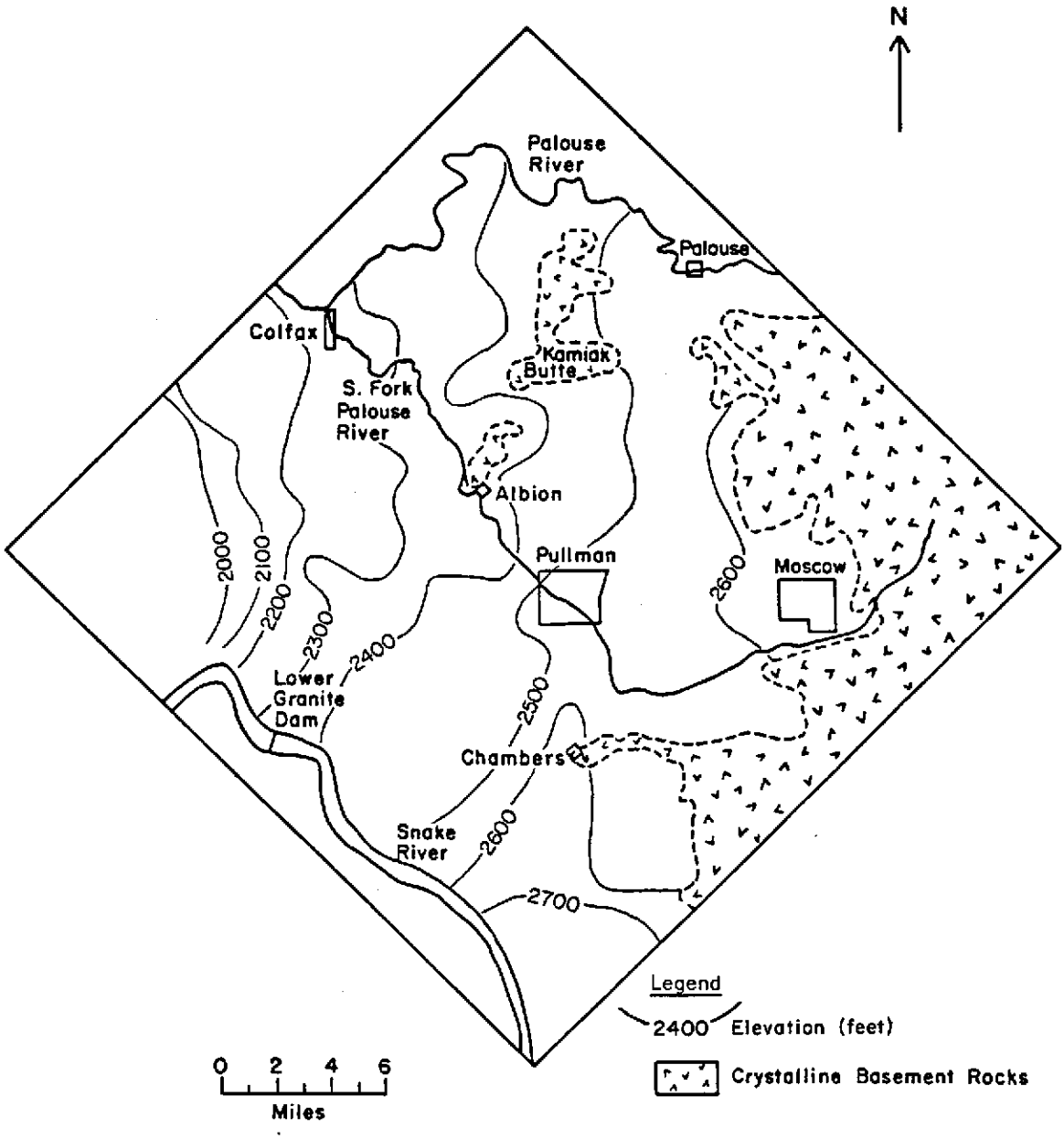


Figure 4. Structural contour map of the top of the Wanapum Basalt Formation (modified from Ringe, 1968).

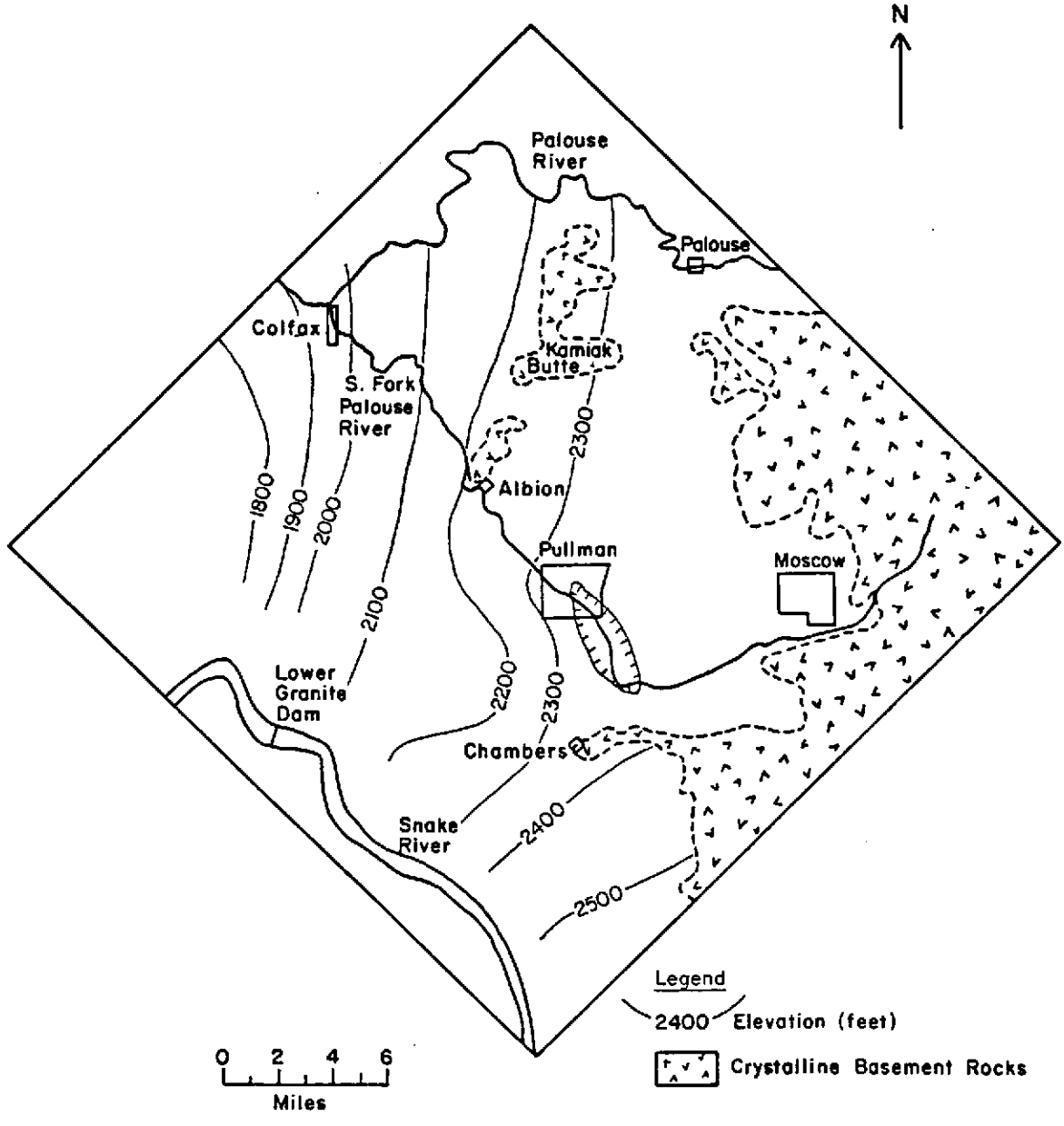


Figure 5. Structural contour map of the top of the Grande Ronde Basalt Formation.

depth. This contact defines the lower limit of the aquifer in the Pullman-Moscow region. Twenty-four magnetotelluric soundings were obtained distributed uniformly across the basin. The first sounding was taken east of Moscow to determine the characteristics of the crystalline rocks. The second sounding was taken near Moscow well 9, which completely penetrates through the basalt, to check the characteristics of a known thickness of basalt. The work at the rest of the soundings incorporated this information.

The final product of the soundings is a contour map of basalt thickness (fig. 6). The total thickness of the basalt is about 1,300 feet at Moscow and 2,000 feet at Pullman. A zone between Moscow and Pullman has a thickness greater than 2,000 feet. The basalt thickens significantly to the northwest where thicknesses are in excess of 3,000 feet.

A map of the elevation of the basalt-crystalline rock contact is derived by subtracting the thickness map from the map of the upper Wanapum surface (fig. 7). This procedure provides another tool for viewing the results of the magnetotelluric investigation. The internal basement low shown on figure 7 may be a result of sounding spacing and location.

The structural contour maps and the surface topographic map define the three hydrostratigraphic units that comprise the hydrogeologic framework. Land surface and the top of the Wanapum Formation define the thickness of the loess unit. The top of the Wanapum Formation and the top of the Grande Ronde Formation define the thickness of the Wanapum Basalt unit. The top of the Grande Ronde Formation and the crystalline

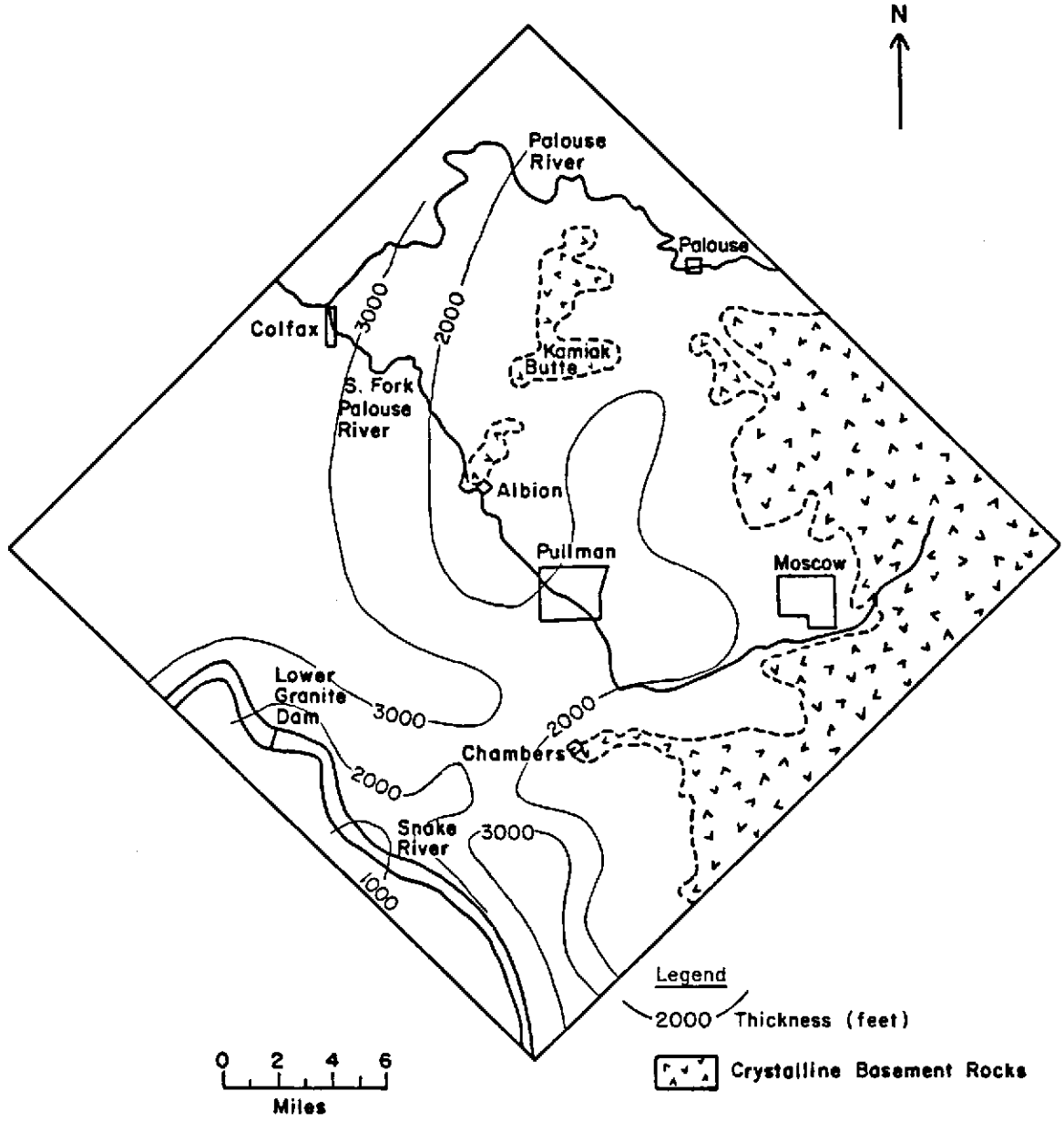


Figure 6. Thickness of the basalt (modified from Klein and others, 1987).

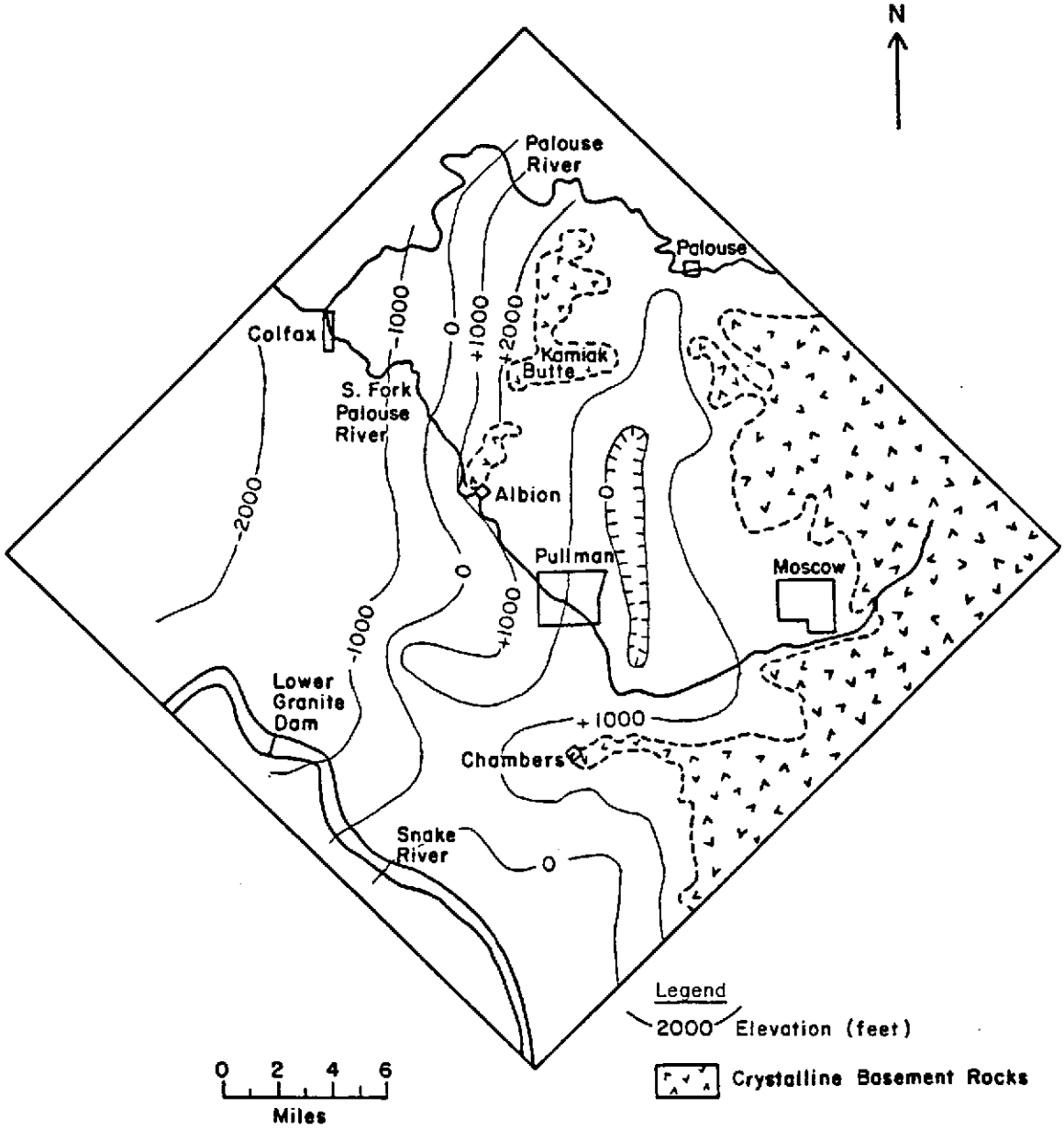


Figure 7. Structural contour map of the top of the crystalline basement rocks.

rock contact define the thickness of the Grande Ronde Basalt unit. The perspective view in figure 8 shows the relative thickness of each layer (not to scale). The Snake River Canyon cuts through the upper two layers and much of the third.

Recharge

Most of the recharge to the ground-water system appears to occur from infiltration of precipitation through the surficial loess. Water levels in the unconfined aquifer in the loess are responsive to seasonal fluctuations of precipitation; water levels indicate that recharge to the loess occurs during the late fall, winter, and spring when high precipitation and little evapotranspiration occur simultaneously. High intensity, low duration precipitation events may produce recharge at other times of the year. Extensive long-term cultivation by heavy machinery may have created a low permeability zone beneath the ploughed horizon in the soil (Williams, personal communication, 1985). Williams and Allman (1969) indicate that bioturbation is an important mechanism in infiltration through the loess. Observations by Williams suggest that maximum recharge through the loess occurs in low areas where the relief is most gentle. Surface runoff and shallow subsurface lateral flow accumulates in these areas during spring snow melt (Williams, personal communication, 1985).

Ground-Water Flow

Ground water in the Pullman-Moscow region appears to flow generally to the west. Maps by Bauer and others (1985) reveal that ground water flows toward the Snake River from both sides of the river. This

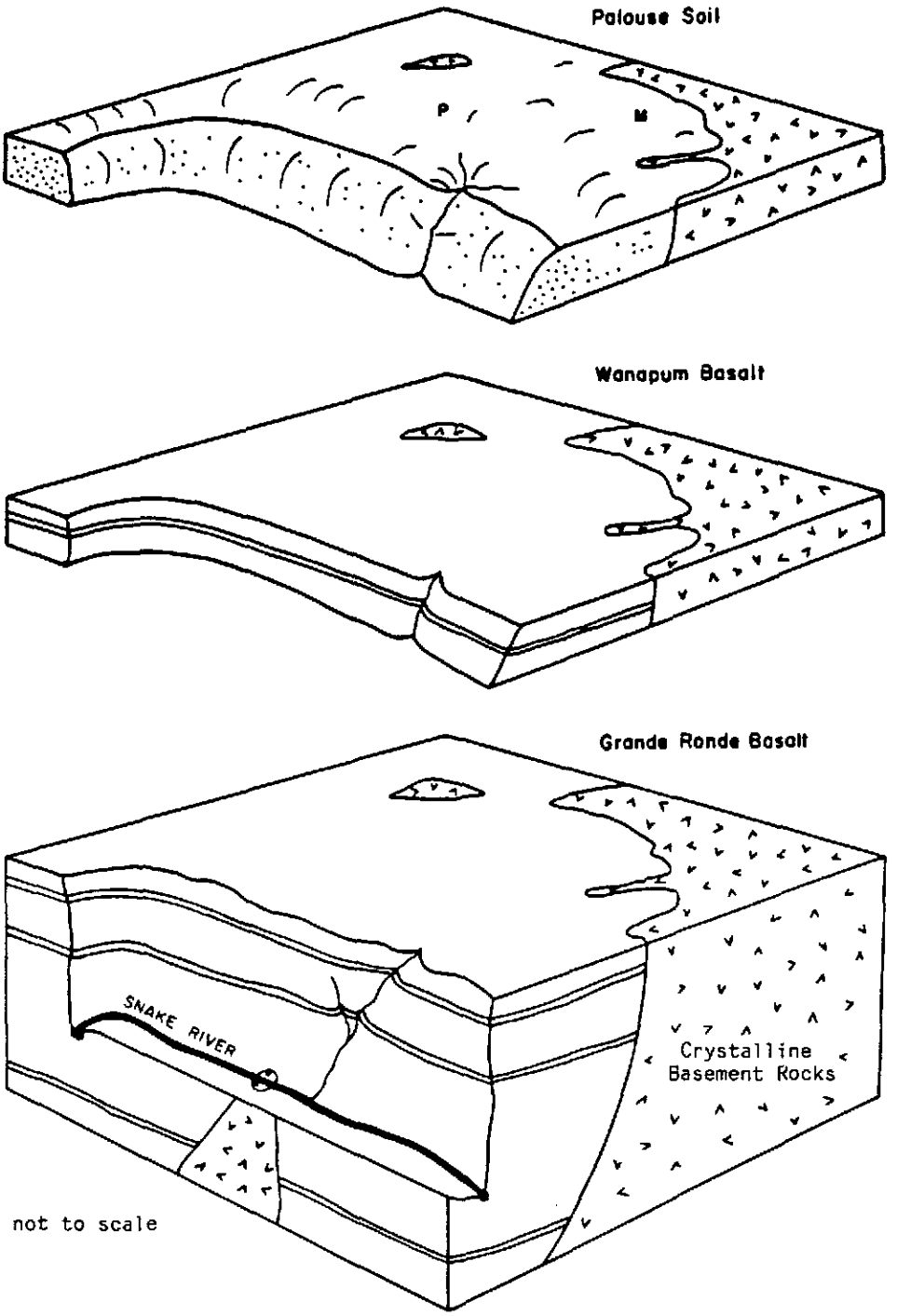


Figure 8. Three-dimensional perspective of the layered aquifer system.

observation is in agreement with the earliest recorded water level measurements by Russell (1897), which indicate a gradient from Moscow to Pullman. Water levels currently are lower in the Grande Ronde Basalt than in the Wanapum Basalt and loess. Wells in the Grande Ronde Basalt along the Snake River have water levels similar to river stage. Water levels in the deepest wells in the basin near Moscow have water levels about 1500 feet higher than the river.

The basalt flow interiors and fine-grained sedimentary interbeds are important controls on the vertical movement of ground water. Thinner fractured basalt flow interiors would be expected to permit significant downward movement of water. Thicker basalt flows have more massive centers that probably impede flow. Lenses of sticky clay may limit the downward movement of water. The magnitude of such vertical leakage is dependent on the areal extent, thickness, and continuity of the lenses. More vertical leakage may occur as the percentage of coarse-grained material in the interbeds increases.

Discharge

The Snake River appears to be the regional ground-water discharge area in the Moscow-Pullman region. Ground water flowing toward the river may discharge as small streams, springs, and seeps along the canyon wall, or it may discharge directly into the river. The rate of discharge directly to the river is unknown; field observations indicate that the canyon wall is a seepage face (Lum, personal communication, 1986). The large surface area of the sides of the Snake River Canyon relative to the area of the Snake River and the preferential horizontal flow paths between the basalt flows imply that a significant portion of the

discharge from the basin may discharge through the sides of the canyon. The rate of discharge is unknown, but it probably does not vary much throughout the year; The deep regional flow system appears to be insensitive to seasonal fluctuations in precipitation. Ground water also discharges to the Palouse River along the northwest side of the region. The Palouse River is incised only into the upper Grande Ronde Basalt; therefore, discharge to the Palouse River is probably much less than discharge to the Snake River.

Ground-water discharge also occurs to small streams from local flow systems in the loess and in the Wanapum Basalt Formation. During the late summer and fall, total stream flow probably is the result of discharge from the shallower ground-water systems. This ground-water component of flow is termed baseflow and is present throughout the year. Surface runoff from precipitation and snow melt is a seasonal component of stream-flow. Streamflow measurements by the U.S. Geological Survey in October, 1984, quantify the average annual component of streamflow attributable to direct connection with the ground-water system (fig. 9). This information is important in the modeling of ground water-surface water interactions.

Ground-Water Pumpage

The Pullman-Moscow area has a history of pumpage increases (fig. 10). Moscow and Pullman are the pumpage centers of the basin, but the municipalities and universities maintain separate wells. Older municipal wells in Moscow and numerous domestic wells bottom in the Wanapum basalt. Most of the municipal and university wells obtain water from the Grande Ronde Basalt Formation.

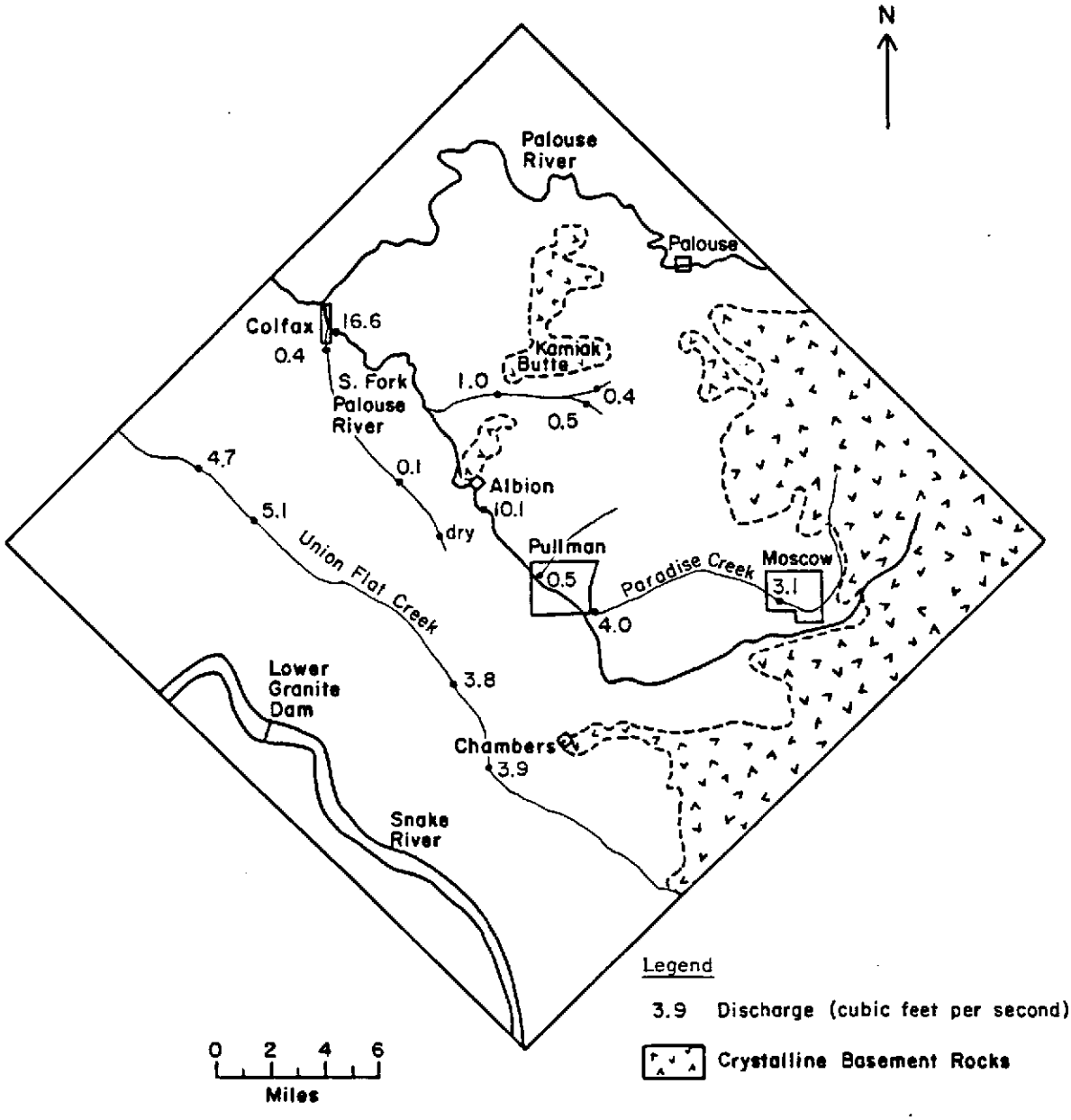


Figure 9. Streamflow measurements, October, 1984 (Blazs, personal communication, 1984).

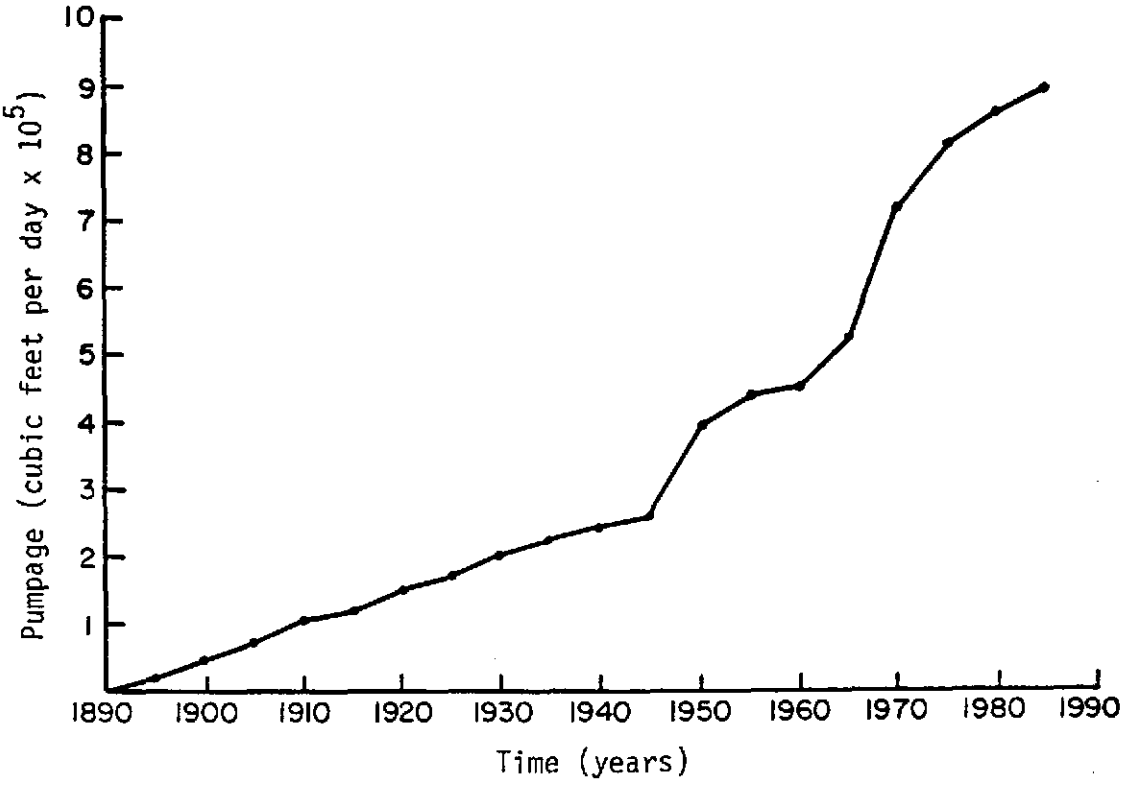


Figure 10. Plot of five-year averages of total pumpage for major wells operated by Pullman, Moscow, Washington State University, and the University of Idaho.

Water Level Declines

Prior to the drilling of wells, ground-water resources in the Pullman-Moscow area were in a state of dynamic equilibrium with ground-water recharge equalling ground-water discharge. Consumptive discharge from pumpage produced an imbalance in the system. The initial response of the system was a reduction in the volume of water stored in the basalt aquifers as a result of water level declines. In many basins, a decline in water levels causes a decrease in natural discharge and/or an increase in natural recharge. This adjustment can produce a new equilibrium if there is a reduction in natural discharge or an increase in the capture of recharge equal to the consumptive pumpage. Ground-water modeling may be used to indicate the extent to which a new equilibrium might be achieved in the Pullman-Moscow area.

Water level declines from pumpage in the Grande Ronde Basalt Formation have been documented in Moscow and Pullman. Hydrographs reveal a history of water level decline that is similar for the two communities (fig. 11). The recent rate of decline is about 1.5 feet annually. Measurable water level declines for the period 1974 to 1985 occurred within a radius of several miles of the pumping centers of Moscow and Pullman (fig. 12). The area over which water levels have declined for the complete history of pumpage is not known. When the area of water level decline reaches the Snake River Canyon, seepage out the canyon wall should decrease. Streams near Moscow and Pullman also should be affected by the lowered ground-water levels. The amount of reduction in natural ground-water discharge caused by pumpage in the Pullman-Moscow area may be estimated using the ground-water flow model.

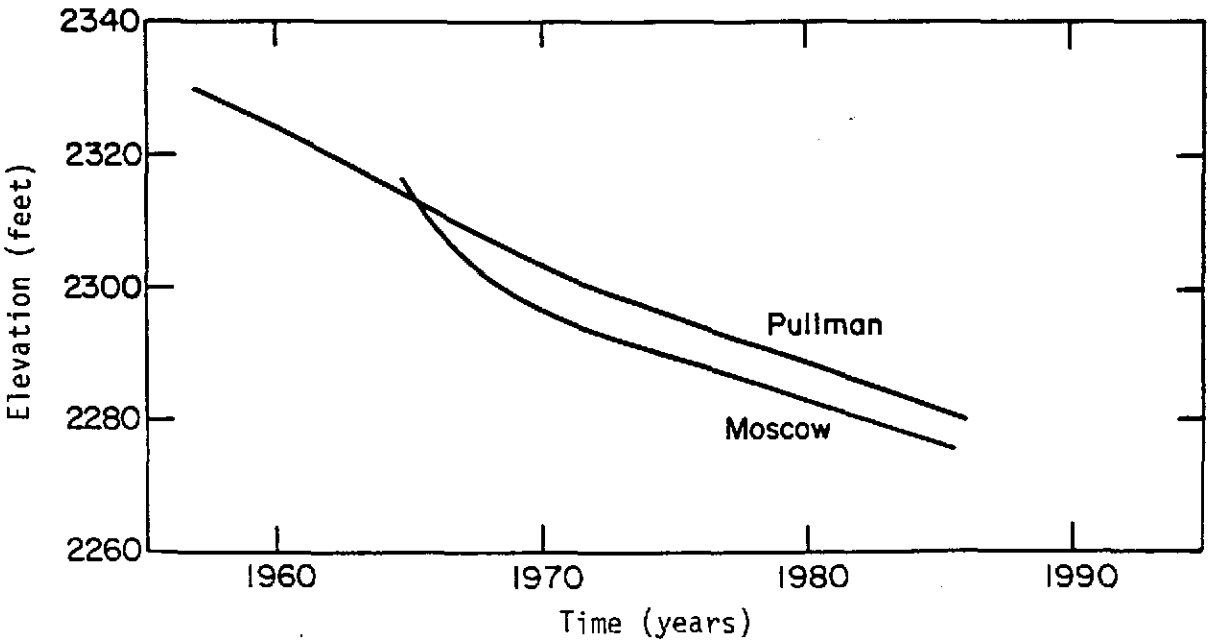


Figure 11. Hydrographs of recent ground-water level declines at Pullman and Moscow.

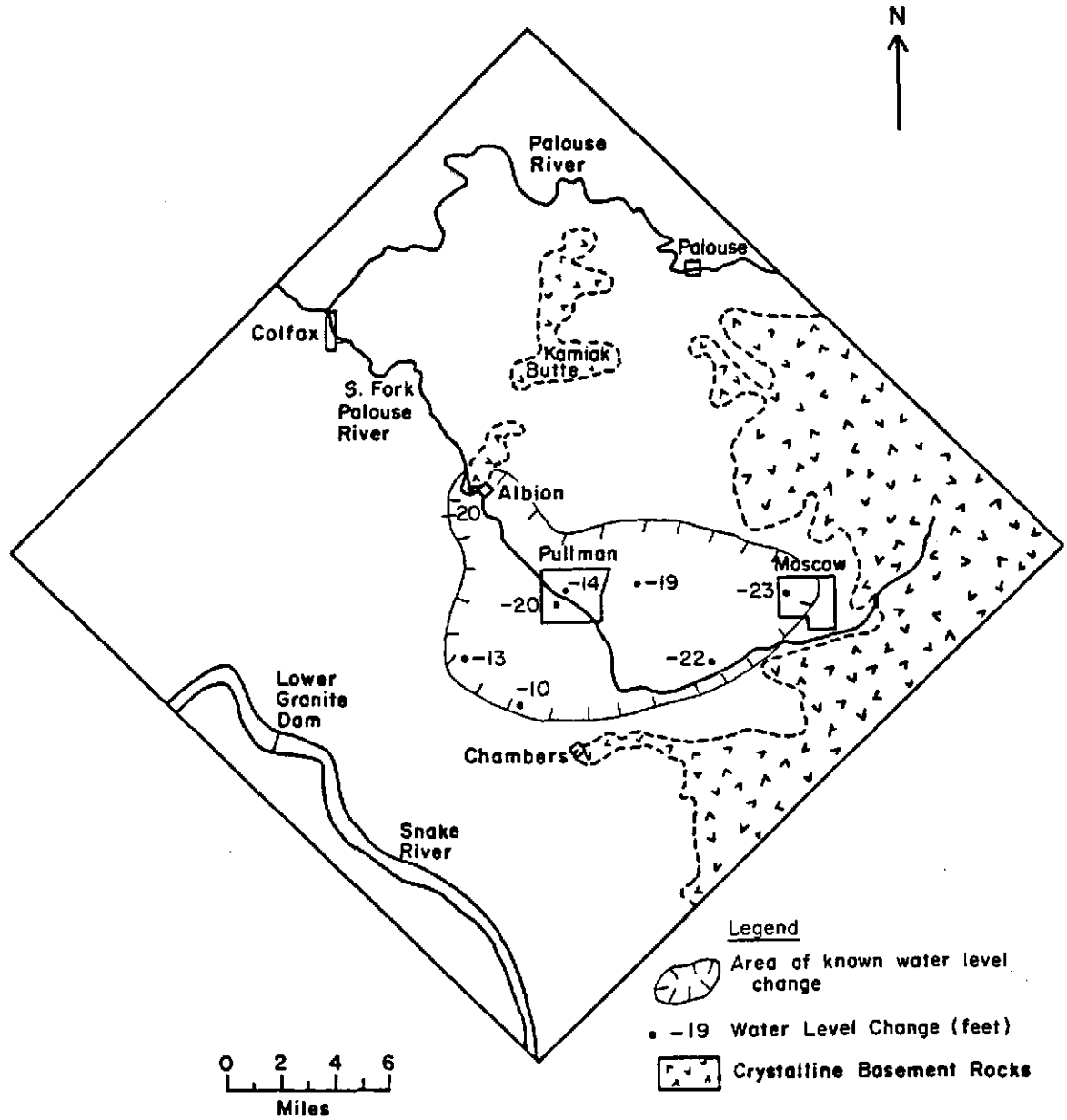


Figure 12. Water level decline in the Grande Ronde Basalt Formation, 1974-85.

The history of ground-water level decline is different for the overlying Wanapum Basalt Formation and loessial Palouse soils. Pumpage from the Wanapum Basalt Formation in Moscow caused water levels to decline in that unit from the 1890's into the 1960's; subsequent cessation in pumpage allowed water levels to recover several ten's of feet in the Wanapum Formation. Water levels in the loess fluctuate in response to the annual precipitation cycle. Water level comparisons between the present study and Barker's (1979) study indicate that water levels in the loess have changed very little over the last decade.

CHAPTER III

MODEL CONSTRUCTION

Introduction

A numerical ground-water model is a mathematical representation of a hydrogeologic framework. Most models approximate the solution of a partial differential equation that describes ground-water flow via finite difference or finite element numerical techniques. A three-dimensional model describes separate subsurface zones or layers that comprise the ground-water flow system. Such layers often are termed hydrostratigraphic units. Hydrogeologic properties of these layers are simulated by assigning values to model cells created by superimposing a grid on each layer. This procedure is termed discretization of space. Boundary conditions are needed to describe the hydraulic conditions along the edges, top, and bottom of the hydrogeologic framework. Model construction is completed when the data that describe the hydrogeologic properties of each zone within the model domain have been collected, analyzed, compiled, and input to the numerical model. Model calibration involves the adjustment of input data in order to reproduce historic water level data. In summary, the modeling procedure transforms the conceptual hydrogeologic framework into a discretized mathematical domain that can be used to simulate the response of a ground-water flow system to superimposed hydraulic stresses. The pumping of ground water from wells is the stress of major interest.

Discretization of Space

A regular grid mesh containing one-half mile square blocks is utilized in this study to discretize the hydrogeologic framework. This size facilitates adequate representation of the distribution of values of hydraulic properties without creating too large a grid. The grid is oriented northwest-southeast in order to make it coincide with the major surface streams that strike in that direction (fig. 13). These streams include the Snake River, Union Flat Creek, and the South Fork of the Palouse River. The grid is intended to extend far enough to include all of the hydrogeologic boundaries or extend far enough that boundaries have little influence on model results in the Pullman and Moscow areas. Zones or portions of zones that occur outside of assigned hydrogeologic boundaries are deactivated by the computer program.

Hydrostratigraphic Units

The model includes three horizontal hydrostratigraphic units. The top layer represents the loess; the second layer represents the Wanapum Basalt Formation; and the third layer represents the Grande Ronde Basalt Formation. The rationale for the selection of these units is presented in the section entitled "Definition of Hydrostratigraphic Units". These units are shown in the idealized cross-section of figure 14. The layers do not have the same areal extent. The loess laps onto the crystalline or metamorphic rocks, while both the loess and Wanapum Basalt are missing at the Snake River Canyon.

The three hydrostratigraphic units of the hydrogeologic framework described previously were assembled into the numerical model. The

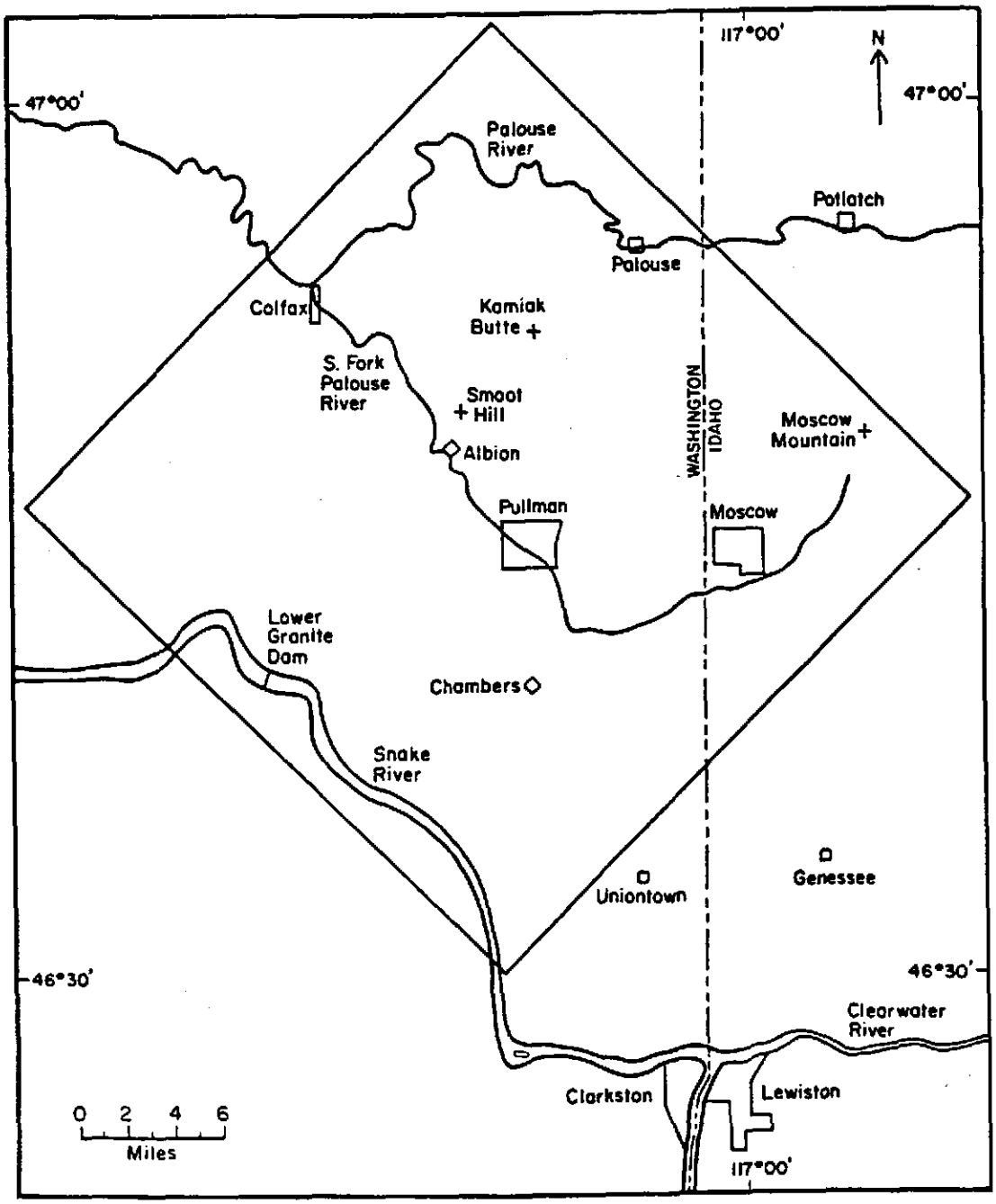
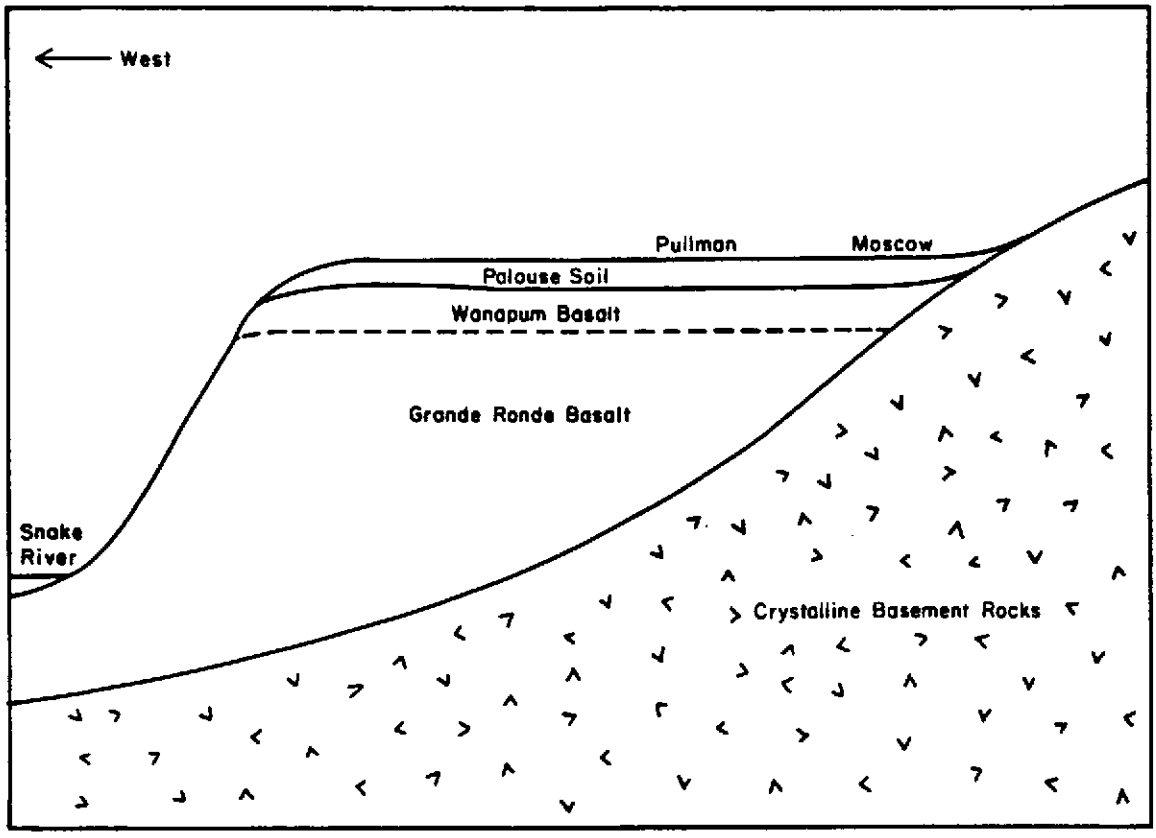


Figure 13. Location and orientation of the model grid.



Cross-section not to scale

Figure 14. Idealized cross-section through the Pullman-Moscow area.

elevation of land surface and the elevation of the top of the Wanapum Formation define the thickness of the loess unit. The elevation of the top of the Wanapum Formation and the elevation of the top of the Grande Ronde formation define the thickness of the Wanapum Basalt unit. The elevation of the top of the Grande Ronde Formation and the elevation of the crystalline rock contact define the thickness of the Grande Ronde Basalt unit. In this manner the thicknesses of each layer are defined throughout the model. Refer to figure 8 for a perspective view of the three layers.

Boundary Conditions

The loess hydrostratigraphic unit is modeled with no-flow boundaries on all sides. Some of this boundary corresponds to the topographic divide along the eastern and southern edges of the model area. The loess is cut by the Snake River and Palouse River and there is no flow across these boundaries. Elsewhere, flow in the loess is very localized with respect to topography; consequently the no-flow boundary was believed to be justified on a regional scale.

Two different types of boundary conditions are used to define the edges of the Wanapum and Grande Ronde hydrostratigraphic units: constant head boundaries and no-flow boundaries (fig. 15). No-flow boundaries are imposed around the eastern half of the model where the basalt flows pinch out against the crystalline rocks. The location of this contact has been studied extensively (Ross, 1965; Bockius, 1985). The low permeability of the crystalline rocks justifies a no flow boundary at the contact of the basalt rocks with the crystalline rocks.

Figure 15. Boundary conditions imposed on the basalt hydrostratigraphic units of the three-dimensional model.

No-flow boundaries also are used along the west and southwest side of the Snake River. A horizontal no-flow boundary beneath the Snake River can be deduced because of upward vertical flow beneath the Snake River. This conclusion is based on the assumption that ground water flows towards the Snake River from either side. Consequently, the boundary is actually located in the center of the river due to symmetry. Similar conditions are assumed for the Palouse River. However, the assumption for the Palouse River is less well supported by field data. The small size of the river implies that it is not a regional discharge area and there may be underflow. In spite of this uncertainty, the boundary is designated as no flow because it is sufficiently distant from the pumping centers of Moscow and Pullman that the effects of errors will be significantly dissipated over the intervening distance. The choice of the no-flow boundary along the Palouse River would cause greater water level declines resulting from pumpage in the model because underflow along the Palouse River would not exist as a source of water to wells in the model.

The remaining segments of the model boundary are designated as constant head boundaries (fig. 15). A constant head boundary creates a ground-water gradient into or out of the aquifer system, depending on the hydraulic heads in the region near the boundary. The model uses this gradient to calculate a flux into or out of the appropriate hydrostratigraphic unit at the location of the boundary. Care must be exercised with constant head boundaries because model pumpage can artificially induce unrealistically large fluxes into the model with a subsequent underprediction of water level decline. This problem is

discussed previously in connection with Barker's (1979) model. The effect that a constant head boundary has on stresses imposed on a ground-water model may be investigated by replacing the constant head boundary with a constant flux boundary and observing the difference in hydraulic heads calculated by the model.

The northwestern edge of the model and segments along the northeast and southeast sides of the model are designated as constant head boundaries. These boundary conditions are imposed on the segments of the boundary that connect the more obvious hydrologic boundaries discussed previously. However, sufficient water level data exists to adequately define the head distribution along the constant head boundaries. These boundaries are also distant from the pumping centers; consequently the same rationale that is used for the no-flow boundary along the Palouse River applies to these areas. Regional water level information indicates that ground water flows out of the model area to the northwest and into the model on the northeast and southeast. The quantity of the flux across each boundary is not known.

Data Inputs

Hydraulic Properties of Hydrostratigraphic Units

Loess. Most infiltration of water in the Pullman-Moscow area is into the surficial loess soil. Hydraulic conductivities of loess can range from several feet to several hundredths of a foot per day (Freeze and Cherry, 1979). McGary and Lambert (1962) note a slightly greater range. The loess may be approximated as homogeneous and isotropic, although the characteristics of earth slumps and mud flows in the loess

suggest that years of cultivation has compacted a low permeability zone beneath the ploughed horizon. Long term infiltration rates of several inches per hour near Moscow (Williams and Allman, 1969) indicate that portions of the loess are on the higher end of the published scale for hydraulic conductivity. Clayey layers that occur within the loess could limit the vertical hydraulic conductivity. A value of 5 feet per day is assumed for the horizontal hydraulic conductivity of the loess; 0.05 feet per day is obtained for the vertical hydraulic conductivity by assuming an anisotropy ratio of 0.01.

Basalt. Basalt flows comprise the majority of the hydrogeologic framework in the Pullman-Moscow region. Table 2 lists values of saturated hydraulic conductivity for basalts as compiled by Rockwell Hanford Operations, U.S. Geological Survey, and University of Idaho researchers. Hydraulic conductivity data compiled for the eastern edge of the Columbia Plateau (Lum, personal communication, 1986) suggest a hydraulic conductivity of 2 feet/day as an average for the entire thickness of basalt. This value is very near the median value of 1.7 feet/day as identified by the RASA project in the Columbia Plateau (Vaccaro, personal communication, 1986). The value of hydraulic conductivity probably is greater than the median near the margins of the plateau where thinner, less massive basalts have a greater percentage of the flows composed of flow tops.

Pumping test data indicate that the horizontal hydraulic conductivity is at least an order of magnitude greater than 2 feet/day in the upper Grande Ronde Basalt near Pullman and Moscow (table 2). This value probably reflects thin basalt flows at the margin of the basin.

Table 2. Hydraulic Coefficients

Source of Data	K_h (ft/day)	K_v (ft/day)	S
Barker (1979)	--	--	0.005
Lum, personal comm. (1986)	0.03-22.0	0.00001-0.001	0.000001-0.001
Luzier and Skrivan (1973)	--	--	0.0015-0.006
Mac Nish and Barker (1976)	--	--	0.00047-0.00475
Ralston, personal comm. (1986)	--	--	0.003-0.02
Strait and Spane (1982a)	2.6-10.9	--	--
Strait and Spane (1982b)	1.6- 3.1	--	--
Strait and Spane (1982c)	0.00000021-0.0000049	--	--
Tanaka and others (1974)	--	--	0.0025

K_h - Horizontal hydraulic conductivty
K_v - Vertical hydraulic conductivity
S^v - Storage coefficient

The effective vertical hydraulic conductivity of the sequence of basalt flows is much more difficult to define. In a layered system, the smallest vertical hydraulic conductivity controls ground-water flow. In the Pullman-Moscow area, these controlling layers consist of flow centers and clay interbeds. Field measurements of vertical hydraulic conductivity do not exist for either the flow interiors or clay interbeds in the area. However, 1×10^{-4} feet per day is a reasonable estimate of vertical hydraulic conductivity for both lithologies (Freeze and Cherry, 1979); initial inputs of vertical hydraulic conductivity incorporated this value.

Different horizontal and vertical hydraulic conductivities may be assigned to each block in the model. Initially, homogeneous hydrostratigraphic units were defined by assigning average values of hydraulic conductivity to each group of cells that constitute a hydrostratigraphic unit. Zones of increasing hydraulic conductivity were introduced to the basalt layers in the model in order to implement the conceptual model of increasing hydraulic conductivity in the basalts as they thin toward the margin of the Columbia Plateau. The final version of the Grande Ronde layer has seven zones.

Recharge Model

Recharge to the ground-water system is evaluated using the U.S. Geological Survey recharge model (Bauer and Vaccaro, 1985). The recharge model simulates the physical processes of soil moisture accumulation, evaporation from the soil, evaporation of intercepted moisture, plant transpiration, surface runoff, and the accumulation and melting of snow. The difference between these terms and precipitation incorporates error and the rate of deep percolation of water beneath the root zone into the ground-water system.

The model calculates the rate of deep percolation on a daily basis. As many years as possible are simulated for the Pullman-Moscow area using measured daily values of precipitation, maximum and minimum air temperature, and stream discharge rates. Calculations based on average monthly or average yearly values of these parameters tend to negate the impacts of high intensity, short duration events that could cause deep percolation.

The recharge model uses a one-half mile square grid system, similar to the one used in the three-dimensional model, to divide the surface into blocks. These blocks are small enough to account for most variations in soil type, vegetation, land use, elevation, slope, aspect, and precipitation. The recharge model calculates the water budget for a control volume that extends from the plant-covered surface down to the maximum root depth. The root zone is divided into 6 inch layers, each of which has its own separate physical characteristics.

The precipitation rate is interpolated to each cell in the model from data collected at several precipitation guages utilizing a distance weighted method; the interpolation includes an adjustment for elevation. If the average daily air temperature falls below $32^{o}F$, all of the precipitation is assumed to be snow and is allowed to be intercepted by the existing plant cover. Potential evapotranspiration is computed based on the Jensen-Haise method (Jensen, 1973). Potential evapotranspiration is calculated based on that which would occur in a fully covered field of mature alfalfa, water nonlimiting. Slope and aspect are also included in this calculation. The alfalfa number is adjusted to the actual cropping pattern in the Pullman-Moscow area via a coefficient (Vaccaro, personal communication, 1986). Surface runoff for each cell in the grid is computed on the basis of the modified Soil Conservation Service method of Wight and Neff (1983).

Any water not accounted for by evapotranspiration and runoff is assumed to infiltrate the soil profile. If the amount of infiltrated water is greater than the difference between the total water holding capacity and the soil moisture content that exists at the time of

calculation, the extra water is assumed to constitute deep percolation and becomes part of the ground-water resource. Under dry conditions, however, plant roots may extract water from below the root zone (Hammel, personal communication, 1986).

Preliminary applications of the recharge model in the Pullman-Moscow area revealed an average recharge rate of 7.4 inches across the basin. This rate appeared to be large (Ralston, personal communication, 1986). Review of the recharge model by U.S. Geological Survey, University of Idaho, and Washington State University researchers revealed that the root depth of crops in the Palouse area was underestimated and crop fallow conditions were overestimated. Loessial soils allow for wheat rooting depths that approach 6 feet compared with 3 feet on an average across the nation (Vaccaro, personal communication, 1986). The recharge model is very sensitive to this variable. Rerunning of the recharge model with a 6 foot rooting depth reduced the recharge rate to an average of 3.6 inches/year to the surface of the basin. This recharge rate is assumed to be a known quantity for operation of the ground-water flow model.

Figure 16 shows the distribution of recharge over the basin based on average precipitation and current land use patterns. Orographic effects on the distribution of recharge can be seen clearly. Lowest values of recharge occur in the Snake River Canyon at elevations below 1000 feet. Recharge increases to near average in the interior of the basin and is greatest in the eastern mountains. The areas of depression in the contours may be related to soil type. The areal variations in recharge are incorporated into the ground-water flow model. Recharge to the ground-water flow model is supplied to the loess layer present at the

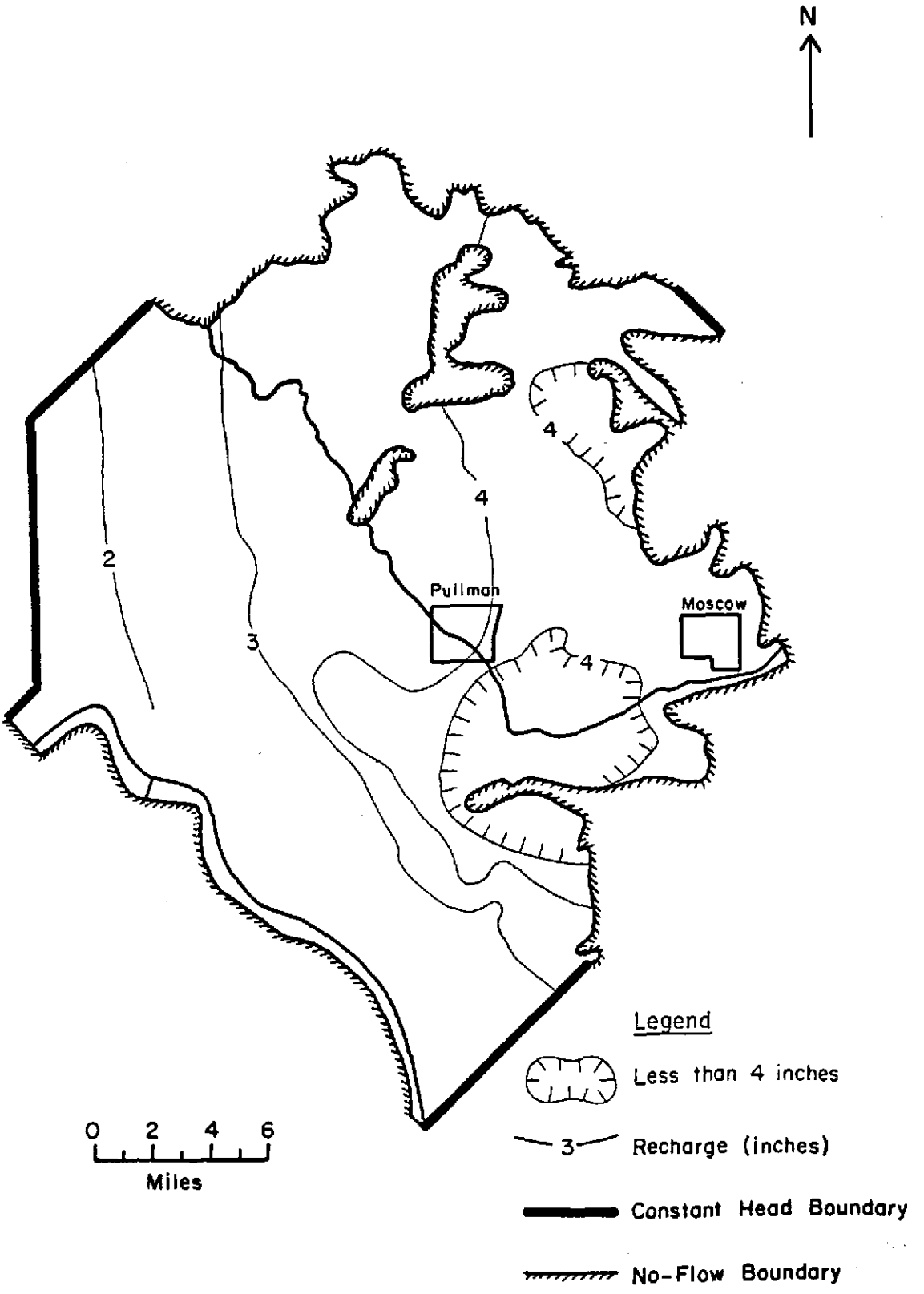


Figure 16. Areal distribution of recharge to the upper layer of the three-dimensional ground-water flow model.

surface except in those areas where the Wanapum or Grande Ronde hydrostratigraphic units are exposed, such as along the Snake River Canyon. To the east, the loess overlies the crystalline basement rocks and extends to the topographic drainage divide.

Hydraulic Connection of Ground Water With Rivers

The River Package is used to simulate river and stream reaches within the ground-water flow model (McDonald and Harbaugh, 1984). River reaches are simulated in the model on a cell by cell basis. Input includes the layer, row, and column in the grid in which the stream flows, the stream stage elevation, the conductance of the riverbed material, and river bottom elevation (McDonald and Harbaugh, 1984). Conductance is the hydraulic conductivity divided by the distance over which the head gradient is calculated. This allows the model to compute a flux either into or out of a river depending on the head gradient from the corresponding layer to the river. The River Package is modified to group the cells that comprise each stream so that the flux may be summed for each stream (Hansen, personal communication, 1985). These fluxes may then be compared to flow measurements of area streams obtained in October, 1984 (fig. 9).

River conductance is based on vertical hydraulic conductivity since most of the communication between the basalt flows and the rivers is assumed to be in the vertical direction. The distance (dz) over which the head gradient is calculated is assumed to be the distance from the cell center to the river bottom. Conceptual and numerical difficulties arise when the cell center elevation is greater than the river bottom elevation. This inconsistency occurs where streams are deeply incised

into a layer. In order to correct this problem, conductance is recalculated based on river bottom and the elevation of the bottom of the hydrostratigraphic unit that is deeply incised. The river conductance calculation is described in detail in Appendix A on page 104.

Seepage Faces

Saturated basalt faces along canyons where water is evapotranspired are termed seepage faces. Seepage faces occur along streams and rivers. The major seepage face in the modeled area is along the Snake River Canyon. The average river level is about 1,700 feet below the loess surface in the Pullman-Moscow area. Smaller seepage faces in the basalt occur along the Palouse River, the South Fork Palouse River, and Union Flat Creek. Seepage faces are significant to the ground-water model because they account for a significant portion of the regional ground-water discharge.

Field investigations revealed that portions of the canyon wall of the Snake River are saturated (Lum, personal communication, 1986). There are areas along the canyon wall where there is dense plant cover and the ground is saturated just below the surface. Other portions of the canyon wall appear dry and have little plant cover. For modeling purposes, the canyon wall is assumed to be saturated completely; therefore the average flux out the canyon wall in the model should be less than potential evapotranspiration because the portions of the canyon wall that appear dry are evapotranspiring water at less than the potential rate.

The Drain and Well Packages (McDonald and Harbaugh, 1984) are used in the model to describe areas where water discharges along a seepage face. The drains produce a gradient dependent flux based on the head in

the adjacent hydrostratigraphic unit and the head assigned to the drain. Drains are used to model seepage faces along the interior stream valleys. Drains initially were used to simulate the seepage face along the Snake River canyon, but problems occurred. The great thickness of Grande Ronde hydrostratigraphic unit did not allow head dependent fluxes to be modeled adequately. The cell-center head calculated by the model generally was below canyon level in the thick Grande Ronde unit, and the drains were mostly inoperational; consequently the drains are replaced in the three-dimensional model by a constant flux implemented by a well function for each cell corresponding to the seepage face. This implementation utilizes the Well Package of the three-dimensional model (McDonald and Harbaugh, 1984).

The Drain Package is modified to calculate fluxes for specified sets of drains along interior streams (Hansen, personal communication, 1985). Drain conductance is calculated similarly to the river conductance except that drain conductance is based solely on horizontal hydraulic conductivity. In the case of interior streams that cut the basalt, the drain conductance must be multiplied by two to account for the seepage face along both stream banks. The model calculates a head gradient and computes fluxes through the drain based on Darcy's Law. The drain conductance calculation is described in detail in Appendix A on page 104.

Cross-Sectional Model Contruction

Cross-sectional models are two-dimensional slices through the three-dimensional model that are constructed for several reasons. They are used during the initial phase of modeling to gain understanding of the

three-dimensional movement of water in the hydrogeologic system. The cross-sectional models also are used as a calibration tool for the three-dimensional model, particularly for vertical hydraulic conductivity. The cross-sectional models provide a cost-effective means of acomplishing that objective. Multiple layers are introduced easily into the Grande Ronde Basalt to investigate the distribution of hydraulic head within this hydrostratigraphic unit. The rationale is to facilitate comparisons between measured water levels for the upper Grande Ronde Basalt Formation and cross-sectional model results.

The cross-sectional models are located on the basis of flow lines drawn perpendicularly to contours of regional hyraulic head distribution. The location of the section lines is shown in figure 17. Good coverage is attained for the interior of the basin. The great thickness of the Grande Ronde unit is modeled as 200 foot thick layers to facilitate simulation of the vertical hydraulic head distribution in the formation and to obtain a more accurate representation of the seepage face in the Snake River Canyon (fig. 18a). The 200 foot division is chosen arbitrarily; it does not represent the actual layering in the Grande Ronde. The exact number of layers depends on the depth to basement along each section, but the average number is 18 layers in the Grande Ronde Formation. The layering allows five or six drains to simulate the seepage face. The flux from these drains forms the basis for the well flux that simulates the seepage face in the three-dimensional model.

Lateral zonation for both horizontal and vertical hydraulic conductivity is incorporated into the construction of the cross-sectional models (fig. 18b). This procedure allows different hydraulic properties

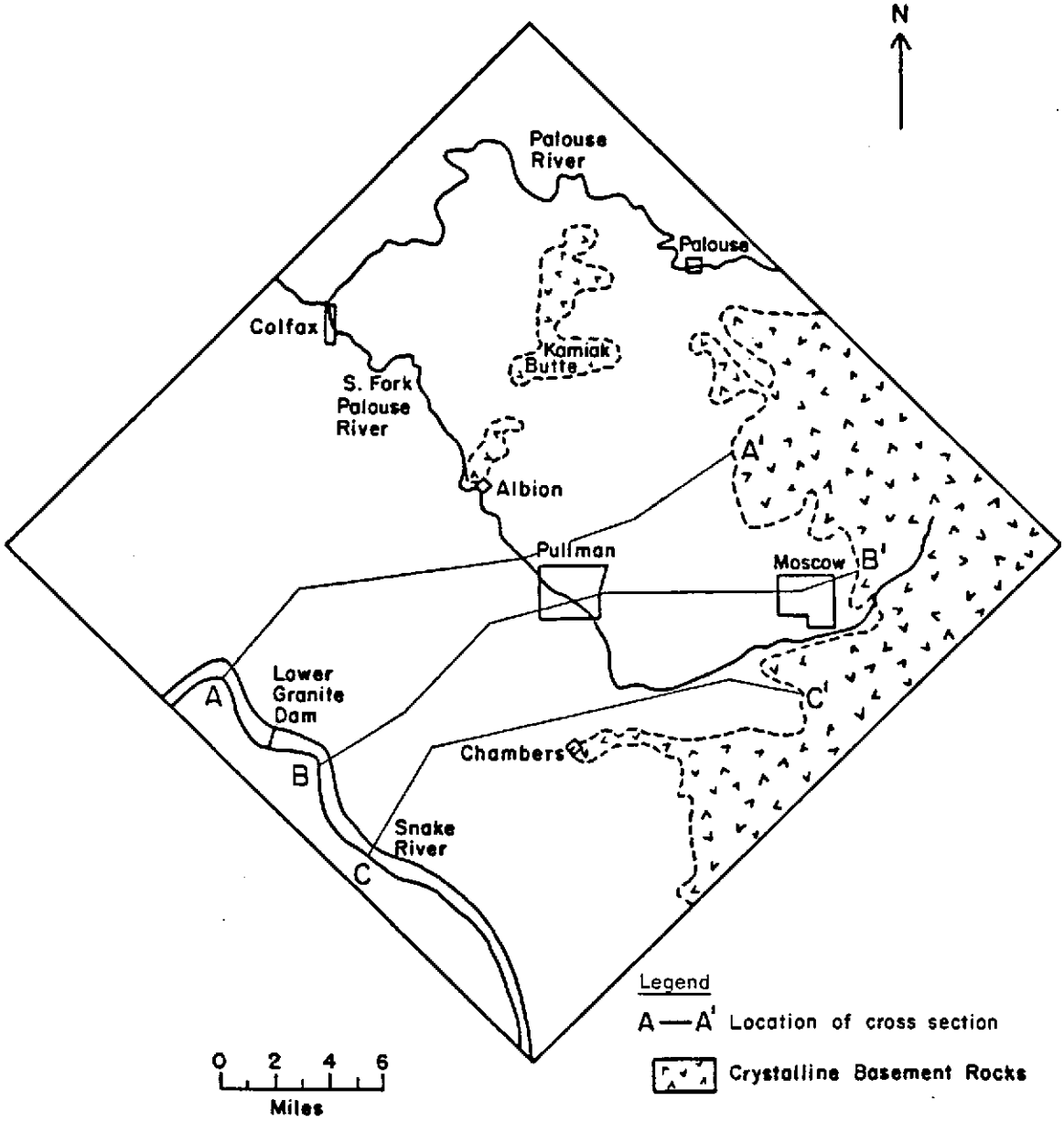


Figure 17. Location of cross-sectional models in the domain of the three-dimensional model.

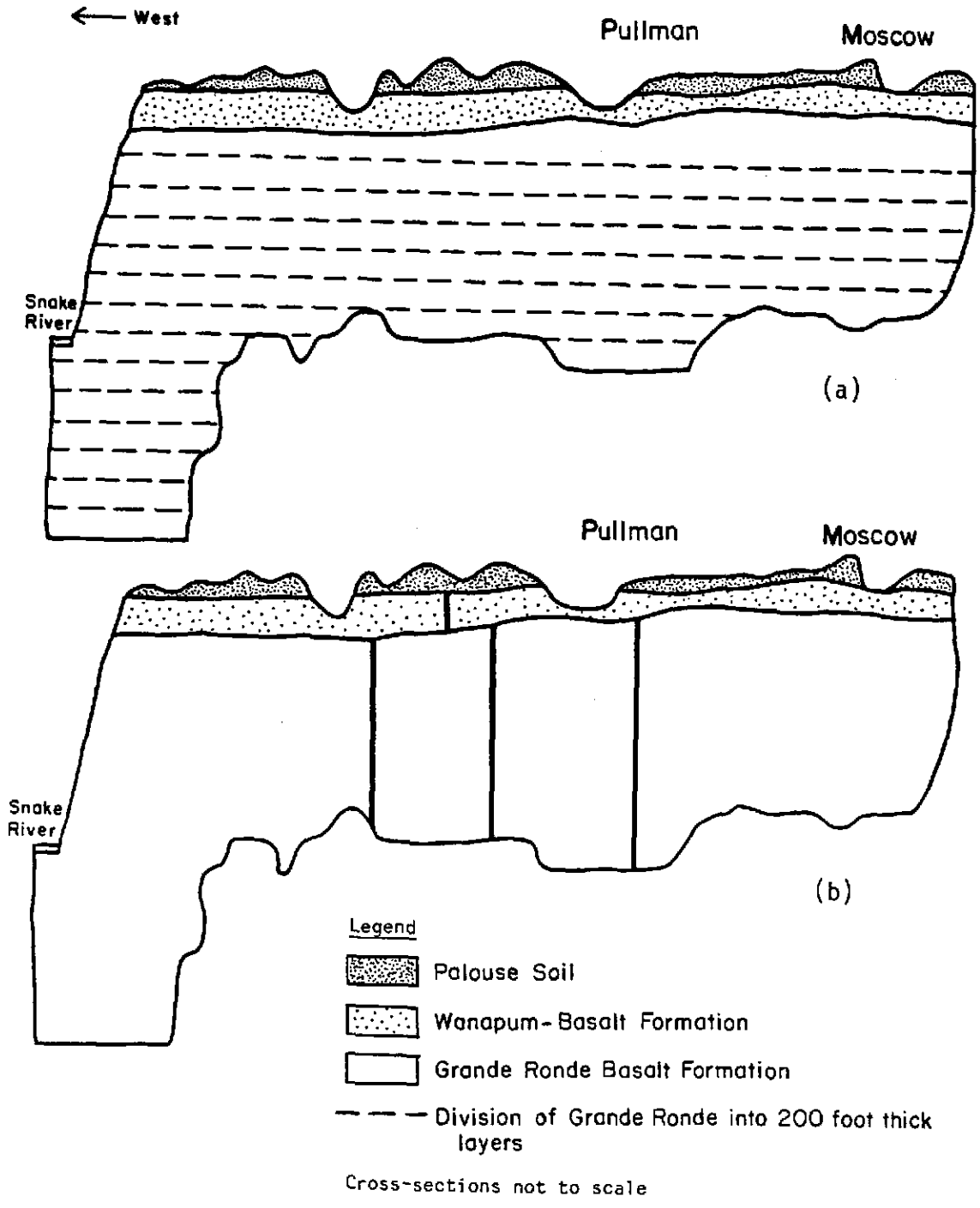


Figure 18. Construction of cross-sectional models: a) layering, b) zonation.

to be entered for each zone. The inclusion of zonation was an evolutionary process that occurred during initial operation of the cross-sectional models. The original version of the cross-sectional models had no zonation; the final version has four zones in the Grande Ronde layer and two in the Wanapum layer. Inability to match observed hydraulic heads with cross-sectional model calculated hydraulic heads led to the inclusion of more zones. Greater complexity within the hydrogeologic framework of the model was required to match the irregular head distribution indicated by the measured water levels.

CHAPTER IV

MODEL CALIBRATION

Introduction

The calibration phase of modeling has the purpose of achieving the closest possible agreement between the numerical model and the physical world that it represents. Konikow (1978, p. 88) notes that "...in practice, the calibration of a deterministic ground-water flow model is frequently acomplished through a trial-and-error adjustment of the model's input data (aquifer properties, sources and sinks, and boundary and initial conditions) to modify the model's output". Wang and Anderson (1982, p. 109) augment this definition by indicating that a model is considered calibrated when output hydraulic heads are in agreement with those heads measured in the field.

The calibration process may be acompanied by a verification process. Verification is not well defined in the hydrogeologic literature. According to Wang and Anderson (1982, p. 110), verification is achieved by demonstrating that the model is capable of reproducing an historical hydrologic event for which field data are available. Konikow (1978) notes that the verification data should be distinct in time from the calibration data. Wang and Williams (1984) indicate that the goal of verification is to determine the uniqueness of the model solution. Konikow (1978 p. 88) puts the debate in perspective by stating that "...nevertheless, a calibrated model can be used to analyze or predict future aquifer responses. The accuracy of its predictions is the best measure of a model's reliability."

The calibration procedure for the Pullman-Moscow ground-water flow model consists of several steps. The cross-sectional models are calibrated to predevelopment conditions. The resulting hydraulic conductivity distributions are applied with little adjustment to a time-average calibration of the three-dimensional model (Prych, 1985, p. 43). The time-average calibration matches the model to average conditions over a selected period of time. The model then is run transiently with no adjustments in hydraulic coefficients to check the results of the calibration by comparing historical water level declines with model calculated water level declines. The ability to match historic water level records provides a measure of verification or reassurance that the model calibration is reasonable. This process would appear to satisfy Wang and Anderson's (1982) definition of verification but does not identify a unique model solution that satisfies Wang and Williams' (1984) definition of calibration.

Cross-Sectional Model Calibration

Cross-sectional models are calibrated to predevelopment hydraulic heads. Predevelopment hydraulic heads are known accurately only for wells at Pullman and Moscow. Wells are considered to penetrate a formation if the elevation of the bottom of the hole is beneath the elevation of the top of the formation. The earliest wells in Moscow tapped the Wanapum Basalt Formation and flowed at land surface. The head was 2,570 feet ± 20 feet (Russell, 1897). Early wells in Pullman tapped the Upper Grande Ronde Basalt Formation where the head was approximately 2,360 feet ± 20 feet (Russell, 1897). In addition to the data points at

Pullman and Moscow, a well is available for calibration near the edge of the Snake River canyon. This well is located near the breaks of the canyon; it penetrates the upper portion of the Grande Ronde Basalt Formation. The water level in this well is assumed to approximate predevelopment conditions within several tens of feet because of its distance from the pumping centers; consequently it is considered acceptable for calibration purposes. The shallow depth to water in this well (200 feet) implies that most of the canyon wall should be a seepage face; therefore all of the drains that simulate the seepage face should be operational in the calibrated cross-sectional models.

Calibration of the cross-sectional models was achieved by varying horizontal hydraulic conductivity and the corresponding vertical hydraulic conductivity ratio for all zones in the basalt hydrostratigraphic units. Horizontal and vertical hydraulic conductivity was held constant in the Palouse soil at 5 and 0.5 feet per day respectively. The horizontal hydraulic conductivity for basalt was varied between 0.1 and 50 feet/day. This range is compatible with reported data for the Columbia River Basalts (Table 2). The vertical hydraulic conductivity was obtained through a multiplier of horizontal hydraulic conductivity. This multiplier ranged between 0.1 and 0.0001. This procedure produced vertical hydraulic conductivities similar to reported values (Table 2). This range is intended to bound the probable distribution of hydraulic conductivity. The purpose of the cross-sectional modeling is to reduce the degrees of freedom for input to the three-dimensional model. Figure 19a shows the four zones and their hydraulic conductivity values in the calibrated model for section B-B'.

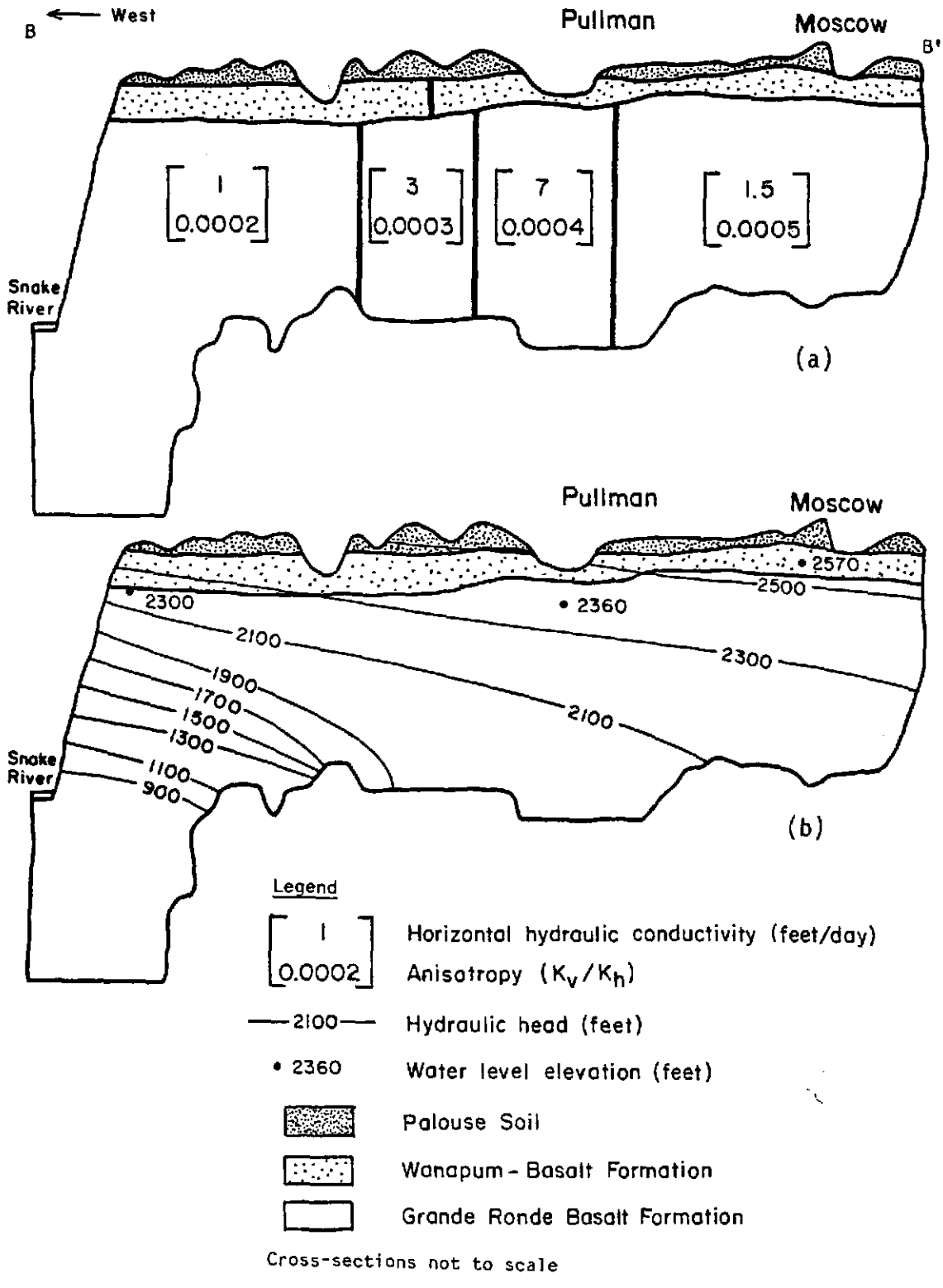


Figure 19. Calibrated cross-sectional model B-B': a) calibrated hydraulic conductivity distribution, b) calibrated hydraulic head distribution.

Contoured values of the cross-sectional model head output match well with reported and/or measured water level measurements along cross-section B-B' (fig. 19b). The contour lines are based on the multi-layer output from the cross-sectional models. The water level at Moscow represents the Wanapum Basalt and the water level at Pullman represents the upper Grande Ronde Basalt, while the water level near the Snake River canyon probably represents a composite Wanapum-upper Grande Ronde water level because the borehole is uncased and bottoms in the Grande Ronde Formation. The 200 foot thick model layers in the Grande Ronde Formation provide reasonable resolution of the hydraulic head distribution of the model output.

Similar hydraulic conductivity distributions resulted from the A-A' and C-C' cross sections. Points on the A-A' and C-C' cross sections that correspond approximately to Pullman and Moscow are calibrated to Russell's (1897) reported values of 2,360 and 2,570 feet respectively. Predevelopment water levels on the western end of these cross-sections near the Snake River are unknown. Water levels in the upper Grande Ronde and Wanapum were calibrated to be below the top of the respective layers. This decision was arbitrary. Cross sections A-A' and C-C' both have zonations similar to cross section B-B'.

The magnitude of the fluxes calculated by the cross-sectional models provides additional input for model calibration. The majority of the flux toward the Snake River is expected to discharge along the canyon wall rather than into the river because of the large surface area of the canyon wall. The average flux out the seepage face calculated from cross-sectional modeling is about 20 inches per year. This flux compares

to a potential evapotranspiration rate of 35-40 inches per year based on the recharge model. The flux calculated by the recharge model is considered reasonable based on limited examinations of the canyon wall (Lum, personal communication, 1986). Fluxes through the drains in the canyon for each of the several hydrostratigraphic units that crop out in the canyon wall are summed for each cross section and averaged across the length of the face. This sum is used as an initial approximation of the flux out the seepage face for input into the 3-D model.

Time-Averaged Three-Dimensional Model Calibration

The model calibration technique incorporates the method of time-averaging (Prych, 1984, p. 43). Time-averaging is a method of approximating average conditions over a discrete time interval of transient conditions in a ground-water flow system. This allows calibration to recent time intervals when data more often are complete. Utilization of a model to simulate time-average conditions requires that the change in storage of water in the aquifer be incorporated into the model as an implicit flux, either as an adjustment to the recharge for each model cell affected by pumpage or as a separate well function for each model cell affected by pumpage. This change in storage flux will be opposite in sign to the water level change in each model cell. The model is then run with the explicit storage coefficient equal to zero using the option for steady-state since storage is accounted for with the implicit flux.

Hydraulic Coefficients

The time-average calibration honors the cross-sectional model results. The hydraulic conductivity distributions obtained from the cross-sectional models are transferred to the three-dimensional model (fig. 20). Initially there was some iteration between operation of the three-dimensional model and the cross-sectional models. Minor changes in hydraulic coefficients necessary in the three-dimensional model were checked by rerunning the cross-sectional models to determine if they were still reasonable. Changes that significantly disrupted the head patterns in the cross-sectional models were disallowed. The horizontal hydraulic conductivity was varied by less than a factor of two in the transition from the steady-state cross-sectional models to the three-dimensional model under time-average conditions. The vertical hydraulic conductivity ratio was varied by an order of magnitude. Given that little is known about this coefficient, an order of magnitude is a relatively small variation.

A single value of storage coefficient is used for the basalt hydrostratigraphic units in the time-average calibration. The final value used is 1×10^{-4}. This is a reasonable value for confined storativity in the basalts. There is most likely some distribution of storativity in the basalts in the Pullman-Moscow area, but this distribution is unknown.

Hydraulic Head Distribution

A reasonable match is obtained between heads produced by the three-dimensional model for the second layer and measured water levels for the Wanapum Basalt Formation (fig. 21). Measured water levels are

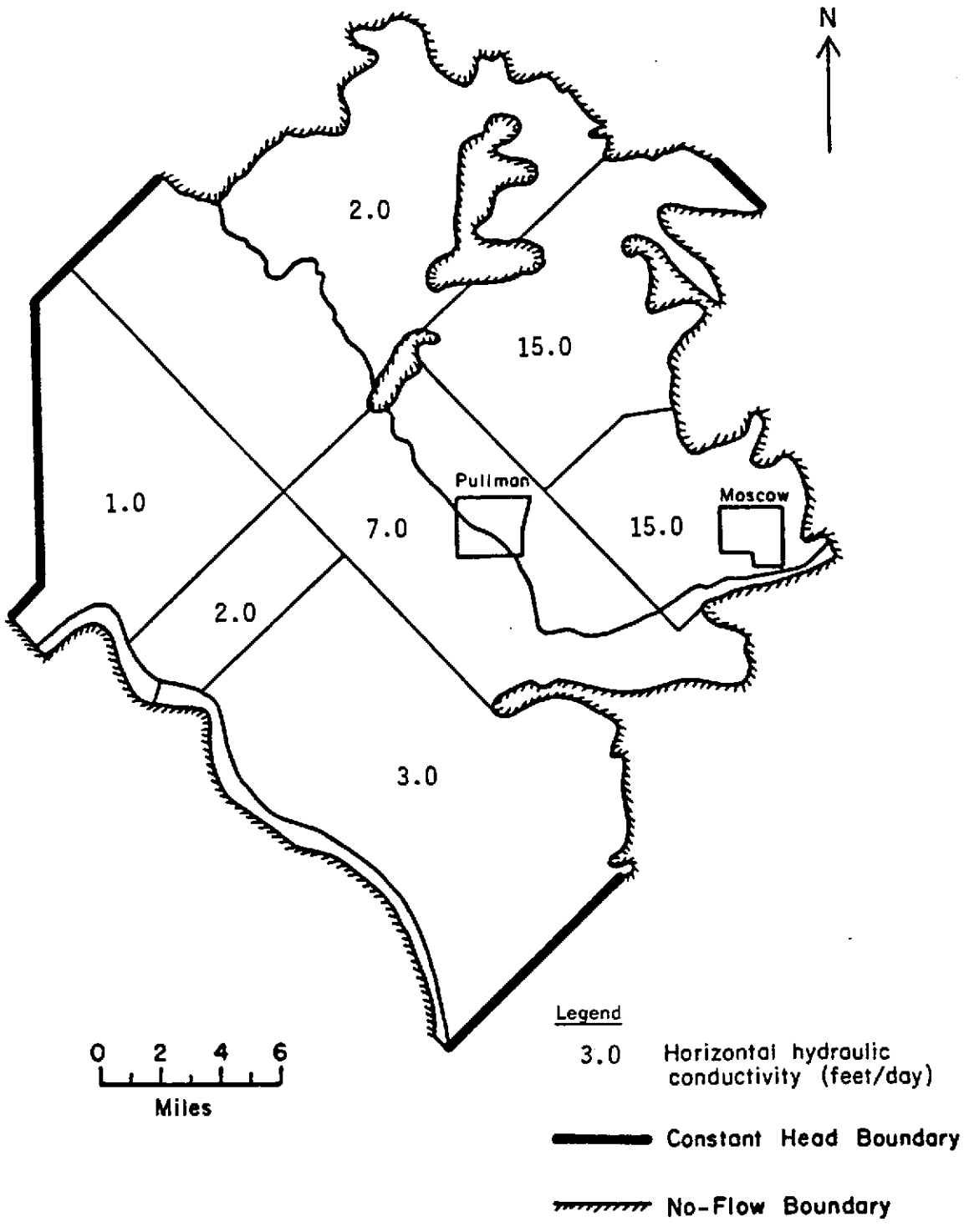


Figure 20. Grande Ronde Basalt formation horizontal hydraulic conductivity distribution that honors the cross-sectional model calibration and the time-average three-dimensional model calibration.

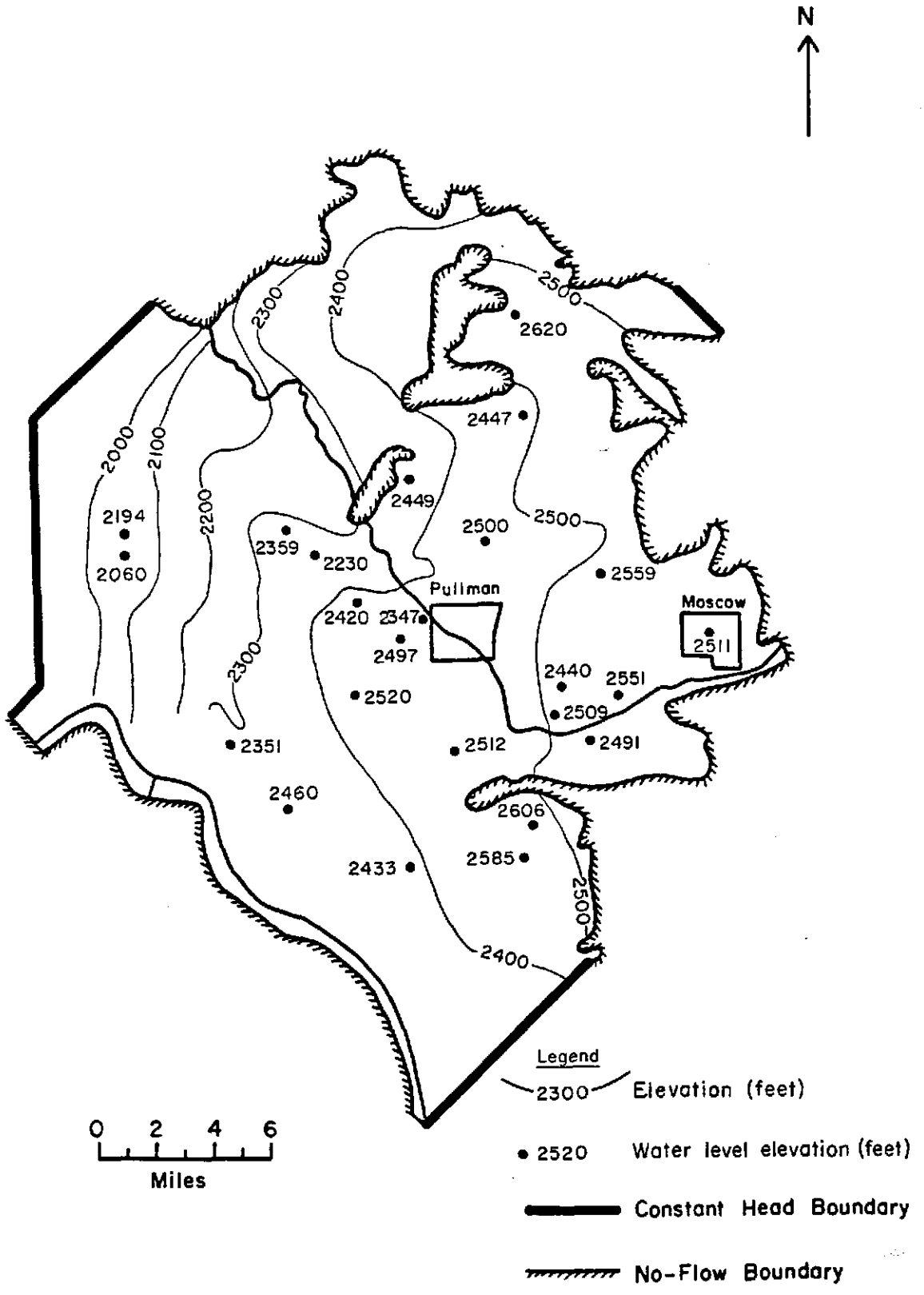


Figure 21. Calibrated distribution of hydraulic head for the Wanapum Basalt Formation.

presented as the average water level for the period 1974 to 1985. The contour lines represent the distribution of hydraulic head in the model. Most of the measured water levels are in general agreement with the contours of model output. Cases where measured water levels are greater than model output probably reflect wells that penetrate only the upper portion of the Wanapum Basalt Formation. The model calculated water levels are representative of fully penetrating wells. Because water levels tend to drop with increasing well depth, the partially penetrating well will tend to have a higher water level. Measured water levels that are lower than model output may be the result of wells along a narrow stream valley. Because most of the stream valleys are small relative to the half-mile square model cells, the model calculated water level for a cell might be dominated by nearby uplands rather than the stream valley. Local effects tend to be smoothed out by the regional nature of the three-dimensional ground-water flow model.

A reasonable calibration also is achieved for the Grande Ronde hydrostratigraphic unit (fig. 22). The contours represent model output hydraulic head values for the lower model layer. Water levels in the Grande Ronde Formation generally are for wells that penetrate the upper part of the formation except for two deep wells at Moscow. The three-dimensional model calculates water levels for the center of the Grande Ronde layer; therefore the average measured water levels for the period 1974 to 1985 presented on figure 22 are adjusted based upon the vertical gradients in the cross-sectional models so that they are comparable directly to heads produced by the three-dimensional model for the Grande Ronde hydrostratigraphic unit. The correction factor lowers measured

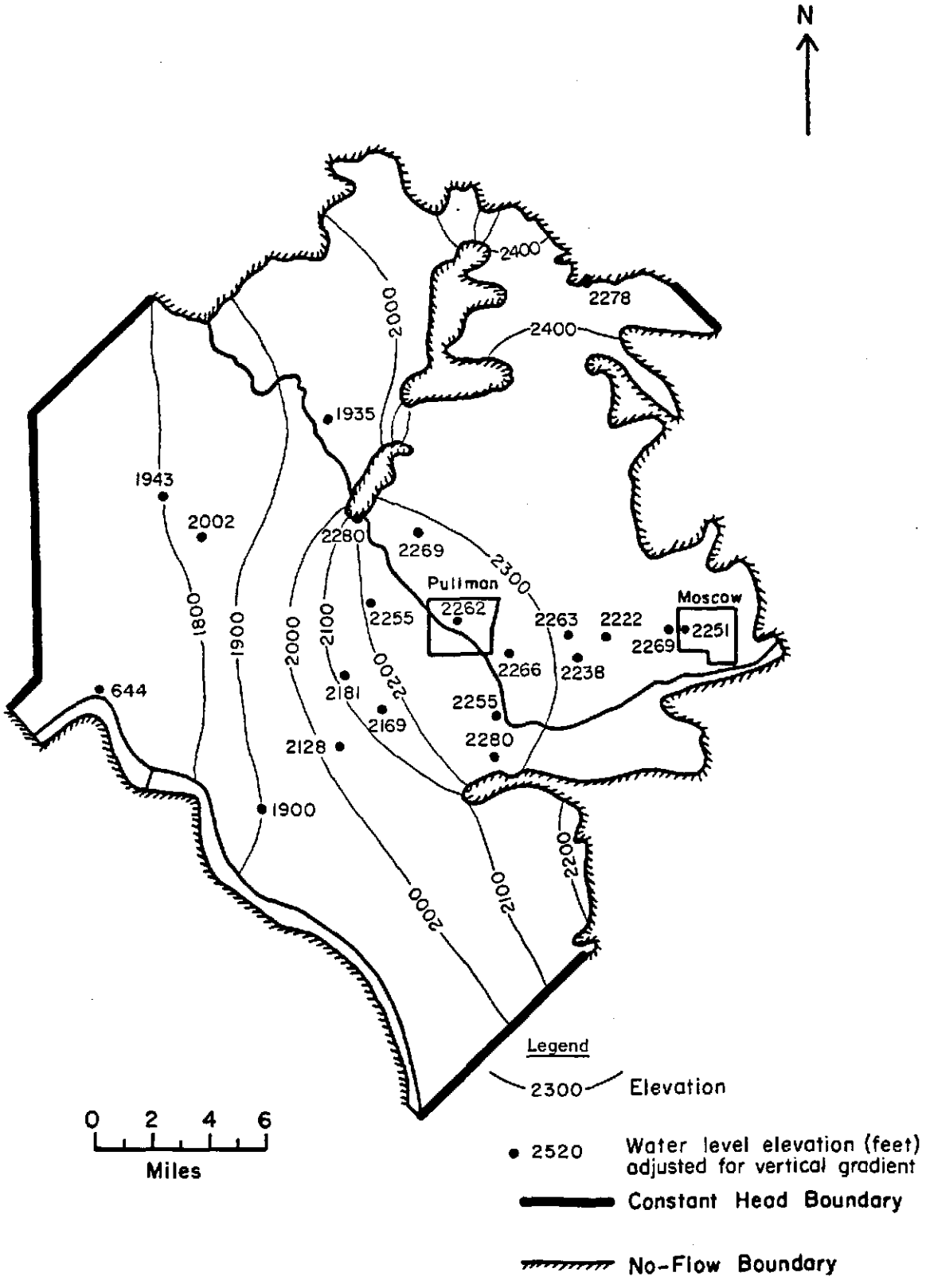


Figure 22. Calibrated distribution of hydraulic head for the Grande Ronde Basalt Formation.

water levels by a few ten's of feet near Moscow and Pullman and by several hundred feet near the canyon.

The match between model calculated hydraulic heads and measured water levels tends to be best around Pullman (fig. 22). Most measured water levels fall within the interval marked by the enclosing contours. Near Moscow, the measured values are several tens of feet less than the model calculated value of approximately 2300 feet. Several factors probably cause this discrepancy. There could be error in the correction factor that was applied to these water levels. This cannot explain all of the difference because the correction factor near Moscow was less than 20 feet. The model output suggests that there is a water level difference of about 60 feet between Moscow and Pullman. Such a gradient is necessary to move water towards the Snake River according to the conceptual model of the ground-water flow system However, this head difference does not appear in the measured water level data for the Grande Ronde Formation. This may result from the measurement of water levels from fully penetrating wells in Moscow and partially penetrating wells in Pullman.

Water Budget Analysis of Time-Average Model

The water budget of the calibrated time-average model presented in Table 3 is reasonable based on knowledge of the hydrogeology of the system. The total recharge to the model is about 139 cubic feet per second. This number is calculated from the recharge distribution over the surface area of the model (fig. 16). The flux of water into the model from recharge is balanced by the flux of water out of the model through wells, drains, rivers, and the constant head boundaries. Almost

48 cubic feet per second leaves the model through the three constant head boundary segments. These boundaries are distant from the pumping centers, and analyses of the fluxes across these boundaries indicate that they have little effect on the model results. Changing the constant head boundaries to constant flux boundaries produces changes in model calculated heads of several tens of feet near the boundaries and only several feet near the pumping centers. The drain flux includes drains along the creeks and the extreme upper reaches of streams east of Moscow. The well flux includes both ground-water pumpage and the flux out the seepage face along the Snake River Canyon. About 31 cubic feet per second reaches the Grande Ronde Basalt layer in the model. The fluxes between layers are summarized in figure 23.

The river discharge summation is divided into the discharges for individual streams (Table 4). These numbers may be compared directly to the streamflow measurements on figure 9. The discharges are generally within an order of magnitude of each other. Such a fit is reasonable given the simplified mathematical treatment of the streams in the model. The agreement of the stream discharges provides additional evidence to support model calibration.

Table 3. Water Budget of Time-Average Model

Summary

	IN (cfs)	OUT (cfs)	SUM (cfs)
Storage	0.0	0.0	0.0
Constant Heads	11.4	59.0	-47.6
Wells	0.1	38.0	-37.9
Drains	0.0	30.1	-30.1
Recharge	138.9	0.0	138.9
Rivers	1.4	24.6	-23.2

0.12 percent discrepancy

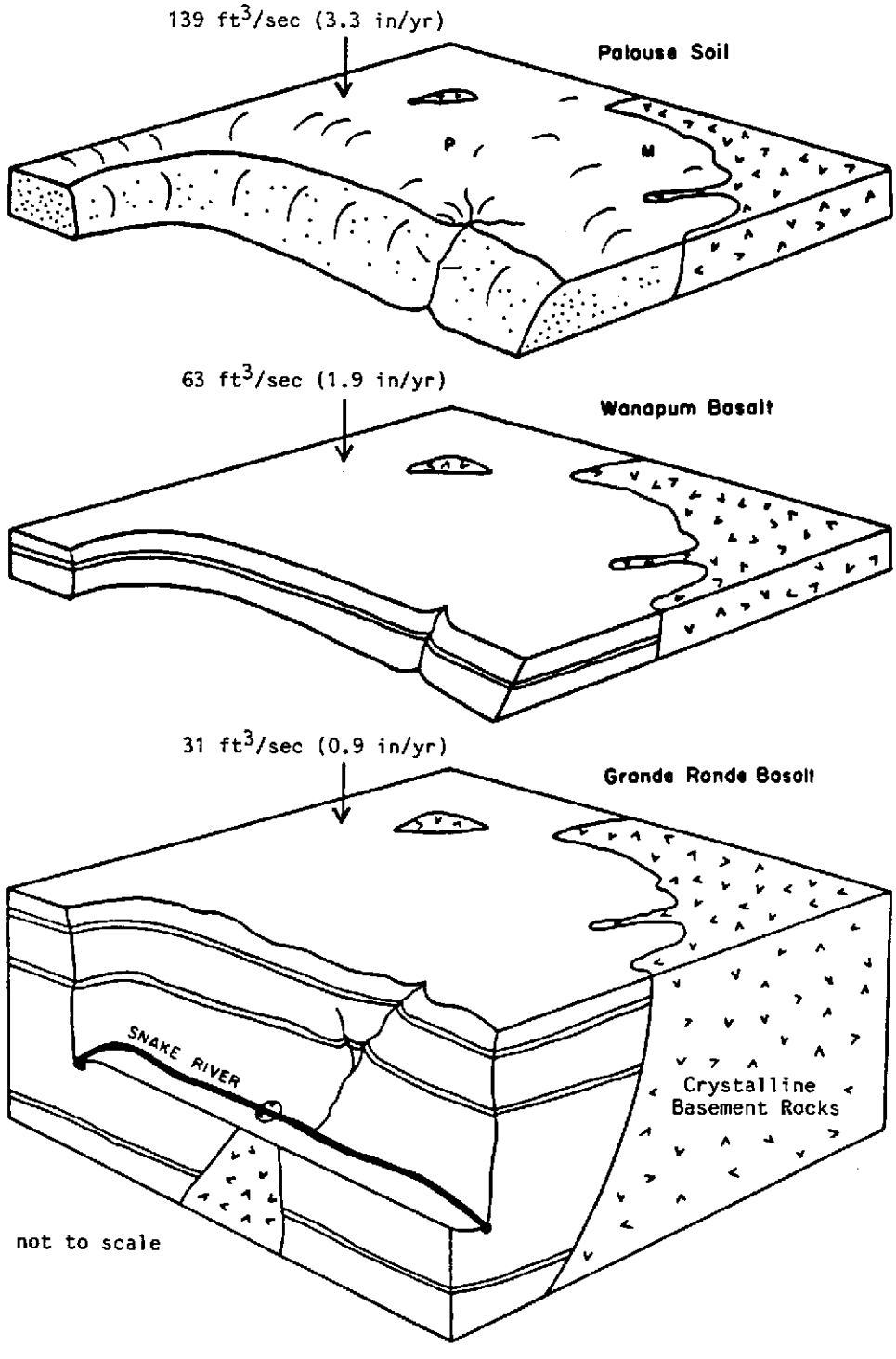


Figure 23. Layer fluxes in the three-dimensional model.

Table 4. Discharge From Model to Rivers (cfs)

Snake River	3.0
S. Fork Palouse above Pullman	1.6
S. Fork Palouse below Pullman	4.6
Palouse River	0.1
Union Flat Creek	3.5
Paradise Creek	1.5
Fourmile Creek	5.3
Missouri Flat Creek	4.4
Spring Flat Creek	1.5

The model appears to be relatively insensitive to changes in storativity over a reasonable range for confined basalt aquifers (1×10^{-3} to 1×10^{-6}). The relative insensitivity of the Pullman-Moscow model to changes in storativity indicates that much of the water pumped from the ground-water system does not come from storage within the aquifer. The source of this water is most likely the result of losses from streams and a reduction in discharge to the Snake River canyon.

Evaluation of Time-Average Calibration

The final step of model construction is an evaluation of the ability of the calibrated model to predict historical water level records. Hydraulic heads computed by the model over time are compared to historical hydrographs for the time period from predevelopment through 1974, the beginning of the time-average calibration period, and then checked against the 1974 to 1985 time-average calibration period. Initial comparison of model results with historic data showed unacceptable differences. Hydrologic coefficients were changed and then checked by rerunning the cross-sectional models and the time-average

three-dimensional model. The history match was then rechecked. Storativity was the primary target during these adjustments because it is the least known of the hydrologic coefficients.

The model simulation begins in 1890 with one well in Pullman, one well in Moscow, and a pumpage rate of less than 1 acre-foot per year. Pumpage is increased over time and wells added to the appropriate cell according to the historical record. Washington State University well 1 (14/45-5F1) and University of Idaho well 3 (39/5-7cbb1) penetrate the Grande Ronde Formation and were chosen for comparison to model results. The wells were chosen based upon completeness of water level records and the fact that they are representative of wells in each municipality.

The historical hydrographs and hydrographs calculated by the model for Pullman and Moscow are shown in figure 24. The shapes of the hydrographs are of primary importance. The differences in the absolute water level elevations between calculated and observed hydrographs result primarily from limitations inherent in representing the Grande Ronde Formation as a single model layer. Most wells in the area penetrate only the upper portion of the Grande Ronde hydrostratigraphic unit. Consequently, the water level record for most wells is for the upper part of the formation, whereas the model calculates water levels representing the complete thickness of the hydrostratigraphic unit.

The curves presented in figure 24 may be used to predict short-term water level declines below present levels for both cities. The rate of water level change is more important for management purposes than is the absolute magnitude of the water level elevation.

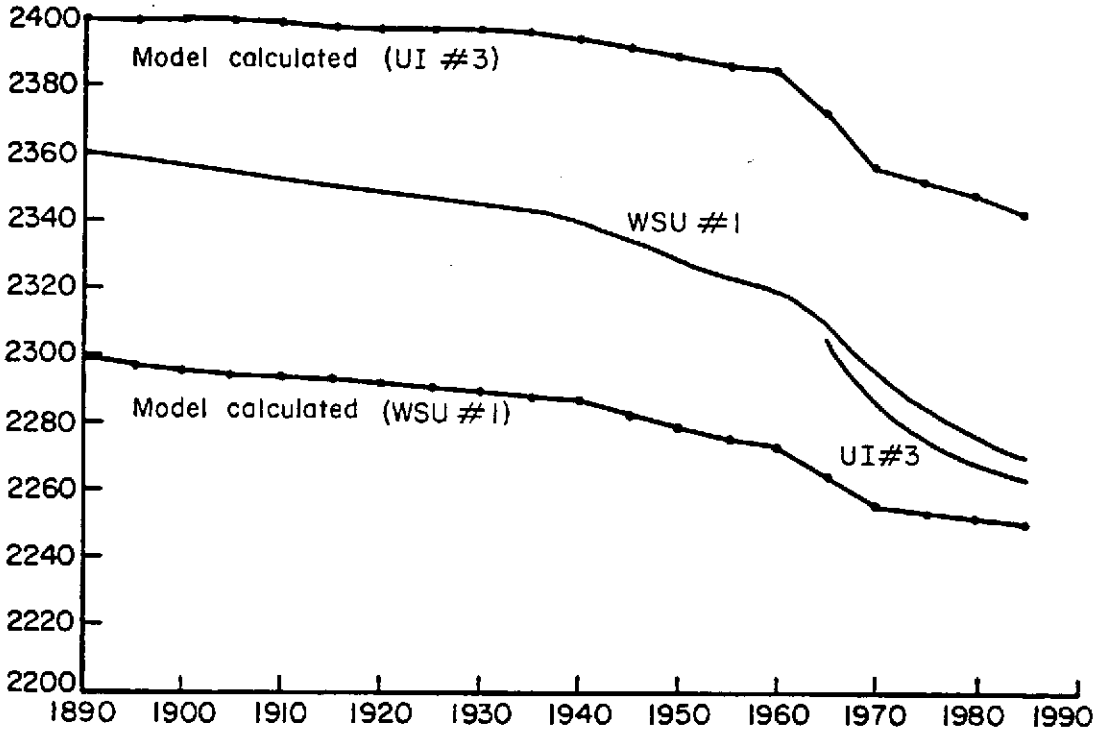


Figure 24. History match evaluation of the calibrated model results for the Grande Ronde Basalt Formation.

CHAPTER V

PREDICTIVE SCENARIOS

Introduction

The common perception among water users in the Pullman-Moscow area is that water consumption and the corresponding pumpage has remained essentially constant over the past decade. Pumpage data indicate that annual ground-water pumpage has continually increased. An analysis of five-year averages of pumpage conducted in order to smooth out the effect of extreme years indicates a nearly steady increase of about 1.7 percent per year since the 1940's (fig. 10). A future decrease in the pumpage rate in the area is not likely; therefore the model predictions focus on water use at or above the 1985 rate of 7,600 acre-feet per year.

Six different projections were examined in order to bracket potential future pumpage patterns (Table 5). Three projections are based on stable pumping rates, and three projections are for various rates of growth in pumpage. These projections are intended to bracket water use based upon the extremes of 3 percent pumpage growth per year and a stabilization of pumpage rates at the 1985 level of 7,600 acre-feet per year.

Table 5. Pumpage Projection Scenarios for 1990 and 2000

Group I: Constant Future Pumpage	Future Pumpage Rates (acre-feet/year)	
	1990	2000
1. Maintain 1985 rate:	7,600	7,600
2. 125 percent 1985 rate:	9,500	9,500
3. 200 percent 1985 rate:	15,000	15,000
Group II: Continual Growth in Pumpage Rates.		
4. 1%/year growth from 1985 rate:	8,000	8,800
5. 2%/year growth from 1985 rate:	8,400	10,200
6. 3%/year growth from 1985 rate:	8,800	11,800

Constant Pumpage Scenarios

The ground-water impacts of future pumpage at three different constant rates are investigated with the model. These rates are listed as Group I in Table 5. The model results indicate that ground-water levels will decline and then stabilize at annual pumpage rates as great as twice the 1985 rate if pumpage is held constant into the future. The elevation of the stabilized water levels and the length of time required to achieve this stabilization are dependent on the pumping rate. Larger pumpage rates increase the depth at which any water level stabilization occurs and increase the time required for such stabilization to occur.

Pumpage at 100 Percent of 1985 Level

The first projection scenario is for a constant pumpage rate at the 1985 level of about 7,600 acre-feet per year. The model results indicate that water levels stabilize in a short time with little additional water level decline (fig. 25, curve a). A reasonable interpretation of this

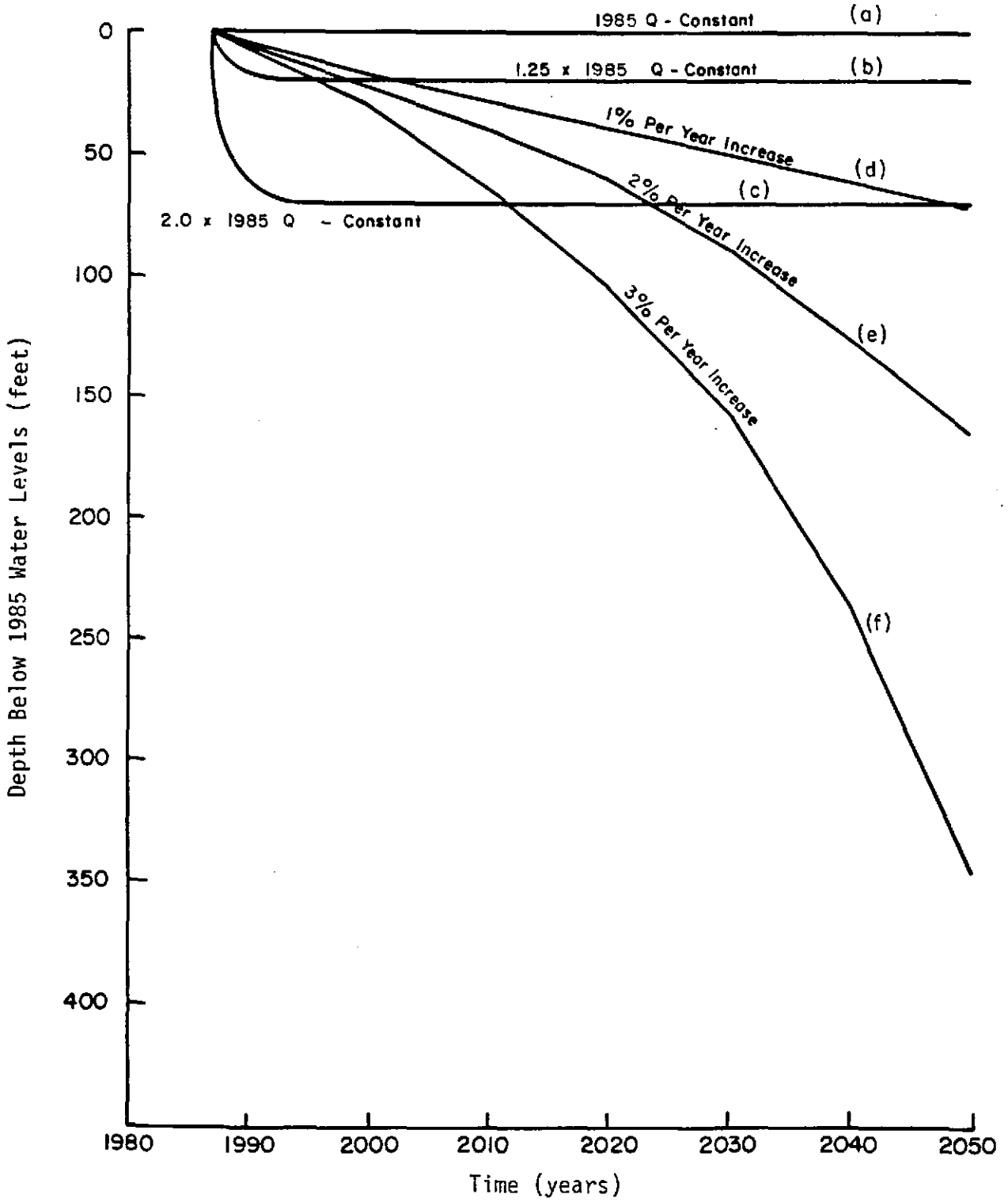


Figure 25. Future ground-water level projections for Pullman and Moscow.

model prediction is that water levels will stabilize within a few decades with perhaps as much as several ten's of feet of additional water level decline. Some lag time is involved in the response of the physical system beyond that predicted by the model because of the single layer representation of the Grande Ronde Formation. The important implication of this predictive scenario is that a stabilization of water levels will occur without extensive water level decline.

Discretion must be exercised in literal interpretation of the model results. The model is based upon a series of assumptions and simplifications with respect to a very complex hydrogeologic system. The accuracy of the three-dimensional model results are discussed in a section entitled "Limitations of Model Predictions".

Pumpage at 125 Percent of 1985 Level

The second projection scenario is for a constant pumpage rate at 125 percent of 1985 levels, about 9,500 acre-feet per year. The model results indicate that water levels will stabilize in about five years with additional water level declines of about twenty feet (fig. 25, curve b). A reasonable interpretation of this model result is that water levels would stabilize within several decades with perhaps as much as several ten's of feet of additional water level decline. Both the stabilization period and the decline of water levels would be greater than for the first option. The important implication of this predictive scenario is that a stabilization of water levels will occur.

Pumpage at 200 Percent of 1985 Level

The third projection scenario is for a constant pumpage rate at 200 percent of 1985 levels. This pumpage rate is about 15,000 acre-feet per year. The model results indicate that water levels will stabilize within about ten years with an additional water level decline of about 70 feet (fig. 27, curve c). A reasonable interpretation of this model result is that water level stability is possible for the area even with a pumpage rate twice that of 1985. Again, care must be taken to consider the model results in the perspective of the assumptions and simplifications involved in model construction.

Increasing Pumpage Rate Scenarios

Annual pumpage rate increases are representative of historical water use trends over the last 40 years. Pumpage rate scenarios that incorporate one percent, two percent, and three percent annual increases are investigated using the model. All three scenarios indicate that water level declines will accompany increases in pumping rates. Figure 25 (d,e,f) shows that the rate of water level decline is proportional to the rate of pumpage increase.

Pumpage Increase at 1 Percent Per Year

The first projection scenario represents a pumpage rate increase of one percent annually from 1985 levels. The pumpage rate will double by the year 2050 at this rate of increase. The model results indicate that water level declines will continue as long as pumpage rates increase (fig. 27, curve d). The rate of decline illustrated is about 1 to 1.5 feet per year. The model results indicate that equilibrium conditions

between recharge and discharge will not occur. The error inherent in this model prediction increases with time into the future. The important implication of this predictive scenario is that water level declines will occur as long as pumpage increases annually, even at the relatively low level of one percent per year.

Pumpage Increase at 2 Percent Per Year

The historical trend of pumpage rate increases in the basin has been an average annual increase of about 1.7 percent since the 1940's. On this basis, the two percent curve shown in figure 27 may be the most indicative of current trends in the basin. The two percent scenario suggests that water level declines would average 2 to 3 feet per year in the Pullman and Moscow areas into the foreseeable future. The rate of annual water level decline would gradually increase in the future.

Pumpage Increase at 3 Percent Per Year

The third projection scenario represents a relatively rapid three percent annual rate of pumpage increase from 1985 levels. The model results indicate that water level declines would occur at rates greater that experienced to date (fig. 25, curve f). Water levels would decline on the order of 30 to 40 feet per decade over the next several decades. The error inherent in this model prediction is probably greater than the other predictive runs because it is the greatest deviation from present conditions.

Limitations of Model Predictions

The model incorporates many simplifying assumptions about the treatment of the aquifer system. Most important are the assumptions of constant heads along some boundaries, homogeneous blocks of aquifer material both laterally and with depth, and the simplified treatment of streams and rivers. Particularly important is the representation of the Grande Ronde Formation as a single layer. These simplifications may allow the model to achieve recharge-discharge equilibrium sooner and with less drawdown than would be experienced in the field.

The use of constant head boundaries was tested by replacing the constant head boundary with a constant flux boundary. This change produced some additional drawdown for all scenarios. However, the amount of drawdown was small, leading to the conclusion that the constant head boundaries are far enough away that they have little impact on predicted water levels at Pullman and Moscow.

The model representation of half-mile square homogeneous blocks of aquifer material do not account for discontinuities that might impede flow and lengthen the time required for equilibrium to be established. Similar problems may apply to leakage from streams.

Recharge and discharge amounts and locations represented in the model control predictive pumpage scenarios. The pattern of ground-water level declines in the region and the extent to which equilibrium will be established are dependent on the interrelationship of ground-water levels and stream and seep areas.

The use of a single layer to represent the Grande Ronde Formation is significant for several reasons. This model characteristic makes it

difficult to compare model results with field data. The single representation probably results in underestimation of the time required for equilibrium conditions to occur.

The limitations described above suggest that only general conclusions should be drawn from model results. This does not lessen the value of the model but rather provides the proper perspective for interpretation of predicted water level patterns.

Implications of Findings on Ground Water as a Resource Base

Ground water presently constitutes the sole water supply source for the cities of Moscow, Idaho, and Pullman, Washington, Washington State University, and the primary supply for the University of Idaho. Recycled waste water is used to irrigate a portion of the University of Idaho campus. The future reliability of ground water as a water supply source thus is very important to the area.

The predictive runs of the model suggest that the cities and universities can rely on the existing ground-water resource without extensive additional water level declines if pumpage rates are stabilized and held constant. Conversely, the model runs suggest that continued water level declines will accompany any continual pattern of increased annual pumpage. The rates of future water level decline are directly related to the rates of increased ground-water usage.

The model results suggest that several avenues of action are warranted in the area. First, a continued effort is needed to upgrade the hydrogeologic knowledge in the area. A greater understanding is needed on locations, controls for, and magnitudes of both recharge and

discharge. Second, the cities and universities should begin planning for measures to curtail continual water level decline in the region. Activities should include water conservation, recharge enhancement, use of treated waste water, and use of water from the Wanapum Formation where ever possible. The model results indicate that there is time for long-term resource planning. Resource planning should be a cooperative effort between hydrogeological specialists and representatives of the major water users.

U of I
Thesis
87-07141

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Predictive runs of the computer model of the ground-water system in the Pullman-Moscow area suggest that the cities and the universities can rely on existing ground-water resources into the future without extensive additional water level declines if pumpage rates are stabilized. This general conclusion is based on a model which uses all available data and current modeling procedures but incorporates a number of simplifying assumptions. Continued data collection and periodic model updating are necessary to maintain the model as a viable management tool.

Specific conclusions are listed below:

1) Magnetotelluric studies indicate that the basalt thickness ranges from 1,300 feet in Moscow and 2,000 feet in Pullman to more than 3,000 feet northwest of Pullman.

2) Results of a recharge model suggest that the average rate of recharge in the Pullman-Moscow area is about 3.6 inches per year with about 1 inch per year reaching the Grande Ronde Basalt Formation, the primary aquifer unit.

3) Most of the discharge from the ground-water resource in the Pullman-Moscow area is to streams within the area and seepage along the canyon walls of the Snake River and to a lesser extent, the Palouse River.

4) The computer model constructed for the Pullman-Moscow area uses one layer to represent the surficial loess, one layer for the Wanapum

Basalt, and one layer for the Grande Ronde Basalt. Cross-sectional models using multiple layers for the Grande Ronde Basalt are used for model calibration.

5) The calibrated three-layer model has hydraulic coefficient ranges as follows:

Horizontal hydraulic conductivity	0.6-15.0 feet/day
Vertical hydraulic conductivity	0.0001-0.0075 feet/day
Storativity	0.0001

6) Model operation suggests that recharge-discharge equilibrium will be achieved with limited additional water level decline if pumpage is stabilized at 1985 rates or up to twice 1985 rates.

7) Model operation suggests that water level decline will persist into the future as long as annual increases in pumpage occur. The run with two percent annual increase in pumpage approximates current annual pumpage increases and current annual water level decline.

8) A program of continued data collection and model updating is needed for the area. Particular emphasis is needed on gaining a better understanding of recharge and discharge locations and amounts.

Recommendations

The present modeling study is another step in the process of understanding the basin. Much information has resulted from the present study. However, much more data collection is needed to strengthen the assumptions and simplifications of the present study. The cities and universities should implement a plan for the collection of more hydrogeologic information. Such a plan should include the systematic

collection of water level and pumpage data with the establishment of a clearing house to tabulate total pumpage for the region.

Further study of the recharge, movement, and discharge of ground water in the area is needed. Particular emphasis should be on evaluation of the recharge distribution calculated for this study and on the nature of ground-water discharge along the Snake River canyon. A lysimeter should be installed to provide detailed data on water movement through the loess. A detailed examination of ground-water discharge characteristics along the Snake River canyon would add much to the understanding of the resource.

Perhaps the most important recommendation is for continued cooperation and communication between the four primary water users. The Pullman-Moscow area has a common ground-water resource. Management of the resource must involve both cities and both universities with input from the two state water management agencies. Further analysis of the ground-water situation will likely be necessary within 10 years. Continued cooperation between local agencies and agencies such as the United States Geological Survey will lead to a better understanding and awareness of the advantages and constraints of ground water as a water source in the Pullman-Moscow region.

REFERENCES CITED

Bockius, S.H., 1985, Geophysical mapping of the extent of basaltic rocks in the Moscow groundwater Basin: M.S. Thesis, University of Idaho, Moscow, Idaho, 83 p.

Barker, R.A., 1979, Computer simulation and geohydrology of a basalt aquifer system in the Pullman-Moscow Basin, Washington and Idaho: Washington State Department of Ecology Water-Supply Bulletin 48, 119 p.

Bauer, H.H., and Vaccaro, J.J., 1987, Documentation of a deep percolation model for estimating ground-water recharge, U.S. Geological Survey Open-File Report, Tacoma, Washington (in press).

Bauer, H.H., Vaccaro, J.J., and Lane, R.C., 1985, Maps showing ground-water levels in the Columbia River Basalt and overlying materials, spring 1983, southeastern Washington: U.S. Geological Survey Water Resources Investigations Report 84-4360, scale 1:500,000, 4 sheets.

Blazs, R.L., 1984, Personal communication: U.S. Geological Survey Water Resources Division, Spokane, Washington.

Blazs, R.L., 1986, Personal communication: U.S. Geological Survey Water Resources Division, Spokane, Washington.

Brown, J.C., 1976, Well construction and stratigraphic information: Pullman test and observation well, Pullman, Washington, College of Engineering Research Report 76/15-6, Washington State University, Pullman, Washington, 35 p.

Bush, J.H., Jr., 1987, Personal communication: Department of Geology, University of Idaho, Moscow, Idaho

Cotton, W.R., Jr., 1982, Hydrochemistry of ground water near Pullman, Washington: M.S. Thesis, Washington State University, 89 p.

Crosthwaite, E.G., 1975, Basic ground-water data for the Moscow Basin, Idaho: U.S. Geological Survey Open-File Report, Boise, Idaho, 96 p.

DeMotte, H., and Miles, W.F., 1933, A study of the Pullman artesian basin: Undergraduate Honors Thesis in Civil Engineering and Geology, Washington State University, Pullman, Washington, 35 p.

Eyck, G.T., and Warnick, C., 1984, Catalog of water reports pertinent to the municipal water supply of Pullman, Washington and Moscow, Idaho-a summary: Idaho Water and Energy Resources Research Institute, University of Idaho, Moscow, Idaho, 56 p.

Foxworthy, B.L., and Washburn, R.L., 1963, Ground water in the Pullman area, Whitman County, Washington: U.S. Geological Survey Water-Supply Paper 1655, 71 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

Hammel, J.E., 1986, Personal communication: Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, Idaho.

Hansen, A.J., Jr., 1985, Personal communication: U.S. Geological Survey Water Resources Division, Tacoma, Washington.

HISARS, Hydrologic Information Storage and Retrieval System, 1986, Department of Agricultural Engineering, University of Idaho, Moscow, Idaho.

Hooper, P.R., and Webster, G.D., 1982, Geology of the Pullman, Moscow West, Colton, and Uniontown 7 1/2 minute quadrangles, Washington and Idaho: State of Washington, Department of Natural Resources, Division of Geology and Earth Resources, Geologic Map GM-26, scale 1:62,500, 1 sheet.

Jensen, M.E., 1973, Consumptive use of water and irrigation water requirements: American Society of Civil Engineers, Irrigation and Drainage Division, 215 p.

Jones, R.W., and Ross, S.H., 1969, Detailed ground water investigation of Moscow Basin: Research Technical Completion Report, Project A-011-IDA, Idaho Water Resources Research Institute, Moscow, Idaho, 11 p.

Jones, R.W., and Ross, S.H., 1972, Moscow basin ground water studies, Idaho Bureau of Mines and Geology, Pamphlet No. 153, 95 p.

Klein, D.P., and Sneddon, R.A., 1985, Depth to electrical basement based on magnetotelluric data in the Moscow, Idaho-Pullman, Washington area: preliminary report to Pacific Northwest Division, U.S. Geological Survey, Denver, Colorado, 23 p.

Klein, D.P., Sneddon, R.A., and Smoot, J.L., 1987, A magnetotelluric study of the thickness of volcanic and sedimentary rock in the Pullman-Moscow Basin of eastern Washington: U.S. Geological Survey Open-File Report, Denver, Colorado (in press).

Konikow, L.F., 1978, Calibration of ground-water models: Proceedings of the Specialty Conference on Verification of Mathematical and Physical Models in Hydraulic Engineering, American Society of Civil Engineers, College Park, Maryland, August 9-11, 1978, p. 87-93.

Lin, C., 1967, Factors affecting ground water recharge in the Moscow Basin, Latah County, Idaho: M.S. Thesis, Washington State University, Pullman, Washington, 86 p.

Lum, W.E., II, 1986, Personal communication: U.S. Geological Survey Water Resources Division, Tacoma, Washington.

Luzier, J.E., and Skrivan, J.A., 1973, Digital simulation and projection of water-level declines in basalt aquifers of the Odessa-Lind area, east-central Washington: U.S. Geological Survey Open-File Report, 56 p.

Mac Nish, R.D., and Barker, R.A., 1976, Digital simulation of a basalt aquifer system, Walla Walla River basin, Washington and Oregon: Washington Department of Ecology Water-Supply Bulletin 44, 51 p.

McDonald, M.G., and Harbaugh, A.W., 1984, A modular three-dimensional finite-difference ground-water flow model, U.S. Geological Survey Open File Report 83-875, 528 p.

McGary, L.M., and Lambert, T.W., 1962, Reconnaissance of ground-water resources of the Jackson Purchase region, Kentucky: U.S. Geological Survey Hydrologic Atlas 13.

Newcomb, R.C., 1965, Geology and ground-water resources of the Walla Walla River basin, Washington-Oregon, Washington Division of Water Resources Water Supply Bulletin 21, 151 p.

Pinder, G.F., 1971, An iterative digital model for aquifer evaluation: U.S. Geological Survey Open-File Report, 65 p.

Prych, E.A., 1983, Numerical simulation of ground-water flow in lower Satus Creek Basin, Yakima Indian Reservation, Washington: U.S. Geological Survey Water-Resources Investigations 82-4065, 78 p.

Ralston, D.R., 1986, Personal communication: Department of Geology, University of Idaho, Moscow, Idaho.

Ringe, L.D., 1968, Geomorphology of the Palouse Hills, southeastern Washington: M.S. Thesis, Washington State University, Pullman, Washington, 73 p.

Ross, S.H., 1965, Contributions to the geohydrology of Moscow Basin, Latah County, Idaho: M.S. Thesis, University of Idaho, Moscow, Idaho, 119 p. and plates.

Russell, I.C., 1897, A reconnaissance in southeastern Washington: U.S. Geological Survey Water-Supply Paper 4, 96 p.

Stanley, W.D., and Frederick, N.V., 1979, U.S. Geological Survey real-time MT system: U.S. Geological Survey Open-File Report 79-R27, 55 p.

Stanley, W.D., and Tinkler, R.D., 1982, A practical low-noise coil system for magnetotellurics: U.S. Geological Survey Open-File Report 83-885, 49 p.

Strait, S.R., and Spane, F.A., Jr., 1982a, Preliminary results of hydrologic testing the composite middle Sentinel Bluffs Basalt flow bottom at borehole RRL-2, SD-BWI-TI-095, Rockwell Hanford Operations, Richland, Washington, 36 p.

Strait, S.R., and Spane, F.A., Jr., 1982b, Preliminary results of testing the composite Umtanum Basalt flow top at borehole RRL-2 (3,568 - 3,781 feet), SD-BWI-TI-105, Rockwell Hanford Operations, Richland, Washington, 45 p.

Strait, S.R., and Spane, F.A., Jr., 1982c, Preliminary results of hydrologic testing the Umtanum Basalt entablature at borehole RRL-2 (3,762 - 3,508 feet), SD-BWI-TI-107, Rockwell Hanford Operations, Richland, Washington, 37 p.

Swanson, D.A., Wright, T.L., Hooper, P.R., and Bentley, R.D., 1979, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457-G, 59 p.

Swanson, D.A., Wright, T.L., Camp, V.E., Gardner, J.N., Helz, R.T., Price, S.M., Reidel, S.P., and Ross, M.E., 1980, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geological Survey Miscellaneous Investigations Series Map I-1139, scale 1:250,000, 2 sheets.

Tanaka, H.H., Hansen, A.J., Jr., and Skrivan, J.A., 1974, Digital-model study of ground-water hydrology, Columbia Basin Irrigation Project area, Washington: Washington Department of Ecology Water-Supply Bulletin 40, 60 p.

Vaccaro, J.J., 1986, Personal communication: U.S. Geological Survey Water Resources Division, Tacoma, Washington.

Vozoff, Keeva, 1972, The magnetotelluric method in the exploration of sedimentary basins: Geophysics, v. 37, no. 1, p. 98-141.

Walters, K.L., and Glancy, P.A., 1969, Reconnaissance of geology and of ground-water occurrence and development in Whitman County, Washington: Washington Department of Water Resources Water Supply Bulletin, 26, 169 p.

Wang, H.F., and Anderson, M.P., 1982, Introduction to groundwater modeling: finite difference and finite element methods: W.H. Freeman and Company, San Francisco, California, 237 p.

Wang, C.P., and Williams, R.E., 1984, Aquifer testing, mathematical modeling, and regulatory risk: Ground Water, v. 22, no. 3, p. 285-296.

Wight, J.R., and Neff, E.L., 1983, Soil-vegetation-hydrology studies, volume II, a user manual for ERHYM: U.S. Department of Agriculture, A.R.S., Agricultural Research Results, ARR-W-29, January, 1983, 38 p.

Williams, R.E., 1985, Personal communication: Department of Geology, University of Idaho, Moscow, Idaho.

Williams, R.E., and Allman, D.W., 1969, Factors affecting infiltration and recharge in a loess covered basin: Journal of Hydrology, v. 8, p. 265-281.

APPENDIX A

THREE-DIMENSIONAL MODEL INPUT AND OUTPUT PROCESSOR SOFTWARE

```
C     A PROGRAM TO SUM THE FLUXES ALONG THE THREE SEGMENTS OF CONSTANT
C     HEAD BOUNDARY IN EACH LAYER OF THE 3-D MODEL.  INPUT TO THE
C     PROGRAM IS CELL BY CELL OUTPUT FROM THE 3-D MODEL.
C
C     CHBSUM - FLUX SUMMATION ALONG A CONSTANT HEAD BOUNDARY SEGMENT.
C     IGROUP - NUMBER OF CONSTANT HEAD CELLS IN THE 3D MODEL.
C     RATE   - FLUX THROUGH INDIVIDUAL CONSTANT HEAD CELLS.
C
      DIMENSION IGROUP(6), CHBSUM(12)
      READ (4,30) (IGROUP(I),I=1,6)
      III = 1
      DO 20 I = 1,6
      DO 10 II = 1,IGROUP(I)
      READ (5,40) RATE
      IF (RATE .LE. 0.0) CHBSUM(III) = CHBSUM(III) + RATE
      IF (RATE .GT. 0.0) CHBSUM(III + 1) = CHBSUM(III + 1) + RATE
10    CONTINUE
      III = III + 2
20    CONTINUE
      LYR = 2
      LYRR= 3
      WRITE (6,50) LYR,CHBSUM(1), CHBSUM(2)
      WRITE (6,50) LYRR,CHBSUM(7), CHBSUM(8)
      WRITE (6,60) LYR,CHBSUM(3), CHBSUM(4)
      WRITE (6,60) LYRR,CHBSUM(9), CHBSUM(10)
      WRITE (6,70) LYR,CHBSUM(5), CHBSUM(6)
      WRITE (6,70) LYRR,CHBSUM(11), CHBSUM(12)
30    FORMAT(6I3)
40    FORMAT(78X,G15.7)
50    FORMAT('  NW CORNER LYR ',I2,5X,2E15.3//)
60    FORMAT('  EAST SIDE LYR ',I2,5X,2E15.3//)
70    FORMAT('  SOUTH     LYR ',I2,5X,2E15.3//)
      STOP
      END
```

```
C     A PROGRAM TO CALCULATE LAYER TO LAYER FLUXES IN THE 3D MODEL.
C
C     DZ12 -  DISTANCE BETWEEN NODE CENTERS IN LAYERS 1 AND 2.
C     DZ23 -  DISTANCE BETWEEN NODE CENTERS IN LAYERS 2 AND 3.
C     HED  -  UNFORMATTED OUTPUT HEADS FROM 3D MODEL.
C     HEAD -  FORMATTED HEADS FROM 3-D MODEL.
C     QP   -  POSITIVE FLUX.
C     QN   -  NEGATIVE FLUX.
C
      DIMENSION HEAD(3,55,55), HED(55,55), DZ12(55,55), DZ23(55,55)
C
      QP12 = 0.
      QN12 = 0.
      QP23 = 0.
      QN23 = 0.
C
      QSUM12 = 0.0
      QSUM23 = 0.0
C
      DO 10 K=1,3
      READ(3)
      READ(3) HED
      DO 10 I=1,55
      DO 10 J=1,55
      HEAD(K,I,J)=HED(J,I)
10    CONTINUE
C
      READ (4,20) ((DZ12(I,J),J=1,55),I=1,55)
      READ (4,20) ((DZ23(I,J),J=1,55),I=1,55)
20    FORMAT (4(12E10.2/),7E10.2)
C
C
      DO 40 K=1,2
      DO 40 I=1,55
      DO 40 J=1,55
      FLOW2 = 0.0
      FLOW3 = 0.0
C     AREA OF A CELL BOTTOM
      AREA = 6969600.00
      IF (HEAD(K,I,J) .LE. 0.0) GO TO 30
      IF (HEAD(K+1,I,J) .LE. 0.0) GO TO 30
C     FLUX = (HEAD(K) - HEAD(K+1)) * VCONT * AREA
       IF (K.EQ.1) FLOW2 = (HEAD(K,I,J)-HEAD(K+1,I,J))*DZ12(I,J)*AREA
       IF (K.EQ.2) FLOW3 = (HEAD(K,I,J)-HEAD(K+1,I,J))*DZ23(I,J)*AREA
       IF (FLOW2 .GT. 0.0) QP12 = QP12 + FLOW2
       IF (FLOW2 .LT. 0.0) QN12 = QN12 + FLOW2
       IF (FLOW3 .GT. 0.0) QP23 = QP23 + FLOW3
       IF (FLOW3 .LT. 0.0) QN23 = QN23 + FLOW3
30    CONTINUE
40    CONTINUE
C
```

```
      QSUM12 = QP12 + QN12
      QSUM23 = QP23 + QN23
C
      WRITE (6,50)
      WRITE (6,60) QP12,QN12,QSUM12
      WRITE (6,140)
      WRITE (6,70) QP23,QN23,QSUM23
      WRITE(6,140)
C
50    FORMAT (25X,'IN',15X,'OUT',13X,'SUM')
60    FORMAT (1H ,'FLUX TO LAYER 2 ',3E16.5)
70    FORMAT (1H ,'FLUX TO LAYER 3 ',3E16.5)
C
      QD1N = 0.0
      QD2N = 0.0
      QD3N = 0.0
C
      READ(5,110) ND
      IF (ND .GT. 1000) GO TO 150
      DO 90 N=1,ND
      READ(5,80) K,I,J,Q
80    FORMAT(10X,3I5,E16.5)
      IF (K .EQ. 1 .AND. Q .LT. 0.0) QD1N = QD1N + Q
      IF (K .EQ. 2 .AND. Q .LT. 0.0) QD2N = QD2N + Q
      IF (K .EQ. 3 .AND. Q .LT. 0.0) QD3N = QD3N + Q
90   CONTINUE
C
      QR1P = 0.0
      QR1N = 0.0
      QR2P = 0.0
      QR2N = 0.0
      QR3P = 0.0
      QR3N = 0.0
      QR1S = 0.0
      QR2S = 0.0
      QR3S = 0.0
C
      READ (5,110) NR
      DO 100 N=1,NR
      READ(5,80) K,I,J,Q
      IF (K .EQ. 1 .AND. Q .GE. 0.0) QR1P = QR1P + Q
      IF (K .EQ. 1 .AND. Q .LT. 0.0) QR1N = QR1N + Q
      IF (K .EQ. 2 .AND. Q .GE. 0.0) QR2P = QR2P + Q
      IF (K .EQ. 2 .AND. Q .LT. 0.0) QR2N = QR2N + Q
      IF (K .EQ. 3 .AND. Q .GE. 0.0) QR3P = QR3P + Q
      IF (K .EQ. 3 .AND. Q .LT. 0.0) QR3N = QR3N + Q
100   CONTINUE
      QR1S=QR1P+QR1N
      QR2S=QR2P+QR2N
      QR3S=QR3P+QR3N
```

```
      K=1
      WRITE(6,120)K,QD1N
      WRITE(6,130)K,QR1P,QR1N,QR1S
      K=2
      WRITE(6,140)
      WRITE(6,120)K,QD2N
      WRITE(6,130)K,QR2P,QR2N,QR2S
      K=3
      WRITE(6,140)
      WRITE(6,120)K,QD3N
      WRITE(6,130)K,QR3P,QR3N,QR3S
110   FORMAT(I5)
120   FORMAT(1H ,'DRAINS IN LYR',I3,16X,E16.5)
130   FORMAT(1H ,'RIVERS IN LYR',I3,3E16.5)
140   FORMAT(1H )
150   CONTINUE
      STOP
      END
```

```
C     A PROGRAM TO PRODUCE ZONED HORIZONTAL AND VERTICAL HYDRAULIC
C     CONDUCTIVITY MATRICES.
      DIMENSION KHTWO(55,55), KHTHR(55,55), KVZNS(55,55) , VPRMS(3,4)
      REAL KHGR(55,55), KHWA(55,55), KVWA(55,55), KVGR(55,55), KH(2,8)
C
C     KH(I,J)    = UP TO 8 VALUES OF KH FOR ZONES(I,J) INPUT MATRIX, L3.
C                  KH(1,J) FOR WANAPUM AND KH(2,J) FOR GRANDE RONDE.
C     KHGR(I,J)  = KH MATRIX FOR GRANDE RONDE.
C     KHTWO(I,J) = J SUBSCRIPTS TO IDENTIFY KH(1,J) FOR WANAPUM.
C     KHTHR(I,J) = J SUBSCRIPTS TO IDENTIFY KH(2,J) FOR GRANDE RONDE.
C     KHWA(I,J)  = KH MATRIX FOR WANAPUM.
C     KVGR(I,J)  = KV/KH RATIO MATRIX FOR GRANDE RONDE.
C     KVWA(I,J)  = KV/KH RATIO MATRIX FOR WANAPUM.
C     KVZNS(I,J) = 4 ZONES TO VARY KV/KH RATIOS.
C     VPRMS(I,J) = KV/KH RATIOS FOR 4 ZONES IN EACH OF 3 LAYERS.
C
      READ (10,30)((VPRMS(I,J),J=1,4),I=1,3)
      READ (11,40)((KH(I,J),J=1,8),I=1,2)
      READ (12,50)((KHTWO(I,J),J=1,55),I=1,55)
      READ (13,50)((KHTHR(I,J),J=1,55),I=1,55)
      READ (14,50)((KVZNS(I,J),J=1,55),I=1,55)
C
      DO 20 J=1,55
      DO 20 I=1,55
         KVWA(I,J) = VPRMS(2,KVZNS(I,J))
         KVGR(I,J) = VPRMS(3,KVZNS(I,J))
         KHWA(I,J) = KH(1,KHTWO(I,J))
         KHGR(I,J) = KH(2,KHTHR(I,J))
20    CONTINUE
C
      WRITE (15,60)((KHWA(I,J),J=1,55),I=1,55)
      WRITE (16,60)((KHGR(I,J),J=1,55),I=1,55)
      WRITE (17,70)((KVWA(I,J),J=1,55),I=1,55)
      WRITE (18,70)((KVGR(I,J),J=1,55),I=1,55)
30    FORMAT (4F10.0)
40    FORMAT (8F5.1)
50    FORMAT (55I1)
60    FORMAT (20F6.1 / 20F6.1 / 15F6.1)
70    FORMAT (20F6.4 / 20F6.4 / 15F6.4)
      STOP
      END
```

```
C     A PROGRAM TO MULTIPLY A MATRIX.
C     READ THICKNESS AND HYDRAULIC CONDUCTIVITY AND PROGRAM WILL
C     CALCULATE A TRANSMISSIVITY MATRIX.
C
      DIMENSION THICK(55,55), TRANS(55,55)
      REAL K(55,55)
      READ (4,20)((THICK(I,J),J=1,55),I=1,55)
      READ (5,20)((K(I,J),J=1,55),I=1,55)
C
      DO 10 J=1,55
      DO 10 I=1,55
         TRANS(I,J)  = THICK(I,J)*K(I,J)
10    CONTINUE
C
      WRITE (6,20)((TRANS(I,J),J=1,55),I=1,55)
20    FORMAT (20F6.0 / 20F6.0 / 15F6.0)
      STOP
      END
```

```
C     A PROGRAM TO PICK HEADS ALONG THE LINES OF THREE CROSS
C     SECTION MODELS FROM 3-D MODEL OUTPUT.
C     HED  -  UNFORMATTED OUTPUT HEADS FROM 3D MODEL.
C     HEAD -  FORMATTED HEADS FROM 3-D MODEL.
C     HLYR -  HEADS FOR EACH LAYER ALONG THE LINE OF SECTION.
C     INUM -  NUMBER OF COLUMNS IN EACH CROSS SECTION MODEL.
C
      DIMENSION HEAD(3,55,55), HED(55,55), HLYR(3,40,3), INUM(3)
      INTEGER XCOL
      DO 10 K=1,3
      READ(4)
      READ(4) HED
      DO 10 I=1,55
      DO 10 J=1,55
      HEAD(K,I,J)=HED(J,I)
10    CONTINUE
      DO 30 ISET = 1,3
         READ (5,80) INUM(ISET)
         DO 30 JCOL=1,INUM(ISET)
            READ (5,90) I,J,XCOL
            DO 20 K=1,3
               HLYR(K,XCOL,ISET) = HEAD(K,I,J)
20          CONTINUE
C
         IF (ISET .EQ. 1) WRITE (6,100) I,J,XCOL,HLYR(1,XCOL,ISET),
     .                    HLYR(2,XCOL,ISET),HLYR(3,XCOL,ISET)
         IF (ISET .EQ. 2) WRITE (7,100) I,J,XCOL,HLYR(1,XCOL,ISET),
     .                    HLYR(2,XCOL,ISET),HLYR(3,XCOL,ISET)
         IF (ISET .EQ. 3) WRITE (8,100) I,J,XCOL,HLYR(1,XCOL,ISET),
     .                    HLYR(2,XCOL,ISET),HLYR(3,XCOL,ISET)
30    CONTINUE
      WRITE (9,40) ((HLYR(K,XCOL,3),XCOL=1,20),K=1,3)
      WRITE (9,70)
      WRITE (9,40) ((HLYR(K,XCOL,3),XCOL=21,40),K=1,3)
      WRITE (9,70)
      WRITE (9,70)
      WRITE (9,70)
      WRITE (9,40) ((HLYR(K,XCOL,2),XCOL=1,20),K=1,3)
      WRITE (9,70)
      WRITE (9,60) ((HLYR(K,XCOL,2),XCOL=21,39),K=1,3)
      WRITE (9,70)
      WRITE (9,70)
      WRITE (9,70)
      WRITE (9,40) ((HLYR(K,XCOL,1),XCOL=1,20),K=1,3)
      WRITE (9,70)
      WRITE (9,50) ((HLYR(K,XCOL,1),XCOL=21,32),K=1,3)
```

```
 40     FORMAT (20F6.0)
 50     FORMAT (12F6.0)
 60     FORMAT (19F6.0)
 70     FORMAT (1H )
 80     FORMAT (I5)
 90     FORMAT (3I5)
 100    FORMAT (3I5,3F10.0)
        STOP
        END
```

```
C     A PROGRAM TO COMPUTE THE DIFFERENCE AND DIFFERENCE SQUARED
C     FOR OBSERVED HEADS RELATIVE TO THE FOUR SURROUNDING NODE
C     CENTER COMPUTED HEADS.
C
C     COEFI  - FEET IN I DIRECTION TO WELL FROM UPPER LEFT NODE CTR
C     COEFJ  - FEET IN J DIRECTION TO WELL FROM UPPER LEFT NODE CTR
C     DIFF   - HEAD OBSERVED MINUS HEAD CALC FOR WELL LOC
C     DIFFSQ - DIFF SQUARED
C     HEAD(K,I,J) - HEAD CALCULATED BY MODEL
C     HEADOB - HEAD OBSERVED IN WELL
C     HEADC  - HEAD CALCULATED FOR WELL LOCATION
C     NUMWEL -  NUMBER OF WELLS
C     SLJT   - SLOPE IN J DIR ALONG TOP OF REP BLOCK
C     SLJB   - SLOPE IN J DIR ALONG BOTTOM OF REP BLOCK
C     SLIL   - SLOPE IN I DIR ALONG LEFT OF REP BLOCK
C     SLIR   - SLOPE IN I DIR ALONG RIGHT OF REP BLOCK
C     SLIA   - SLOPE AVERAGE IN I DIRECTION
C     SLJA   - SLOPE AVERAGE IN J DIRECTION
C     SUMDIF - SUM OF DIFF FOR NUMWEL
C     SUMSQ  - SUM OF DIFFSQ FOR NUMWEL
C
C     I,J,K FOR WELL IS ALWAYS NEAREST NODE CENTER TO LEFT AND UP
C     REP BLOCK IS THE CELL SIZED BLOCK FORMED BY CONNECTING FOUR
C     ADJACENT NODE CENTERS
C
C        I,J          I,J+1
C          .            .
C
C             *
C           WELL
C
C
C          .            .
C        I+1,J        I+1,J+1
C
C     PROGRAM READS MODEL OUTPUT HEADS FOR ALL K,I,J
C     IN DO LOOP 1 TO NUMWEL:
C     PROGRAM READS WELL K,I,J,COEFI,COEFJ,HEADOB
C     CALCULATES SLOPES IN I AND J DIR
C     CALCULATES AVERAGE SLOPE IN I AND J DIR
C     CALCULATES HEAD FOR WELL LOCATION
C     CALCULATES DIFFERENCE BETWEEN OBSERVED AND CALCULATED
C     SUMS THE DIFF
C     SQUARES THE DIFF
C     SUMS THE SQUARES
C     WRITES THE K,I,J,COEFI,COEFJ,HEADOB,HEADC,DIFF,DIFFSQ
C     END LOOP
C     WRITES SUMDIF
C     WRITES SUMSQ
C     END
C
C
```

```
      DIMENSION HEAD(3,55,55),HED(55,55)
C
C
      DO 10 K=1,3
      READ(4)
      READ(4) HED
      DO 10 I=1,55
      DO 10 J=1,55
      HEAD(K,I,J)=HED(J,I)
10    CONTINUE
C
C
C
      DO 100 ISET = 1,2
C
      SUMDIF=0.0
      SUMSQ=0.0
C
      READ(5,30) NUMWEL
C
C     WRITES TITLE FOR OUTPUT
C
      WRITE(6,70)
C
      DO 20 IWEL=1,NUMWEL
      DIFF=0.0
      DIFFSQ=0.0
      SLIT=0.0
      SLIB=0.0
      SLJL=0.0
      SLJR=0.0
      SLIA=0.0
      SLJA=0.0
      COEFI=0.0
      COEFJ=0.0
      HEADOB=0.0
      K=0
      I=0
      J=0
      READ(5,40)K,I,J,COEFI,COEFJ,HEADOB
C
      SLJT=(HEAD(K,I,J+1)-HEAD(K,I,J))/2640.
      SLJB=(HEAD(K,I+1,J+1)-HEAD(K,I+1,J))/2640.
      SLJA=(SLJT+SLJB)/2.
C
      IF(SLJT .GT. 1.0 .OR. SLJT .LT. -1.0) SLJA=SLJB
      IF(SLJB .GT. 1.0 .OR. SLJB .LT. -1.0) SLJA=SLJT
C
C
      SLIL=(HEAD(K,I+1,J)-HEAD(K,I,J))/2640.
      SLIR=(HEAD(K,I+1,J+1)-HEAD(K,I,J+1))/2640.
      SLIA=(SLIL+SLIR)/2.
```

```
      IF (SLIL .GT. 1.0 .OR. SLIL .LT. -1.0) SLIA=SLIR
      IF (SLIR .GT. 1.0 .OR. SLIR .LT. -1.0) SLIA=SLIL
C
      HEADC=HEAD(K,I,J)+(SLIA*COEFI+SLJA*COEFJ)
      DIFF=HEADOB-HEADC
      SUMDIF=SUMDIF+DIFF
      DIFFSQ=DIFF*DIFF
      SUMSQ=SUMSQ+DIFFSQ
C
      WRITE(6,50)K,I,J,COEFI,COEFJ,HEADOB,HEADC,DIFF,DIFFSQ
C     WRITE(6,80)K,I,J,HEAD(K,I,J),HEAD(K,I+1,J),
C    .HEAD(K,I,J+1),HEAD(K,I+1,J+1)
C     WRITE(6,90)SLJT,SLJB,SLJA,SLIL,SLIR,SLIA
C
20    CONTINUE
C
      WRITE(6,60)SUMDIF,SUMSQ
C
30    FORMAT(I10)
40    FORMAT(3I5,3F10.0)
50    FORMAT(3I5,5F10.2,G10.2)
60    FORMAT(/'   SUM OF THE DIFFERENCES=',G10.2,/'   SUM OF THE SQUARES
     . OF THE DIFFERENCES=',G10.2///)
70    FORMAT('   K    I    J      COEFI      COEFJ     HEADOB     HEADC
     .  DIFF      DIFFSQ'/)
80    FORMAT(3I5,4F10.0)
90    FORMAT(15X,6F10.4/)
C
100   CONTINUE
      STOP
      END
```

```
C     PROGRAM TO COMPUTE SOURCE/SINK TERMS FOR TIME-AVERAGE SIMULATION.
C     SINK TERM FOR EACH NODE REPRESENTS THE AVERAGE RATE OF RELEASE OF
C     WATER FROM STORAGE FOR THE TIME AVERAGE PERIOD.
C
C     AREA OF CELL - 2640 * 2640 SQUARE FEET.
C     CORRECTION FACTOR - CONVERTS NODAL FLUX FROM CUBIC FEET PER
C       11 YEARS TO CUBIC FEET PER DAY.
C     ISINK - WATER LEVEL CHANGE FOR 11 YEARS
C     S - STORAGE OF LAYER
C     SOURCE/SINK - WELL FUNCTION REPRESENTING:  WATER LEVEL CHANGE *
C       STORATIVITY * AREA OF CELL * CORRECTION FACTOR.
C
      DIMENSION ISINK(55,55,3), SINK(55,55,3), S(3)
C
      CORR = 1.0/(365. * 11.0)
C
      TOTP2 = 0.0
      TOTN2 = 0.0
      TOTP3 = 0.0
      TOTN3 = 0.0
C
      READ (3,60) ((ISINK(I,J,2),J=1,55),I=1,55)
      READ (4,60) ((ISINK(I,J,3),J=1,55),I=1,55)
      READ (5,70) (S(I),I=2,3)
C
      DO 40 I=1,55
      DO 40 J=1,55
      SINK(I,J,2) = ISINK(I,J,2) * 2640. * 2640. * CORR * S(2)
      SINK(I,J,3) = ISINK(I,J,3) * 2640. * 2640. * CORR * S(3)
      IF (J .GT. 34) GO TO 10
      GO TO 30
10    IF (I .GT. 34) GO TO 20
      GO TO 30
20    SINK(I,J,2) = SINK(I,J,2) *  1.0
      SINK(I,J,3) = SINK(I,J,3) *  1.0
30    CONTINUE
40    CONTINUE
C
      DO 50 K=2,3
      DO 50 I=1,55
      DO 50 J=1,55
      IF(SINK(I,J,K) .NE. 0.0) WRITE(63,80)K,I,J,SINK(I,J,K)
      IF(SINK(I,J,2) .GT. 0.0) TOTP2 = TOTP2 + SINK(I,J,2)
      IF(SINK(I,J,2) .LT. 0.0) TOTN2 = TOTN2 + SINK(I,J,2)
      IF(SINK(I,J,3) .GT. 0.0) TOTP3 = TOTP3 + SINK(I,J,3)
      IF(SINK(I,J,3) .LT. 0.0) TOTN3 = TOTN3 + SINK(I,J,3)
50    CONTINUE
C
      WRITE (100,90) TOTP2,TOTN2, TOTP3, TOTN3
C
```

```
60    FORMAT(55I2)
70    FORMAT(2F10.0)
80    FORMAT(3I10,F10.0)
90    FORMAT(' WELLS REPRESENTING TIME AVERAGE CHANGE'/,
     .' LYR 2 WELLS',2F10.0,' LYR 3 WELLS',2F10.0)
C
      STOP
      END
```

```
C     A PROGRAM TO CALCULATE VCONT FOR 3D MODEL FROM LAYER THICKNESS,
C     KV RATIO AND KH FOR EACH LAYER.  BASED ON HARMONIC MEAN OF KV'S.
C
      COMMON THICK(55,55,3),
     .       HALFTH(55,55,3),
     .       KH(55,55,3),
     .       KV(55,55,3),
     .       VC(55,55,3)
      REAL KH1,KVR1,KH,KV
C
C     THICK(I,J,K)  - LYR THICKNESS
C     HALFTH(I,J,K) - LYR HALF-THICKNESS
C     KH(I,J,K)     - LYR HORIZ CONDUCTIVITY
C     KV(I,J,K)     - LYR TO LYR VERT. CONDUCTIVITY ANISOTROPHY RATIO
C                     MULT BY KH TO GET VERT HYD COND
C     VC(I,J,K)     - CALC VCONT
C
      READ(60,90) THK1,KH1,KVR1
      READ(61,92) ((THICK(I,J,2),J=1,55),I=1,55)
      READ(62,92) ((THICK(I,J,3),J=1,55),I=1,55)
      READ(63,92) ((KH(I,J,2),J=1,55),I=1,55)
      READ(64,92) ((KH(I,J,3),J=1,55),I=1,55)
      READ(65,92) ((KV(I,J,2),J=1,55),I=1,55)
      READ(66,92) ((KV(I,J,3),J=1,55),I=1,55)
C
      DO 10 I=1,55
      DO 10 J=1,55
      THICK(I,J,1) = THK1
      KH(I,J,1)    = KH1
      KV(I,J,1)    = KVR1
      DO 10 K=1,3
      KV(I,J,K) = KV(I,J,K) * KH(I,J,K)
      HALFTH(I,J,K) = THICK(I,J,K) / 2.0
10    CONTINUE
C
C     CALCULATE VCONT.
C
      DO 80 I=1,55
      DO 80 J=1,55
C
C     CALCULATE HARMONIC MEAN KV = D/((D/KV)+(D/KV)).
C
      TOP = HALFTH(I,J,1) + HALFTH(I,J,2)
      DEN = (HALFTH(I,J,1)/KV(I,J,1)) + (HALFTH(I,J,2)/KV(I,J,2))
      IF(DEN .LE. 0.0) GO TO 20
      KV(I,J,1) = TOP / DEN
20    CONTINUE
      TOP = HALFTH(I,J,2) + HALFTH(I,J,3)
      DEN = (HALFTH(I,J,2)/KV(I,J,2)) + (HALFTH(I,J,3)/KV(I,J,3))
      IF(DEN .LE. 0.0) GO TO 30
      KV(I,J,2) = TOP / DEN
30    CONTINUE
```

```
C     CALCULATE VCONT FROM HARMONIC MEAN KV AND D BETWEEN NODE CENTERS
C
      HTH = HALFTH(I,J,1) + HALFTH(I,J,2)
      IF(HTH .LE. 0.0) GO TO 40
      VC(I,J,1) = KV(I,J,1)/HTH
      GO TO 50
40    CONTINUE
      WRITE(70,96) I,J,HTH
50    CONTINUE
C
      HTH = HALFTH(I,J,2) + HALFTH(I,J,3)
      IF(HTH .LE. 0.0) GO TO 60
      VC(I,J,2) = KV(I,J,2)/HTH
      GO TO 70
60    CONTINUE
      WRITE(70,98) I,J,HTH
70    CONTINUE
C
80    CONTINUE
C
      WRITE(67,94) (((VC(I,J,K),J=1,55),I=1,55),K=1,2)
C
90    FORMAT(3F10.0)
92    FORMAT(2(20F6.0/)15F6.0)
94    FORMAT(4(12E10.3/)7E10.3)
96    FORMAT('  PROBLEM IN VCONT 1-2',2I5,F10.1)
98    FORMAT('  PROBLEM IN VCONT 2-3',2I5,F10.1)
      STOP
      END
```

```
C     A PROGRAM TO GENERATE INPUT DATA SETS SIMULATING SEEPAGE FACES
C     AND RIVERS.
C
C     ANIS      -  HORIZONTAL TO VERTICAL ANISOTROPY OF LAYER.
C     COND1     -  LATERAL HYDRAULIC CONDUCTIVITY OF LAYER #1.
C     CDR       -  UNIQUE NODAL DRAIN CONDUCTANCE (SEE COMMENT C1).
C     CRIV      -  UNIQUE NODAL RIVER CONDUCTANCE (SEE COMMENT C2).
C     DEPTH     -  RIVER DEPTH. UNIQUE TO IRCH OF RIVER.
C     DRCOND    -  UNIT CELL NODAL DRAIN CONDUCTANCE. UNIQUE TO LAYER.
C     HEIGHT    -  HEIGHT OF SEEPAGE FACE IN STREAM VALLEY OR
C                  CANYON FACE WHERE LAYER IS TERMINATED.
C     IRATIO    -  RATIO OF LENGTH OF REACH IN CELL TO CELL WIDTH.
C     IRCH      -  REACH OF RIVER IDENTIFIER. RANGE 2 TO 18.
C     KH        -  HORIZONTAL HYDRAULIC CONDUCTIVITY FOR WANAPUM
C                  AND GRANDE RONDE LAYERS.
C     KVR       -  HORIZONTAL TO VERTICAL RATIO OF HYDRAULIC
C                  CONDUCTIVITY.
C     M         -  THE CALCULATED VERTICAL DISTANCE FROM A RIVER
C                  BOTTOM TO THE CELL CENTER.
C     MTYPE     -  RIVER OR DRAIN IDENTIFIER, RANGE 1 TO 8.
C     PAIR      -  2.0 MULTIPLIER.  STREAMS INCISING ONE OR SEVERAL
C                  LAYERS NECESSITATES A PAIR OF DRAINS IN EACH CELL
C                  TO SIMULATE THE SEEPAGE FACE ON EITHER BANK.  EACH
C                  LAYER INCISED BY A STREAM WILL HAVE TWO DRAINS.
C                  PAIR ENABLES ONE INPUT VALUE FOR DRAIN PAIRS.
C     RATIO     -  REAL EQUIVALENT OF IRATIO.
C     RCOND     -  UNIT CELL NODAL RIVER CONDUCTANCE.
C                  UNIQUE TO LAYER AND IRCH.
C     RIVALT    -  ALTITUDE OF RIVER IN CELL.
C     THKWA     -  THICKNESS OF WANAPUM FOR HEIGHT OF SEEPAGE FACE
C                  IN CANYON TYPE 7.
C     TOP       -  IN DESCENDING ORDER: ALSD, TOP WANAPUM, TOP GRANDE
C                  RONDE, TOP OF THE CRYSTALLINE BASEMENT.
C     WACENT    -  ALTITUDE OF WANAPUM FORMATION CENTER.
C     WELL      -  WELL FUNCTION TO SIMULATE DRAIN FLUX AT SNAKE CANYON.
C     WID       -  RIVER WIDTH, UNIQUE TO IRCH OF RIVER.
C
C
C                  TYPE  RIVER   DRAIN    EXPLANATION
C
C                    1     1       1      UPPER REACHES OF SMALL STREAMS
C                                         (FLOWING ON LOESS).
C
C                    2     2       1,2    LOWER REACHES OF SMALL STREAMS
C                                         (FLOWING ON WANAPUM BASALT).
C
C                    3     3       1,2,3  PALOUSE RIVER& SNAKE CANYON ED
C                                         (FLOWING ON GRANDE RONDE WITH
C                                         LAYERS PRESENT AT CELL LOCATIO
C
C                    4     3       -      SNAKE RIVER.
C
```

```
C                    5     -     3        SNAKE CANYON.  SEEPAGE FACE IN
C                                         RONDE (SIMULATED BY WELLS).
C
C                    6     -     1        EXTREME UPPEROF SMALL STREAMS
C
C                    7     -     1,2      EDGE OF SNAKE CANYON (LOESS AN
C                                         WANAPUM TERMINATE).
C
C                    8     3     3        SNAKE RIVER TRIBUTARY CANYONS
C                                         WITH SMALL STREAMS.
C
C                  NOTE:  DUE TO UNMANAGEABLE SENSITIVITY OF DRAINS
C                  TO NODE CENTER HEAD VALUES, SOME DRAINS ARE REPLACED
C                  WITH WELLS IN THE 3-DIMENSIONAL MODEL.
C                  A WELL IS WRITTEN FOR TYPE 3 NEAR SNAKE CANYON,
C                  TYPE 5, TYPE 7 LAYER 2, AND TYPE 8.
C
C
      INTEGER MTYPE(55,55),IRCH(55,55),IRATIO(55,55)
      REAL M,KH,KVR
      COMMON WID(18),HEIGHT(3),DEPTH(18)
      COMMON RIVALT(55,55),RATIO(55,55),WACENT(55,55),TOP(55,55,4)
      COMMON RCOND(55,55,3),DRCOND(55,55,3),KH(55,55,3)
      COMMON KVR(55,55,3), THKWA(55,55)
C
      READ(50,260) ((MTYPE(I,J),J=1,55),I=1,55)
      READ(50,260) ((IRCH(I,J),J=1,55),I=1,55)
      READ(50,260) ((IRATIO(I,J),J=1,55),I=1,55)
C
      READ(51,270) ((RIVALT(I,J),J=1,55),I=1,55)
      READ(51,270) (((TOP(I,J,K),J=1,55),I=1,55),K=1,4)
      READ(51,270) ((THKWA(I,J),J=1,55),I=1,55)
C
      READ(52,280) (WID(I),I=1,18)
      READ(52,280) (HEIGHT(I),I=1,3)
      READ(52,280) (DEPTH(I),I=1,18)
      READ(52,280) COND1
      READ(52,280) ANIS1
      READ(52,280) ET
      READ(52,280) SEEP
C
      READ(53,270) ((KH(I,J,2),J=1,55),I=1,55)
      READ(54,270) ((KH(I,J,3),J=1,55),I=1,55)
      READ(55,270) ((KVR(I,J,2),J=1,55),I=1,55)
      READ(56,270) ((KVR(I,J,3),J=1,55),I=1,55)
C
      READ(57,270) ((WACENT(I,J),J=1,55),I=1,55)
C
C     COEFFICIENTS TO ALTER CONDUCTANCE ON A GLOBAL BASIS.
      DRCOEF  = 1.0
      RIVCOF = 1.0
C
```

```
      PAIR = 2.0
      WEL3 = 0.0
      WEL2 = 0.0
C
C
      DO 100 I=1,55
      DO 100 J=1,55
      RATIO(I,J) = IRATIO(I,J) * 0.1
      IF (RATIO(I,J) .LE. 0.001) RATIO(I,J) = 1.0
100   CONTINUE
C
C
C     DRAIN CONDUCTANCE = {CELL WIDTH * LATERAL HYDRAULIC CONDUCTIVITY /
C     CELL HALF WIDTH (DISTANCE OVER WHICH HEAD IS DISSIPATED) *
C     CORRECTION COEFFICIENT}.  ONE VALUE PER CELL.
C
C     LATER COMPUTED TO INCLUDE SEEPAGE FACE HEIGHT.  RATIO OF CELL
C     WIDTH TO SEEPAGE FACE HEIGHT DEPENDENT ON PARTICULAR CELL
C     CHARACTERISTICS.
C
      DO 110 I=1,55
      DO 110 J=1,55
      DRCOND(I,J,1) = 2640.0 * COND1 * DRCOEF / 1320.0
      DRCOND(I,J,2) = (2640.0 * KH(I,J,2) * DRCOEF) / 1320.0
      DRCOND(I,J,3) = (2640.0 * KH(I,J,3) * DRCOEF) / 1320.0
110   CONTINUE
C
C
C     RIVER BED CONDUCTANCE = {CELL WIDTH * VERTICAL HYDRAULIC
C     CONDUCTIVITY *  CORRECTION COEFFICIENT}.  (VERTICAL HYDRAULIC
C     CONDUCTIVITY = HORIZONTAL HYDRAULIC CONDUCTIVITY * ANISOTROPY.)
C
C     LATER COMPUTED TO INCLUDE PARTICULAR CELL CHARACTERISTICS:
C     RATIO OF NODAL RIVER REACH LENGTH TO CELL WIDTH, RIVER WIDTH,
C     LENGTH OF FLOW PATH FROM CELL CENTER TO BOTTOM OF RIVER (RBOT).
C
      DO 120 I=1,55
      DO 120 J=1,55
      RCOND(I,J,1) = COND1 * ANIS1 * 2640.0 * RIVCOF
      RCOND(I,J,2) = KH(I,J,2) * KVR(I,J,2) * 2640.0 * RIVCOF
      RCOND(I,J,3) = KH(I,J,3) * KVR(I,J,3) * 2640.0 * RIVCOF
120   CONTINUE
C
C
      DO 250 I=1,55
      DO 250 J=1,55
      MT = 0
      MT = MTYPE(I,J)
      IF (MT .EQ. 0) GO TO 220
      IF (MT .NE. 1) GO TO 130
```

```
C                                                                  TYPE 1
C
C                                                                  DRAIN
      LYR = 1
      ELEV = RIVALT(I,J) + 5.0
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * PAIR * HEIGHT(LYR)
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
C
C
C                                                                  RIVER
      LYR = 1
      RBOT = RIVALT(I,J) - DEPTH(IRCH(I,J))
      THK = (TOP(I,J,LYR) - TOP(I,J,LYR + 1)) / 2.0
      CTR = TOP(I,J,LYR) - THK
      M = RBOT - CTR
      IF (M .LT. 1.0) M=(RBOT - TOP(I,J,LYR + 1))/2.0
      IF (M .GT. 75.0) M = 5.0
      IF (M .LT. 1.0) M = 1.0
      CRIV = (WID(IRCH(I,J)) * RCOND(I,J,LYR) * RATIO(I,J)) / M
      WRITE(61,310) LYR,I,J,RIVALT(I,J),CRIV,RBOT,IRCH(I,J),M,MT
C
      GO TO 220
130   CONTINUE
      IF (MT .NE. 2) GO TO 140
C                                                                  TYPE 2
C
C                                                                  DRAIN
      LYR = 1
      ELEV = TOP(I,J,LYR + 1) + 5.0
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * PAIR * HEIGHT(LYR)
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
C                                                                  DRAIN
      LYR = 2
      HGT = TOP(I,J,LYR) - RIVALT(I,J)
      IF (HGT .LT. 10.0) HGT = 10.0
      ELEV = RIVALT(I,J) + (HGT / 2.0)
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * PAIR * HGT
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
C                                                                  RIVER
      LYR = 2
      RBOT = RIVALT(I,J) - DEPTH(IRCH(I,J))
      THK = (TOP(I,J,LYR) - TOP(I,J,LYR + 1)) / 2.0
      CTR = TOP(I,J,LYR) - THK
      M = RBOT - CTR
      IF (M .LT. 1.0) M=(RBOT - TOP(I,J,LYR + 1))/2.0
      IF (M .LT. 1.0) M = 1.0
      CRIV = (WID(IRCH(I,J)) * RCOND(I,J,LYR) * RATIO(I,J)) / M
      WRITE(61,310) LYR,I,J,RIVALT(I,J),CRIV,RBOT,IRCH(I,J),M,MT
C
```

```
      GO TO 220
140   CONTINUE
      IF(MT .NE. 3) GO TO 170
C                                                              TYPE 3
C
C                                                              DRAIN
      LYR = 1
      ELEV = TOP(I,J,LYR + 1) + 5.0
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * PAIR * HEIGHT(LYR)
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
C
C
C                                                              DRAIN
      LYR = 2
      HGT = TOP(I,J,LYR) - TOP(I,J,LYR+1)
      IF (HGT .LT. 10.0) HGT = 10.0
      ELEV = TOP(I,J,LYR + 1) + (HGT / 2.0)
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * PAIR * HGT
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
C                                                              DRAIN
      LYR = 3
      HGT = TOP(I,J,LYR) - RIVALT(I,J)
      IF (HGT .LT. 10.0) HGT = 10.0
      ELEV = RIVALT(I,J) + (HGT / 2.0)
      IF (J .LE. 12) GO TO 150
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * PAIR * HGT
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
      GO TO 160
150   CONTINUE
C                                                              WELL
      C = 0.0
      WRITE(60,300) LYR,I,J,ELEV,C,IRCH(I,J),MT
      WELL = 2640.0 * 2640.0 * ET * RATIO(I,J)
      WELL = -1.0 * WELL
      WRITE(62,320) LYR,I,J,WELL,TOP(I,J,1),IRCH(I,J),MT
      WEL3 = WEL3 + WELL
160   CONTINUE
C
C                                                              RIVER
      LYR = 3
      RBOT = RIVALT(I,J) - DEPTH(IRCH(I,J))
      THK = (TOP(I,J,LYR) - TOP(I,J,LYR + 1)) / 2.0
      CTR = TOP(I,J,LYR) - THK
      M = RBOT - CTR
      IF (M .LT. 1.0) M = (RBOT - TOP(I,J,LYR + 1)) / 2.0
      IF (M .LT. 1.0) M - 1.0
      CRIV - (WID(IRCH(I,J)) * RCOND(I,J,LYR) * RATIO(I,J)) / M
      WRITE(61,310) LYR,I,J,RIVALT(I,J),CRIV,RBOT,IRCH(I,J),M,MT
C
```

```
      GO TO 220
170   CONTINUE
      IF (MT .NE. 4) GO TO 180
C                                                              TYPE 4
C
C                                                              RIVER
      LYR = 3
      RBOT = RIVALT(I,J) - DEPTH(IRCH(I,J))
      THK = (TOP(I,J,LYR) - TOP(I,J,LYR + 1)) / 2.0
      CTR = TOP(I,J,LYR) - THK
      M = RBOT - CTR
      IF (M .LT. 1.0) M = (RBOT - TOP(I,J,LYR + 1)) / 2.0
      IF (M .LT. 1.0) M = 1.0
      CRIV = (WID(IRCH(I,J)) * RCOND(I,J,LYR) * RATIO(I,J)) / M
C
      WRITE(61,310) LYR,I,J,RIVALT(I,J),CRIV,RBOT,IRCH(I,J),M,MT
C
      GO TO 220
180   CONTINUE
      IF (MT .NE. 5) GO TO 190
C                                                              TYPE 5
C
C                                                              DRAIN
      LYR = 3
      ELEV = TOP(I,J,1)
C     CDR = DRCOND(I,J,LYR) * RATIO(I,J) * 2640
      CDR = 0.0
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
      WELL = 2640.0 * 2640.0 * ET * RATIO(I,J)
      WELL = -1.0 * WELL
      WRITE(62,320) LYR,I,J,WELL,TOP(I,J,1),IRCH(I,J),MT
      WEL3 = WEL3 + WELL
C
      GO TO 220
190   CONTINUE
      IF (MT .NE. 6) GO TO 200
C                                                              TYPE 6
C
C                                                              DRAIN
      LYR = 1
      IR = 20
      ELEV = TOP(I,J,1)
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * HEIGHT(LYR)
      WRITE(60,300) LYR,I,J,ELEV,CDR,IR,MT
C
      GO TO 220
200   CONTINUE
      IF (MT .NE. 7) GO TO 210
```

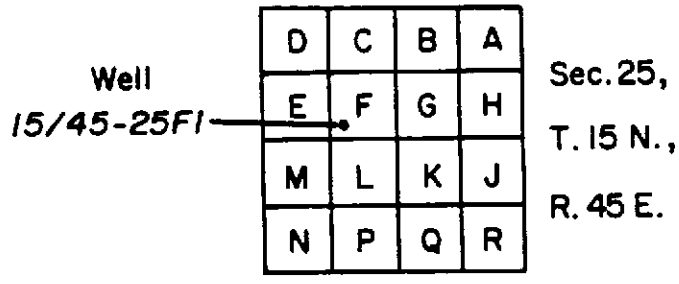
```
C                                                                  TYPE 7
C
C                                                                  DRAIN
      LYR = 1
      ELEV = TOP(I,J,LYR + 1) + 5.0
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * HEIGHT(LYR)
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
C                                                                  DRAIN
      LYR = 2
      ELEV = WACENT(I,J)
      IF (THKWA(I,J) .LT. 10.0) THKWA(I,J) = HEIGHT(LYR) * 2.0
      CDR = DRCOND(I,J,LYR) * RATIO(I,J) * (THKWA(I,J)/2.0)
      CDR = 0.0
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
C
C     CELL WIDTH IS 2640 FEET.  NOTE ONE-HALF CELL WIDTH
C     FOR LENGTH OF DRAIN FACE IN WANAPUM.
C
      WELL = 2640.0 * 1320.0 * ET * RATIO(I,J)
      WELL = WELL * (-1.0)
      WRITE(62,320) LYR,I,J,WELL,THKWA(I,J),IRCH(I,J),MT
      WEL2 = WEL2 + WELL
C
      GO TO 220
210   CONTINUE
      IF (MT .NE. 8) GO TO 230
C                                                                  TYPE 8
C
C                                                                  DRAIN
      LYR = 3
      HTH = ((TOP(I,J,LYR) - RIVALT(I,J))/2.0)
      ELEV = RIVALT(I,J) + HTH
C     CDR = DRCOND(I,J,LYR) * RATIO(I,J) * PAIR * HTH * 2.0
      CDR = 0.0
      WRITE(60,300) LYR,I,J,ELEV,CDR,IRCH(I,J),MT
C
      WELL = 2640.0 * 2640.0 * ET * RATIO(I,J)
      WELL = -1.0 * WELL
      WRITE(62,320) LYR,I,J,WELL,TOP(I,J,1),IRCH(I,J),MT
      WEL3 = WEL3 + WELL
C                                                                  RIVER
      LYR = 3
      RBOT = RIVALT(I,J) - DEPTH(IRCH(I,J))
      THK = (TOP(I,J,LYR) - TOP(I,J,LYR + 1)) / 2.0
      CTR = TOP(I,J,LYR) - THK
      M = RBOT - CTR
      IF (M .LT. 1.0) M = (RBOT - TOP(I,J,LYR + 1)) / 2.0
      IF (M .LT. 1.0) M = 1.0
      CRIV = (WID(IRCH(I,J)) * RCOND(I,J,LYR) * RATIO(I,J)) / M
      WRITE(61,310) LYR,I,J,RIVALT(I,J),CRIV,RBOT,IRCH(I,J),M,MT
```

```
      GO TO 220
C
220   CONTINUE
      GO TO 250
230   WRITE (67,240) LYR,I,J,MT
240   FORMAT ('  FOR LYR,ROW,COL',3I5,'   MT IS OUT OF RANGE',I5)
C
250   CONTINUE
C
      WRITE(100,290) WEL2,WEL3
C
260   FORMAT (55I2)
270   FORMAT (20F6.1 / 20F6.1 / 15F6.1)
280   FORMAT (F10.0)
290   FORMAT (' LYR 2 WELLS',F10.0,'  LYR 3 WELLS',F10.0,'  FOR DRAIN
     .SUBSTITUTION')
300   FORMAT (3I5,F10.0,E10.3,260X,10X,I10,10X,I5)
310   FORMAT (3I5,F10.0,E10.3,F10.0,260X,I10,F10.0,I5)
320   FORMAT (3I10,F10.0,260X,F10.0,2I5)
      STOP
      END
```

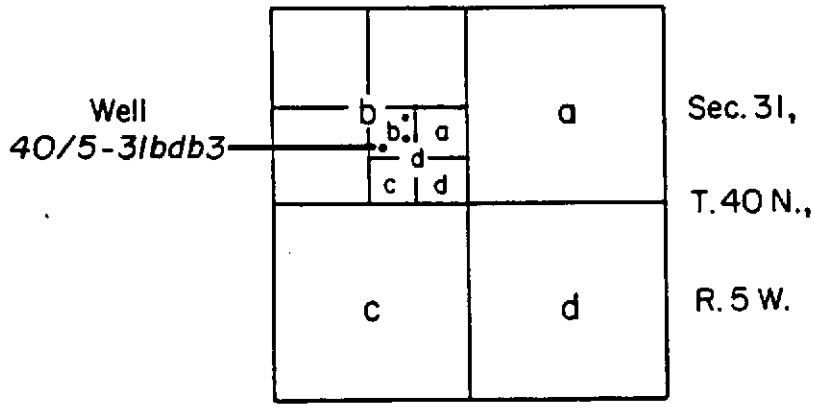
APPENDIX B

WELL NUMBERING SYSTEMS OF WASHINGTON AND IDAHO

Idaho and Washington identify wells based on the township and range system but divide the sections differently. Idaho wells are referenced to the Boise baseline and meridian while Washington wells are referenced to the Willamette baseline and meridian. Both states identify the township, range, and section of the well in question, and use letter codes to divide the quarter-quarter sections. In Washington, quarter-quarter sections are divided by letters in a similar manner to which sections are numbered in a township. Letters begin in the northeast corner and wind around in alphabetical order. In Idaho, quarter sections are lettered counter-clockwise. The same method is used for quarter-quarter and quarter-quarter-quarter sections. This letter code is then added to the township range section number to provide a location for the well. If there is more than one well in the smallest subdivision, then these several wells are numbered in order. The Washington well 15/45-25F1 and the Idaho well 40/5-31bdb3 are located on the following page.



Well Numbering System of Washington



Well Numbering System of Idaho

APPENDIX C

WELL DATA AND MASS WATER LEVEL MEASUREMENTS

WASHINGTON WELLS

LOCATION OF WELL	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FT MSL)	WELL DEPTH (FT)	DEPTH TO WATER BELOW LSD (FT)	WATER LEVEL ALTITUDE (FT MSL)	ALTITUDE OF CASED INTERVAL (FT MSL)	ALTITUDE OF OPEN INTERVAL (FT MSL)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
13/44-05C1	(34,10)	J. RYAN	2540	--	80. R	2460	--	--	W	--
13/44-11H1	(41,13)	J. DAVIS	2455	-130	11.18	2444	--	--	W	98
13/44-12P1	(42,13)	J. DAVIS	2440	70	7.29	2433	2425-2440	2370-2425	W	92
13/44-12P2	(42,13)	J. DAVIS	2505	165	61.59	2443	2487-2505	2340-2487	GR	1
13/45-01B1	(49,26)	R. HOOD	2740	--	20.47	2720	--	--	B	--
13/45-03M2	(46,21)	E. DRUFFEL	2618	100	18.85	2599	--	--	W	28
13/45-05D1	(42,18)	G. SENTER	2558	190	4.04	2554	2538-2558	2368-2538	W	0
13/45-10L1	(47,20)	P. KIRPIS	2663	137	78.47	2585	2613-2663	2526-2613	W	26
14/43-24M1	(27,10)	YOUNG	2430	165	78.94	2351	2290-2430	2265-2290	W	52
14/43-24M2	(27,11)	YOUNG	2420	-8	6.00	2414	--	--	U	--
14/43-24R1	(29,11)	H. WEGNER	2350	162	7.68	2342	2343-2350	2188-2343	W	86
14/43-25N1	(29, 9)	A. TOWNSEND	2480	250	37.65	2442	2460-2480	2230-2460	W	74
14/43-25N2	(29, 8)	A. TOWNSEND	2420	350	121.	2299	--	--	GR	3
14/44-01E1	(31,24)	R. HARLOW	2565	375	108.22	2457	--	--	GR	4
14/44-01J1	(32,25)	HENDRICKS	2660	200	0.00	2660	--	--	?U	--
14/44-01L1	(32,24)	B. BELL	2620	275	221.18	2399	--	--	W	75
14/44-01M3	(31,23)	195&WWPUL	2535	--	46.40	2489	--	--	W	--
14/44-02J1	(31,24)	R. HARLOW	2530	--	11.64	2518	--	--	?U	--
14/44-02M2	(30,22)	D. BLOOMFIELD	2498	102	34.26	2464	2468-2498	2396-2468	W	29
14/44-09J2	(30,19)	KIEFER	2485	286	210.	2275	2467-2485	2199-2167	?GR	-1
14/44-14P2	(33,19)	WSU DAIRY #2	2550	432	286. A	2264	2200-2550	2120-2200	GR	2
14/44-16F1	(30,17)	E. BROCH	2405	160	120.02	2285	--	--	?GR	-3
14/44-21R1	(33,15)	HATLEY	2340	150	13.41	2327	--	--	GR	0
14/44-23A1	(35,19)	R. WILBURN	2560	-90	40. R	2520	--	--	W	4
14/44-28A1	(33,15)	V. RUMLEY	2385	111	43.71	2341	--	--	W	66
14/44-31A1	(32,13)	BREWER	2460	--	3.72W	2456	--	--	W,U	--
14/44-34C1	(35,15)	N. HATLEY	2455	200	0.00	2455	2437-2455	2255-2437	W	83

LOCATION OF WELL	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FT MSL)	WELL DEPTH (FT)	DEPTH TO WATER BELOW LSD (FT)	WATER LEVEL ALTITUDE (FT MSL)	ALTITUDE OF CASED INTERVAL (FT MSL)	ALTITUDE OF OPEN INTERVAL (FT MSL)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
14/45-01F1	(39,33)	PUL. TEST	2470	982	213.61	2256	2270-2470	1488-2270	GR	35
14/45-03H3	(38,31)	WWP	2460	259	198.94	2261	2282-2460	2201-2282	GR	7
14/45-03P1	(38,29)	S. JORSTAD	2460	--	19.65	2440	--	--	W	--
14/45-04D1	(35,29)	WSU #6	2535	702	266.5 A	2268	2143-2535	1833-2143	GR	17
14/45-04N1	(36,28)	WSU	2390	95	>95.	--	--	--	W	100
14/45-05D1	(33,27)	PULLMAN #1	2342	164	67.22	2275	2308-2342	2178-2308	GR	5
14/45-05D3	(33,27)	PULLMAN #3	2340	167	69.37	2271	2300-2340	2173-2300	GR	5
14/45-05F1	(34,27)	WSU #1(OBS)	2364	145	92.87	2271	2304-2364	2219-2304	GR	3
14/45-05F4	(34,28)	WSU #4	2364	275	95.00A	2269	--	--	GR	7
14/45-06D4	(32,26)	H. WOO	2515	220	168.21	2347	2475-2515	2295-2475	W	107
14/45-07E1	(34,24)	H. COLE	2530	82	33.21	2497	2522-2530	2448-2522	W	30
14/45-08E1	(35,25)	PULLMAN #5	2447	712	175.45	2271	--	--	GR	21
14/45-08J4	(36,26)	J. ASKINS	2420	223	147.65	2272	--	--	GR	4
14/45-09E1	(37,27)	M. WISE	2415	67	9.05W	2406	2395-2415	2348-2395	W	71
14/45-09E2	(37,27)	H. NEIL	2420	240	142.97	2277	2398-2420	2180-2398	GR	4
14/45-10P1	(39,28)	H. STRATTON	2540	--	31.45	2509	--	--	W	--
14/45-15B1	(40,28)	G. LEONARD	2610	213	147.62	2462	2515-2610	2397-2515	W	57
14/45-16E1	(38,26)	W. STRATTON	2400	110	DRY	--	2360-2400	2290-2360	W	100
14/45-16G1	(39,26)	WSU SPILLMAN	2480	400	215. A	2265	2448-2480	2080-2448	GR	9
14/45-16R1	(40,26)	G. WISE	2418	195	142.87	2275	2243-2418	2223-2243	GR	4
14/45-19G1	(37,22)	J. BENSCOTER	2575	198	13.50	2562	--	--	W	70
14/45-20A1	(39,24)	JACOBSON	2550	--	37.77	2512	--	--	W	--
14/45-21H2	(41,25)	SEARS	2440	--	166.86	2273	--	--	GR	--
14/45-22P2	(42,25)	A. FAIRBANKS	2464	250	185.67	2278	2444-2464	2214-2444	GR	14
14/45-23A1	(43,28)	R. DRUFFEL	2480	--	0.00	2480	--	--	U	--
14/45-23R1	(44,28)	R. MEYER	2520	80	38.74	2481	2474-2520	2440-2474	W	42
14/45-24F1	(44,29)	--	2505	--	13.96	2491	--	--	W	--
14/45-26J2	(45,26)	WEBER FARM	2545	223	42.99	2502	2483-2545	2318-2483	W	120
14/45-26J1	(45,26)	WEBER FARM	2545	--	9.34	2536	--	--	?U	--
14/45-36Q2	(48,26)	J. WHITMAN	2680	127?	4.44	2676	2623-2680	2553-2623	W	0

LOCATION OF WELL	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FT MSL)	WELL DEPTH (FT)	DEPTH TO WATER BELOW LSD (FT)	WATER LEVEL ALTITUDE (FT MSL)	ALTITUDE OF CASED INTERVAL (FT MSL)	ALTITUDE OF OPEN INTERVAL (FT MSL)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
14/46-07N1	(43,32)	J. BRADEN	2570	100	16.41	2554	--	--	W	27
14/46-07N3	(43,32)	J. BRADEN	2570	353	306.62	2263	2505-2570	2217-2505	GR	6
14/46-19F1	(45,30)	L. BROWN	2485	180	11.52W	2473	--	--	GR	3
15/43-08B1	(10,18)	KINCAID	~2100	--	157.49	1943	--	--	GR	--
15/43-16J1	(14,17)	J. GHILCHRIST	~2100	138	97.82	2002	--	--	GR	-1
15/43-18H1	(11,15)	R. MILLER	2270	160	75.93	2194	2180-2270	2110-2180	W	-3
15/43-18R1	(11,14)	M. MILLER	2140	~130	80. R	2060	--	--	W	20
15/43-21A1	(15,17)	--	~2230	~30	24.33	2206	--	--	U	--
15/44-01G1	(23,33)	A. CLARK	2380	157	18.56	2371	2340-2380	2213-2340	W	0
15/44-01N1	(23,32)	G. CLARK	2450	73	0.85	2449	2415-2450	2377-2415	W	0
15/44-11F1	(23,30)	V. BIDDLE	2435	140	0.	2435	--	--	W	0
15/44-11F2	(23,30)	V. BIDDLE	2430	225	FLOWING	2430	--	--	B	--
15/44-15G2	(23,27)	ALBION #1	2390	290	180. R	2210	--	--	GR	600
15/44-15G3	(23,27)	ALBION #2	2400	--	112.	2288	--	--	GR	--
15/44-21D1	(22,24)	M. MCCROSKEY	2355	177	125.44	2230	2335-2355	2178-2335	?W,U	95
15/44-24D1	(26,28)	J. MORRISON	2380	35	7.92	2372	--	--	U	--
15/44-24E1	(26,28)	J. MORRISON	2375	135	120.19	2255	--	--	W	100
15/44-24F1	(27,29)	J. MORRISON	2390	165	21.50	2378	--	--	W	125
15/44-26L1	(27,25)	M. HARLOW	2390	160	120.97	2269	2370-2390	2230-2370	GR	0
15/44-35E1	(28,24)	V. MICHAELSON	2412	300	130.15	2282	2373-2412	2112-2373	GR	11
15/44-35F1	(28,25)	V. MICHAELSON	2435	96	14.86	2420	--	--	W	36
15/45-06E	(23,34)	A. CLARK	2480	--	76.77	2403	--	--	W	--
15/45-07Q1	(26,33)	G. LAWSON	2525	150?	48.30	2477	--	--	W	37
15/45-08L1	(27,34)	H. ROSSEBO	2480	124	22.05	2458	2440-2480	2360-2440	W	39
15/45-08M2	(27,34)	R. HOWELL	2495	290	>210.	<2285	2440-2495	2205-2440	GR	3
15/45-10M1	(30,36)	R. GILLESPE	2510	~200	180. R	2330	--	--	W	113
15/45-16B1	(29,35)	R. WHITMORE	2500	200	21.62	2478	--	--	W	113
15/45-16K1	(30,34)	R. WHITMORE	2520	--	18.70	2501	--	--	W	--
15/45-19E2	(28,30)	G. LAWSON	2445	110	18.95	2426	--	--	W	63

LOCATION OF WELL	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FT MSL)	WELL DEPTH (FT)	DEPTH TO WATER BELOW LSD (FT)	WATER LEVEL ALTITUDE (FT MSL)	ALTITUDE OF CASED INTERVAL (FT MSL)	ALTITUDE OF OPEN INTERVAL (FT MSL)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
15/45-20H2	(30,32)	D. PORT	2530	~130	30.56	2500	--	--	W	50
15/45-24C1	(35,38)	--	2540	350	60.	2480	--	--	GR	15
15/45-25A2	(37,37)	M. BOYD	2650	215	114.10	2536	--	--	W	63
15/45-25Q1	(38,36)	L. BOYD	2609	264	50. R	2559	2544-2609	2345-2544	W	107
15/45-30G4	(30,29)	USDA AG EXP	2520	371	249.40	2271	--	--	GR	10
15/45-32C2	(32,29)	PULLMAN #6	2430	518	152.10	2278	2196-2430	1912-2196	GR	17
15/45-32N2	(33,28)	PULLMAN #4	2356	954	73.22	2283	1957-2356	1402-1957	GR	35
15/45-34L2	(36,31)	WSU WHITLAOW#5	2510	396	238. A	2272	2210-2510	2114-2210	GR	9
15/45-35F1	(37,33)	MOS-PUL AIRPT	2531	172	7.00	2524	--	--	W	126
15/46-06L1	(33,43)	T. QUIST	2620	--	29.20	2591	--	--	W	--
15/46-06P2	(33,42)	S. FLEENOR	2625	100	53.02	2572	--	--	W	31
15/46-08L1	(35,43)	F. FLEENOR	~2700	280	13.99	2686	--	--	B	--
15/46-20N1	(38,39)	H. NELSON	2570	--	5.87	2563	--	--	U	--
16/43-25D1	(10,27)	NELSON	2140	20	17. R	2123	--	--	U	--
16/44-29F1	(14,30)	R. COCKING	2135	~500	400. R	1735?	--	--	GR	22
16/45-10A2	(21,47)	F. ELLS	2630	50	11.52	2620	--	--	W	~30
16/45-15P1	(23,44)	M. KUEHNER	2495	100	7.99W	2487	--	--	U?,W	--
16/45-22K1	(24,43)	E. RUPP	2470	165	42.02	2428	2442-2470	2305-2442	W	102
16/45-27Q3	(26,41)	L. THOMPSON	2460	--	12.98	2447	--	--	W	--
16/45-28H1	(24,41)	J. REDFIELD	2450	--	95.02	2355	--	--	W	--
16/45-29J1	(23,39)	D. HARLOW	2430	--	56.75	2373	--	--	W	--

IDAHO WELLS

LOCATION OF WELL	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FT MSL)	WELL DEPTH (FT)	DEPTH TO WATER BELOW LSD (FT)	WATER LEVEL ALTITUDE (FT MSL)	ALTITUDE OF CASED INTERVAL (FT MSL)	ALTITUDE OF OPEN INTERVAL (FT MSL)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
39/05-07DAD2	(45,40)	MOSCOW #2	2568	320	49.	2511	--	--	W	157
39/05-07DAD3	(45,40)	MOSCOW #3	2568	261	58.	2502	--	--	W	124
39/05-07	(43,39)	MOSCOW #8	2620	1458	367.	2253	--	--	GR	113
39/05-7CBB1	(43,39)	UI #3	2567	1336	294.65	2272	--	--	GR	106
39/05-08BDB	(45,41)	MOSCOW #6	~2600	1308	334. R	2266	--	--	GR	78
39/05-16DDB	(49,41)	D. GENTRY	2620	?55	37.00	2583	--	--	W,U?	-6
39/05-30AA	(48,36)	D. SINCLAIR	2620	--	3.00	2617	--	--	U	--
39/06-12	(43,38)	MOSCOW #9	2538	1252	287.	2251	--	--	GR	93
39/06-12DAA1	(43,38)	UI #4	2554	747	284.66	2255	--	--	GR	47
40/05-30CA	(40,43)	F. WARD	2638	--	125.38	2513	--	--	W	--
40/05-31DB	(41,42)	K. ROGERS	2635	--	30. R	2605	--	--	W,U?	--
40/06-19CB	(36,43)	C. LADWIG	2770	258	12.17	2758	--	--	W,U?	0
40/06-25DA	(39,42)	D. CLARK	2680	--	27.74	2652	--	--	W	--
40/06-36AD	(40,41)	A. CARSON	2610	135	0.00	2610+	--	--	W	40

R-----REPORTED
W-----WINTER MEASUREMENT
+-----FLOWING AT THIS ALTITUDE
A-----AIRLINE MEASUREMENT
N-----APPROXIMATE

U-----UNCONSOLIDATED
W-----WANAPUM FORMATION
GR----GRANDE RONDE FORMATION
B-----BASEMENT (GRANITE)

GEOHYDROLOGY AND NUMERICAL MODEL ANALYSIS OF GROUND-WATER FLOW IN THE PULLMAN-MOSCOW AREA, WASHINGTON AND IDAHO

by W.E. Lum II, U.S. Geological Survey, Tacoma, Washington
J.L. Smoot, Batelle Pacific Northwest Laboratory, Richland, Washington
D.R. Ralston, University of Idaho, Moscow, Idaho

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 89-4103

Prepared in cooperation with the

UNIVERSITY OF IDAHO, WASHINGTON STATE UNIVERSITY
and the CITIES OF MOSCOW, IDAHO, and PULLMAN, WASHINGTON

Tacoma, Washington
1989

MICROFILMED
MAR 19 1990

Applicant's Exhibit #8 Admitted

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
1201 Pacific Avenue - Suite 600
Tacoma, Washington 98402

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Box 25425, Federal Center, Bldg. 810
Denver, Colorado 80225

CONTENTS

	Page
Abstract	1
Introduction	2
Purpose and scope	3
Previous investigations	3
Well-numbering system	4
Description of the study area	5
Physiography and land use	5
Precipitation	7
Surface-water resources	7
Geohydrology	8
Geology and structure	8
Water-bearing characteristics of geologic units	11
Geohydrologic units	11
Recharge	14
Ground-water movement	18
Ground-water pumpage	19
Historical water-level changes	20
Numerical ground-water-flow model	25
Three-dimensional model construction	25
Discretization of space	25
Model layers	27
Hydraulic properties of model layers	28
Boundary conditions	29
Recharge to the model	33
Hydraulic connection of ground water with rivers	36
Drains	36
Seepage faces	36
Cross-sectional model construction	37
Calibration of models	40
Cross-sectional model calibration	41
Time-averaged three-dimensional model calibration	44
Water-budget analysis of time-averaged model	50
Simulation of historical water-level changes due to pumping of ground water	52
Estimated effects due to pumping of ground water	54
Constant-pumpage-rate scenarios	55
Increasing-pumpage-rate scenarios	56
Sources of pumped water	57
A comparison of the model results with those of a previous study	58
Limitations of the model	61
Suggestions for future investigations	62
Conclusions	62
References cited	64

ILLUSTRATIONS

		Page
Figure 1.	Diagram showing well-numbering systems of Washington and Idaho	4
2.	Map showing the location of Pullman-Moscow area	6
3.	Diagram of the stratigraphy and water-bearing characteristics of the geologic units in the Pullman-Moscow area	9
4-7.	Maps showing:	
	4. The altitude of the top of the Wanapum Basalt	12
	5. The altitude of the top of the Grande Ronde Basalt	13
	6. The thickness of the basalt	15
	7. The altitude of the top of the crystalline basement rocks	16
8.	Diagram showing three-dimensional perspective of the layered aquifer system	17
9.	Diagram showing 5-year average pumpage from wells operated by Pullman, Moscow, Washington State University, and the University of Idaho	20
10.	Hydrograph showing ground-water level declines in wells in Pullman and Moscow, 1890-1985	22
11-13.	Maps showing the:	
	11. Water-level changes in the Grande Ronde Basalt, 1974-1985	23
	12. Water-level changes in the Wanapum Basalt, 1974-1985	24
	13. Location and orientation of the modeled area, showing selected cells	26
14.	Idealized geologic section through the Pullman-Moscow area showing the geohydrologic units	27
15-17.	Maps showing the:	
	15a-c. Grid used to subdivide the study area for the ground-water model and the boundary conditions for the:	
	(a) loess geohydrologic unit;	30
	(b) Wanapum geohydrologic unit; and	31
	(c) Grande Ronde geohydrologic unit	32
	16a,b. Areal distribution of recharge to the three-dimensional ground-water-flow model based on	
	(a) predevelopment conditions; and	34
	(b) current land-use and farming practices	35
	17. Location of cross-sectional models in the domain of the three-dimensional model	38
18.	Diagrammatic sketch of cross-sectional model B-B', showing layering	39
19.	Diagrammatic sketch showing calibrated cross-sectional model B-B': (a) calibrated hydraulic conductivity distribution, (b) calibrated hydraulic head of distribution	43
20-21.	Maps showing distribution of the hydraulic conductivity and ratio of horizontal to vertical hydraulic conductivity distribution for:	
	20. The Wanapum geohydrologic unit	46
	21. The Grande Ronde geohydrologic unit	47

ILLUSTRATIONS--Continued

		Page
22-23.	Maps showing calibrated distribution of hydraulic head for time-averaged conditions, 1974-1985, for:	
	22. The Wanapum geohydrologic unit	48
	23. The Grande Ronde geohydrologic unit	49
24-25.	Diagrams showing a comparison of observed and simulated water levels in wells in the Pullman and Moscow areas for:	
	24. 1890-1985	53
	25. 1975-1985	54
26-27.	Graphs showing simulated water levels at a variety of pumpage rates for:	
	26. Pullman, Wash.	55
	27. Moscow, Idaho	56
28.	Map showing the location of the ground-water-flow model boundaries and the 'barrier zone' of Barker	59

TABLES

		Page
Table 1.	Average monthly precipitation for Pullman, Wash., and Moscow, Idaho	7
2.	Hydraulic properties for the Columbia River Basalt Group	28
3.	Summary of water budget for time-averaged simulation	51
4.	Simulated average flow into selected rivers and measured stream discharges in study area	51
5.	Observed and simulated water-level declines in the Grande Ronde geohydrologic unit, 1896-1975	60
6.	Simulated water-level declines in the Grande Ronde geohydrologic unit, 1975-2000	60
7.	Records of selected wells in the study area	end of report

CONVERSION FACTORS

For the convenience of readers who may prefer to use metric units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per year (ft/yr)	0.3048	meter per year (m/yr)
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
	0.028317	cubic meter per second (m^3/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

GEOHYDROLOGY AND NUMERICAL MODEL ANALYSIS OF GROUND-WATER FLOW IN THE PULLMAN-MOSCOW AREA, WASHINGTON AND IDAHO

By W.E. Lum II, J.L. Smoot, and D.R. Ralston

ABSTRACT

The Pullman-Moscow area of southeastern Washington and northern Idaho depends on ground water as the principal source of water, but increasing pumpage rates and declining ground-water levels indicate a need for ground-water management. Using data from a study done by the U.S. Geological Survey in the 1970's and up-to-date data collected for this study, a three-dimensional numerical computer model of the ground-water-flow system was constructed to provide an understanding of the geohydrology of the study area.

The ground-water-flow model incorporates three layers--an overlying surficial loess layer, a Wanapum Basalt layer, and a Grande Ronde Basalt layer. A ground-water-system recharge rate was estimated using a methodology developed by the U.S. Geological Survey. Ground-water discharge was modeled as ground-water pumping, flow to rivers and streams, and flow out of seepage faces, where a layer is incised by a river valley. Three cross-sectional flow models, distributed across the domain of the three-dimensional model along estimated flow lines in the Grande Ronde Basalt, were used to obtain hydraulic coefficient input for the three-dimensional model. The three-dimensional model was calibrated using the time-averaged method for the period 1974-85, and was evaluated by simulating historical pumpage rate changes (1890-1985) and comparing simulated with observed water-level changes.

Model results suggest that ground-water levels would stop declining if ground-water pumpage were to stabilize at a constant level. However, ground-water levels will continue to decline in the foreseeable future as long as ground-water pumpage continues to increase.

Further study of the recharge, movement, and discharge of ground water in the area is needed to increase the accuracy of any ground-water-flow model to predict the response of the flow system to future pumping stresses.

INTRODUCTION

The Pullman-Moscow area of southeastern Washington and northern Idaho depends on ground water as the principal source of water. Primary pumpage is from the Miocene Grande Ronde Formation of the Yakima Basalt Subgroup of the Columbia River Basalt Group and associated interbedded sediments. Water is used for municipal supplies for the city of Pullman, Wash. (about 85 miles south of Spokane); the Washington State University (located in Pullman); the city of Moscow, Idaho (about 8 miles east of Pullman); and the University of Idaho (located in Moscow). Water levels in wells in the deeper basalts have declined slowly but steadily since the wells were first drilled in the 1890's. Because of the declining water levels, there has been local concern that water availability might limit development in the area.

To try to understand the response of the ground-water-flow system to pumping and to help develop a management strategy to protect the ground water, two mathematical models were developed by other investigators prior to this study. These efforts began with the image-well model of Jones and Ross (1969). Later modeling was done by the U.S. Geological Survey (Barker, 1979). The model described by Barker simulated that water levels would continue to decline in the area even if pumping rates of ground water did not increase. That model also simulated that the rate of water-level decline from 1976 to 2000 would average about 1.5 feet per year if pumping of ground water increased at a rate of 3 percent per year (Barker, 1979).

Between 1976 and 1985, average annual pumpage of ground water has increased at a rate of only about 1 percent per year. Water levels in Pullman and Moscow have continued to decline. However, the rate of decline continued unabated at about 1.5 feet per year, a rate of decline that had been associated with a much higher rate of increase in ground-water pumping (Barker, 1979). The continuing decline and its rate prompted renewed local concern.

Representatives of the two universities, the two cities, the State of Washington Department of Ecology, and the U.S. Geological Survey met in 1984 to discuss the area's water problems. The group acknowledged the deficiency in knowledge of the system and the need for an updated predictive tool to guide future management decisions. As a result, the cities of Pullman and Moscow and the University of Idaho and Washington State University entered into a cooperative agreement with the U.S. Geological Survey to help support this effort to collect new geohydrologic data and then to construct a new model of the ground-water system in the Pullman-Moscow area. A critical part of the study was a magnetotelluric geophysical survey conducted by personnel of the U.S. Geological Survey to delineate the thickness of the basalt in the basin. Geohydrologic data were used to construct an updated model using the U.S. Geological Survey modular ground-water-flow program (McDonald and Harbaugh, 1988). The model was used to calculate future water-level changes under various pumping scenarios. This report presents the details of field data collection, data interpretation, model construction, model operation, and an analysis of results.

Purpose and Scope

The purpose of this report is to document the results of a study to: 1) define the geohydrology of the area around Pullman, Wash., and Moscow, Idaho; and 2) construct and calibrate a three-dimensional ground-water-flow model for the area to calculate the effect of changes in the rate of withdrawal on the ground-water system. This study updates the work done in the 1970's by the U.S. Geological Survey (Barker, 1979). Data collected for this study included:

1) Water-level measurements in all wells measured during 1974-75 and reported on by Barker (1979).
2) Rate of ground-water withdrawal for all water users in the study area through 1985.
3) Data on the lateral extent, thickness, and hydraulic characteristics of all geologic units present in the study area.

Specific objectives of the study included:

1) Defining data needs and collecting data to update the current understanding of the ground-water-flow system of the area;
2) Defining the thickness of the basalt in the study area using a magnetotelluric geophysical technique;
3) Constructing and calibrating a three-dimensional numerical model of the flow system;
4) Operating the model under various management plans, and evaluating their impacts on the geohydrologic features of the area; and
5) Comparing the results of the model presented in this report with results of a two-dimensional finite-difference ground-water-flow model by Barker (1979).

Previous Investigations

Ground-water investigations in the Pullman-Moscow area began in the late 1800's. Russell (1897) made the first geohydrologic reconnaissance of the area. DeMotte and Miles (1933) investigated the source of the artesian water levels in Moscow and Pullman. Barker (1979), Foxworthy and Washburn (1963), and Walters and Glancy (1969) defined the basic geohydrology of the area.

Barker (1979), Foxworthy and Washburn (1963), Ross (1965), Lin (1967), Ringe (1968), Brown (1976), and Cotton (1982) provided discussions of the geology of the area. Swanson and others (1979) and Drost and Whiteman (1986) discussed the stratigraphy and geology of the Columbia River Basalt Group. Swanson and others (1980) and Hooper and Webster (1982) provided surficial geologic maps of the area. Ross (1965), Jones and Ross (1972), Crosthwaite (1975), Barker (1979), and Whiteman (1986) provided information on wells, water levels in the basin, and the ground-water-flow system. Bauer and others (1985) showed the regional ground-water levels in the basalt. Williams and Allman (1969) discussed mechanisms for recharge and infiltration in the surficial loessial soils. Jones and Ross (1972) and Barker (1979) did the previous ground-water-modeling studies.

The results of a magnetotelluric geophysical survey done by the Geologic Division of the U.S. Geological Survey to provide data on basalt thickness for this study were described by Klein and others (1987). Bockius (1985) did a magnetic geophysical survey to better delineate the buried basalt-granite contact in the Idaho part of the basin. Eyck and Warnick (1984) provided a comprehensive listing (a lengthy annotated bibliography) of documents about ground water and water supply in the Pullman-Moscow area.

Well-Numbering System

Idaho and Washington identify wells on the basis of the township and range system, but divide the sections differently. Idaho wells are referenced to the Boise baseline and meridian, and Washington wells are referenced to the Willamette baseline and meridian. Both States identify the township, range, and section of the well and use letter codes to divide the quarter-quarter sections. In Washington, quarter-quarter sections are divided by letters in a similar manner to which sections are numbered in a township. Letters begin in the northeast corner and wind around in alphabetical order. In Idaho, quarter sections are lettered counter-clockwise. The same method is used for quarter-quarter and quarter-quarter-quarter sections. This letter code is then added to the township-range-section number to provide a location for the well. If there is more than one well in the smallest subdivision, then these several wells are numbered usually in order of drilling. Examples of the well-numbering systems are shown in figure 1, for Washington well 15/45-25F1 and Idaho well 40/5-31bdb3.

MICROFILMED
MAR 19 1990

DESCRIPTION OF THE STUDY AREA

The study area is located in southeast Washington and northern Idaho, and includes parts of Whitman County, Washington, and Latah County, Idaho. The total area investigated is about 750 mi^2. About 150 mi^2 near Pullman and Moscow was investigated in detail, and the remainder of the study area at a reconnaissance level.

Physiography and Land Use

Pullman and Moscow lie within a shallow elliptical basin bordered on the north, east, and south by a broken horseshoe-shaped ring of mountains and hills of granite, gneiss, and quartzite. The physiographic divide on the east side of the basin is the crest of the Moscow Mountains, in Idaho. The northern margin of the basin is a semicircle of prominent hills, including Kamiak Mountain and Smoot Hill (fig. 2). A series of lower hills ending near Chambers marks the southern border.

The basin floor consists of a moderately dissected lava plain that has a thick cover of wind-deposited silt, or loess. Altitudes in this area range from 2,225 feet above sea level near Albion, Washington, to about 2,550 feet in Moscow, Idaho. The rounded, loess-covered hills generally rise 200 to 300 feet above the narrow intervening stream channels. From the air, the hilltops show a marked concordance, and if connected, they would form a fairly even surface having a gentle westward slope (after Foxworthy and Washburn, 1963).

The gentle slope is interrupted southwest of Pullman by the canyon of the Snake River. The loess-covered hills are gently rounded to within about 1 to 2 miles of the river. Altitudes of the tops of the hills are about 2,200 feet near Lower Granite Dam to about 2,900 feet between Uniontown and Clarkston. The altitude of the river behind Lower Granite Dam is about 740 feet; below the dam it is about 640 feet. The intervening canyon wall is extremely steep. The land surface in this canyon is vertical in places, and slopes of 25 percent are common.

The canyon probably has a significant effect on ground-water flow in the area. Numerous small springs and seeps occur in the canyon along its steeply sloping walls. Abundant native grasses and isolated, dense stands of shrubs may indicate subirrigation from regional ground-water discharge.

The urban areas of Moscow and Pullman account for only a few percent of the land area within the basin. Dryland farming of the loess constitutes the major land use in the study area. The primary crops are wheat, peas, and lentils. Rainfall is ample for the crops because the large soil-moisture storage capacity carries the crops through the dry summer; little irrigated agriculture exists. In parts of Whitman County, Wash., the common farming practice is to alternate fallow years with crop-growing years. The fallow year allows an increase in moisture stored in the soil zone to be used by crops the next year. In eastern Whitman County, however, generally east of a line through Colfax, Pullman, and Chambers (fig. 2), there is sufficient precipitation and resultant increased soil moisture to allow a crop to be grown every year (Robert Allen, U.S. Department of Agriculture, Pullman, Wash., oral commun., 1985).

MICROFILMED
MAR 1 9 1990

Precipitation

Average annual precipitation gradually increases west to east in the region. Long-term records indicate an average annual precipitation of about 22 inches in Pullman and about 24 inches in Moscow ([U.S.] National Oceanic and Atmospheric Administration, 1987a and 1987b). East of Moscow, precipitation abruptly increases to about 40 inches per year as the altitude abruptly increases near Moscow Mountain. Precipitation falling on the basin generally is of low intensity and is seasonal. Most of the precipitation falls between November and April, with dry conditions during the summer. Table 1 shows average monthly precipitation for Pullman and Moscow.

Surface-Water Resources

The Snake River is the largest surface-water body in the study area. The U.S. Army Corps of Engineers operates Lower Granite Lock and Dam on the Snake River southwest of Pullman. Pool elevation upstream from the dam is about 740 feet above sea level. Average annual discharge through the dam for the years 1978 to 1985 (period of available records) was 56,250 ft^3/s (U.S. Geological Survey, 1987). The Palouse River is the only other major river; its average annual discharge at Colfax, Wash., for the period of available records (1964-72 and 1976-86) was 388 ft^3/s (U.S. Geological Survey, 1988).

Several perennial streams also drain the area, including the South Fork Palouse River, Paradise Creek, Fourmile Creek, and Union Flat Creek (fig. 2). A small amount of lawn and pasture irrigation is derived from these streams. The cities of Pullman and Moscow put treated sewage effluent into the South Fork Palouse River and Paradise Creek, respectively. In Moscow, some treated sewage effluent is also used for irrigation.

The upper reaches of streams in the study area generally flow on the loessial soils of the basin, whereas the lower reaches are incised into the basalt bedrock. The Snake and the Palouse Rivers are entrenched in the basalt.

MICROFILMED

MAR 19 1990

GEOHYDROLOGY

The occurrence and movement of ground water in the Pullman-Moscow area is dependent on the geohydrology of the area, including the nature of the geologic units and their water-bearing characteristics, and sources of recharge to and discharge from the ground-water system. The development of a model of ground-water flow can improve the understanding of the system by integrating all pertinent geohydrologic information. Such a model can then be used to evaluate the effects of ground-water withdrawals (pumping).

Geology and Structure

The geology of the Pullman-Moscow area consists of an irregular buried surface of pre-Tertiary crystalline rocks (Klein and others, 1987), overlain by the Miocene Columbia River Basalt Group and interbeds that are capped by Pleistocene Palouse Loess (Swanson and others, 1980). The geologic units are shown diagrammatically in figure 3. The crystalline basement rocks primarily are granites, although some metamorphic rocks occur in the northern part of the basin.

Miocene basalts interbedded with sediments overlie the crystalline rocks. Basaltic lava was extruded from fissures located near Pullman and elsewhere in southeastern Washington and northeastern Oregon (Swanson and others, 1980). A series of flows over millions of years produced the layers that make up the existing basalt sequence. The thickness of the layers averages 40 to 80 feet, although layers 200-feet thick have been observed.

Basalt flows fracture at the surface as they cool and solidify from the molten state. Three sets of joints commonly occur, two in the vertical direction and one in the horizontal direction. Columnar hexagonal joints that form columns 0.5 to 6 feet in width, and blocky joints fracturing parts of the basalt into pieces commonly about 0.5 foot in diameter, occur in the vertical direction (Newcomb, 1965). Platy fractures occur in the horizontal direction irregularly throughout most of the thickness of a flow. In addition, regional fractures hundreds or thousands of feet long may intersect several flows and have widely varying widths.

The basalt flows in the Pullman-Moscow basin are classified into the Wanapum and Grande Ronde Basalts of the Yakima Basalt Subgroup of the Columbia River Basalt Group (Swanson and others, 1979). Wanapum and Grande Ronde Basalts can be differentiated geochemically by magnesium and titanium concentrations--the Wanapum Basalt contains large concentrations of titanium and small concentrations of magnesium, and the Grande Ronde Basalt contains large concentrations of magnesium and small concentrations of titanium. The Wanapum Basalt is separated from the Grande Ronde Basalt by the Vantage Member (interbed) of the Miocene Ellensburg Formation. The Vantage Member occurs widely throughout the Columbia Plateau and is composed of siltstone, claystone, and tuffaceous rocks (Swanson and others, 1979).

MICROFILMED

MAR 19 1990

f3

MICROFILMED
MAR 19 1990

Numerous sedimentary interbeds like the Vantage Member commonly are mixed with the basalt, particularly near the margins of the Columbia Plateau. They were produced in lakes created when basalt flows dammed streams that existed during the eruption process. Soils also may have formed on the interbeds or on the basalt surfaces. Subsequent lava flows may have covered the sediments and created new lakes. Interbeds commonly are encountered during well drilling near Moscow and Pullman. Lithologies include clays, sands, and gravels. Laterally, the interbeds tend to thin and become finer to the west, but their spatial distribution has not been mapped adequately. Some drillers' logs for wells east of Moscow report hundreds of feet of clay.

Little structural deformation of the basalt flows has been detected in the Pullman-Moscow area. Foxworthy and Washburn (1963) note the possibility of broad flexures in the basalt. Some subsidence appears to have occurred to the west (Brown, 1976). The basalts generally dip a few degrees to the northwest. Cross sections by Brown do not reveal any structure other than the regional dip. The dip increases northwest of Pullman (Walters and Glancy, 1969). This increase may be the result of greater subsidence in that area. The basalts dip in the opposite direction in the Idaho part of the basin, possibly because of compaction of clay interbeds due to loading by overlying basalt flows and interbeds.

Other investigators have speculated on the presence of structural features in the Pullman and Moscow area that may have an effect on ground-water flow. Barker (1979) provided a definitive discussion on all the theories, but concluded that more data collection (test drilling and possibly more geophysical surveys) is necessary to determine the nature of these features, their location, and their effect on the ground-water system.

The geophysical study done by Klein and others (1987) was intended to provide some information about these features. The results indicate that there are considerable variations in the altitude of the bedrock-basalt interface (see fig. 7, p. 16). However, no specific features were identified that relate directly to the 'barrier zone' of Barker (1979). (Barker's investigation is discussed on page 57.) Test drilling to determine water-level variations with depth, aquifer permeabilities, and stratigraphic information to better define the features postulated by Barker was not included in this study.

Pleistocene Palouse Loess covers the relatively flat surface of the Wanapum Basalt. The loess originated in the Pasco basin about 95 miles west of the study area. Loess was deposited as large dunes that form the present topography. Thickness of the loess ranges from several hundred feet at the crests of the loessial dunes to zero where streams penetrate through to the underlying basalt. The loess is fine-grained and contains a well-developed silt-loam soil.

MICROFILMED

MAR 19 1990

Water-Bearing Characteristics of Geologic Units

The loess, basalt, and crystalline basement rocks all contain sufficient saturated permeable material to yield water to wells and springs (fig. 3). The loess has a high water-holding capacity. Unconfined ground water occurs in the loess, with the water table conforming roughly to the topography (Williams and Allman, 1969). Water levels fluctuate in response to the annual wet and dry cycle of precipitation. No long-term declines in water levels in wells open to the loess were reported by well owners during this study. Sufficient water is available in the loess for some stock and domestic supplies. Small springs are common at the contact of the loess and underlying basalt, particularly along stream valleys.

Basalts constitute the major producing aquifers in the basin. Most of the water is present in the fractured zones near the tops and bottoms of the basalt flows. Wells that penetrate one or more of these zones have the highest yields. The deepest wells in the area are at Moscow; they fully penetrate the basalt flows and are completed in the underlying crystalline rocks. Near Moscow, sandy interbeds can be a significant source of water.

The crystalline and metamorphic rocks underlying the basalt are generally less permeable than the basalt. They yield only small quantities of water for domestic use and for stock watering along the eastern margin of the study area. The source of water to these wells was not investigated for this study.

Geohydrologic Units

Three geohydrologic units were defined on the basis of the correlation of hydrologic properties with mappable geologic units. They are the Palouse Loess, the Wanapum Basalt, and the Grande Ronde Basalt. The loess ranges in thickness from 0 to 300 feet in the study area and unconformably overlies the Wanapum Basalt. The Wanapum Basalt is as much as 250 feet thick in the study area. The contact between the Wanapum Basalt and the Grande Ronde Basalt (where the Vantage Member of the Ellensburg Formation usually occurs) was determined from borehole-sample geochemistry and maps of surface exposures.

Structure contour maps of the top of the Wanapum Basalt and Grande Ronde Basalt are shown in figures 4 and 5, respectively. These maps incorporate information from available literature (see Previous Investigations section) and borehole geochemistry data (B.W. Drost, U.S. Geological Survey, written commun., 1986). The maps indicate that the regional dip of the basalts is to the northwest.

The Vantage Member is treated as part of the Grande Ronde Basalt for convenience of mapping, the same approach used for the Columbia Plateau Regional Aquifer-System Analysis (RASA) model (J.J. Vaccaro, U.S. Geological Survey, oral commun., 1986).

MICROFILMED
MAR 19 1990

14

MICROFILMED
MAR 19 1990

MICROFILMED
MAR 19 1990

A magnetotelluric geophysical investigation of the Pullman-Moscow area (Klein and others, 1987) was done in support of this study to help define the geohydrologic framework. This geophysical technique identifies the depth to the contact between the Grande Ronde Basalt and crystalline rocks. This contact defines the lower limit of the basalt in the Pullman-Moscow area. Twenty-four magnetotelluric soundings were obtained, distributed across the study area. A contour map of the thickness of the Wanapum and Grande Ronde Basalts plus interbedded deposits was developed from the soundings (fig. 6). The thickness of the basalt is about 1,300 feet near Moscow and 2,000 feet near Pullman, and greater than 2,000 feet between Moscow and Pullman. Thickness is greater in the western part of the study area, and is in excess of 3,500 feet west of Colfax.

A map of the altitude of the contact between basalt and crystalline rock (fig. 7) was derived by subtracting the thickness of basalt from the top of the Wanapum Basalt unit. The area in figure 7 where the top of the crystalline rocks is shown to be below sea level is not supported by any data other than magnetotelluric surveys, and may be a result of errors in interpretation or incorrect sounding spacing or location (D.P. Klein, U.S. Geological Survey, oral commun., 1987). The basalt may be thinner than what is shown in figure 7 (by an unknown amount) in that area.

The structure contour maps and the surface topographic map define the geometry of the three geohydrologic units that comprise the geohydrologic framework in the study area. The perspective view in figure 8 shows the relation between the layers. The Snake River canyon cuts through the upper two layers and much of the third.

Recharge

Most of the recharge to the ground-water system appears to be from infiltration of precipitation through the surficial loess. Water levels in the loess are responsive to seasonal fluctuations of precipitation; water levels indicate that recharge to the loess occurs during the late fall, winter, and spring, coincident with high precipitation and low evapotranspiration. High-intensity, short-duration precipitation events may produce recharge at other times of the year. Observations by Williams suggest that maximum recharge through the loess occurs in valleys between the rolling hills made of loess, where the relief is most gentle. Surface runoff and shallow subsurface lateral flow accumulate in these areas during spring snowmelt (R.E. Williams, University of Idaho, oral commun., 1985).

Deep percolation of water below the soil zone and rooting depth of crops (essentially recharge) has been calculated as part of the U.S. Geological Survey RASA program in a study of the Columbia River Plateau in Washington, Idaho, and Oregon. The recharge is calculated for river/stream drainage basins and uses daily records (usually over a 22-year period) of temperature, precipitation, streamflow, and crop and noncrop water-demand data. The resulting rate of recharge represents a long-term average (Bauer and Vaccaro, 1987). Using this methodology, the recharge for two basins in the study area, under both predevelopment conditions (before farming) and current farming practices, was calculated and is shown below:

16

18

Basin	Recharge, in inches per year: Predevelopment land use	Recharge, in inches per year: Current farming practice
South Fork Palouse River	4.13	2.79
Union Flat Creek	2.98	3.65

The recharge rate in Union Flat Creek basin has increased under the current farming practice of alternating fallow and crop years. During the fallow year, soil moisture increases and more water gets below the root zone to become recharge (Bauer and Vaccaro, 1989). The practice of growing a crop every year, common in the South Fork Palouse River basin, has actually caused a 32-percent decrease in the average recharge rate. The relationships of increased recharge in areas where fields are fallow or crop in alternate years and decreased recharge where crops are grown every year are common in the areas of the Columbia Plateau where dryland farming is the dominant agricultural technique (Bauer and Vaccaro, 1989). As will be shown later, recharge from local rainfall is the source of most ground water under Pullman and Moscow. A net reduction in recharge in the area may have a significant impact on the ground-water system.

Ground-Water Movement

Recharge to the ground-water system in the Pullman-Moscow study area is principally by infiltration of precipitation. The water moves vertically and laterally in the loess and in the Wanapum and Grande Ronde Basalts; flow is generally from east to the west and northwest (Bauer and others, 1985; Whiteman, 1986). This observation is in agreement with the earliest recorded water-level measurements by Russell (1897), which indicate a gradient from Moscow to Pullman. Water levels currently are lower in the Grande Ronde Basalt than in the Wanapum Basalt and loess, indicating that downward flow of ground water also is occurring.

Fractures within the basalt flows and fine-grained sedimentary interbeds are important controls on the vertical movement of ground water. Sedimentary interbeds are more common in the eastern part of the study area. Near Moscow, which is near the eastern edge of basalt flows, interbeds make up as much as 50 percent of the thickness of water-bearing materials (Lin, 1967; and Jones and Ross, 1972). Thinner basalt flows may be present in those areas, and thus may have interiors that are more fractured and permit significant downward movement of water. To the west, thicker basalt flows have more massive centers that probably impede flow. Interbeds consisting of poorly permeable clay may slow the downward movement of water. The magnitude of such vertical leakage is dependent on the areal extent, thickness, and continuity of the clay layers. More vertical leakage may occur as the percentage of coarse-grained material in the interbeds increases.

The Snake River appears to be a ground-water-discharge area for the Moscow-Pullman area. Water levels in shallow wells in the Grande Ronde Basalt along the Snake River are similar to river surface altitude. Water levels in the deepest wells in the basin, near Moscow, are about 1,500 feet higher than the river. Ground water flowing toward the river may discharge as small streams, springs, and seeps along the canyon wall, or it can discharge directly into the river. The rate of discharge directly to the river is unknown. The surface area of the walls of the Snake River canyon is significantly larger than the area of the Snake River and the preferential flow paths between the basalt flows is horizontal; for these reasons, a significant part of the discharge from the basin may be through the sides of the canyon and may represent discharge from the regional ground-water-flow system.

The small seasonal fluctuations in water levels in deep wells in the study area indicate that the deep regional flow system probably is insensitive to the seasonal fluctuations in precipitation. The rate of discharge from the sides of the canyon is unknown, but probably is fairly constant. Ground water also discharges to the Palouse River along the northwest edge of the study area. The Palouse River is incised only into the upper part of the Grande Ronde Basalt. Being at a higher altitude than the Snake River, the Palouse River probably receives much less ground-water discharge than does the Snake River.

Ground water discharges to small streams from local flow systems in the loess and in the Wanapum Basalt. During the late summer and fall, discharge from the shallower ground-water systems probably is the sole source of streamflow. This ground-water component of flow is termed baseflow and is present throughout the year.

Ground-Water Pumpage

The Pullman-Moscow area has a history of pumpage increases (fig. 9). The cities of Moscow and Pullman are the pumpage centers of the basin, and the municipalities and universities maintain separate wells. In Moscow, older municipal wells and numerous domestic wells are finished in the Wanapum Basalt. As shown in figure 9, pumpage from the Wanapum Basalt has decreased substantially after about 1965. This was due to poor water quality and declining water levels. Currently, only about 3 percent of water pumped for municipal uses comes from the Wanapum Basalt. All other municipal and university wells in Pullman and Moscow obtain water from the Grande Ronde Basalt.

The rate of ground-water pumpage has increased in the study area from about 27,000 ft^3/d (about 200,000 gal/d) to about 260,000 ft^3/d (about 2,000,000 gal/d) during the period 1891-1945. The average annual rate of increase for that period is about 4½ percent. From 1946 to 1975, ground-water pumpage increased to about 820,000 ft^3/d (about 6,100,000 gal/d), an average annual increase of about 4 percent. From 1976 to 1985, the rate of increase in ground-water pumpage slowed significantly to about 1 percent per year. Total ground water pumped in 1985 was about 910,000 ft^3/d (about 6,800,000 gal/d).

19

Historical Water-Level Changes

Prior to the drilling of wells, the ground-water system in the Pullman-Moscow area was in a state of dynamic equilibrium, with ground-water recharge equalling ground-water discharge. Discharge of ground water from pumping that started before 1900 produced an imbalance in the system. The initial response of the system was a reduction in the volume of water stored in the basalt. This is common; any development of ground-water resources causes a response, usually the drawdown of water levels. In many basins, a sustained decline in water levels causes a decrease in natural discharge and (or) an increase in natural recharge. Streams near Moscow and Pullman may be affected by the lowered ground-water levels; streamflow may be reduced. The adjustment to the pumpage can produce a new equilibrium if there is a reduction in natural discharge or an increase in the capture of recharge equal to the pumpage. Ground-water modeling, which will be discussed subsequently, will be used to indicate the extent to which a new equilibrium might be achieved in the Pullman-Moscow area.

MICROFILMED
MAR 19 1990

Water-level declines caused by pumpage from the Grande Ronde Basalt Formation have been documented in Moscow and Pullman (Barker, 1979, and numerous other references; see Previous Investigations). Hydrographs reveal a history of water-level decline that is similar for the two communities (fig. 10). The rate of decline was about 1.5 feet annually for the period 1946-85. Water-level declines of as much as 20 feet in the Grande Ronde Basalt for the period 1974-85 occurred within a radius of several miles of Moscow and Pullman (fig. 11).

The history of ground-water-level changes is different for the overlying Wanapum Basalt. Pumpage from the Wanapum Basalt near Moscow caused water levels to decline in that unit from the 1890's into the 1960's; significant reductions in pumpage since about 1965 (see Ground-Water Pumpage, p. 32) reportedly allowed water levels to recover several tens of feet in the Wanapum Basalt (Gary Presol, City Engineer, Moscow, Idaho, written commun., 1985). The recovery of water levels during the period 1974-85 is shown in figure 12.

Water levels in the loess fluctuate in response to the annual precipitation cycle and are reported by well owners not to have changed significantly during 1974-85.

MICROFILMED
MAR 19 1990

10

22

11

$\frac{1}{8}$ 12

NUMERICAL GROUND-WATER-FLOW MODEL

A numerical ground-water-flow model is a mathematical representation of the geohydrologic framework of the area investigated, the hydraulic properties of the materials present, and the hydraulic connection to the surrounding ground-water-flow system. Input to the model describes thickness and extent of zones or layers that compose the ground-water-flow system. Such layers commonly represent aquifers or geohydrologic units. Hydraulic properties of these layers are simulated by assigning values to model cells created by superimposing a grid on each layer. Hydraulic conditions must be described along the boundaries of the model. Model construction is completed when the data that describe the hydraulic properties and boundary conditions of each layer within the model have been collected, analyzed, compiled, and input to the numerical model.

For this study, one three-dimensional model and three two-dimensional cross-sectional models were constructed. The computer program used is that of McDonald and Harbaugh (1988). The cross-sectional models were used to evaluate various changes to the three-dimensional model of ground-water flow in the study area and as an aid to calibrate the three-dimensional model. The three-dimensional model was calibrated to simulate time-averaged conditions in the study area during 1974-85, and was evaluated by simulating historical water-level changes during 1890-1985. The calibrated model then was used to simulate water-level changes that would result from hypothetical pumping rates.

Three-Dimensional Model Construction

A three-dimensional numerical ground-water model was used to simulate the movement of ground water in the Palouse Loess, Wanapum Basalt, and Grande Ronde Basalt. Details of construction of the model are described below.

Discretization of Space

A regular grid mesh was used in this study to divide the study area into one-half-mile-square cells. This grid size adequately represents the distribution of values of hydraulic properties without creating too large a grid, or a grid with too many cells for available computer storage space. The grid is oriented northwest-southeast in order to make it coincide with several major streams and rivers that flow northwestward (fig. 13). These streams include the Snake River, Union Flat Creek, and the South Fork Palouse River.

MICROFILMED
MAR 19 1990

13

Model Layers

The model includes three geohydrologic units that are represented in the model by layers. The top layer represents the Palouse Loess; the middle layer represents the Wanapum Basalt; and the bottom layer represents the Grande Ronde Basalt. For the purposes of this report the hydraulic characteristics of all interbeds are lumped with the basalt formation they are contained within. The Vantage Member of the Ellensburg Formation is considered part of the Grande Ronde Basalt. The rationale for the selection of these units is in the section titled "Geohydrologic Units." These units are shown in the idealized cross section of figure 14. The layers do not have the same areal extent. The loess laps onto the crystalline basement rocks, and both the loess and Wanapum Basalt are missing in parts of the Snake River canyon.

The loess and the Wanapum Basalt (each less than 300 feet thick) were assigned as individual model layers. The much thicker Grande Ronde (up to 3,000 feet thick) was also assigned to one model layer. It was not subdivided for two significant reasons. First, a mappable logical division (a 'marker' bed or single basalt flow) could not be found in the Grande Ronde Basalt; second, data indicate that in the Pullman and Moscow area the basalt probably acts as one hydrologic unit.

14

MICROFILMED
MAR 19 1990

Hydraulic Properties of Model Layers

Most infiltration of water in the Pullman-Moscow area is into the surficial loess soil. Hydraulic conductivities of loess can range from less than 0.01 foot per day (ft/d) to about 10 ft/d (Freeze and Cherry, 1979). McGary and Lambert (1962) note a slightly greater range. The loess may be approximated as homogeneous and isotropic, although field observations of the characteristics of earth slumps and mudflows in the loess that years of cultivation have compacted a zone beneath the plowed soil horizon. This zone of compacted material may have different hydraulic characteristics, but they are not known. Long-term infiltration rates of several inches per hour near Moscow (Williams and Allman, 1969) indicate that parts of the loess are highly permeable. Clayey layers that occur within the loess could limit the vertical hydraulic conductivity. On the basis of these limited data, the horizontal hydraulic conductivity of the loess was estimated to be 5 ft/d. The vertical hydraulic conductivity of the loess was estimated to be 0.05 ft/d by assuming an anisotropy ratio of 0.01.

Basalt flows comprise most of the geohydrologic framework in the Pullman-Moscow area. Table 2 lists values of hydraulic properties for basalts as compiled by Rockwell Hanford Operations, U.S. Geological Survey, and University of Idaho researchers. Horizontal hydraulic conductivity data compiled for the eastern edge of the Columbia Plateau near the study area suggest a hydraulic conductivity of 2 ft/d as an average for the entire thickness of basalt. This value was used in the initial data input to the model, and is near the median value of 1.7 ft/d identified by the RASA project for the Columbia Plateau (J.J. Vaccaro, U.S. Geological Survey, oral commun., 1986).

12

MICROFILMED
MAR 19 1990

Near the margins of the plateau where thinner, less massive basalt flows compose a greater percentage of the total thickness, the value of hydraulic conductivity probably exceeds the median value. There, flows composed of broken or vesicular basalt and interbedded materials are more common. Pumping-test data indicate that the horizontal hydraulic conductivity in the upper Grande Ronde Basalt near Pullman and Moscow is at least an order of magnitude greater than the average of 2 ft/d.

The effective (or bulk value) vertical hydraulic conductivity of the sequence of basalt flows is more difficult to define. In a layered system, the layer with the lowest vertical hydraulic conductivity controls ground-water flow. In the Pullman-Moscow area, these controlling layers probably are the centers of the basalt flows and the clay interbeds, for which there are no field measurements of vertical hydraulic conductivity. However, 0.001 ft/d (an anisotropy ratio of 0.0005) is assumed to be a reasonable estimate of vertical hydraulic conductivity for both lithologies (Freeze and Cherry, 1979), and this value was used as initial input to the model.

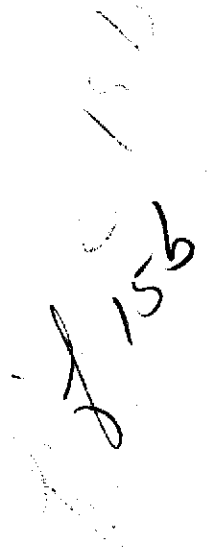
Boundary Conditions

The loess geohydrologic unit is modeled with no-flow boundaries on all horizontal sides (fig. 15a). Part of this boundary is formed by the topographic divide along the eastern and southern edges of the model area. It is assumed that little or no ground water leaves or enters the model at those areas. No-flow boundaries are also used where the loess is cut through by the Snake and Palouse Rivers. The bottom of the loess is hydraulically connected to the Wanapum or Grande Ronde Basalt layers, if present; if underlain by basement rocks, there is a no-flow boundary.

Two types of boundary conditions are used to represent the edges of the Wanapum and Grande Ronde geohydrologic units: no-flow boundaries and constant-head boundaries (fig. 15b and c). No-flow boundaries are imposed around the eastern half of the model where the basalt flows pinch out against the crystalline rocks. The location of these pinch outs has been studied extensively (Ross, 1965; Bockius, 1985). Although small quantities of ground water are present in these basement rocks, their relatively lower permeability justifies a no-flow boundary at the contact with the basalt. A no-flow boundary also underlies the basalt layers where they are in direct contact with the basement rocks. No-flow boundaries also are used along the west and southwest sides of the study area near the Snake River. A horizontal no-flow (streamline) boundary beneath the Snake River is assumed because ground-water flow is upward to the Snake River. This conclusion is based on the assumption that ground water flows towards the Snake River from either side.

Boundary conditions similar to those for the Snake River are assumed for the Palouse River. The smaller size of the Palouse River suggests that it may not be a regional discharge area and that there may be underflow of ground water. Despite this uncertainty, however, the boundary is designated as no-flow (streamline) because it was thought to be sufficiently distant from the pumping centers of Moscow and Pullman that the effects of drawdown would be insignificant. The use of the no-flow boundary along the Palouse River may cause greater simulated water-level declines resulting from pumpage in the model because underflow along the Palouse River does not exist as a potential source of water to wells in the model.

15a



15c

The remaining segments of the model boundary for the Wanapum and Grande Ronde layers are designated as constant head (fig. 15b and c). A constant-head boundary creates a ground-water gradient into or out of the modeled area, depending on the hydraulic heads near the boundary. The model uses this gradient to calculate a flux into or out of the appropriate geohydrologic unit at the location of the boundary. The northwestern edge of the model and segments along the northeast and southeast sides of the model are designated constant-head boundaries. Sufficient water-level data exist to define adequately the head distribution along the constant-head boundaries. These boundaries are also distant from the pumping centers; consequently, the same rationale that is used for the no-flow boundary along the Palouse River applies to these areas. Regional water-level information indicates that ground water flows into the model area on the northeast and southeast and out of the model area to the northwest. The modeled area extends far enough that effects of pumpage in the Pullman and Moscow areas should have little influence on conditions at the edges (lateral boundaries).

Recharge to the Model

Recharge to the ground-water-flow model as a result of precipitation is applied to the uppermost active model layer. This most commonly is the loess layer, but can be the Wanapum or Grande Ronde layers if they are at the surface. Recharge was calculated for two basins, South Fork Palouse River and Union Flat Creek, using the deep percolation model by Bauer and Vaccaro (previously discussed, p. 14), for both current land-use and farming practices and predevelopment (before farming) conditions. In these two basins, these calculated values of recharge were used in the ground-water-model. In areas outside these two basins, a regression equation (Bauer and Vaccaro, 1989) was used to allocate recharge as a function of long-term average annual precipitation and current farming practices. In areas where farming is not occurring, recharge was set to predevelopment rates.

Recharge is input to the ground-water-flow model for each cell to incorporate the areal variations in recharge. Figure 16a shows the distribution of average annual recharge over the study area under predevelopment conditions; recharge under current land-use and farming practices is shown in figure 16b. Lowest values of recharge occur in the Snake River canyon. Recharge generally increases toward the interior of the area and is greatest in the east where precipitation is also greatest, due to orographic effects in the mountains.

For predevelopment conditions (fig. 16a) the average annual recharge applied over the area of the three-dimensional model was about 150 ft^3/s and for current conditions and farming practices (fig. 16b) about 136 ft^3/s. There has been a net decrease in recharge to the ground-water system in the study area of about 10 percent and the areal distribution has been changed. This apparently is due, at least in part, to the practice of growing a crop every year in parts of the study area (Bauer and Vaccaro, 1989). Crops use more water than did the natural vegetation, resulting in a decrease in the amount of water that gets below the root zone and becomes recharge. In the South Fork Palouse River basin, where both Pullman and Moscow are located and where crops are grown every year, there has been a reduction in recharge of about 13 ft^3/s, or 32 percent, from predevelopment recharge. By comparison, average pumpage during 1981-85 for the same area was about 10 ft^3/s (6,700,000 gal/d). The reduction in recharge exceeds the amount of pumpage from the same area.

Fig 16a

1166

Hydraulic Connection of Ground Water With Rivers

Rivers may either contribute water to the modeled area or drain water from it, depending on the simulated head gradient between the river and the model layer. River reaches are simulated on a cell-by-cell basis (see figures 15a, b, and c). Input data to the model include the layer, row, and column in the grid through which the stream flows, the stream-stage altitude, a conductance value, and a river-bottom altitude (McDonald and Harbaugh, 1988). Conductance is proportional to the hydraulic conductivity and thickness of the material underlying the river.

River conductance for this model is based on vertical hydraulic conductivity of the loess or basalt, because most of the hydraulic connection between the model layer and the rivers is assumed to be in the vertical direction. McDonald and Harbaugh (1988) describe a riverbed lined with a lower-permeability material. That material can be any thickness and is assumed to be the limiting factor in water movement in and out of the river. In the Pullman-Moscow area, the lowest permeability material that the water moving to or from a river must flow through is probably the interior of a basalt flow or a clayey interbed deposit.

Drains

Ground water flowing horizontally in an aquifer may discharge as a spring (a point of ground-water discharge) or seep (discharge over a wider area) where the aquifer is truncated by a valley. Drains were used to simulate discharge from the ground-water system in those places. For example, if the altitude of the drain in a valley is below the simulated water table altitude in a model cell, then discharge from the ground water is simulated to occur.

Drains are placed in all cells where the aquifers are incised and the physical conditions exist for discharge to occur. Typically, intermittant stream reaches were simulated by a drain and perennial reaches were simulated by a drain and river in each cell. Input data to the model include layer, row, and column in the model grid system, the drain altitude, and a conductance value (McDonald and Harbaugh, 1988). Drain conductance for this model is based on the horizontal hydraulic conductivity of the layer where the drain occurs.

Seepage Faces

Seepage faces commonly occur along streams and rivers where the water table is near the surface. Water is available to be evapotranspired by vegetation or it may seep into streams or rivers. Some seepage faces can be simulated with drains (described above).

MICROFILMED
MAR 19 1990

Field investigations revealed areas along the canyon wall of the Snake River where plant cover is dense and where the soil and rock material is saturated just below the surface. Other parts of the canyon wall appear dry and have substantially less plant cover. The canyon wall of the Snake River represents a major seepage face in the modeled area. This seepage face may extend from river level (about 740 feet above sea level) to near the top of the canyon, some 1,700 feet higher. For modeling purposes, the canyon wall is assumed to act as a seepage face. Minor seepage faces occur along the Palouse River, the South Fork Palouse River, and Union Flat Creek.

Drains initially were used to simulate the seepage face along the Snake River canyon in the three-dimensional model. The drains produce a gradient-dependent flux based on the head in the adjacent geohydrologic unit and the head assigned to the drain. However, the great thickness of Grande Ronde geohydrologic unit did not allow gradient-dependent fluxes to be represented adequately, because in some cases the model-calculated head for those cells was below the bottom of the canyon and the drains were inoperative. Consequently, the drains were replaced in the three-dimensional model by a constant flux boundary for each cell corresponding to the seepage face. The method of determining the flux rate is discussed in the section Time-Averaged Three-Dimensional Model Calibration (p. 43).

Cross-Sectional Model Construction

The cross-sectional models used in this study are two-dimensional slices constructed through the three-dimensional flow system. They were used during the initial phase of modeling to gain understanding of the three-dimensional movement of water, and to help calibrate the three-dimensional model. Multiple model layers were introduced easily into the Grande Ronde Basalt in the cross-sectional models to investigate the distribution of hydraulic head within this thick geohydrologic unit. Simulating many layers facilitated comparisons between measured water levels in wells open only to the upper part of the Grande Ronde Basalt and water levels calculated by the three-dimensional model that represent the average for the entire thickness of the Grande Ronde Basalt.

The cross-sectional models were located along flow lines drawn perpendicular to contours of regional hydraulic-head distribution (not shown). The regional hydraulic-head distribution was obtained from Whiteman (1986) for the Grande Ronde Basalt. The location of the section lines is shown in figure 17. The flow lines chosen for the Grande Ronde Basalt do not fit the hydraulic-head distribution in the overlying Wanapum Basalt. Ground-water flow in the Wanapum Basalt generally represents a local flow system and that in the Grande Ronde Basalt represents a regional flow system (see Freeze and Cherry, 1979); therefore, flow lines in the two basalt geohydrologic units may be different. This may compromise the results of the cross-sectional models.

MICROFILMED

MAR 19 1990

MICROFILMED
MAR 19 1990

An example of the cross-sectional model is shown in figure 18 using cross-section B-B'. Boundaries of the cross-sectional models are similar to those of the three-dimensional model. A recharge flux (predevelopment rate, figure 16a, calculated using Bauer and Vaccaro, 1987) is applied to the uppermost active layer. The east and west edges are no-flow boundaries (fig. 18) where the geohydrologic units pinch out onto the basement rocks or where vertical flow probably occurs upward to the Snake River, respectively. The great thickness of the Grande Ronde unit was modeled as a series of 200-foot-thick layers, each with a drain at the canyon, to facilitate simulation of the vertical hydraulic-head distribution in the formation, and to obtain a more accurate representation of the seepage faces in the Snake River canyon. The 200-foot division was chosen arbitrarily (basalt flows may be thinner); it does not represent the actual layering in the Grande Ronde. The exact number of layers used in the Grande Ronde Basalt depends on the depth to basement along each section, but the average number for the three cross-sectional models is 18 layers. The layering allows drains to simulate the seepage face along the canyon. The flux from these drains forms the basis for the well flux that simulates the seepage face in the three-dimensional model (see Cross-Sectional Model Calibration, p. 40). The loess and Wanapum Basalt each were simulated as single layers as in the three-dimensional model.

MICROFILMED
MAR 19 1990

Calibration of Models

The purpose of the calibration phase of modeling is to achieve the closest possible agreement between the numerical model and the physical world that it represents. Konikow (1978) notes that "...in practice, the calibration of a deterministic ground-water-flow model is frequently accomplished through a trial-and-error adjustment of the model's input data (aquifer properties, sources and sinks, and boundary and initial conditions) to modify the model's output". Wang and Anderson (1982) augment this definition by indicating that a model is considered calibrated when output hydraulic heads are in agreement with those heads measured in the field.

The calibration process may be accompanied by a verification process. Verification is not well defined in the geohydrologic literature. According to Wang and Anderson (1982), verification is achieved by demonstrating that the model is capable of reproducing a historical hydrologic event for which field data are available. Konikow (1978) notes that the verification data should be distinct in time from the calibration data. Wang and Williams (1984) indicate that the goal of verification is to determine that the model has not been uniquely tuned to the calibration data set.

For this study, three cross-sectional models were calibrated independently to reproduce steady-state predevelopment conditions, and the three-dimensional model was calibrated to reproduce time-averaged conditions during 1974-85. The three-dimensional model then was used to simulate historical drawdown in the area due to pumping during 1890-1985. This last step was intended to be a verification of the model, but much back-tracking, iterating from the cross-sectional to three-dimensional time-averaged to three-dimensional historical drawdown models, occurred. The calibrated models are a product of all the available data sets, so the model does not strictly fit the calibrated and verified criteria discussed above. Konikow (1978) states that "...a model that has been calibrated only to reproduce historical data should not be considered a verified model. Nevertheless, a calibrated model can be used to analyze or predict future aquifer responses. The accuracy of its predictions is the best measure of a model's reliability."

The cross-sectional and three-dimensional models initially were constructed using the best estimates for all input data. Then, each cross sectional model was calibrated. Hydraulic coefficients were reevaluated, changed as appropriate, and then checked by rerunning the cross-sectional models. The areal distribution of hydraulic coefficients was mapped from results of the cross-sectional models and used as input data to the three-dimensional model. The three-dimensional model first was calibrated to match average conditions during 1974-85, a time-average steady-state simulation (Prych, 1983). If a change in hydraulic coefficients was required in the three-dimensional model, the change also was made in the appropriate cross-sectional model and checked to be sure the change did not alter significantly the calibration of that model. Iterating through this process is time-consuming, but is designed to keep all hydraulic coefficients in a range of reasonable values. The least-known values of hydraulic coefficients were those most likely to be changed. The least known and better known input data are listed below.

MICROFILMED
MAR 19 1990

Least known input data:

1) Vertical hydraulic conductivity
2) Horizontal hydraulic conductivity
3) River and drain conductance values
4) Storage coefficient

Better known input data:

1) Thickness and extent of the Grande Ronde Basalt
2) Thickness and extent of the Wanapum Basalt
3) Recharge rate
4) Boundary conditions

When the cross-sectional models were calibrated, the range of uncertainty in the 'least known' input data was large, and the data were adjusted through all possible values considered reasonable on the basis of a literature search. Data from the calibrated cross-sectional models were used as input to the three-dimensional model also, but during calibration of the three-dimensional model, the adjustments were smaller. Horizontal hydraulic conductivity was changed only within a factor of 2 in the three-dimensional model from that determined in the cross-sectional models. Vertical hydraulic conductivity values (the least well-known hydraulic characteristic) were changed only within a factor of 10 from that of the cross-sectional models. When the three-dimensional model was run to simulate water-level change caused by historic changes in pumping (1890-1985), only the storage coefficient was changed, by as much as a factor of 10, to improve the fit of calculated to observed water levels.

Cross-Sectional Model Calibration

Cross-sectional models constructed for this study are calibrated to simulate predevelopment (no pumpage) conditions. Predevelopment recharge rates were used. One of the criteria used to determine if the models were calibrated was that simulated water levels closely match observed water levels. Predevelopment water levels are known approximately for only a few wells near Pullman and Moscow. The earliest wells in Moscow tapped the Wanapum Basalt and flowed at land surface. The potentiometric head was 2,570 feet $\pm$ 20 feet (Russell, 1897). Early wells in Pullman tapped the upper part of the Grande Ronde Basalt where the head was approximately 2,360 feet $\pm$ 20 feet (Russell, 1897). A well located near the edge of the Snake River canyon (14/43-25N2, table 7, end of report) was used as another calibration data point for model B-B'. The water level in this well is assumed to approximate predevelopment conditions within several tens of feet because of its distance from the pumping centers. This well penetrates the Wanapum Basalt and the upper part of the Grande Ronde Basalt (total depth 350 feet). The shallow depth to water in this well (about 121 feet) implies that most of the canyon wall may be a seepage face; therefore, another cross-sectional model calibration criterion was that all of the drains that simulate the seepage face should be active.

MICROFILMED
MAR 19 1990

The cross-sectional models were calibrated by varying horizontal and vertical hydraulic conductivity of the basalt geohydrologic units. Horizontal and vertical hydraulic conductivity were held constant in the Palouse Loess soil at 5 and 0.05 ft/d, respectively. The horizontal hydraulic conductivity for basalt was varied between 0.1 and 50 ft/d. This range is compatible with reported data for the Columbia River Basalt Group (table 2). The vertical hydraulic conductivity was estimated to be a (smaller) multiple of horizontal hydraulic conductivity. The vertical hydraulic conductivity ranged between 10 and 10,000 smaller than the horizontal hydraulic conductivity (representing an anisotropy ratio). This range is intended to bound the probable distribution of hydraulic conductivities. The cross-sectional models were constructed to allow investigation of changes in both horizontal and vertical hydraulic conductivity values. In each cross-sectional model the basalts were divided vertically into distinct zones of similar hydraulic properties, four for the Grande Ronde Basalt and two for the Wanapum Basalt. The inclusion of these zones was an evolutionary process that occurred during initial operation of the cross-sectional models. The original version of the cross-sectional models had no zonation, but because observed water levels could not be matched with hydraulic heads calculated by the cross-sectional models, the zones were added. Figure 19a shows the zones and their values of hydraulic conductivity for the calibrated model for section B-B'. Similar zones were used in models A-A' and C-C', which are not shown.

The zones of differing hydraulic characteristics used in the calibrated cross-sectional models probably represent natural changes in the rock materials. On the basis of the results of the three cross-sectional models, the horizontal hydraulic conductivity of the Grande Ronde Basalt is lower in the western part of the study area than in the east. In the west, the basalt flows are thicker and may be less fractured, and thus have a lower conductivity. In the east, the opposite occurs. Basalt flows are thinner and fractured and have a higher hydraulic conductivity. To the west, the interflow zones may contain finer grained sediments. In the calibrated cross-sectional models the vertical hydraulic conductivity of the basalts (including the interbeds) was a smaller fraction of the horizontal value; thus, vertical hydraulic conductivity is lower, reflecting the geology.

Contours of the hydraulic heads simulated by the cross-sectional model match well with reported and (or) observed water levels along cross-section B-B' (fig. 19b). The contour lines are based on the multilayer output from the cross-sectional models. The water level at Moscow represents the Wanapum Basalt at one point, and the water level at Pullman represents the upper Grande Ronde Basalt at one point; the water level near the Snake River canyon probably represents a composite water level of the Wanapum and upper Grande Ronde at one point.

Points on cross-sections A-A' and C-C' that correspond approximately to Pullman and Moscow are calibrated to water-level values reported by Russell (1897) of 2,360 and 2,570 feet, respectively. Predevelopment water levels on the western end of these cross sections near the Snake River are unknown. Water levels in the upper Grande Ronde and Wanapum near the canyon are calibrated to be just above the top of the respective layers. This decision was based on the best available data.

The results of the cross-sectional models were used to map the areal distribution of hydraulic characteristics. This was used as input to the three-dimensional model.

The magnitude of the drain fluxes calculated by the cross-sectional models at the Snake River canyon provides additional input for the three-dimensional model calibration. Field examinations of the canyon seepage face indicate that the discharge of ground water is probably occurring; however, the quantity of discharge cannot be calculated directly or measured. Average annual precipitation in this part of the study area is about 17 in./yr and the potential evapotranspiration rate is at least 40 in./yr (Bauer and Vaccaro, 1989). The average rate of flux out the seepage face of the Snake River canyon, calculated from cross-sectional modeling, is equivalent to about 25 in./yr. This flux is used for input into the three-dimensional model as an initial approximation of the flux out the Snake River canyon seepage face.

Time-Averaged Three-Dimensional Model Calibration

The model-calibration technique used in this study incorporates a method averaging hydrologic conditions over a known period (Prych, 1983). Time-averaging allows calibration of a three-dimensional model to recently collected data, which are commonly more complete than historical data. The period chosen was 1974 to 1985. Barker (1979) had collected data in 1974, and data on all aspects of the ground-water-flow system were collected for this study in 1985. All transient conditions (changing water levels or pumping rates) are averaged over the same period so that they can be accounted for in what then becomes a steady-state simulation. Recharge rates based on current land-use and farming practices were simulated.

The hydraulic-conductivity distributions for both the Wanapum and Grande Ronde Basalts, obtained from the cross-sectional models, were transferred to the three-dimensional model. The loess was assigned the same values used in the cross-sectional modeling. The horizontal hydraulic conductivities of the basalts were varied by no more than a factor of 2 in the transition from the steady-state cross-sectional models to the three-dimensional model under time-averaged conditions. The vertical hydraulic conductivity ratio was varied by one order of magnitude. Given that little is known about this ratio, an order of magnitude is a reasonable variation.

A uniform value of storage coefficient was used for the basalt geohydrologic units in the time-average calibration. The final value used was 0.001. This is a reasonable value for confined aquifers in the basalts. There is most likely some nonuniform distribution of storage coefficient in the basalts in the Pullman-Moscow area, but this distribution is unknown.

A trial-and-error approach was used to calibrate the model. The goal was to simulate as closely as possible the observed average water levels for 1974-1985 and base flow in streams in the study area. The better known input data for the model (thickness and extent of the geohydrologic units, recharge, and boundary conditions) were not altered during calibration. The input data least well known (hydraulic coefficients including horizontal and vertical hydraulic conductivity and the storage coefficient) were altered within a range that was considered reasonable on the basis of a literature search.

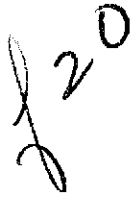
Initially, the seepage face near the Snake River was simulated using drains. As previously described (p. 35), this was not adequate. A constant flux boundary was substituted, with a rate of discharge equal to 25 in./yr withdrawn from the seepage face, the rate determined from the cross-sectional modeling. During the calibration process, this rate eventually was reduced to a rate equal to about 10 in./yr. This lesser rate is reasonable, based on field observations that significant but unmeasurable discharge probably is occurring at the seepage face. Evapotranspiration of water at the seepage face could occur because the rate is smaller than the estimated potential evapotranspiration rate (40 in./yr) less precipitation (about 17 in./yr).

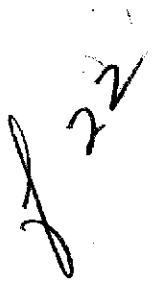
All changes to hydraulic coefficients and discharge rate at the seepage face of the Snake River canyon were evaluated during this calibration process. If horizontal hydraulic conductivity of the Wanapum Basalt was changed in one zone in the three-dimensional model, the change also was made in the appropriate cross-sectional model. Only if the change helped calibrate both models would it be accepted and left in the input data sets.

Values of horizontal hydraulic conductivity in the calibrated model for the Wanapum Basalt ranged from 0.4 ft/d to 0.6 ft/d; for the Grande Ronde Basalt, the range was from 0.4 ft/d to 12.0 ft/d. The ratio of horizontal to vertical hydraulic conductivity, the anisotropy of the geohydrologic unit, was 500:1 for the Wanapum and ranged from 2,000:1 to 5,000:1 for the Grande Ronde. The range of resulting vertical hydraulic conductivity was 0.0008 to 0.0012 ft/d for the Wanapum and 0.0001 to 0.0025 for the Grande Ronde. The distribution of calibrated values for hydraulic characteristics for the Wanapum Basalt is shown in figure 20 and for the Grande Ronde in figure 21.

Eventually, after iterating between the cross-sectional models and the three-dimensional model, a reasonable match was obtained between simulated heads produced by the three-dimensional model and observed water levels for the Wanapum Basalt (fig. 22). The observed water levels shown are the average water levels for 1974 to 1985. The contour lines show the distribution of simulated water levels (for fully penetrating wells) in the model. Most of the measured water levels are in general agreement with the simulated water levels. Where measured water levels are greater than simulated water levels, the wells may penetrate only the upper part of the Wanapum Basalt. Because water levels are known to decrease with increasing well depth in most of the study area, a partially penetrating well may have a higher water level. Measured water levels that are lower than model output may be from wells along a narrow stream valley. Because most of the stream valleys are small relative to the half-mile-square model cells, the model-calculated water level for a cell might be dominated by nearby uplands rather than the stream valley. Local effects and water levels tend to be smoothed out by the regional nature of the three-dimensional ground-water-flow model.

A reasonable match also was achieved for the Grande Ronde geohydrologic unit (fig. 23). The contours represent simulated water levels. Observed water levels in the Grande Ronde Basalt generally are from wells that penetrate the upper part of the basalt, except for two deep wells at Moscow. The three-dimensional model calculates the average water levels over the thickness of the cell. To correct for partial penetration of the wells, the average measured water levels for 1974 to 1985 presented in figure 23 are adjusted using the results of the cross-sectional models. The corrected water





$\frac{1}{8} \cdot 2^3$

levels for wells are comparable directly to water levels calculated by the three-dimensional model for the Grande Ronde geohydrologic unit. The correction factor for partial penetration lowers measured water levels by a few feet near Moscow and Pullman, where vertical gradients are low, and by several hundred feet near the canyon, where vertical gradients are high.

The model output suggests that there is a water-level difference of about 40 feet between Moscow and Pullman. However, this head difference does not appear in the measured water-level data for the upper part of the Grande Ronde; water levels in Moscow and Pullman are nearly the same. This difference between the simulated and observed hydrologic conditions is not understood at this time.

Barker (1979) found that a similar gradient between Moscow and Pullman was calculated at first by the model constructed for his study. In trying to correct this perceived error, Barker chose to simulate some type of undefined geologic structure that was controlling the hydrology of the area between Pullman and Union Flat Creek (the 'barrier zone'). Other investigators had speculated that feeder dikes or geologic structures may exist in that area; Barker speculated that the geologic features may have reduced hydraulic conductivity (see Barker, 1979, for an in-depth discussion). Barker reduced the hydraulic conductivity of the primary aquifer system by a factor of about 0.01 in that area. He then was able to adjust other input data in that model so that it simulated the observed (small or nonexistent) gradient in the Grande Ronde Basalt between Moscow and Pullman.

The 'barrier zone' concept was extensively investigated for this study, but even with new geophysical data and new water-level data, the existence, location, nature, and hydraulic characteristics of any geologic feature that may coincide with the 'barrier zone' of Barker are uncertain. Neither the cross-sectional models nor the three-dimensional model described in this report incorporates a feature that specifically correlates with the 'barrier zone.' In general, however, the results of the calibrated models discussed in this report indicate that the hydraulic conductivity of the Grande Ronde Basalt is highest east of Pullman and decreases to the west (fig. 21), in agreement with Barker's findings.

Simulated discharge of ground water to streams also was compared with measured streamflow values during calibration of the model. The results are discussed as part of the next section of the report.

Water-Budget Analysis of Time-Averaged Model

The water budget of the calibrated time-averaged model is presented in table 3. Recharge to the model is about 136 ft^3/s, calculated from the recharge distribution over the surface area of the model (fig. 16b) and based on current land-use and farming practices. About 13 ft^3/s enters the model on the south and northeast constant-head boundaries. The flux of water into the model from recharge and constant-head boundaries is balanced by the flux of water out of the model through wells, drains, rivers, and the constant-head boundaries. More than 19 ft^3/s leaves the model through the three constant-head boundary segments simulating the regional flow system at those locations.

13

The drain flux includes drains along the creeks and the extreme upper reaches of streams east of Moscow. Although not shown in table 3, about 32 ft^3/s leaks downward from the overlying layers and reaches the Grande Ronde Basalt layer in the model. Discharge from the Grande Ronde Basalt is mostly to the Snake River and its associated seepage face. Average pumpage from wells during 1974-85 was 9.4 ft^3/s.

Simulated streamflow in reaches of selected rivers and streams is shown in table 4. The sum of the simulated river flux and the simulated drain flux represents the quantity of water that the model calculates is flowing from the ground-water system toward a river valley and into a river. Streamflow measurements in the same reach are shown for comparison. In general, measured streamflow is less than the model-calculated value. This may be due to inaccuracies in simulating these rivers and drains and because the model does not account for any evapotranspiration losses that may occur in the river valley.

14

MICROFILMED
MAR 19 1990

Simulation of Historical Water-Level Changes Due to Pumping of Ground Water

When the model had been calibrated, it was verified (or evaluated) by simulating historical changes in the rate of pumping of ground water in the area and comparing the resulting water levels with records of water-level change during 1890-1985. Washington State University well 1 (14/45-5F1) and University of Idaho well 3 (39/5-7cbb1) penetrate the Grande Ronde Basalt and were chosen for comparison of model results with observed conditions. The wells were chosen on the basis of completeness of water-level records and the fact that they are representative of wells in each municipality. A three-dimensional model simulation that begins in 1890 with one well in Pullman, one well in Moscow, and a combined pumping rate of about 200,000 gal/d reproduces historical water-level declines in the study area. During the simulation, pumping was increased over time and new wells were added according to historical records.

Recharge to the model for this simulation was varied with time. Pre-development recharge (fig. 16a) was simulated from 1890 to 1945 as farming in the area was gradually increasing. For 1946-1960 an arithmatic average of pre-development and current (fig. 16b) recharge was applied to the model, representing the transition period to current land-use and farming practices. For 1961-1985, recharge based on figure 16b values representing current land-use and farming practices was applied to the model.

The observed and simulated water levels for Pullman and Moscow are shown in figure 24. There is a close correlation between observed and simulated water levels. Barker's (1979) simulated historical water-level decline for Pullman is shown for comparison. (Barker's model is discussed later on pages 57-59.) Differences (as much as 10-30 feet) in the absolute water-level altitude between simulated and observed hydrographs may result from limitations inherent in representing the Grande Ronde Basalt as a single model layer. Most wells in the area penetrate only the upper part of the Grande Ronde geohydrologic unit. Consequently, the water-level record for most wells is for the upper part of the formation, whereas simulated water levels represent the average over the model layer.

Figure 25 shows a more detailed comparison between simulated and observed drawdown in one well each in Pullman and Moscow during 1975-85. Available records show that the average increase in pumping rate in the area for that period was about 1 percent per year. Model runs simulating both 1 and 1½ percent annual increases are shown, and simulated drawdown compares well with measured drawdown.

MICROFILMED
MAR 19 1990

$\int_0^{2^4}$

125

Estimated Effects Due To Pumping Of Ground Water

A common misperception among water users in the Pullman-Moscow area was that water consumption and the corresponding pumpage had remained essentially constant over the period 1976-85. Available pumpage data indicate that annual ground-water pumpage has continually increased (see fig. 9). An analysis of 5-year averages of pumpage (5-year averages are used to smooth out year-to-year variations) indicates increases of about 4½-percent per year during 1891-1945, 4-percent per year during 1946-1975, and 1-percent per year during 1976-85. Model projections are based on water use at or above the 1981-85 average rate of about 6,700,000 gal/d.

Six projections of water pumpage were examined. Three were based on stable pumping rates and three were for various rates of increase in pumpage. These projections were intended to bracket water use on the basis of the extremes of a stabilization of pumpage at the 1981-85 average rate and 2-percent pumpage growth per year. The distribution of pumpage remains the same as in 1981-85 in all simulations. If pumpage increased in Pullman [illegible] of 2 percent annually, it was assumed to increase by the same amoun[illegible] Moscow.

MICROFILMED

MAR 19 1990

Constant-Pumpage-Rate Scenarios

The effects on the ground-water system of future pumpage at three constant rates were investigated with the model. The model simulation of future conditions indicates that ground-water levels will decline and then stabilize at annual pumpage rates as great as twice the 1985 rate if pumpage is held constant at the increased rate into the future. The altitude of the stabilized water levels and the length of time required to achieve this stabilization depend on the pumping rate--the larger the pumping rates, the greater the depth at which any water-level stabilization occurs and the more time required for stabilization.

The first scenario is for a constant pumpage rate equal to the average 1981-85 rate of about 6,700,000 gal/d. The model results indicate that water levels near both Pullman and Moscow stabilize in a few years with little additional water-level decline below 1985 levels (figs. 26 and 27, curve a). The actual response of the physical system may take longer than predicted by the model because of the single-layer representation of the Grande Ronde Basalt; it may take several years for water-level declines to stabilize.

f 26

MICROFILMED
MAR 19 1990

The second scenario assumed constant pumpage rate at 125 percent of average 1981-85 rates, about 8,500,000 gal/d. The model results indicate that water levels will stabilize in about 5 years with water-level declines of about 20-30 feet (figs. 26 and 27, curve b). Both the stabilization period and the decline of water levels are greater than for the first scenario.

The third scenario assumes a constant pumpage rate equal to 200 percent of average 1981-85 rates. This pumpage rate is about 13,400,000 gal/d. The model results indicate that water levels will stabilize, possibly within about 10 years, with a water-level decline of about 90-110 feet (figs. 26 and 27, curve c).

Increasing-Pumpage-Rate Scenarios

Annual pumpage rate increases are representative of historical water-use trends over the last 100 years. Pumpage rate scenarios that incorporate ½-, 1-, and 2-percent annual increases (from each preceding year) were investigated using the model. All three scenarios indicate that water-level declines will accompany increases in pumping rates. Figures 26 and 27 (curves d,e,f) show that the rate of water-level decline is proportional to the rate of pumpage increase.

MICROFILMED
MAR 19 1990

The first scenario assumes a pumping rate increase of ½ percent annually. The initial rate was the average for 1981-85. At this rate of increase, the pumpage rate would be double that of the 1981-1985 average in about 140 years. The model results indicate that even at this seemingly small rate of increase, water levels would continue to decline in the study area (figs. 26 and 27, curve d). The rate of decline would be about 0.5 ft/yr in both Pullman and Moscow. Equilibrium between recharge and discharge did not occur for this scenario. Water-level declines are simulated to occur as long as pumpage increases annually, even at the relatively low rate of ½ percent per year.

In a scenario assuming a pumpage rate increase of 1 percent annually from average 1981-85 rates, the pumpage rate will double in about 70 years. The model results indicate that water-level declines will continue as long as pumpage rates increase (figs. 26 and 27, curve e). The simulated rate of decline is about 1 ft/yr.

In a scenario assuming a pumping rate increase of 2 percent annually from 1981-85 rates, the pumping rate will double in about 35 years. This scenario suggests that water-level declines would average 2 to 2.3 ft/yr in the Pullman and Moscow areas (figs. 26 and 27, curve f). The rate of annual water-level decline gradually would increase.

Sources of Pumped Water

In all these scenarios, the water budget calculated by the model was examined to determine the source of the additional water being pumped. The major source of some of that water (about 40-50 percent) is reduced flow from aquifers in the model to simulated streams and rivers or reduced flow out of simulated drains. Perennial reaches of streams in the study area could have a reduced flow in late summer or could become intermittent reaches, going dry earlier and staying dry longer as pumping of ground water increases. About 20-30 percent of the increased pumpage comes from aquifer storage. The remaining water pumped (about 20-25 percent) was derived from reduced outflow from the model (or increased inflow to the model) at the constant-head boundaries.

The simulated flow of ground water to the Snake River remained virtually unaffected by increased pumping. The implication is that sufficient water was captured from other sources of recharge (or reduced discharge) such as streams, rivers, and drains closer to the pumping centers than the Snake River.

MICROFILMED
MAR 19 1990

A COMPARISON OF MODEL RESULTS WITH THOSE OF A PREVIOUS STUDY

Barker (1979) constructed a two-dimensional finite-difference ground-water-flow model of a part of the area investigated for this study (fig. 28). His model was calibrated to simulate accurately the observed water-level changes in the upper part of what is referred to in this report as the Grande Ronde geohydrologic unit (fig. 24).

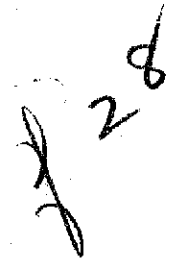
Barker (1979) simulated the upper Grande Ronde as a heterogeneous aquifer with a fixed thickness of 1,000 feet. The average thickness of the Grande Ronde for this report in the same area is about 2,000 feet, but varies considerably. Aquifer hydraulic conductivities in most of Barker's model ranged from 4 to 26 ft/d. In this report, Grande Ronde hydraulic conductivities ranged from 5 to 12 ft/d for the same area. Barker reduced hydraulic conductivities in the 'barrier zone' to 0.1 to 1.0 ft/d. In this report, hydraulic conductivities between Pullman and the Snake River are as low as 0.4 ft/d. Calibrated storage coefficient values are 0.005 (Barker, 1979) and 0.001 (this report).

Significant differences between the two models occur in how recharge to the ground-water system is calculated and how much recharge is occurring in the area. Barker used a head-dependent 'leakance' flux as recharge to the Grande Ronde Basalt. During model calibration, the 'leakance' was adjusted as one of the unknowns. This is a common technique that allows a two-dimensional model (which Barker described) to simulate approximately the three-dimensional flow. Barker had no other independent method to calculate recharge. Simulating conditions for 1975, the 'leakance' recharge rate to the Grande Ronde amounted to 0.67 in./yr. In this report, using the Bauer and Vaccaro (1987) methodology (and current conditions of land use), recharge to the loess is about 2.8 in./yr and the ground-water-flow model calculates that about 2 in./yr gets into the Grande Ronde geohydrologic unit in the area modeled by Barker (1979).

There are similarities in the results of the two models in that they predict similar responses of water levels in the Grande Ronde Basalt to historical changes in the pumping rate of ground water. Table 5 shows the observed water-level decline in Pullman and Moscow (1896-1975) and a comparison of simulated water-level declines in Pullman and Moscow from Barker's study and this report.

Barker (1979) summarized three scenarios of future pumping rates. Using the model described in this report, those same rates of change in pumping rate were simulated. Similar water-level declines in Pullman and Moscow are estimated by simulating no increase in the rate of pumping in both models. Simulating increases in pumping of 3 and 4.6 percent per year with both models points to a discrepancy between the models. The model in this report predicts considerably more drawdown than did Barker (table 6). An examination of the simulated water budgets leads to an explanation of this discrepancy. By the year 2000, when pumping is either two or three times what it was in 1975

MAR 1 9 1990



(at 3- and 4.6-percent increases per year, respectively) Barker (1979) predicts that about 90 percent of the additional water pumped will be from storage in the aquifer. The model described in this report, simulating similar pumpage scenarios, calculates that about 9 to 15 percent of the water will come from storage, and the remainder will be drawn toward the pumping centers from streams and drains. This results in larger predicted drawdowns in water levels.

Pumping of ground water increased in the Pullman-Moscow area by an average annual rate of 1 percent during 1976-85. Observed drawdown in the Grande Ronde Basalt for 1974-85 ranged from 14-20 feet near Pullman and 10-18 feet near Moscow (see fig. 11). To correspond to the period simulated by the models (1976-85), drawdown during 1976-85 is estimated to be about 12-16 feet and 8-25 feet, respectively. The model in this report calculated that drawdown was about 11 feet in both cities during 1976-85, assuming a 1-percent increasing rate of pumpage. Barker (1979) does not simulate an equivalent increase in pumpage. However, in a scenario of 3-percent per year increase, water-level drawdown in Pullman and Moscow was simulated to be about 13 feet (Barker, 1979). At a lesser rate of increase, simulated drawdown would be smaller.

15

16

MICROFILMED

MAR 19 1990

LIMITATIONS OF THE MODEL

Discretion must be exercised in use of the model results. The three-dimensional ground-water-flow model incorporates many simplifying assumptions about the flow system. Most important are the assumptions of constant heads along some boundaries, homogeneous blocks of aquifer material both laterally and with depth, and the simplified treatment of streams and rivers. Particularly critical to the model developed in this study is the representation of the Grande Ronde Basalt as a single layer. These simplifications may allow the model to achieve recharge-discharge equilibrium sooner and with less drawdown than would be experienced under actual conditions in the study area.

The use of constant-head boundaries was tested by replacing the constant-head boundary with a constant-flux boundary. This change produced some additional drawdown over most of the model for all future pumping scenarios. The additional drawdown was small (1 to 3 feet), but was apparent at all model boundaries, indicating that the effects of pumping in Pullman and Moscow may have wider (areal) impact on the ground-water system than previously thought. Conversely, because the amounts of drawdowns were small, it indicates that the constant-head boundaries are far enough away that they have little impact on predicted water levels at Pullman and Moscow.

The model representation of half-mile-square homogeneous blocks of aquifer material does not account for discontinuities (such as faults, dikes, poorly permeable interbeds) that might impede flow and lengthen the time required for equilibrium to be established. Similar problems may apply to leakage from streams.

Using a single layer to represent the Grande Ronde Basalt makes it difficult to compare model results with field data. The single-layer representation may result in underestimation of the time required for equilibrium conditions.

Simulated drawdown matches observed drawdown closely in Pullman and Moscow for the period 1891-1985. It is probable that the simulated rates and amounts of drawdown in the three scenarios where pumpage increased every year are reasonably accurate projections for the period 1985-2005. The total drawdown and time to equilibrium of the scenarios where pumping did not change from the average rate of 1981-85 and the step-increased rates of 1.25x and 2.00x have a large potential error, the time to equilibrium being the most uncertain.

MICROFILMED

MAR 19 1990

SUGGESTIONS FOR FUTURE INVESTIGATIONS

This study is a step in the long process of understanding the geohydrology of the basin. Much information has resulted from the study; however, more data collection is needed to strengthen the assumptions and simplifications of this study. The systematic collection of water-level and pumpage data for the area and dissemination of that information to the public may be helpful in increasing public awareness of the value of the resource. Further examination of the recharge, movement, and discharge of ground water in the area is needed, with emphasis on evaluating the recharge distribution calculated for this study. Lysimeter studies could provide detailed data on water movement through the loess, which is useful in quantifying recharge rates. A detailed examination of ground-water discharge characteristics along the Snake River canyon would add much to the understanding of the resource.

Further investigation of the 'barrier zone' of Barker (1979) is warranted because of the importance of knowing if it limits water movement into and (or) out of the Pullman area. Information on water-level change with depth below land surface is needed throughout the area to help understand if the Grande Ronde Basalt is acting as a single aquifer.

CONCLUSIONS

Increasing pumpage rates and declining ground-water levels in the Columbia River Basalt Group of the Pullman-Moscow area of Washington and Idaho indicate a need for ground-water management. A three-dimensional numerical computer model of the ground-water-flow system was constructed to provide an understanding of the geohydrology of the study area. The ground-water-flow model incorporates an overlying surficial loess layer, a Wanapum Basalt layer, and a Grande Ronde Basalt layer. A ground-water-system recharge rate was estimated using a methodology developed by the U.S. Geological Survey. Ground-water discharge was modeled as ground-water pumping, flow to rivers and streams, and flow out of seepage faces, where a layer is incised by a river valley. Three cross-sectional flow models distributed across the domain of the three-dimensional model along estimated flow lines in the Grande Ronde Basalt provide an efficient means of obtaining hydraulic coefficient input for the three-dimensional model. The three-dimensional model was calibrated using the time-averaged method for 1974-85 and evaluated by simulating historical pumpage rate changes (1890-1985) and comparing simulated with observed water-level changes.

Predictive runs of the computer model of the ground-water system suggest that the cities and the universities can rely on existing ground-water resources into the future without extensive additional water-level declines if pumpage rates are stabilized. This general conclusion is based on a model that uses all available data and current modeling procedures, but incorporates a number of simplifying assumptions. Continued data collection and periodic model updating are necessary to maintain the model as a viable management tool.

MICROFILMED

MAR 19 1990

Specific conclusions are listed below:

(1) Model simulations suggest that recharge-discharge equilibrium will be achieved with limited additional water-level decline if pumpage is stabilized at 1981-1985 average rates.

(2) Model simulations suggest that water-level declines will persist into the future as long as annual increases in pumpage occur.

(3) Average annual increases in pumpage at a rate of about 2 percent will result in water-level declines of more than 2 ft/yr in both Pullman and Moscow.

(4) In every case of increasing pumpage, the source of the extra water pumped was reduced flow to streams and drains and reduced water in storage in aquifers simulated in the model. The closer the stream/drain is to the pumping center, the more it is affected. The ground-water flow to the Snake River is virtually unaffected by pumping near Pullman and Moscow.

(5) Results of a model simulating ground-water recharge indicate that the average rate of recharge to the ground-water system in the Pullman-Moscow area is about 2.8 in./yr with about 2 in./yr reaching the Grande Ronde Basalt.

(6) Current farming practices used near Pullman and Moscow where a crop is grown every year have reduced the amount of recharge to the ground-water system. The reduced recharge may have contributed significantly to water-level declines in the study area.

(7) Most of the discharge from the ground-water system in the Pullman-Moscow area is to streams within the area and seepage along the canyon walls of the Snake River and the Palouse River.

(8) Magnetotelluric studies indicate that the basalt thickness ranges from 1,300 feet in Moscow and 2,000 feet in Pullman to more than 4,000 feet northwest of Pullman.

(9) The calibrated three-dimensional ground-water-flow model has hydraulic coefficient ranges as follows:

Loess:	
Horizontal hydraulic conductivity	5.0 feet/day
Vertical hydraulic conductivity	0.05 feet/day
Basalt:	
Horizontal hydraulic conductivity	0.4-12.0 feet/day
Vertical hydraulic conductivity	0.0001-0.0025 feet/day
Storage coefficient	0.001

(10) A program of continued data collection and model updating is needed for the area. Particular emphasis is needed on gaining a better understanding of locations and amounts of recharge and discharge.

REFERENCES CITED

Barker, R.A., 1979, Computer simulation and geohydrology of a basalt aquifer system in the Pullman-Moscow Basin, Washington and Idaho: Washington Department of Ecology Water-Supply Bulletin 48, 119 p.

Bauer, H.H., and Vaccaro, J.J., 1987, Documentation of a deep percolation model for estimating ground-water recharge: U.S. Geological Survey Open-File Report 86-536, 180 p.

Bauer, H.H., and Vaccaro, J.J., 1989, Estimates of ground-water recharge to the Columbia Plateau regional aquifer system, Washington, Oregon, and Idaho, for predevelopment and current land-use conditions: U.S. Geological Survey Water-Resources Investigations Report 88-4108, in press.

Bauer, H.H., Vaccaro, J.J., and Lane, R.C., 1985, Maps showing ground-water levels in the Columbia River Basalt and overlying materials, spring 1983, southeastern Washington: U.S. Geological Survey Water-Resources Investigations Report 84-4360, scale 1:500,000, 4 sheets.

Bockius, S.H., 1985, Geophysical mapping of the extent of basaltic rocks in the Moscow groundwater basin: M.S. Thesis, University of Idaho, Moscow, Idaho, 83 p.

Brown, J.C., 1976, Well construction and stratigraphic information: Pullman test and observation well, Pullman, Washington: College of Engineering Research Report 76/15-6, Washington State University, Pullman, Washington, 35 p.

Cotton, W.R., Jr., 1982, Hydrochemistry of ground water near Pullman, Washington: M.S. Thesis, Washington State University, 89 p.

Crosthwaite, E.G., 1975, Basic ground-water data for the Moscow Basin, Idaho: U.S. Geological Survey Open-File Report, Boise, Idaho, 96 p.

DeMotte, H., and Miles, W.F., 1933, A study of the Pullman artesian basin: Undergraduate Honors Thesis in Civil Engineering and Geology, Washington State University, Pullman, Washington, 35 p.

Drost, B.W., and Whiteman, K.J., 1986, Surficial geology, structure, and thickness of selected geohydrologic units in the Columbia Plateau, Washington: U.S. Geological Survey Water-Resources Investigations Report 84-4326, scale 1:500,000, 11 sheets.

Eyck, G.T., and Warnick, C., 1984, Catalog of water reports pertinent to the municipal water supply of Pullman, Washington, and Moscow, Idaho - a summary: Idaho Water and Energy Resources Research Institute, University of Idaho, Moscow, Idaho, 56 p.

Foxworthy, B.L., and Washburn, R.L., 1963, Ground water in the Pullman area, Whitman County, Washington: U.S. Geological Survey Water-Supply Paper 1655, 71 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 604 p.

Hooper, P.R., and Webster, G.D., 1982, Geology of the Pullman, Moscow West, Colton, and Uniontown 7½-minute quadrangles, Washington and Idaho: State of Washington, Department of Natural Resources, Division of Geology and Earth Resources, Geologic Map GM-26, scale 1:62,500, 1 sheet.

Jones, R.W., and Ross, S.H., 1969, Detailed ground water investigation of Moscow Basin: Research Technical Completion Report, Project A-011-IDA, Idaho Water Resources Research Institute, Moscow, Idaho, 11 p.

----1972, Moscow basin ground water studies, Idaho Bureau of Mines and Geology, Pamphlet No. 153, 95 p.

Klein, D.P., Sneddon, R.A., and Smoot, J.L., 1987, A magnetotelluric study of the thickness of volcanic and sedimentary rock in the Pullman-Moscow Basin of eastern Washington: U.S. Geological Survey Open-File Report 87-140, 30 p.

Konikow, L.F., 1978, Calibration of ground-water models: Proceedings of the Specialty Conference on Verification of Mathematical and Physical Models in Hydraulic Engineering, American Society of Civil Engineers, College Park, Maryland, August 9-11, 1978, p. 87-93.

Lin, C., 1967, Factors affecting ground water recharge in the Moscow Basin, Latah County, Idaho: M.S. Thesis, Washington State University, Pullman, Washington, 86 p.

Luzier, J.E., and Skrivan, J.A., 1973, Digital simulation and projection of water-level declines in basalt aquifers of the Odessa-Lind area, east-central Washington: U.S. Geological Survey Open-File Report, 56 p.

MacNish, R.D., and Barker, R.A., 1976, Digital simulation of a basalt aquifer system, Walla Walla River basin, Washington and Oregon: Washington Department of Ecology Water-Supply Bulletin 44, 51 p.

McDonald, M.G., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Techniques of Water-Resources Investigations, 586 p.

McGary, L.M., and Lambert, T.W., 1962, Reconnaissance of ground-water resources of the Jackson Purchase region, Kentucky: U.S. Geological Survey Hydrologic Atlas 13.

Newcomb, R.C., 1965, Geology and ground-water resources of the Walla Walla River basin, Washington-Oregon: Washington Division of Water Resources Water-Supply Bulletin 21, 151 p.

Prych, E.A., 1983, Numerical simulation of ground-water flow in lower Satus Creek Basin, Yakima Indian Reservation, Washington: U.S. Geological Survey Water-Resources Investigations Report 82-4065, 78 p.

Ringe, L.D., 1968, Geomorphology of the Palouse Hills, southeastern Washington: M.S. Thesis, Washington State University, Pullman, Washington, 73 p.

Ross, S.H., 1965, Contributions to the geohydrology of Moscow Basin, Latah County, Idaho: M.S. Thesis, University of Idaho, Moscow, Idaho, 119 p. and plates.

Russell, I.C., 1897, A reconnaissance in southeastern Washington: U.S. Geological Survey Water-Supply Paper 4, 96 p.

Strait, S.R., and Spane, F.A., Jr., 1982a, Preliminary results of hydrologic testing the composite middle Sentinel Bluffs Basalt flow bottom at borehole RRL-2, SD-BWI-TI-095, Rockwell Hanford Operations, Richland, Washington, 36 p.

----1982b, Preliminary results of testing the composite Umtanum Basalt flow top at borehole RRL-2 (3,568-3,781 feet), SD-BWI-TI-105, Rockwell Hanford Operations, Richland, Washington, 45 p.

Swanson, D.A., Wright, T.L., Hooper, P.R., and Bentley, R.D., 1979, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457-G, 59 p.

Swanson, D.A., Wright, T.L., Camp, V.E., Gardner, J.N., Helz, R.T., Price, S.M., Reidel, S.P., and Ross, M.E., 1980, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geological Survey Miscellaneous Investigations Series Map I-1139, scale 1:250,000, 2 sheets.

Tanaka, H.H., Hansen, A.J., Jr., and Skrivan, J.A., 1974, Digital-model study of ground-water hydrology, Columbia Basin Irrigation Project area, Washington: Washington Department of Ecology Water-Supply Bulletin 40, 60 p.

U.S. Geological Survey, 1987, Water Resources Data, Washington--water year 1985: U.S. Geological Survey Water-Data Report WA-85-1, 460p.

-----1988, Water Resources Data, Washington--water year 1986: U.S. Geological Survey Water-Data Report WA-86-1, 517p.

[U.S.] National Oceanic and Atmospheric Administration, 1987a, Climatological Data, Idaho, Annual Summary 1986: v. 89, 34 p.

-----1987b, Climatological Data Washington, Annual Summary 1986: v. 90, 36 p.

Walters, K.L., and Glancy, P.A., 1969, Reconnaissance of geology and of ground-water occurrence and development in Whitman County, Washington: Washington Department of Water Resources Water-Supply Bulletin 26, 169 p.

Wang, H.F., and Anderson, M.P., 1982, Introduction to groundwater modeling: finite difference and finite element methods: San Francisco, Calif., W.H. Freeman and Company, 237 p.

Wang, C.P., and Williams, R.E., 1984, Aquifer testing, mathematical modeling, and regulatory risk: Ground Water, v. 22, no. 3, p. 285-296.

Whiteman, K.J., 1986, Ground-water levels in three basalt hydrologic units underlying the Columbia Plateau in Washington and Oregon, spring 1984: U.S. Geological Survey Water-Resources Investigations Report 86-4046, scale 1:500,000, 4 sheets.

Williams, R.E., and Allman, D.W., 1969, Factors affecting infiltration and recharge in a loess covered basin: Journal of Hydrology, v. 8.

Table 7.--Records of selected wells in the study area

Local well number: Numbered by township, range, section, and 40-acre subdivision, as described on page 4.

Model cell location: Model cell location (row number, column number) of well.

Well owner: Name of owner or tenant.

Altitude of land surface (ft): Altitude of land-surface datum, in feet, with reference to sea level (National Geodetic Vertical Datum of 1929).

Well depth (ft): As measured, in feet below land-surface datum, by U.S. Geological Survey personnel or other agencies or as reported by well drillers or owners.

Depth to water below LSD: Measured (or reported, R) depth to water surface below land surface datum (LSD). Measured in spring 1985 unless specified: W, means winter 1985 measurement; A, means airline measurement.

Water-level altitude: Altitude of water level in feet above sea level for water-level measurement in previous column. +, well flows at land surface.

Altitude of cased interval: Altitude above sea level in feet of interval in well that is cased.

Altitude of open interval: Altitude above sea level of interval in well that is open to formation.

FMT YLD WTR: Geohydrologic unit yielding water to well, U, means unconsolidated loess; W, means Wanapum Basalt; GR, means Grande Ronde Basalt; and B, means granitic basement rocks.

Percent of formation that well penetrates: Percent that open well interval is of total thickness of geohydrologic unit.

-- : Data not available.

WELL NUMBER	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FEET)	WELL DEPTH (FEET)	DEPTH TO WATER BELOW LSD (FEET)	WATER LEVEL ALTITUDE (FEET)	ALTITUDE OF CASED INTERVAL (FEET)	ALTITUDE OF OPEN INTERVAL (FEET)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
13/44-05C1	(34,10)	J. RYAN	2,540	--	80. R	2,460	--	--	W	--
13/44-11H1	(41,13)	J. DAVIS	2,455	130	11.18	2,444	--	--	W	98
13/44-12P1	(42,13)	J. DAVIS	2,440	70	7.29	2,433	2,425-2,440	2,370-2,425	W	92
13/44-12P2	(42,13)	J. DAVIS	2,505	165	61.59	2,443	2,487-2,505	2,340-2,487	GR	1
13/45-01B1	(49,26)	R. HOOD	2,740	--	20.47	2,720	--	--	B	--
13/45-03M2	(46,21)	E. DRUFFEL	2,618	100	18.85	2,599	--	--	W	28
13/45-05D1	(42,18)	G. SENTER	2,558	190	4.04	2,554	2,538-2,558	2,368-2,538	W	--
13/45-10L1	(47,20)	P. KIRPIS	2,663	137	78.47	2,585	2,613-2,663	2,526-2,613	W	26
14/43-24M1	(27,10)	YOUNG	2,430	165	78.94	2,351	2,290-2,430	2,265-2,290	W	52
14/43-24M2	(--,--)	YOUNG	2,420	8	6.00	2,414	--	--	U	--
14/43-24R1	(29,11)	H. WEGNER	2,350	162	7.68	2,342	2,343-2,350	2,188-2,343	W	86
14/43-25N1	(29, 9)	A. TOWNSEND	2,480	250	37.65	2,442	2,460-2,480	2,230-2,460	W	74
14/43-25N2	(29, 8)	A. TOWNSEND	2,420	350	121.	2,299	--	--	GR	3
14/44-01E1	(31,24)	R. HARLOW	2,565	375	108.22	2,457	--	--	GR	4
14/44-01J1	(32,25)	HENDRICKS	2,660	200	0.00	2,660	--	--	U	--
14/44-01L1	(32,24)	B. BELL	2,620	275	221.18	2,399	--	--	W	75
14/44-01M3	(31,23)	195 & WWPUL	2,535	--	46.40	2,489	--	--	W	--
14/44-02J1	(31,24)	R. HARLOW	2,530	--	11.64	2,518	--	--	U	--
14/44-02M2	(30,22)	D. BLOOMFIELD	2,498	102	34.26	2,464	2,468-2,498	2,396-2,468	W	29
14/44-09J2	(30,19)	KIEFER	2,485	286	210.	2,275	2,467-2,485	2,199-2,167	GR	--
14/44-14P2	(33,19)	WSU DAIRY #2	2,550	432	286. A	2,264	2,200-2,550	2,120-2,200	GR	2
14/44-16F1	(30,17)	E. BROCH	2,405	160	120.02	2,285	--	--	GR	--
14/44-21R1	(33,15)	HATLEY	2,340	150	13.41	2,327	--	--	GR	--
14/44-23A1	(35,19)	R. WILBURN	2,560	90	40. R	2,520	--	--	W	4
14/44-28A1	(33,15)	V. RUMLEY	2,385	111	43.71	2,341	--	--	W	66
14/44-31A1	(32,13)	BREWER	2,460	--	3.72W	2,456	--	--	W,U	--
14/44-34C1	(35,15)	N. HATLEY	2,455	200	0.00	2,455	2,437-2,455	2,255-2,437	W	83

WELL NUMBER	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FEET)	WELL DEPTH (FEET)	DEPTH TO WATER BELOW LSD (FEET)	WATER LEVEL ALTITUDE (FEET)	ALTITUDE OF CASED INTERVAL (FEET)	ALTITUDE OF OPEN INTERVAL (FEET)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
14/45-01F1	(39,33)	PUL. TEST	2,470	982	213.61	2,256	2,270-2,470	1,488-2,270	GR	35
14/45-03H3	(38,31)	WWP	2,460	259	198.94	2,261	2,282-2,460	2,201-2,282	GR	7
14/45-03P1	(38,29)	S. JORSTAD	2,460	--	19.65	2,440	--	--	W	--
14/45-04D1	(35,29)	WSU #6	2,535	702	267. A	2,268	2,143-2,535	1,833-2,143	GR	17
14/45-04N1	(36,28)	WSU	2,390	95	DRY	--	--	--	W	100
14/45-05D1	(33,27)	PULLMAN #1	2,342	164	67.22	2,275	2,308-2,342	2,178-2,308	GR	5
14/45-05D3	(33,27)	PULLMAN #3	2,340	167	69.37	2,271	2,300-2,340	2,173-2,300	GR	5
14/45-05F1	(34,27)	WSU #1 (OBS)	2,364	145	92.87	2,271	2,304-2,364	2,219-2,304	GR	3
14/45-05F4	(34,28)	WSU #4	2,364	275	95. A	2,269	--	--	GR	7
14/45-06D4	(32,26)	H. WOO	2,515	220	168.21	2,347	2,475-2,515	2,295-2,475	W	100
14/45-07E1	(34,24)	H. COLE	2,530	82	33.21	2,497	2,522-2,530	2,448-2,522	W	30
14/45-08E1	(35,25)	PULLMAN #5	2,447	712	175.45	2,271	--	--	GR	21
14/45-08J4	(36,26)	J. ASKINS	2,420	223	147.65	2,272	--	--	GR	4
14/45-09E1	(37,27)	M. WISE	2,415	67	9.05W	2,406	2,395-2,415	2,348-2,395	W	71
14/45-09E2	(37,27)	H. NEIL	2,420	240	142.97	2,277	2,398-2,420	2,180-2,398	GR	4
14/45-10P1	(39,28)	H. STRATTON	2,540	--	31.45	2,509	--	--	W	--
14/45-15B1	(40,28)	G. LEONARD	2,610	213	147.62	2,462	2,515-2,610	2,397-2,515	W	57
14/45-16E1	(38,26)	W. STRATTON	2,400	110	DRY	--	2,360-2,400	2,290-2,360	W	100
14/45-16G1	(39,26)	WSU SPILLMAN	2,480	400	215. A	2,265	2,448-2,480	2,080-2,448	GR	9
14/45-16R1	(40,26)	G. WISE	2,418	195	142.87	2,275	2,243-2,418	2,223-2,243	GR	4
14/45-19Q1	(37,22)	J. BENSCOTER	2,575	198	13.50	2,562	--	--	W	70
14/45-20A1	(39,24)	JACOBSON	2,550	--	37.77	2,512	--	--	W	--
14/45-21H2	(41,25)	SEARS	2,440	--	166.86	2,273	--	--	GR	--
14/45-22P2	(42,25)	A. FAIRBANKS	2,464	250	185.67	2,278	2,444-2,464	2,214-2,444	GR	14
14/45-23A1	(43,28)	R. DRUFFEL	2,480	--	0.00	2,480	--	--	U	--
14/45-23R1	(44,28)	R. MEYER	2,520	80	38.74	2,481	2,474-2,520	2,440-2,474	W	42
14/45-24F1	(44,29)		2,505	--	13.96	2,491	--	--	W	--
14/45-26J2	(45,26)	WEBER FARM	2,545	223	42.99	2,502	2,483-2,545	2,318-2,483	W	100
14/45-26J1	(45,26)	WEBER FARM	2,545	--	9.34	2,536	--	--	U	--
14/45-36Q2	(48,26)	J. WHITMAN	2,680	127	4.44	2,676	2,623-2,680	2,553-2,623	W	0

WELL NUMBER	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FEET)	WELL DEPTH (FEET)	DEPTH TO WATER BELOW LSD (FEET)	WATER LEVEL ALTITUDE (FEET)	ALTITUDE OF CASED INTERVAL (FEET)	ALTITUDE OF OPEN INTERVAL (FEET)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
14/46-07N1	(43,32)	J. BRADEN	2,570	100	16.41	2,554	--	--	W	27
14/46-07N3	(43,32)	J. BRADEN	2,570	353	306.62	2,263	2,505-2,570	2,217-2,505	GR	6
14/46-19F1	(45,30)	L. BROWN	2,485	180	11.52W	2,473	--	--	GR	3
15/43-08B1	(10,18)	KINCAID	2,100	--	157.49	1,943	--	--	GR	--
15/43-16J1	(14,17)	J. GHILCHRIST	2,100	138	97.82	2,002	--	--	GR	--
15/43-18H1	(11,15)	R. MILLER	2,270	160	75.93	2,194	2,180-2,270	2,110-2,180	W	--
15/43-18R1	(11,14)	M. MILLER	2,140	130	80. R	2,060	--	--	W	20
15/43-21A1	(--,--)		2,230	30	24.33	2,206	--	--	U	--
15/44-01G1	(23,33)	A. CLARK	2,380	157	18.56	2,371	2,340-2,380	2,213-2,340	W	0
15/44-01N1	(23,32)	G. CLARK	2,450	73	0.85	2,449	2,415-2,450	2,377-2,415	W	0
15/44-11F1	(23,30)	V. BIDDLE	2,435	140	0.--	2,435	--	--	W	0
15/44-11F2	(23,30)	V. BIDDLE	2,430	225	FLOWING	2,430+	--	--	B	--
15/44-15G2	(23,27)	ALBION #1	2,390	290	180. R	2,210	--	--	GR	100
15/44-15G3	(23,27)	ALBION #2	2,400	--	112.	2,288	--	--	GR	--
15/44-21D1	(22,24)	M. MCCROSKEY	2,355	177	125.44	2,230	2,335-2,355	2,178-2,335	W,U	95
15/44-24D1	(26,28)	J. MORRISON	2,380	35	7.92	2,372	--	--	U	--
15/44-24E1	(26,28)	J. MORRISON	2,375	135	120.19	2,255	--	--	W	100
15/44-24F1	(27,29)	J. MORRISON	2,390	165	21.50	2,378	--	--	W	100
15/44-26L1	(27,25)	M. HARLOW	2,390	160	120.97	2,269	2,370-2,390	2,230-2,370	GR	0
15/44-35E1	(28,24)	V. MICHAELSON	2,412	300	130.15	2,282	2,373-2,412	2,112-2,373	GR	11
15/44-35F1	(28,25)	V. MICHAELSON	2,435	96	14.86	2,420	--	--	W	36
15/45-06E	(23,34)	A. CLARK	2,480	--	76.77	2,403	--	--	W	--
15/45-07Q1	(26,33)	G. LAWSON	2,525	150	48.30	2,477	--	--	W	37
15/45-08L1	(27,34)	H. ROSSEBO	2,480	124	22.05	2,458	2,440-2,480	2,360-2,440	W	39
15/45-08M2	(27,34)	R. HOWELL	2,495	290	210. R	2,285	2,440-2,495	2,205-2,440	GR	3
15/45-10M1	(30,36)	R. GILLESPE	2,510	200	180. R	2,330	--	--	W	100
15/45-16B1	(29,35)	R. WHITMORE	2,500	200	21.62	2,478	--	--	W	100
15/45-16K1	(30,34)	R. WHITMORE	2,520	--	18.70	2,501	--	--	W	--
15/45-19E2	(28,30)	G. LAWSON	2,445	110	18.95	2,426	--	--	W	63
15/45-20H2	(30,32)	D. PORT	2,530	130	30.56	2,500	--	--	W	50

WELL NUMBER	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FEET)	WELL DEPTH (FEET)	DEPTH TO WATER BELOW LSD (FEET)	WATER LEVEL ALTITUDE (FEET)	ALTITUDE OF CASED INTERVAL (FEET)	ALTITUDE OF OPEN INTERVAL (FEET)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
15/45-24C1	(35,38)		2,540	350	60.	2,480	--	--	GR	15
15/45-25A2	(37,37)	M. BOYD	2,650	215	114.10	2,536	--	--	W	63
15/45-25Q1	(38,36)	L. BOYD	2,609	264	50. R	2,559	2,544-2,609	2,345-2,544	W	100
15/45-30G4	(30,29)	USDA AG EXP	2,520	371	249.40	2,271	--	--	GR	10
15/45-32C2	(32,29)	PULLMAN #6	2,430	518	152.10	2,278	2,196-2,430	1,912-2,196	GR	17
15/45-32N2	(33,28)	PULLMAN #4	2,356	954	73.22	2,283	1,957-2,356	1,402-1,957	GR	35
15/45-34L2	(36,31)	WSU WHITLAOW #5	2,510	396	238. A	2,272	2,210-2,510	2,114-2,210	GR	9
15/45-35F1	(37,33)	MOS-PUL AIRPT	2,531	172	7.00	2,524	--	--	W	100
15/46-06L1	(33,43)	T. QUIST	2,620	--	29.20	2,591	--	--	W	--
15/46-06P2	(33,42)	S. FLEENOR	2,625	100	53.02	2,572	--	--	W	31
15/46-08L1	(35,43)	F. FLEENOR	2,700	280	13.99	2,686	--	--	B	--
15/46-20N1	(38,39)	H. NELSON	2,570	--	5.87	2,563	--	--	U	--
16/43-25D1	(10,27)	NELSON	2,140	20	17. R	2,123	--	--	U	--
16/44-29F1	(14,30)	R. COCKING	2,135	500	400. R	1,735	--	--	GR	22
16/45-10A2	(21,47)	F. ELLS	2,630	50	11.52	2,628	--	--	W	--
16/45-15P1	(23,44)	M. KUEHNER	2,495	100	7.99W	2,487	--	--	U,W	--
16/45-22K1	(24,43)	E. RUPP	2,470	165	42.02	2,428	2,442-2,470	2,305-2,442	W	100
16/45-27Q3	(26,41)	L. THOMPSON	2,460	--	12.98	2,447	--	--	W	--
16/45-28H1	(24,41)	J. REDFIELD	2,450	--	95.02	2,355	--	--	W	--
16/45-29J1	(23,39)	D. HARLOW	2,430	--	56.75	2,373	--	--	W	--
39/05-07DAD2	(45,40)	MOSCOW #2	2,568	320	49.	2,511	--	--	W	100
39/05-07DAD3	(45,40)	MOSCOW #3	2,568	261	58.	2,502	--	--	W	100
39/05-07BDA2	(43,39)	MOSCOW #8	2,620	1,458	367.	2,253	--	--	GR	100
39/05-07CBB1	(43,39)	UI #3	2,567	1,336	294.65	2,272	--	--	GR	100
39/05-08BDB1	(45,41)	MOSCOW #6	2,600	1,308	334. R	2,266	--	--	GR	78
39/05-16DDB1	(49,41)	D. GENTRY	2,620	55	37.00	2,583	--	--	W,U	--
39/05-30AAB1	(48,36)	D. SINCLAIR	2,620	--	3.00	2,617	--	--	U	--

WELL NUMBER	MODEL CELL LOCATION	WELL OWNER	ALTITUDE OF LAND SURFACE (FEET)	WELL DEPTH (FEET)	DEPTH TO WATER BELOW LSD (FEET)	WATER LEVEL ALTITUDE (FEET)	ALTITUDE OF CASED INTERVAL (FEET)	ALTITUDE OF OPEN INTERVAL (FEET)	FMT YLD WTR	PERCENT OF FORMATION THAT WELL PENETRATES
39/06-12DBA1	(43,38)	MOSCOW #9	2,538	1,252	287.	2,251	--	--	GR	93
39/06-12DAA1	(43,38)	UI #4	2,554	747	284.66	2,255	--	--	GR	47
40/05-30CA 1	(40,43)	F. WARD	2,638	--	125.38	2,513	--	--	W	--
40/05-31DB 1	(41,42)	K. ROGERS	2,635	--	30. R	2,605	--	--	W,U	--
40/06-19CB 1	(36,43)	C. LADWIG	2,770	258	12.17	2,758	--	--	W,U	0
40/06-25DA 1	(39,42)	D. CLARK	2,680	--	27.74	2,652	--	--	W	--
40/06-36AD 1	(40,41)	A. CARSON	2,610	135	0.00	2,610	--	--	W	40

Table 1.--Average monthly precipitation for Pullman, Wash., and Moscow, Idaho, 1956-77 and 1951-80, respectively

	Average monthly precipitation, in inches											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Pullman	3.1	2.1	2.1	1.6	1.5	1.6	0.5	1.0	1.1	1.7	2.8	3.1
Moscow	3.2	2.1	2.0	2.0	2.0	1.7	0.7	1.1	1.1	1.8	3.0	3.3

Table 2.--Hydraulic properties for the Columbia River Basalt Group

Source of data	Hydraulic conductivity, in feet per day		Storage coefficient
	Horizontal	Vertical	
Barker (1979)	0.09-26	--	0.005
Luzier and Skrivan (1973)	0.5-80	--	0.0015-0.006
MacNish and Barker (1976)	2.9	0.004	0.00047-0.00475
Strait and Spane (1982a)	2.6-10.9	--	--
Strait and Spane (1982b)	1.6-3.1	--	--
Tanaka and others (1974)	7.4	--	0.0025

Table 3.--Summary of water budget for time-averaged simulation

	Quantity of water, in cubic feet per second		
	In	Out	Sum
Constant-head boundaries	12.8	-19.3	-6.5
Wells, pumpage	0	-9.4	-9.4
Snake River and seepage face	0	-40.5	-40.5
Drains	0	-41.6	-41.6
Rivers	.3	-38.4	-38.1
Recharge	136	0	+136
Sum	+149	-149	0

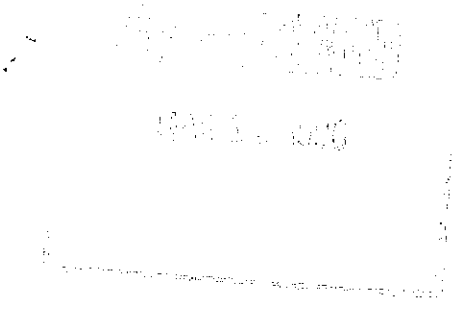


Table 4.--Simulated average flow into selected rivers and measured stream discharges in study area

[Values are in cubic feet per second]

River reach	Simulated average flow into reach [1] (net flow)	Measured stream discharge in October 1984
Snake River	-40.5	--
South Fork Palouse River:		
above Pullman, Wash.	-5.1	1.4
mouth to Pullman, Wash	-11.8	[2]15
Sum of South Fork Palouse River	-16.9	[2]17
Palouse River	-10.3	--
Union Flat Creek	-20.5	4.7
Paradise Creek	-4.0	[2]4.0
Fourmile Creek	-6.8	--
Missouri Flat Creek	-6.3	.5
Spring Flat Creek	-5.4	.4

[1] This is the net sum of simulated discharge to the river reach and to the drains immediately adjacent to the river reach. Negative values represent net loss from the model to the stream.

[2] Ungaged sewage plant effluent included in this measured discharge.

Table 5.--Observed and simulated water-level declines in the Grande Ronde geohydrologic unit, 1896-1975

	Water-level decline, in feet		
		Simulated, for model cell	
	Observed (well data)	Barker, 1979	This report
Pullman	about 75	70-75	87
Moscow	about 60-80	80-85	91

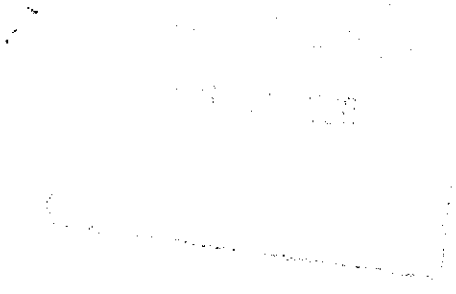
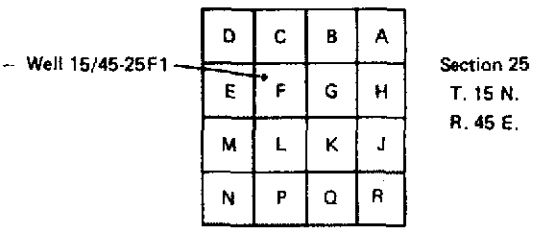
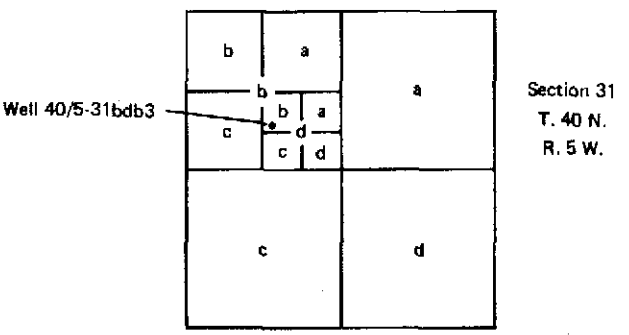


Table 6.--Simulated water-level declines in the Grande Ronde geohydrologic unit, 1975-2000

Percent increase per year in pumping rate over that of 1971-75	Water-level decline, in feet			
	Barker 1979		This report	
	Pullman	Moscow	Pullman	Moscow
0	8.5	8.5	4.5	5.0
3	30-40	30-40	93	96
4.6	40-50	50-60	170	177



Well Numbering System of Washington



Well Numbering System of Idaho

Figure 1.--Well-numbering systems of Washington and Idaho.

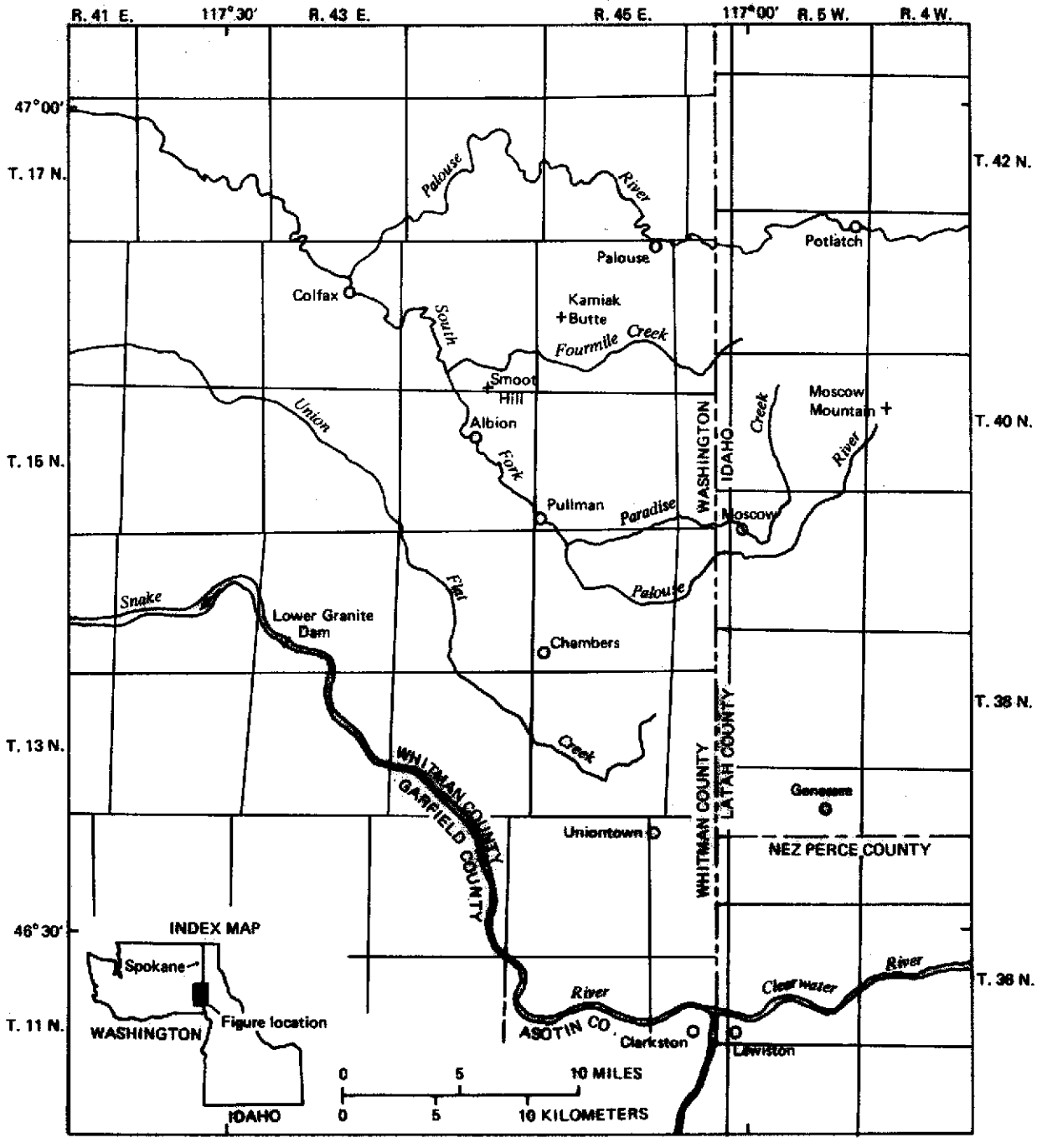


Figure 2.--Location of Pullman-Moscow area.

MICROFILMED
MAR 19 1990

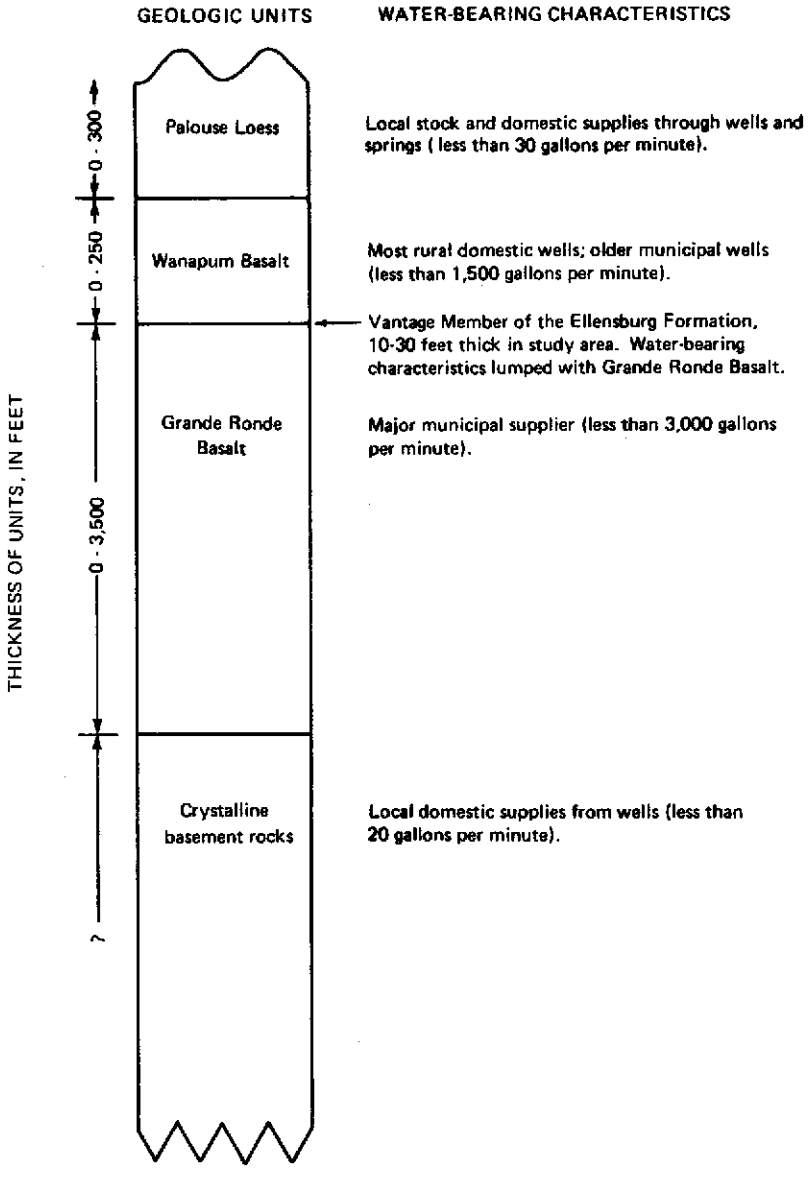


Figure 3.--Stratigraphy and water-bearing characteristics of the geologic units in the Pullman-Moscow area.

DOCUMENTED
MAR 19 1990

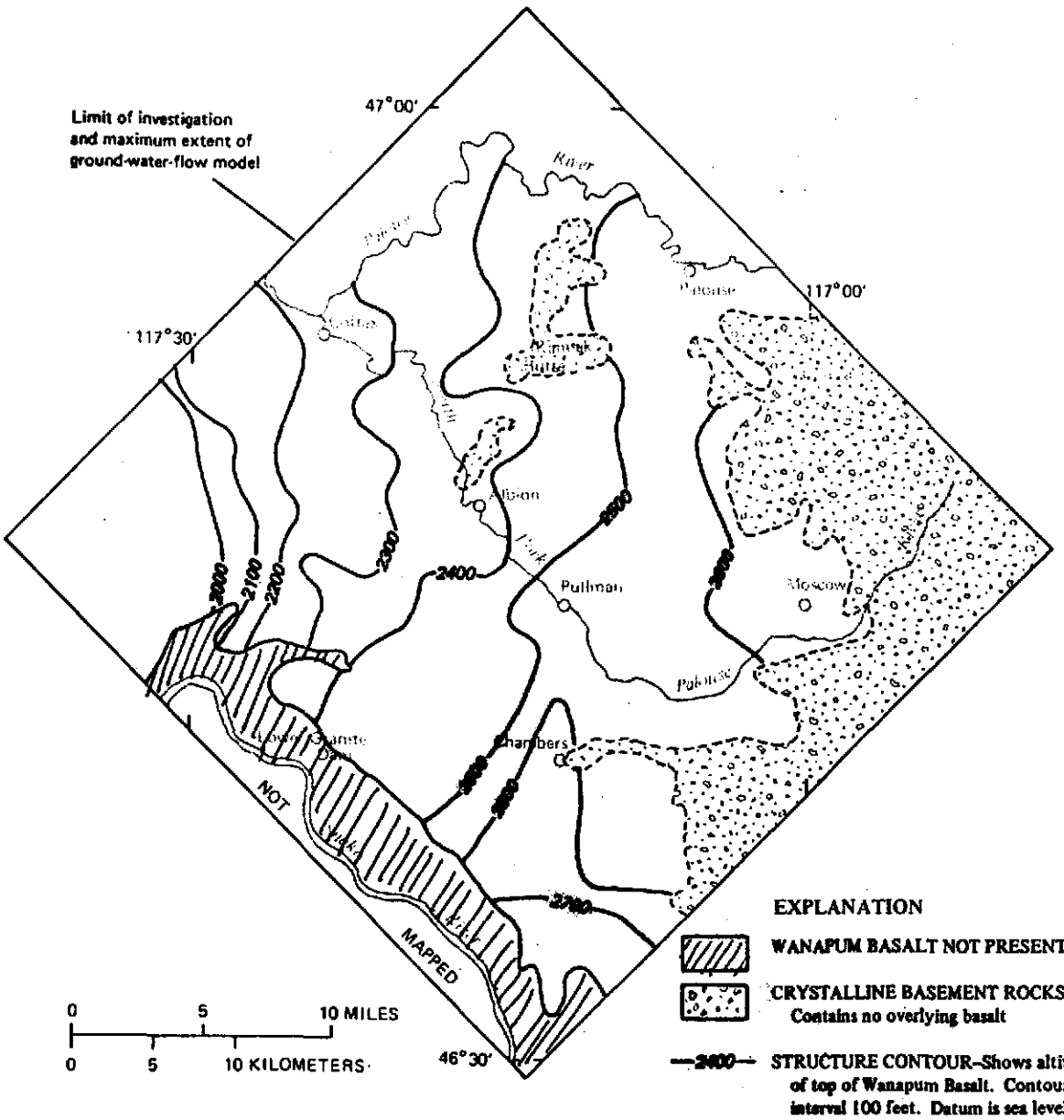


Figure 4.–Altitude of the top of the Wanapum Basalt.

MAR 1 9 1990

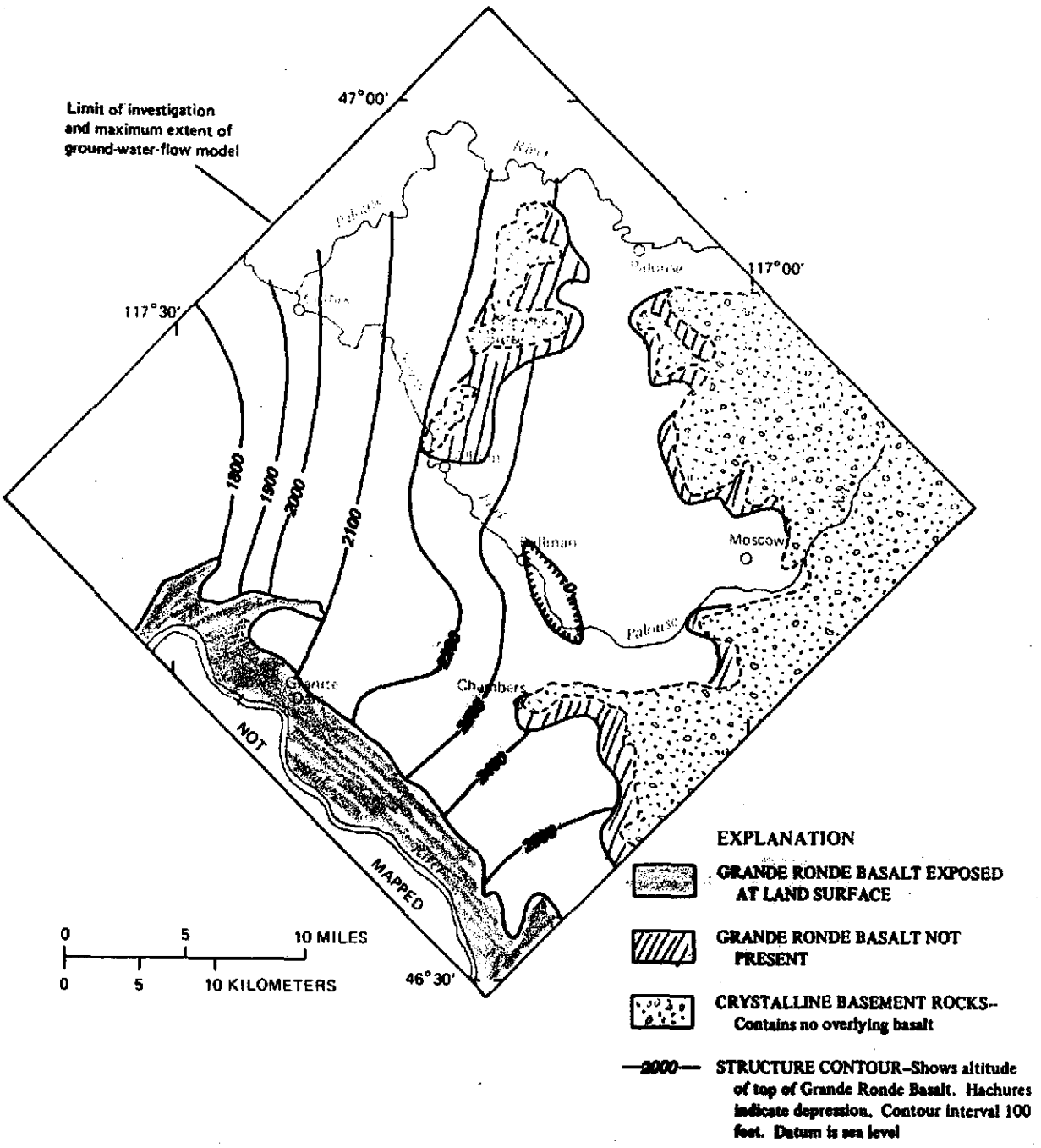


Figure 5.--Altitude of the top of the Grande Ronde Basalt.

MICROFILMED
MAR 19 1990

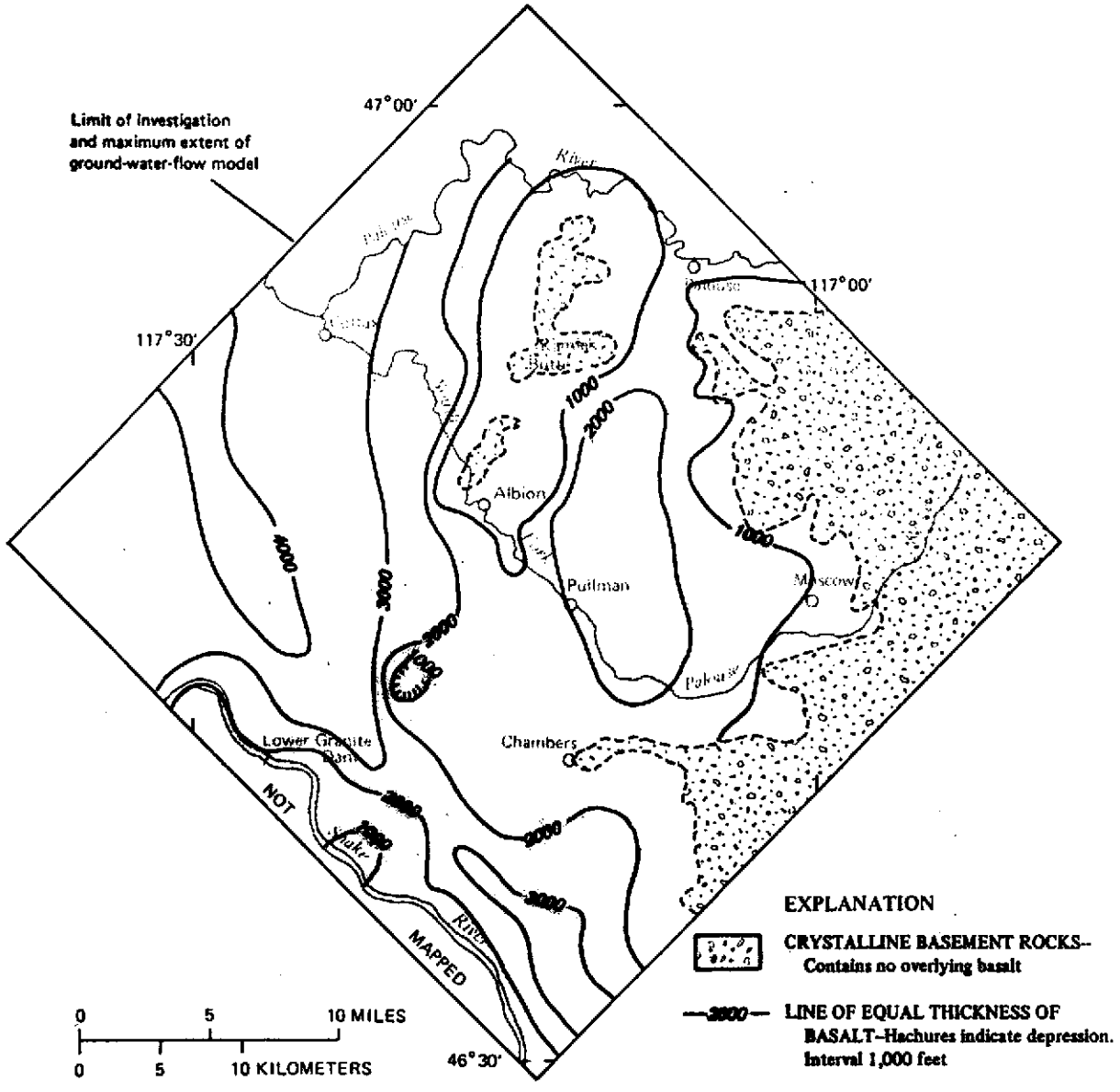


Figure 6.–Thickness of the basalt (modified from Klein and others, 1987).

MICROFILMED
MAR 19 1990

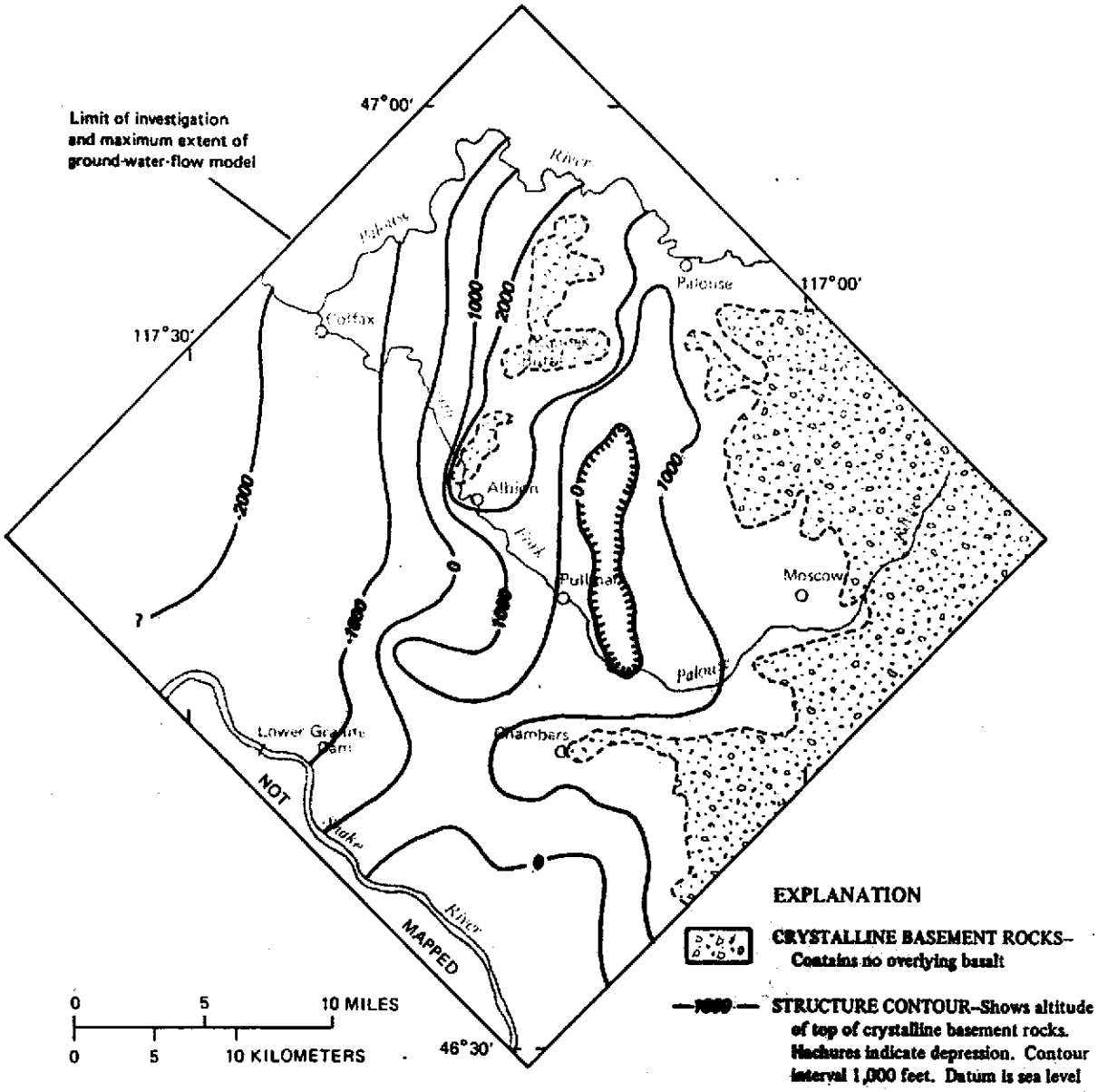


Figure 7.--Altitude of the top of the crystalline basement rocks.

MICROFILMED
MAR 19 1990

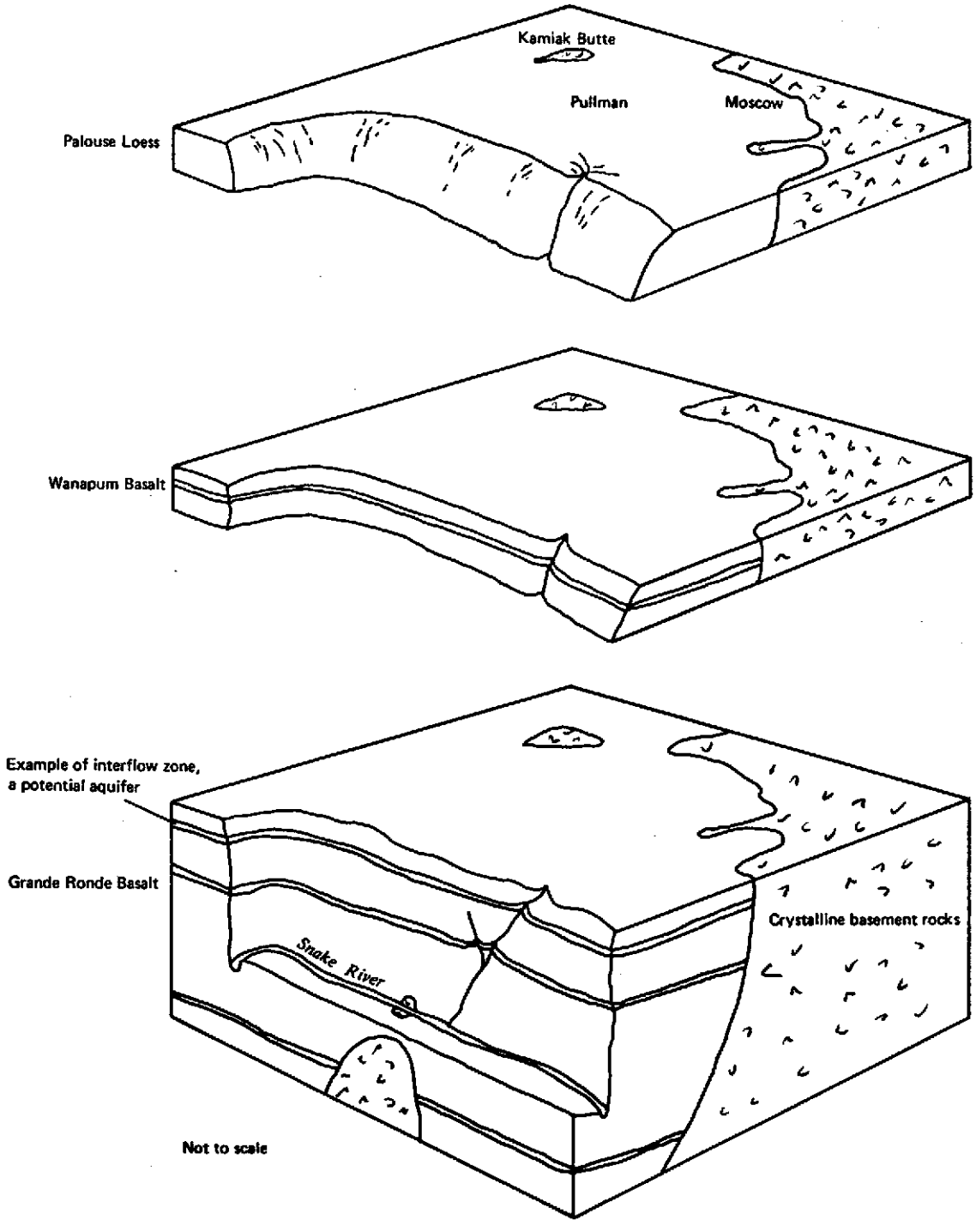


Figure 8.–Three-dimensional perspective of the layered aquifer system.

MICROFILMED
MAR 19 1990

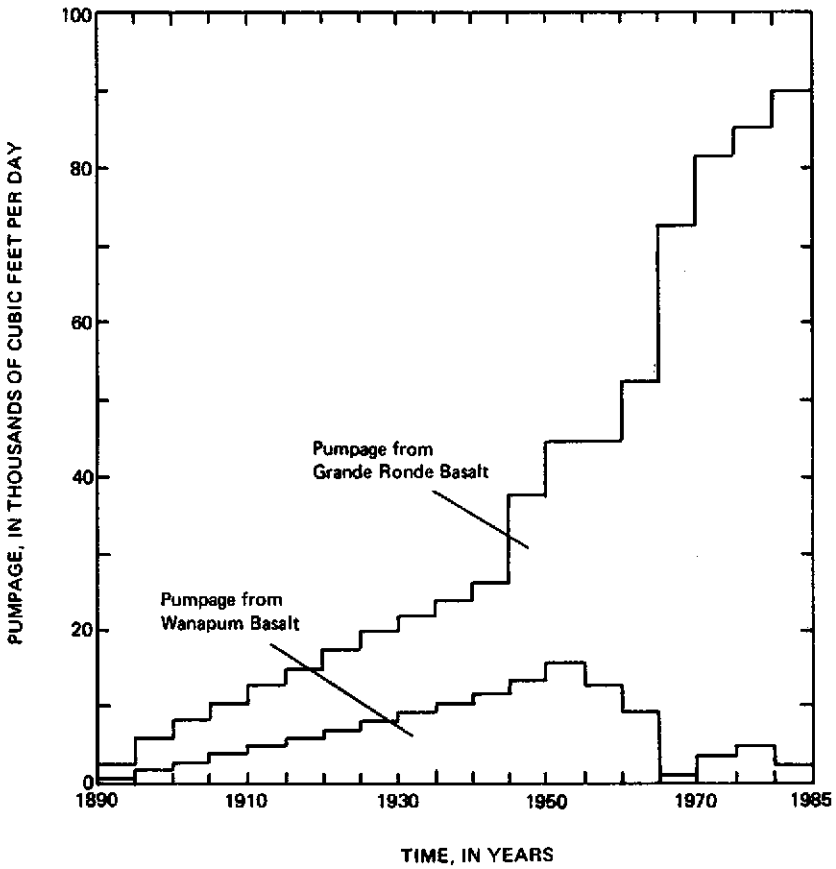


Figure 9.--Five-year average pumpage from wells operated by Pullman, Moscow, Washington State University, and the University of Idaho.

MICROFILMED
1980

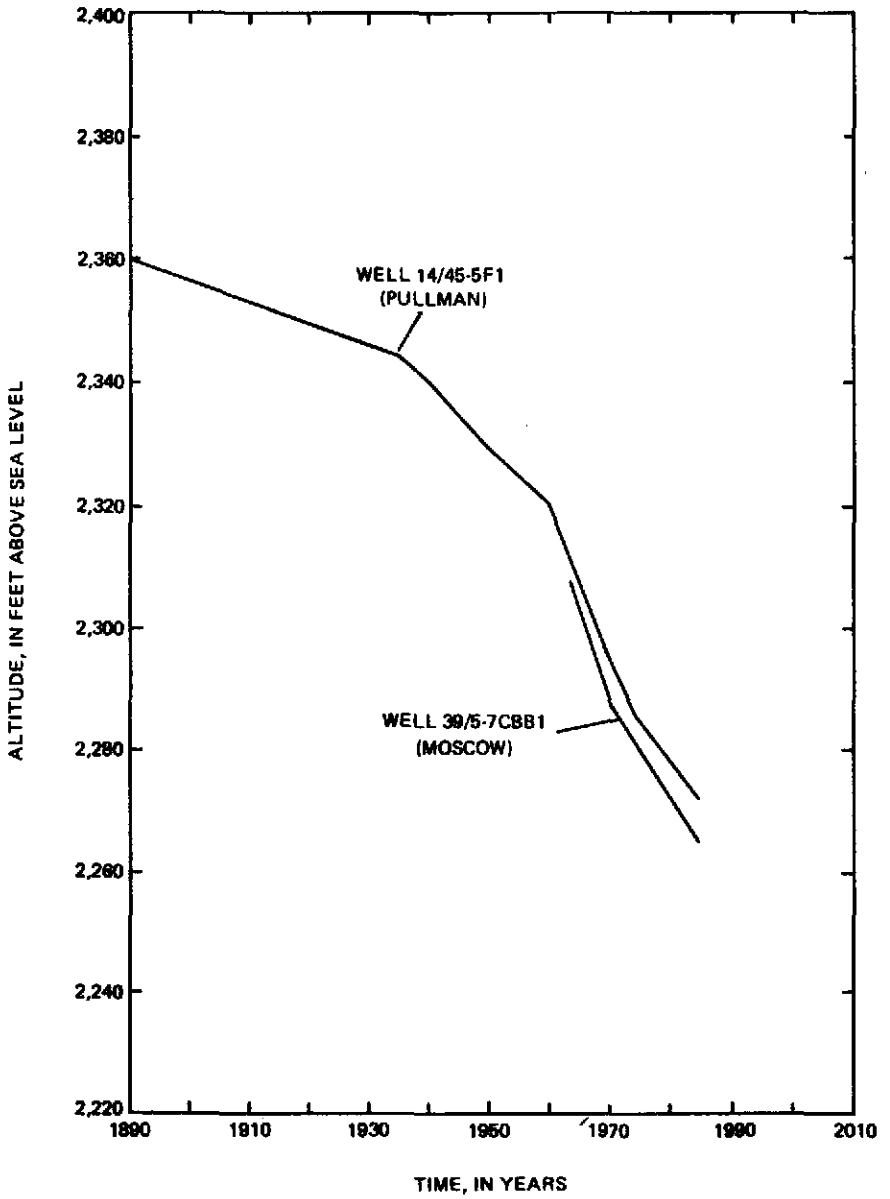


Figure 10.--Ground-water-level declines in wells in Pullman and Moscow, 1890-1985.

MED
MAR 1 0 1990

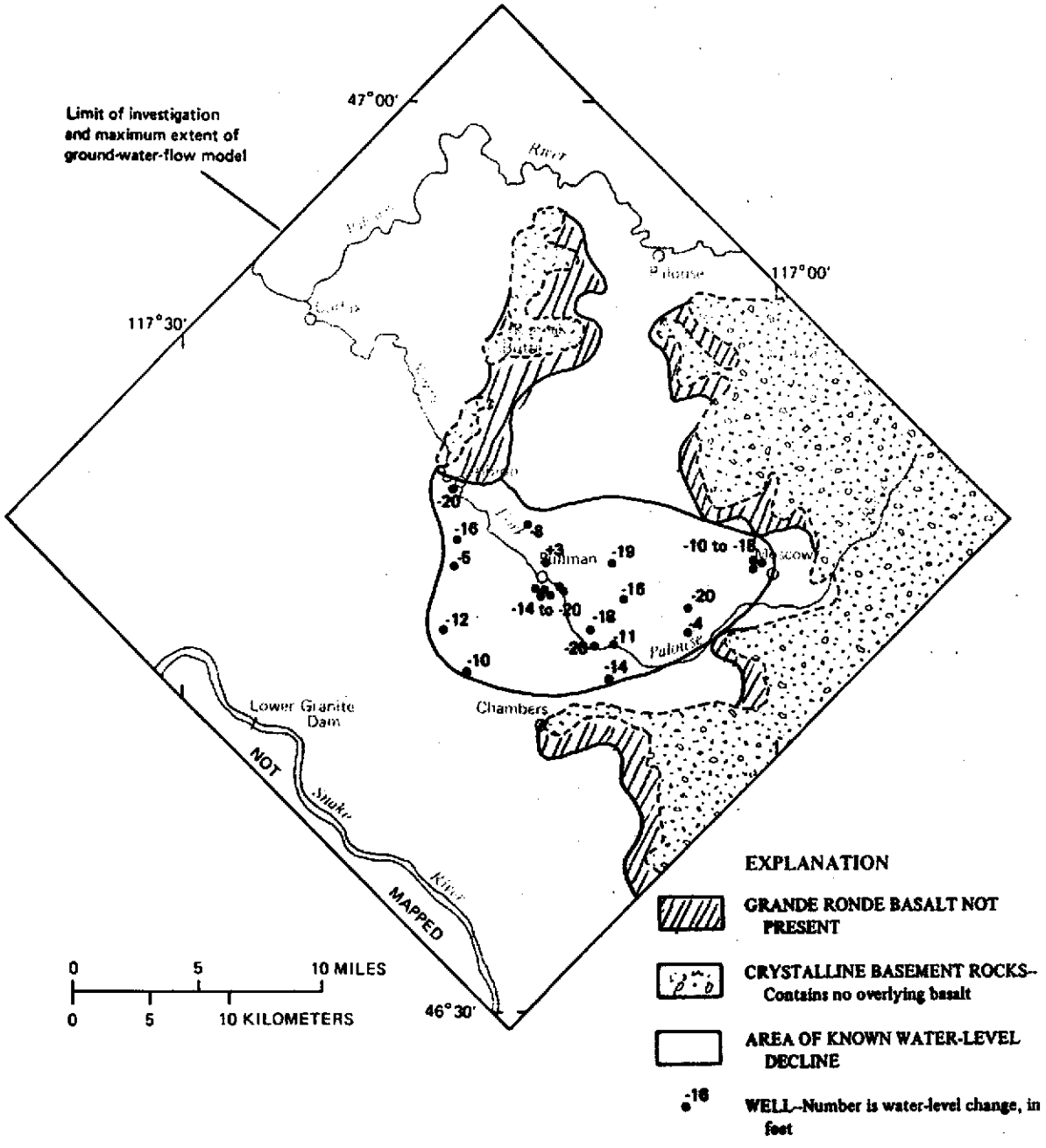


Figure 11.–Water-level changes in the Grande Ronde Basalt, 1974-1985.

MICROFILMED
MAR 19 1990

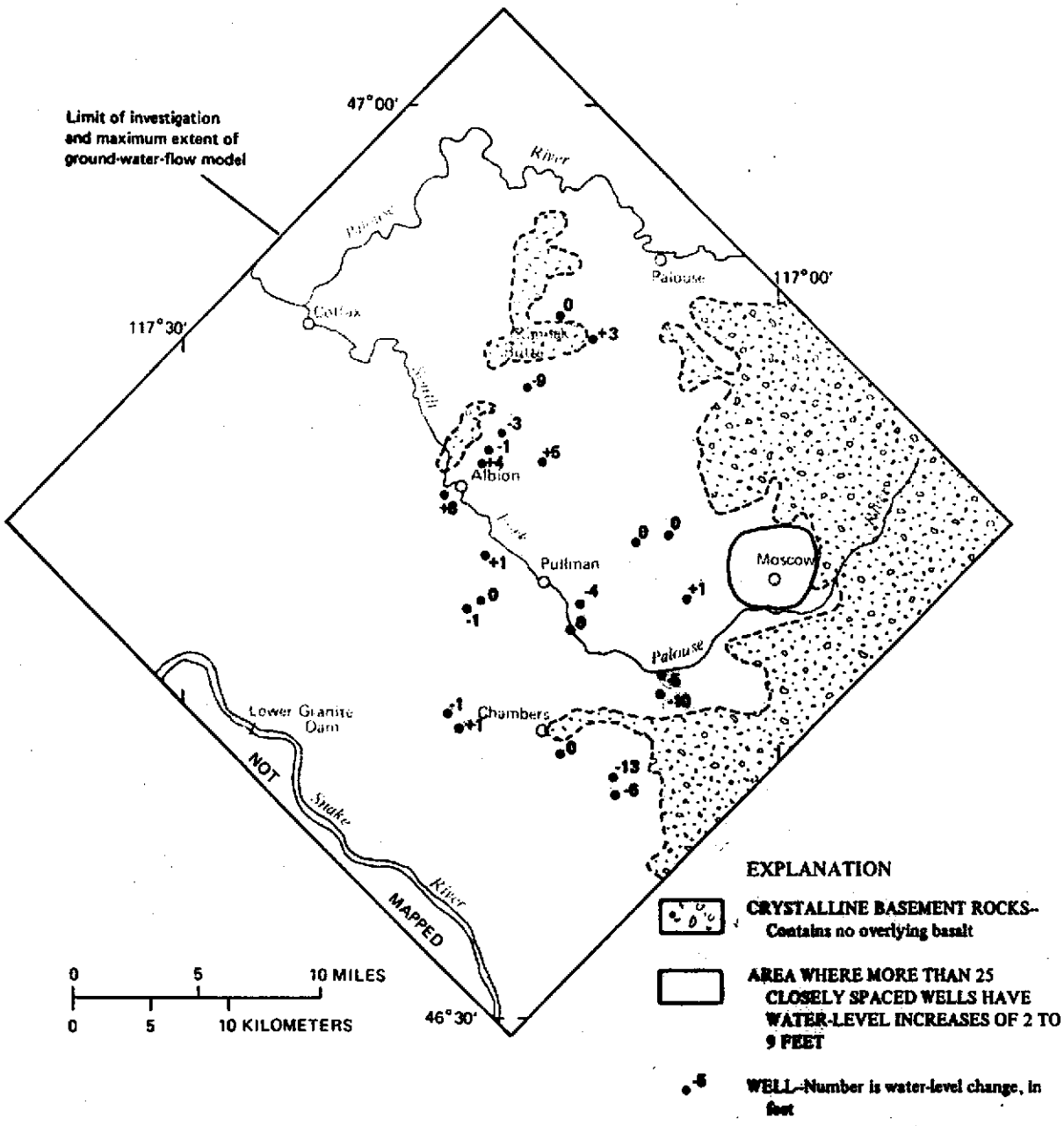


Figure 12.--Water-level changes in the Wanapum Basalt, 1974-1985.

MICROFILMED
MAR 19 1990

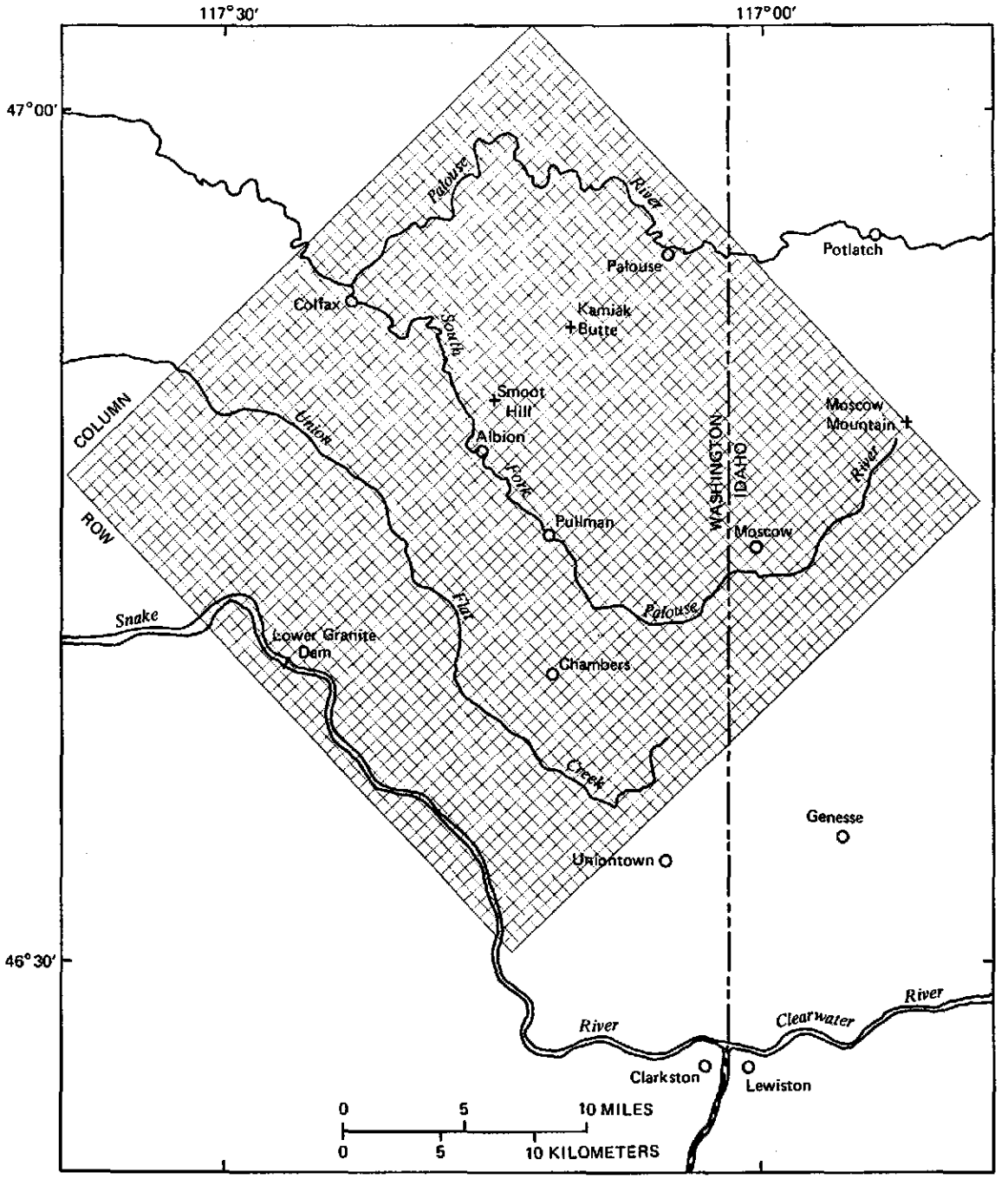


Figure 13.--Location and orientation of the modeled area.

MAR 19 1990

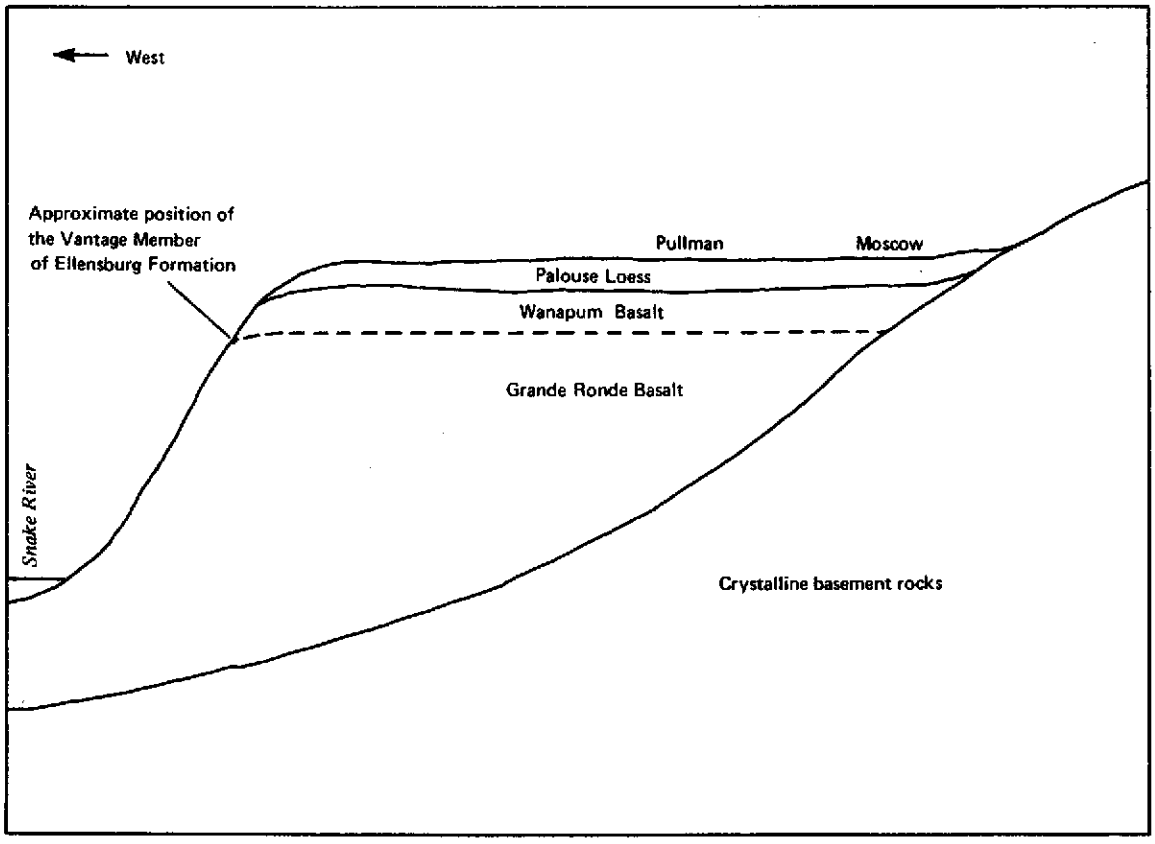


Figure 14.--Idealized geologic section through the Pullman-Moscow area showing the geohydrologic units.

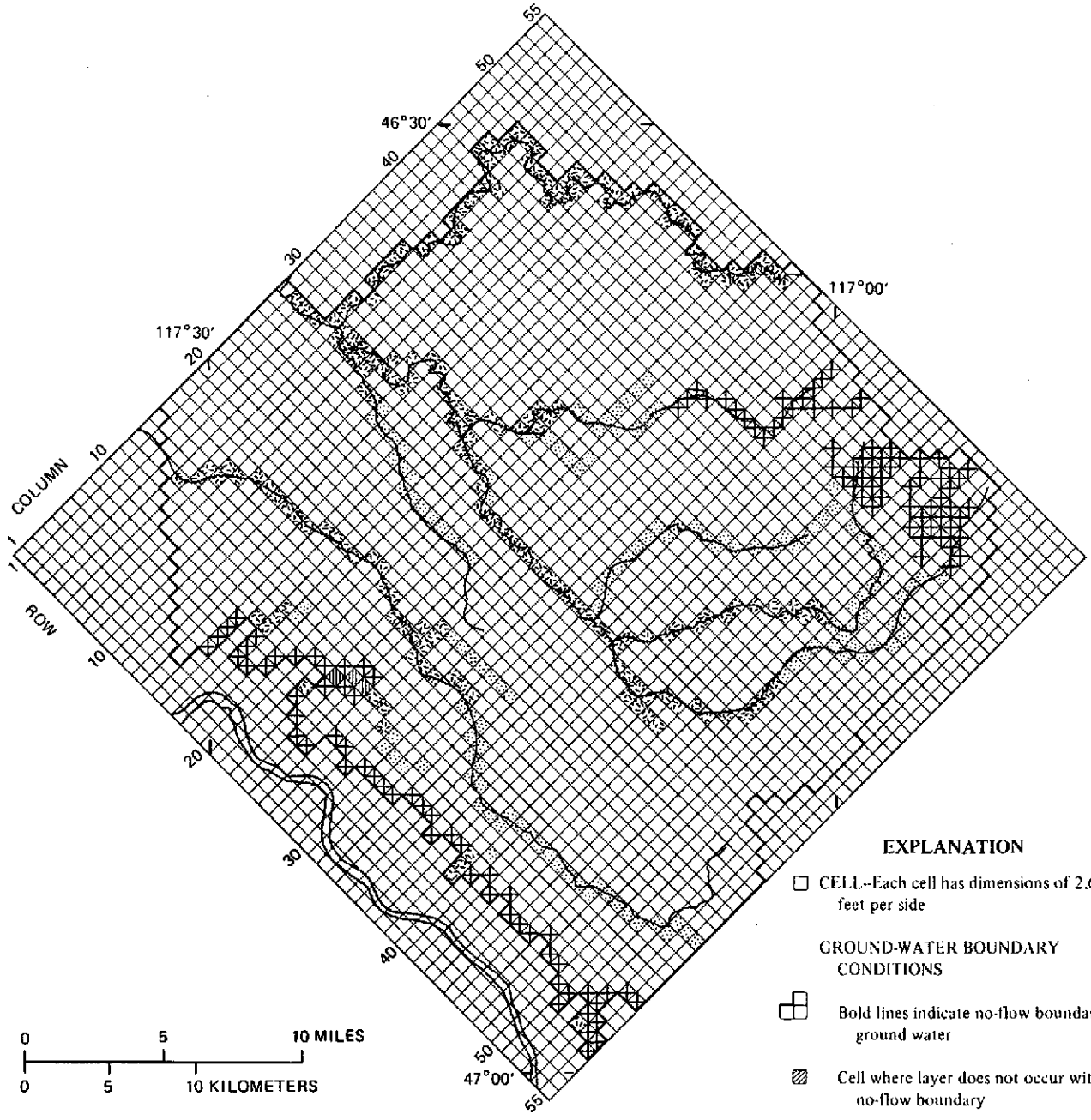


Figure 15a.--Grid used to subdivide the study area for the ground-water model and boundary conditions for the lower ground-water unit.

RECEIVED
MAR 19 1990

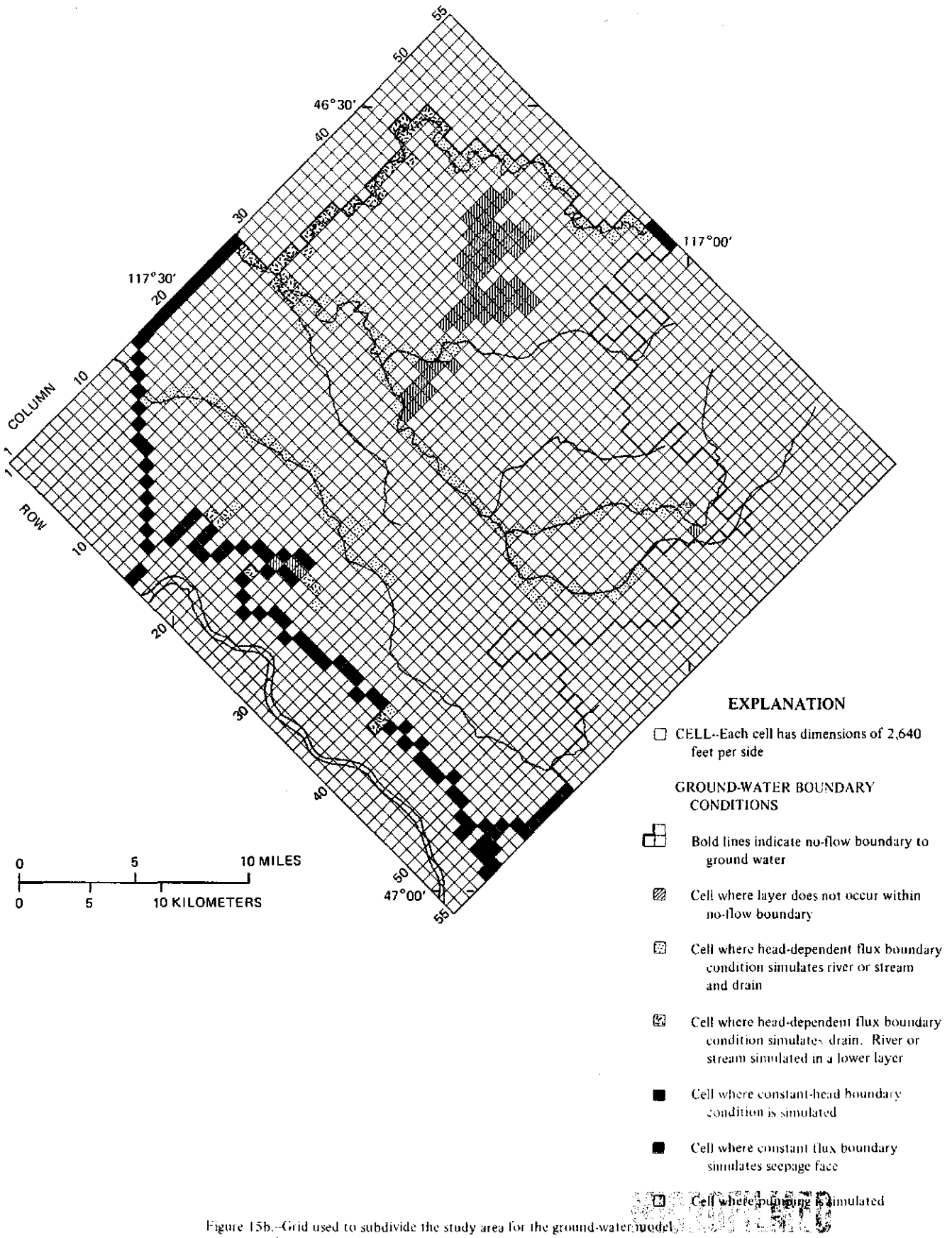


Figure 15b.--Grid used to subdivide the study area for the ground-water model, and boundary conditions for the Wanapum geohydrologic unit.

MAR 19 1990

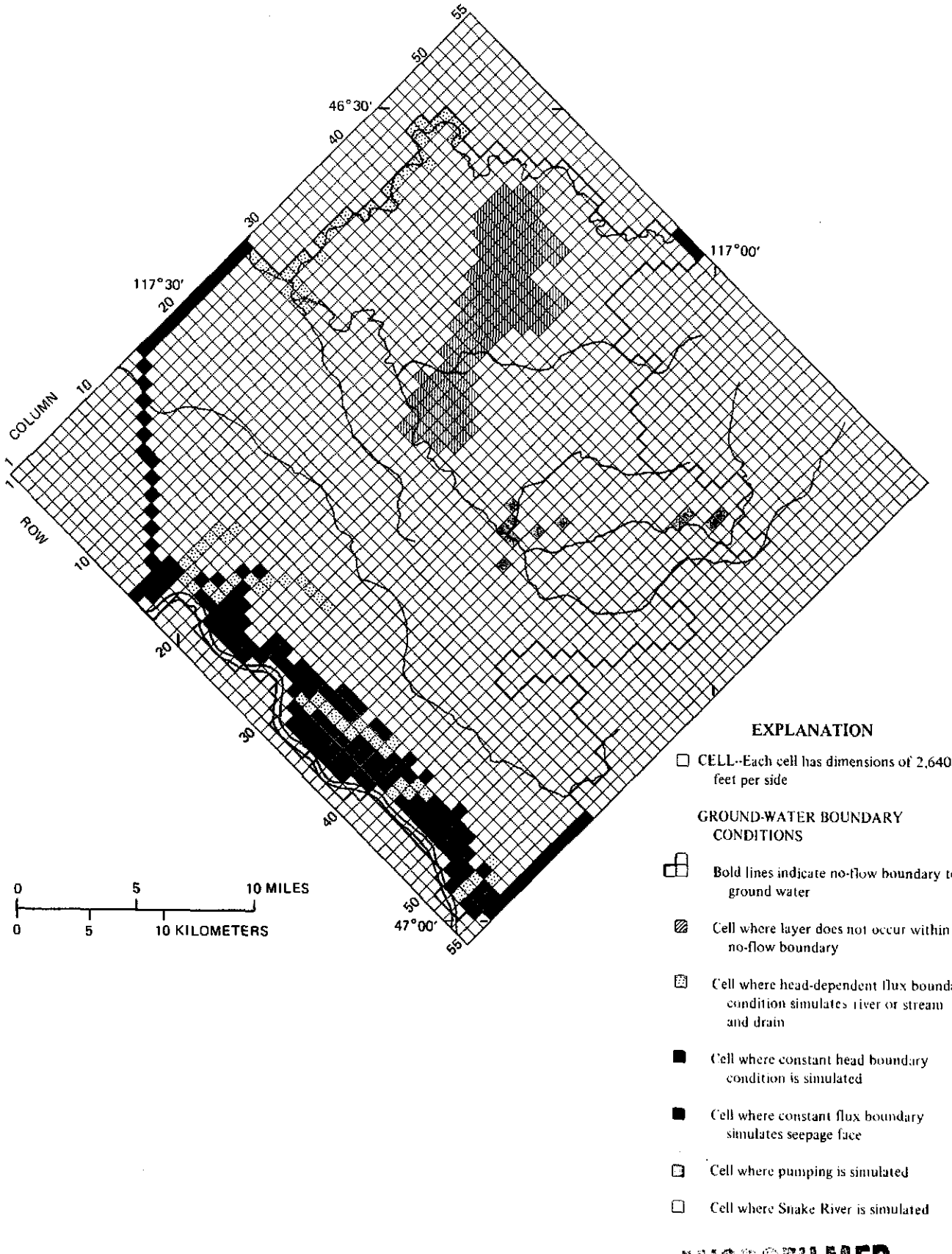


Figure 15c.--Grid used to subdivide the study area for the ground-water model and boundary conditions for the Grande Ronde geohydrologic unit.

MICROFILMED
MAR 19 1990

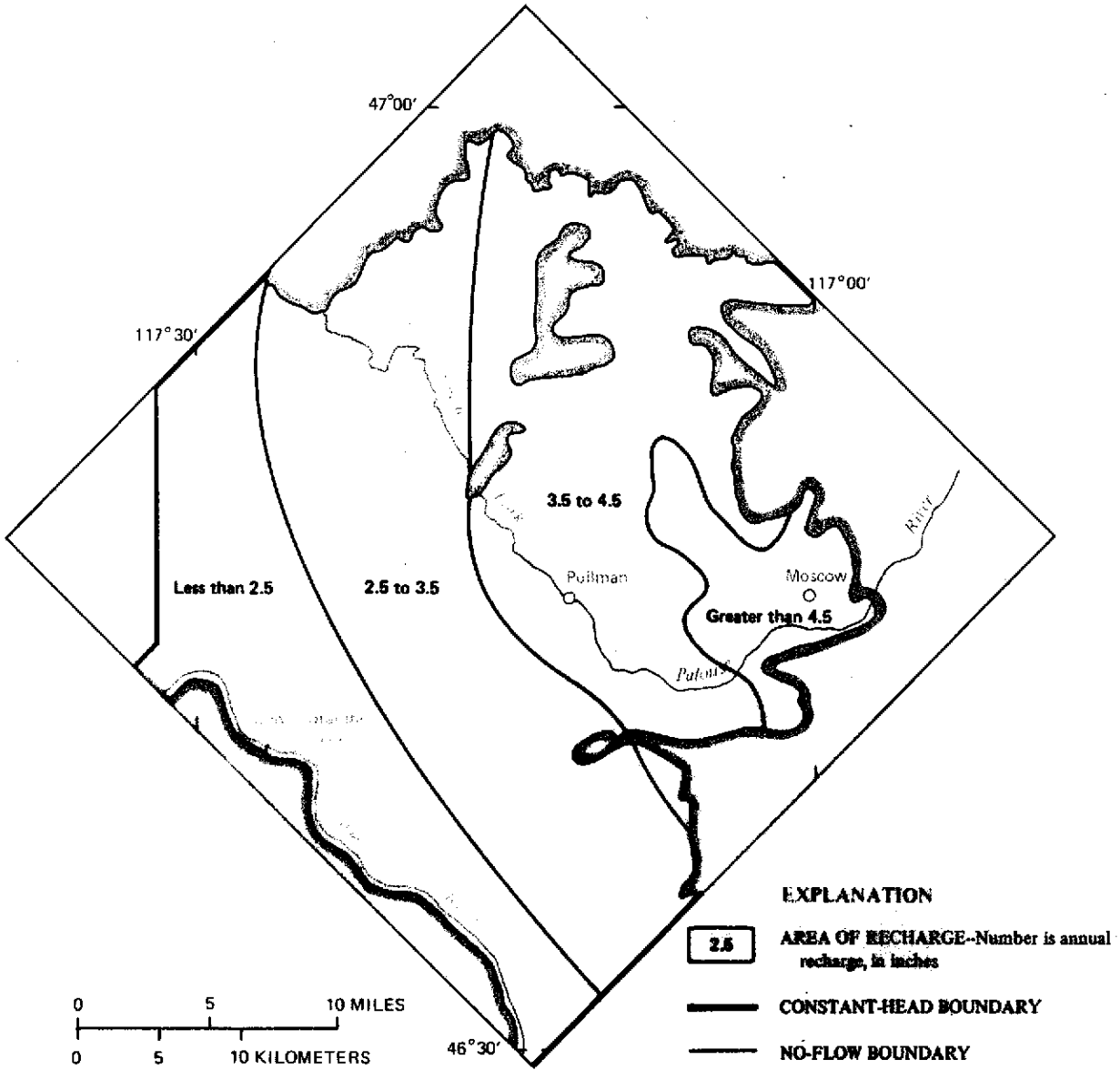


Figure 16a.--Areal distribution of recharge to the three-dimensional ground-water-flow model based on predevelopment conditions

MICROFILMED
MAR 19 1990

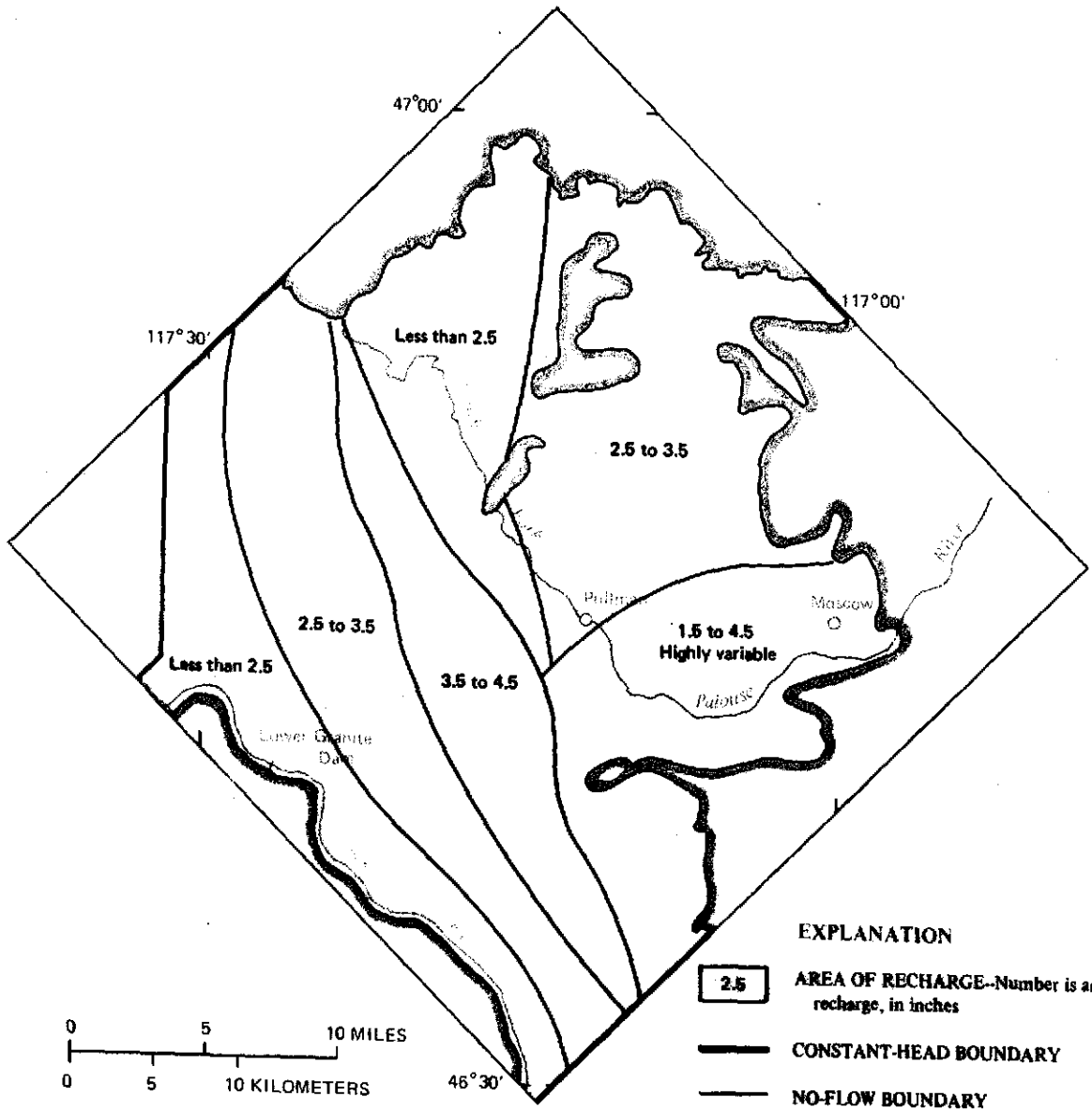


Figure 16b.--Areal distribution of recharge to the three-dimensional ground-water-flow model based on current land use and farming practices.

MICROFILMED
MAR 19 1990

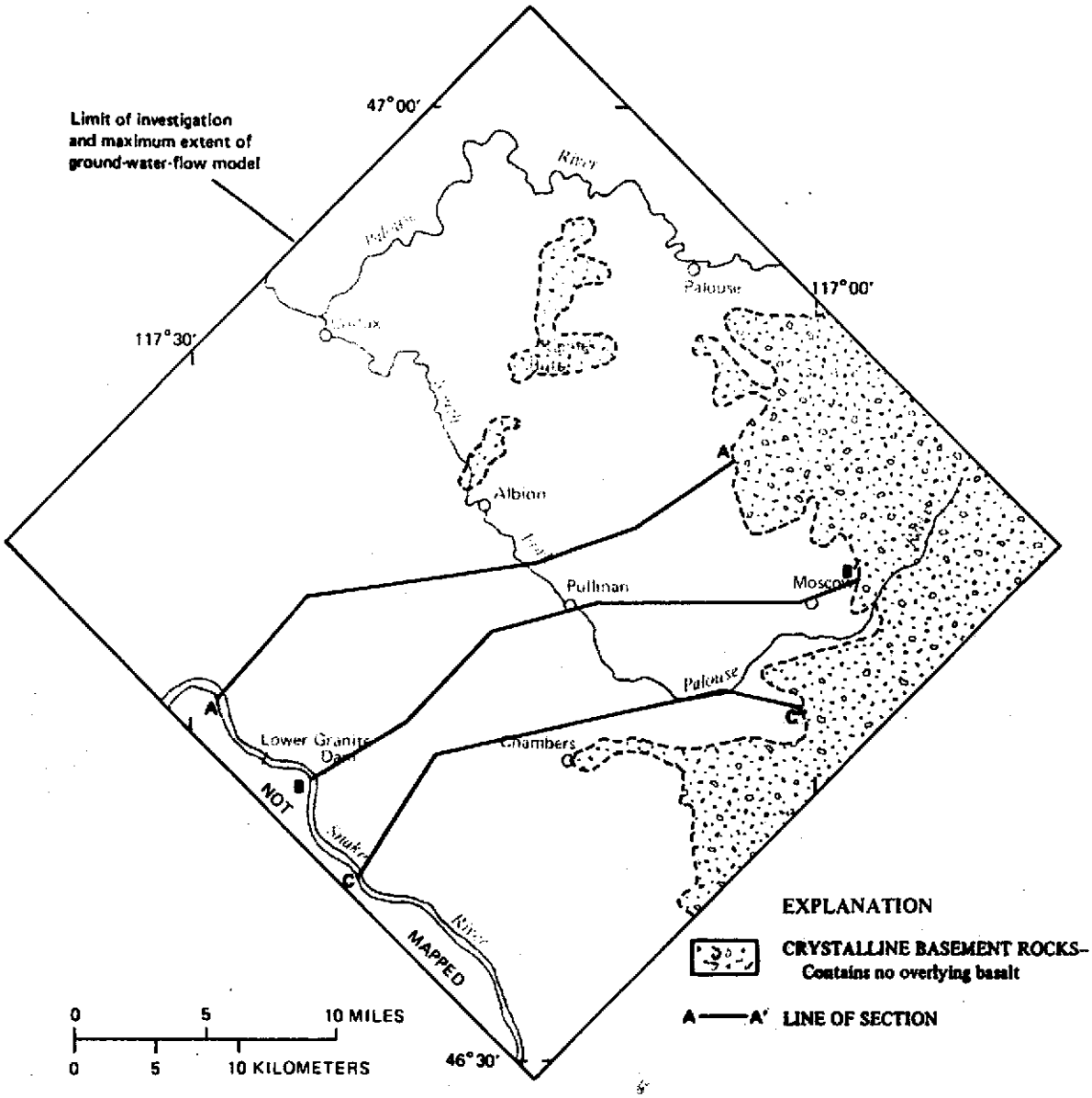


Figure 17.–Location of cross-sectional models in the domain of the three-dimensional model.

MICROFILMED
MAR 19 1990

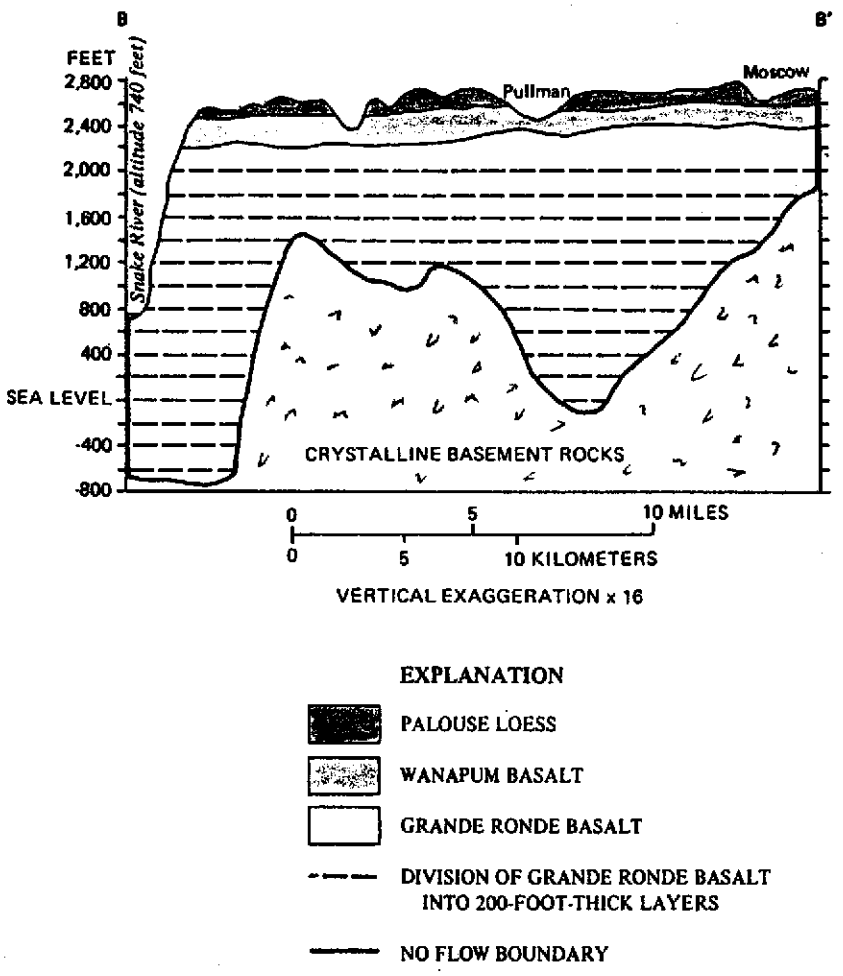
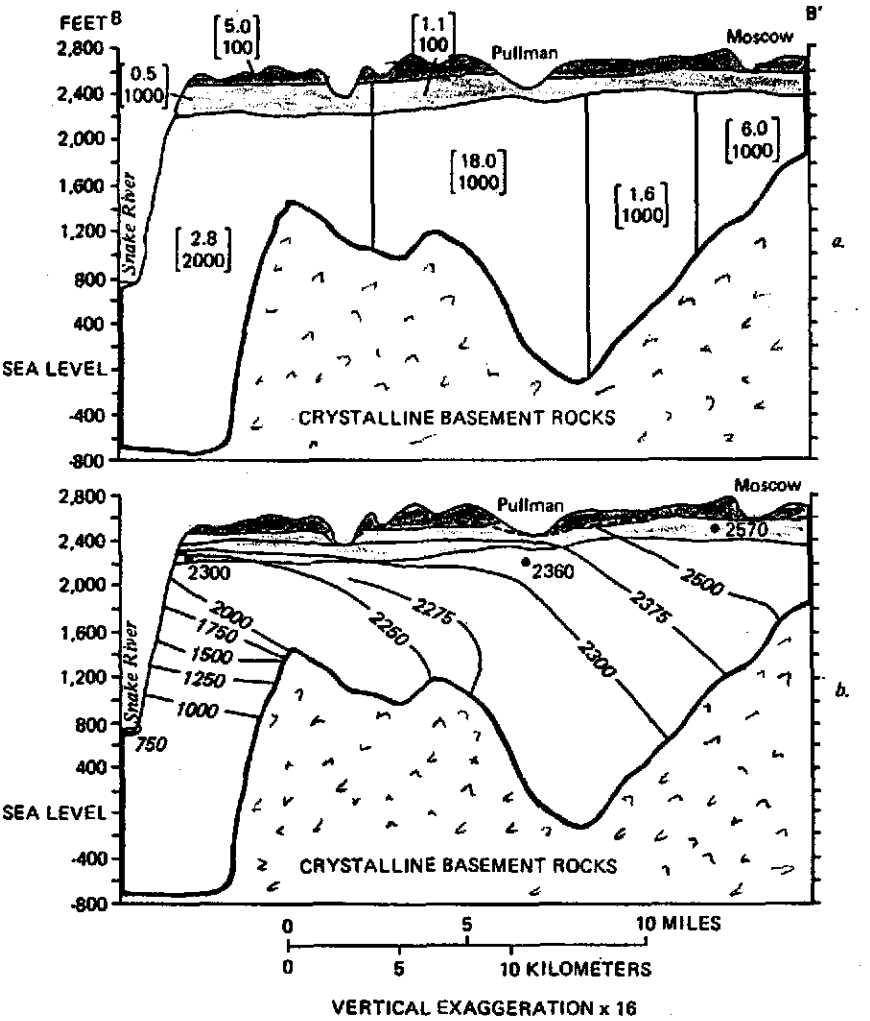


Figure 18.--Diagrammatic sketch of cross-sectional model B-B', showing layering.

MAR 19 1990



EXPLANATION

PALOUSE LOESS

WANAPUM BASALT

GRANDE RONDE BASALT

[0.5 / 1000] ZONES OF CALIBRATED HYDRAULIC CONDUCTIVITY--Upper number is horizontal hydraulic conductivity, in feet per day. Lower number is ratio of horizontal to vertical hydraulic conductivity, anisotropy

—1500— WATER-LEVEL CONTOUR--Shows altitude of calculated hydraulic head. Contour interval in feet, is variable. Datum is sea level

•2360 MEASURED WATER-LEVEL SITE--Number is altitude in feet above sea level

NO-FLOW BOUNDARY

WATER TABLE

Figure 19.--Calibrated cross-sectional model B-B': a) calibrated hydraulic conductivity distribution, b) calibrated hydraulic head distribution.

RELEASED
MAR 19 1990

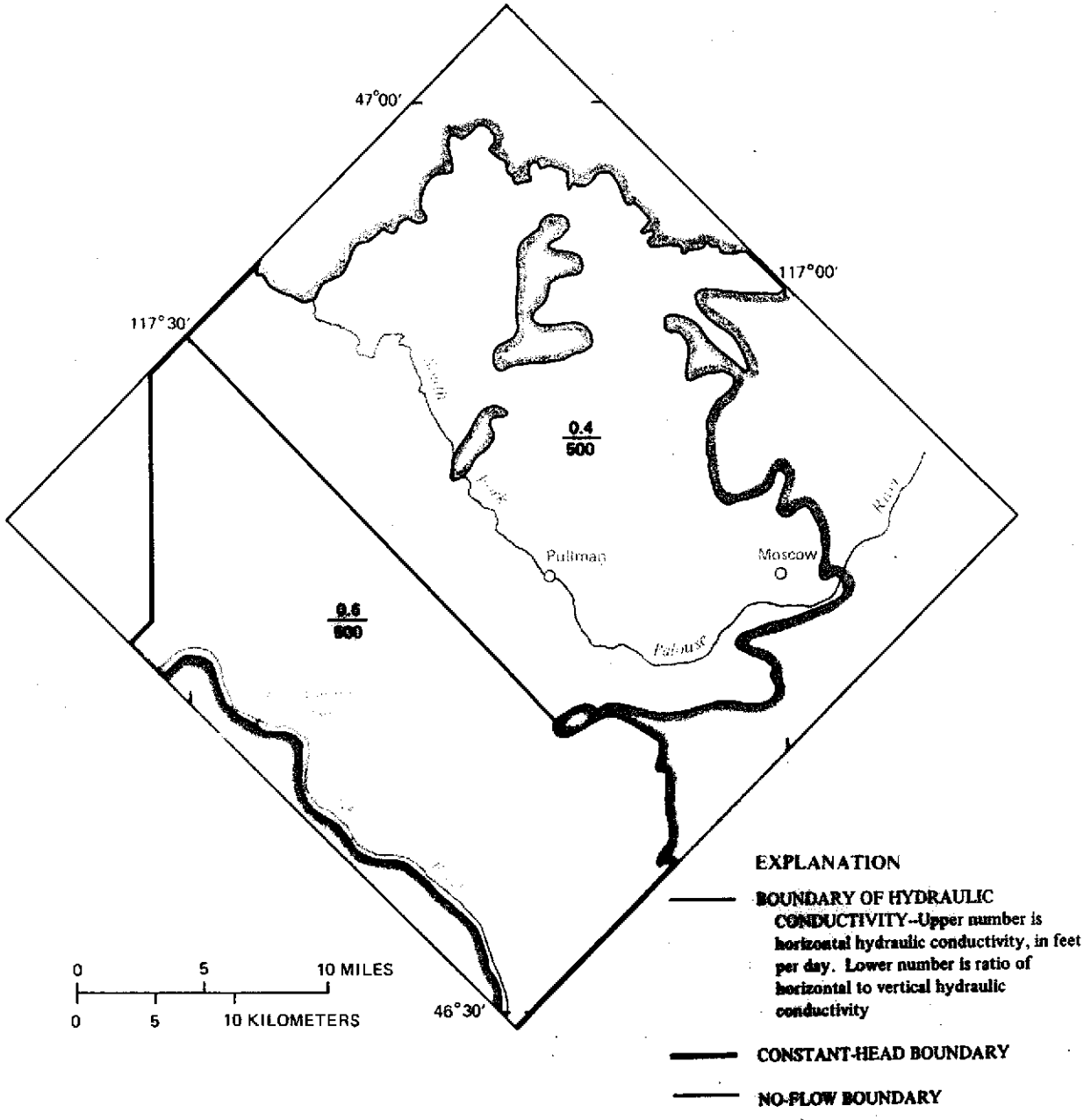


Figure 20.--Distribution of horizontal hydraulic conductivity and ratio of horizontal to vertical hydraulic conductivity for the Wanapum geohydrologic unit. Based on the cross-sectional model calibration and the time-averaged three-dimensional model calibration.

MAR 19 1990

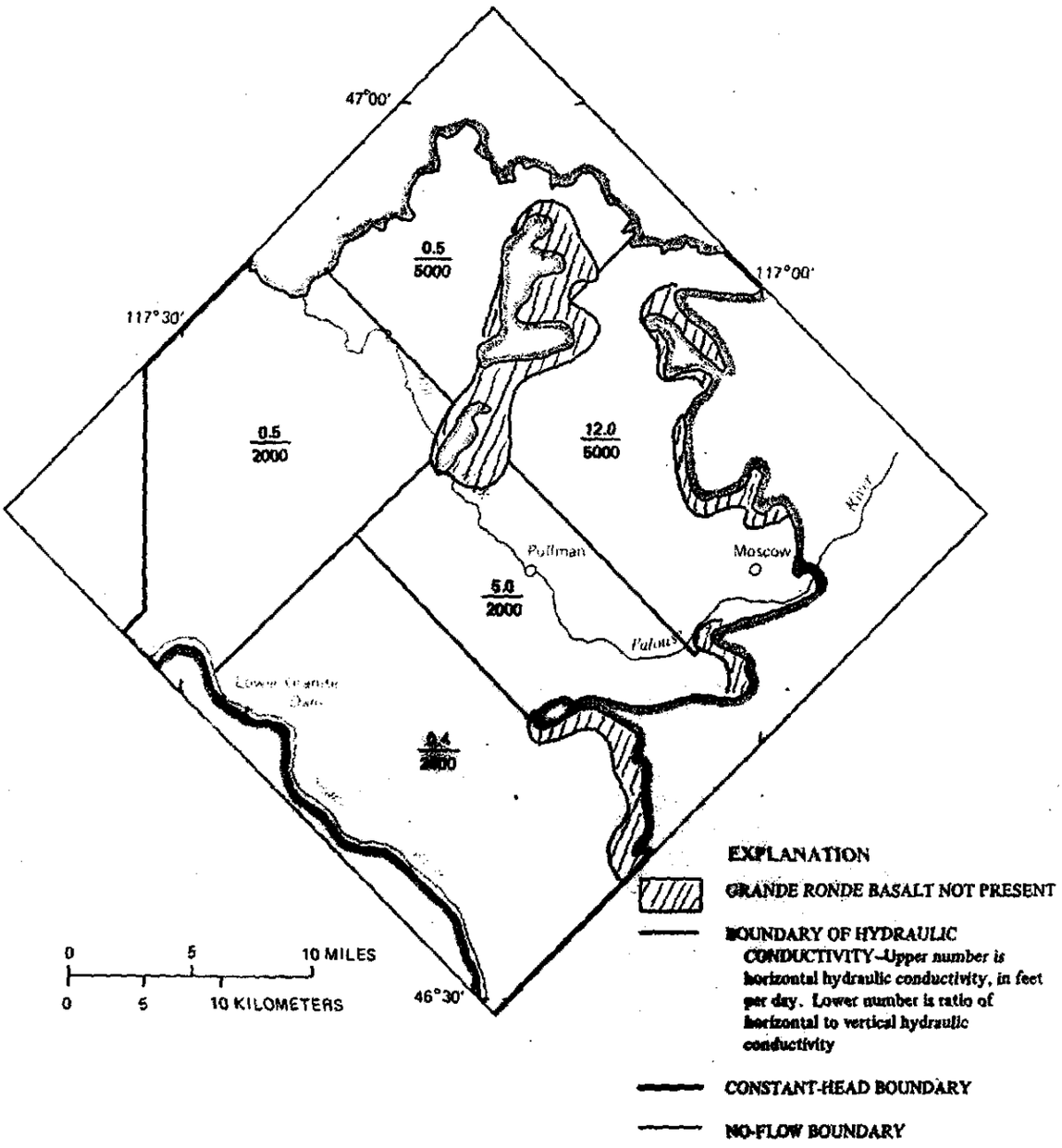
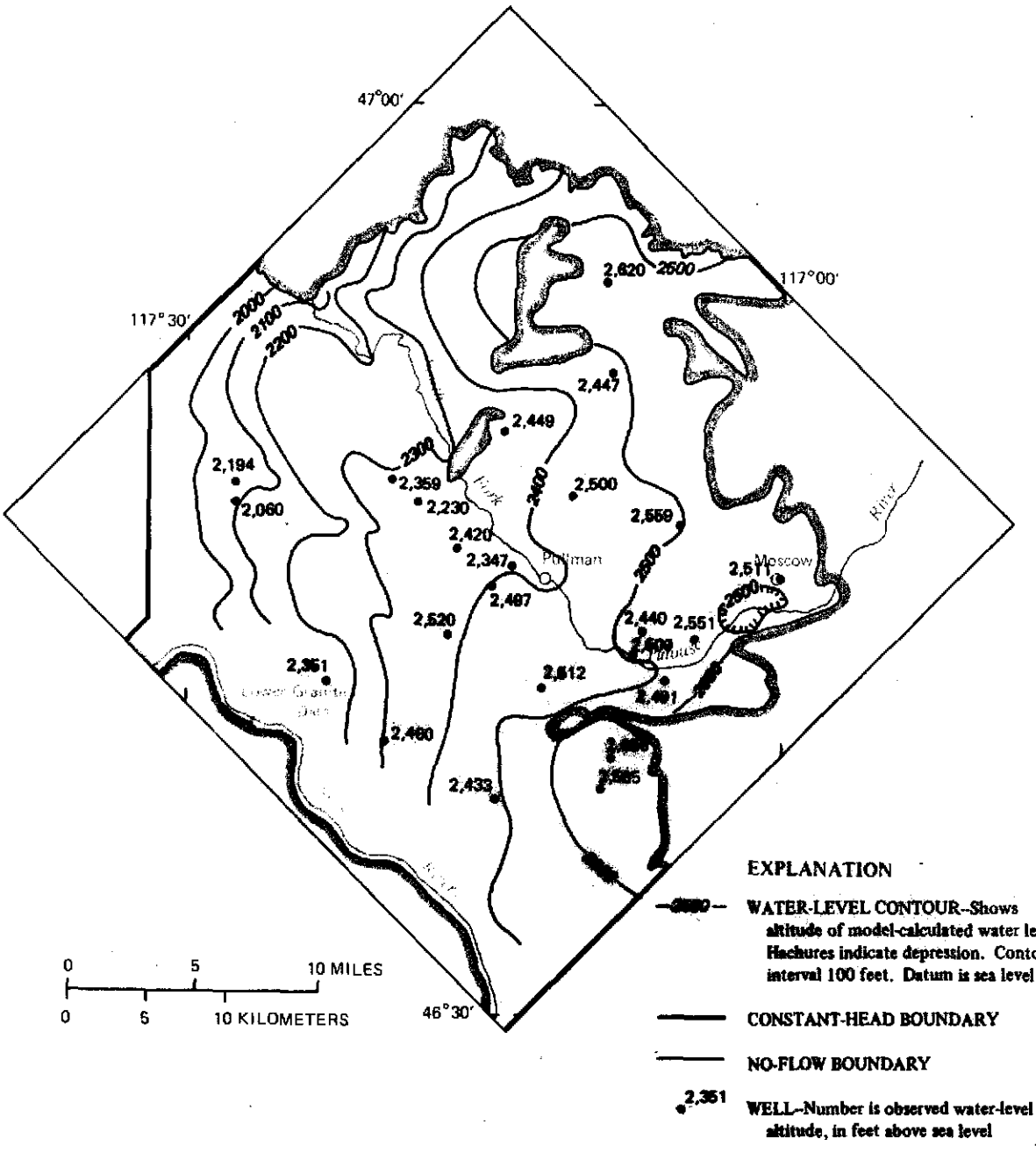


Figure 21.–Distribution of horizontal hydraulic conductivity and ratio of horizontal to vertical hydraulic conductivity of the Grande Ronde geohydrologic unit. Based on the cross-sectional model calibration and the time-averaged three-dimensional model calibration.

MICROFILMED

MAR 19 1990



geohydrologic unit

Figure 22.--Calibrated distribution of hydraulic head for the Wanapum Basalt for time-averaged conditions, 1974-1985.

MAR 1 S 1990

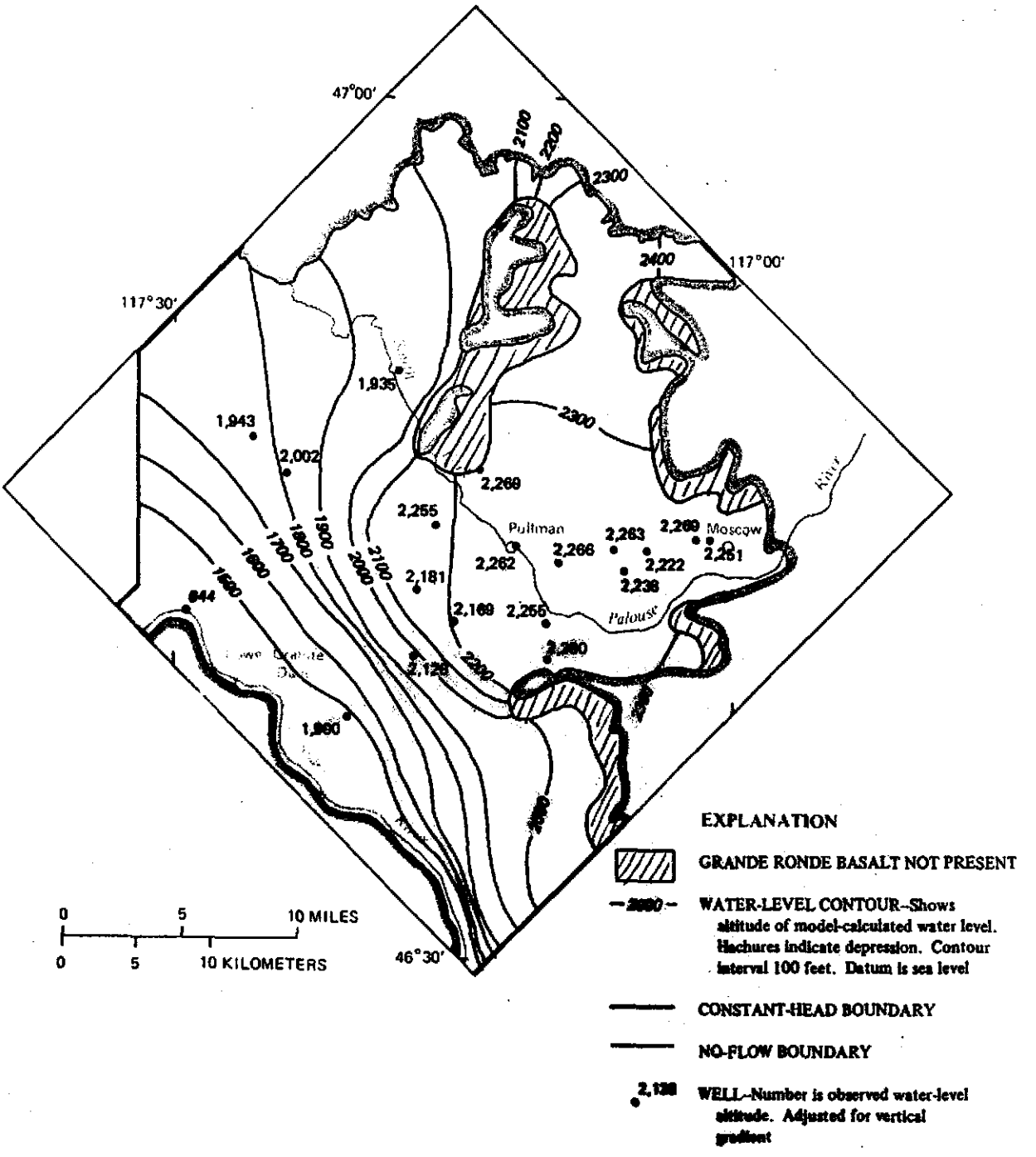


Figure 23.--Calibrated distribution of hydraulic head for the Grande Ronde Basalt for time-averaged conditions, 1974-1985.

MICROFILMED

MAR 1 9 1990

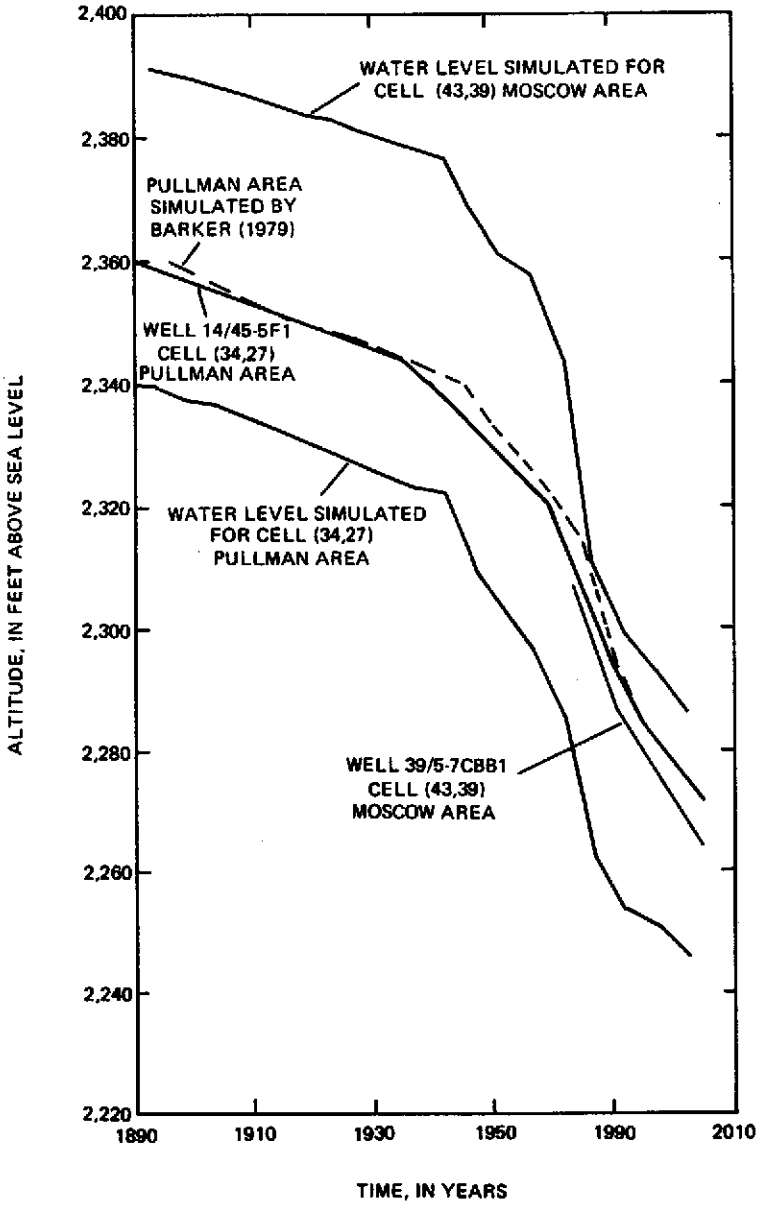


Figure 24.--Comparison of observed and simulated water levels in wells in the Pullman and Moscow area, 1890-1985.

MICROFILMED
MAR 19 1990

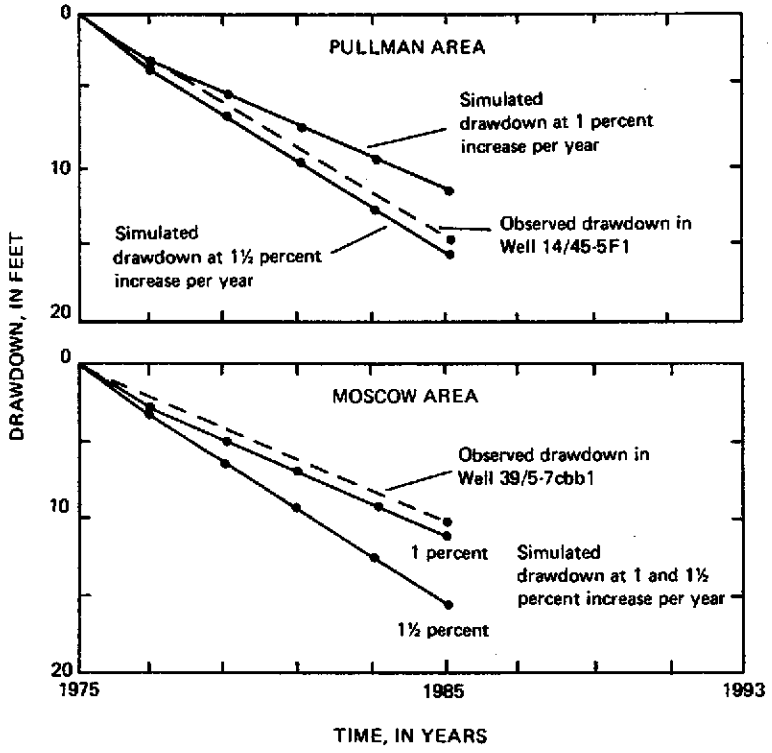


Figure 25.--Comparison of observed and simulated water levels in wells in the Pullman and Moscow area, 1975-1985.

MICROFILMED
MAR 19 1990

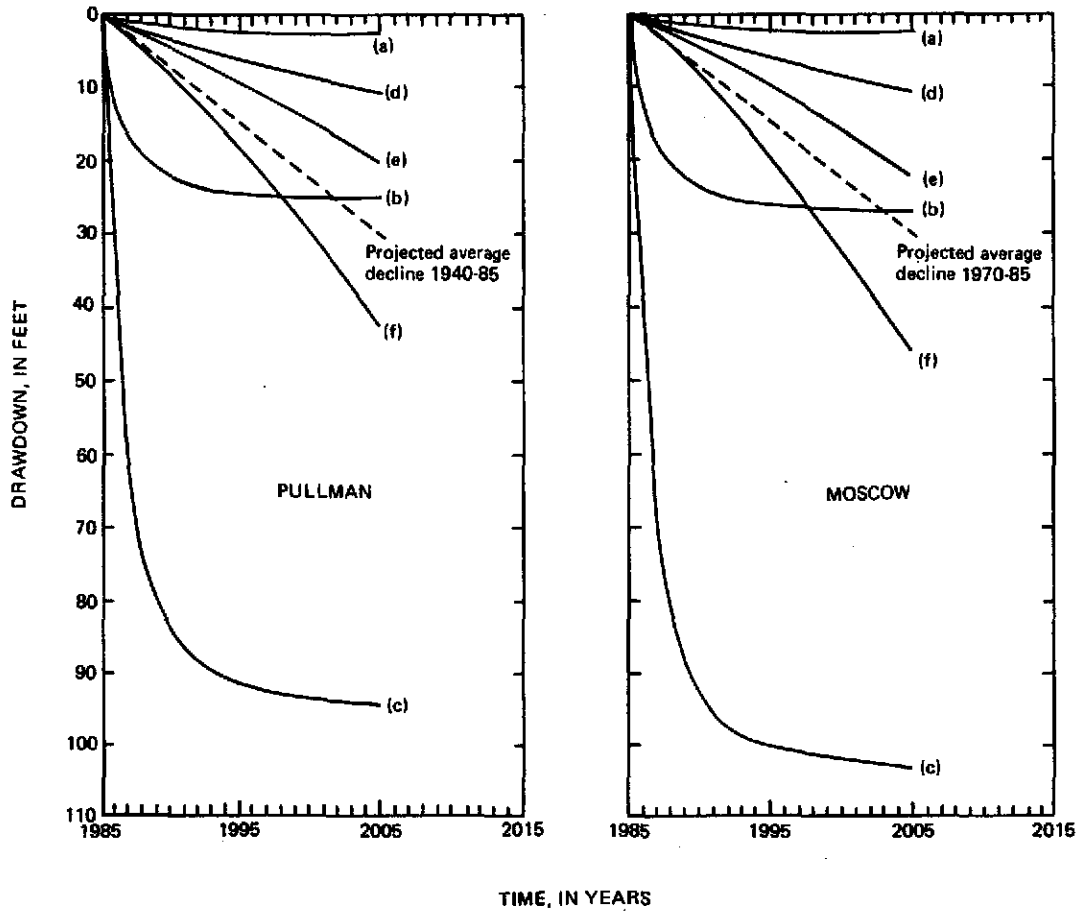


Figure 26.--Simulated water levels at a constant pumpage rate equal to: (a) the 1981-1985 average rate; (b) 125 percent of the 1981-85 average rate; and (c) 200 percent of the 1981-85 average rate; and at an annual pumpage rate increase from each preceeding year of: (d) ½ percent; (e) 1 percent; and (f) 2 percent; starting with the 1981-1985 average rate.

MICROFILMED
MAR 19 1990

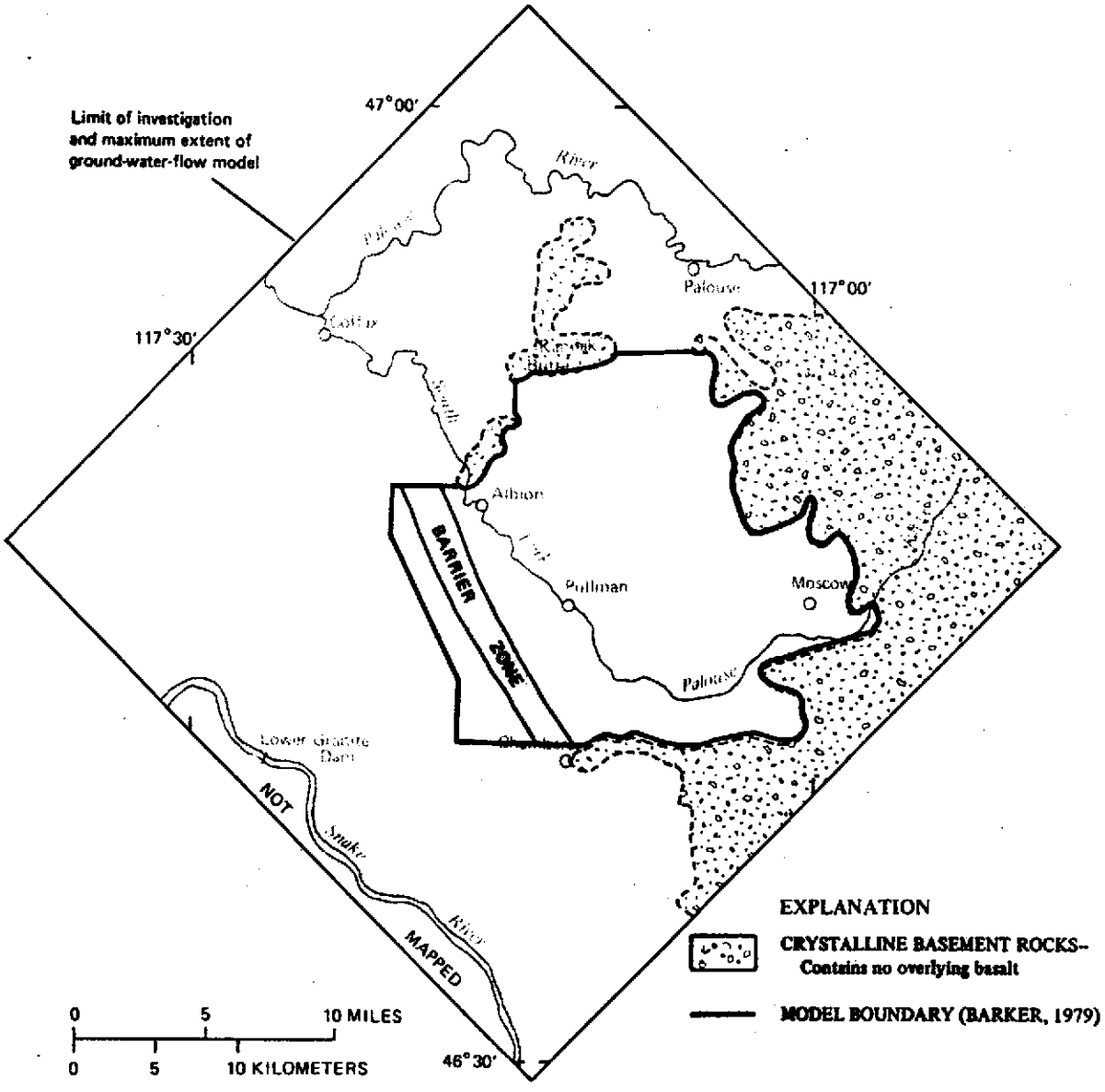


Figure 28.–Location of the ground-water-flow model boundaries and the 'barrier zone' of Barker (1979).

MICROFILMED
1990