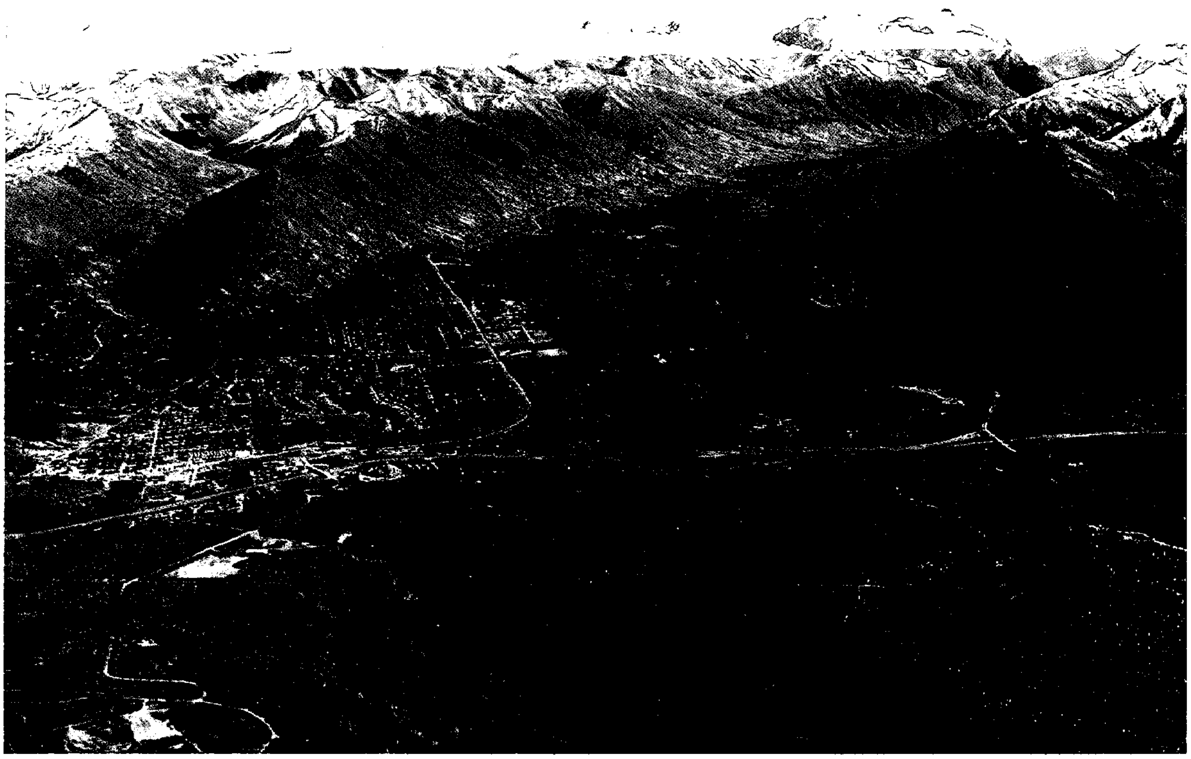
TASK 1
WELL DRILLING PROGRAM

Appendix

Eagle River Water Resource Study



Municipality of Anchorage
Water and Sewer Utilities

LL

December 1981

TASK 1
WELL DRILLING PROGRAM

Appendix

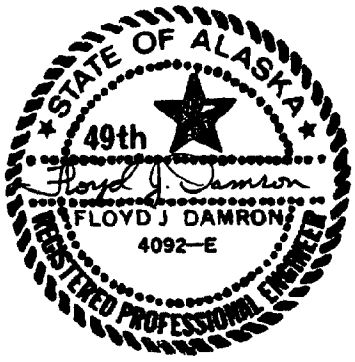
Eagle River Water Resource Study

Municipality of Anchorage
Water and Sewer Utilities

CH2M HILL

December 1981

Cover photo by: Air Photo Tech, Inc.



This report was prepared under the supervision of a registered professional engineer.

The preparation of this report was financed in part by funds from the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, administered by the Division of Community Planning, Alaska Department of Community and Regional Affairs.

K13765.B0

PREFACE

To pursue the recommendations for further study that were prescribed in the Metropolitan Anchorage Urban Study, completed by the U.S. Corps of Engineers in 1979, the Municipality of Anchorage engaged CH2M HILL to conduct the Eagle River Water Resource Study. The purpose of the study is to investigate the potential sources of water supply from the Eagle River Valley. The original scope of the study comprised four tasks:

Task 1	Well Drilling Program
Task 2	Preliminary Damsite Investigation
Task 3	Flour Water Treatment Study
Task 4	Transmission Main Design

Task 5, Eklutna Lake Alternative Water Source Evaluation, was added to the scope after the completion of the first four tasks.

The report for each task is bound separately and is an appendix to the Executive Summary of the entire study. This Appendix I is the report for Task 1, Well Drilling Program.

ACKNOWLEDGMENTS

CH2M HILL appreciates the assistance provided by the following parties during performance of Task 1, Well Drilling Program:

- The Anchorage Water and Sewer Utilities staff contributed valuable information and comments during weekly task meetings, updated the task scope of work, and provided overall administrative assistance.
- Eklutna, Inc., provided ready access to its property for the drilling program and provided pertinent information and comments at weekly meetings.
- The U.S. Geological Survey performed the geophysical logging of the wells and made important comments at weekly meetings.
- M-W Drilling, Inc., drilled the water wells in a timely manner and responded resourcefully to difficult and unpredictable field conditions.
- Geothermal Surveys, Inc., provided the personnel and equipment to perform the geothermal surveys.
- Ranney Method Western Corporation reviewed existing data and recommended sites for shallow groundwater exploration.

SUMMARY AND CONCLUSIONS

Task 1, Well Drilling Program, was the first of four tasks in the Eagle River Water Resource Study. The purpose of the study was to investigate the potential of the Eagle River Valley to supply subsurface or surface water to the Municipality of Anchorage to meet projected increased water demands.

The purpose of Task 1 was to locate and analyze deep and shallow groundwater sources in the middle Eagle River Valley, upstream of the damsite recommended in Task 2 of this study. CH2M HILL's responsibilities were to define geologic materials above bedrock and to aid the U.S. Geological Survey (USGS) by making the CH2M HILL boreholes accessible for geophysical logging, providing wells for aquifer pumping tests, and facilitating sampling of groundwater quality.

Eight test wells were drilled with depths ranging from 50 to 765 feet. The table on the following page summarizes the drilling. The first five wells were drilled to locate and analyze shallow and deep groundwater aquifers. These wells were drilled along two valley traverses identified by the U.S. Geological Survey, 4 miles upstream of the confluence of the Eagle River and its South Fork (Upstream Study Area). Two additional wells were drilled in the Downstream Study Area near the damsite recommended in Task 2 of this study, 2 miles downstream of the mouth of the South Fork. One shallow well was drilled near the mouth of the South Fork in the South Fork Study Area to evaluate the potential for a shallow groundwater collection system.

No aquifers were penetrated that could produce enough water to meet a significant portion of the projected Municipality of Anchorage demands. Consequently, no pump tests were performed.

Very thick sequences of lake-deposited silts and clays underlie the valley upstream of the South Fork, and possibly extend downstream past the South Fork. This indicates that a deep glacial lake was backfilled by fine sediments that now underlie the existing valley floor. One hole near the valley center encountered a poor aquifer at a depth of 690 to 750 feet, overlying bedrock.

Near the recommended damsite, relatively shallow bedrock occurs on both sides of the river. It is only 20 to 25 feet deeper than the river channel. Clays and silts make up most of the formation overlying the bedrock. However, the well on the south side of the river penetrated a 5-foot sequence of water-bearing sands and gravels immediately over the bedrock. This aquifer may be able to provide sufficient quantities of groundwater for local development.

TEST WELL DATA

Well No.	Location	Depth of Well	Depth to Bedrock	Aquifers
1	Upstream Study Area	314[a]		Poor or None Found
2	Upstream Study Area	765	750	Poor or None Found
3	Upstream Study Area	350		Poor or None Found
4	Upstream Study Area	130		Poor or None Found
5	Upstream Study Area	305		Poor or None Found
6	Downstream Study Area	160	130	Poor or None Found
7	South Fork Study Area	50		Poor or None Found
8	Downstream Study Area	88	74	Fair

[a] Depth at which glacial till boulder was encountered.

The USGS suggested that more groundwater potential might exist in an old side channel, 800 feet downstream of this well. The side channel might have been an ancient Eagle River outlet. This area was not investigated because the old Eagle River dump might be a local source of groundwater contamination. Additionally, aquifers in the area probably do not contain enough storage capacity for the Municipality's needs because the area is too small to contain sufficient aquifer volume.

Several areas were considered for shallow groundwater development, including a braided section of the stream several miles upstream of the South Fork. Of the areas considered, the mouth of the South Fork was the most promising. A shallow well near the mouth of the South Fork was drilled to 50 feet. No significant volume of water was found, and the geological formation encountered was clay from 16 feet to the bottom of the hole. Because this layer of clay would isolate a well from rapid river recharge, this area was abandoned for shallow groundwater considerations.

The Task 1 drilling program has led to the following conclusions about the development of groundwater in the Eagle River Valley:

- There is very little potential for a significant groundwater supply source from the Eagle River Valley.

- Low-permeability silts and clays make up most of the subsurface geology in the middle Eagle River Valley. It is hypothesized that these fine-grained sediments filled glacial lakes to form the existing valley floor.

- Although development of shallow groundwater might be possible in the valley, it could not fulfill the future needs of the Municipality of Anchorage. Winter flows of the Eagle River are low and cannot recharge shallow aquifers without affecting fisheries; therefore, these aquifers cannot sustain year-round demands.

- A 70-million-gallon-per-day water source for the Municipality of Anchorage from the Eagle River can be developed through the construction of a dam and impoundment of surface water. (See Appendix II, Preliminary Damsite Investigation.)

CONTENTS

		Page
	Preface	iii
	Acknowledgments	v
	Summary and Conclusions	vii
1	Introduction	1-1
	Background	1-1
	Site Description	1-4
	Purpose and Scope	1-5
	Limitations	1-9
2	Previous Studies	2-1
	Synopsis of Previous Studies	2-1
	Summary of Previous Studies	2-12
3	Test Hole Drilling	3-1
	Drilling Program	3-1
	Exploration and Examination of Alternatives	3-9
	Summary	3-15
4	Recommendations	4-1
5	Bibliography	5-1

Exhibit. Ranney Method Western Corporation Report

TABLES

		Page
3-1	Land Area Required for Shallow Groundwater Supply	3-14
3-2	Test Well Data	3-17

FIGURES

1-1	Vicinity Map	1-2
1-2	Projected Water Demand Increase 1980-2025	1-3
1-3	Eagle River Valley Test Wells and Other Subsurface Investigations	1-7
2-1	R. W. Retherford Associates Test Hole Boring Log	2-3
2-2	Tryck, Nyman, and Hayes Test Well No. 2 Boring Log	2-4
2-3	MAUS-USGS Test Well Boring Log	2-7
3-1	CH2M HILL Test Well No. 1 Boring and Geophysical Logs	3-3
3-2	CH2M HILL Test Well No. 2 Boring and Geophysical Logs	3-4
3-3	CH2M HILL Test Well No. 3 Boring and Geophysical Logs	3-6
3-4	CH2M HILL Test Well No. 4 Boring and Geophysical Logs	3-7
3-5	Middle Eagle River Valley Geologic Cross Section	3-8
3-6	CH2M HILL Test Well No. 5 Boring Log	3-10
3-7	CH2M HILL Test Well No. 6 Boring Log	3-11
3-8	CH2M HILL Test Well No. 8 Boring Log	3-13
3-9	CH2M HILL Test Well No. 7 Boring Log	3-16

Chapter 1
INTRODUCTION

The population and, thus, the water supply needs of the metropolitan Anchorage area are growing rapidly. Presently, surface water from Ship Creek and groundwater wells in the Anchorage Bowl supply most of the Municipality's water. However, if present growth trends continue, these sources will not meet future needs.

BACKGROUND

In 1974 the United States Congress authorized the U.S. Army Corps of Engineers to perform the Metropolitan Anchorage Urban Study (MAUS), which was completed in 1979. The purpose of the MAUS was "to evaluate the adequacy of the developed water supply in the metropolitan Anchorage area, to determine future water demands, to assess sources for water supply development, and to formulate water supply plans to meet the increased future demand" (U.S. Army Corps of Engineers, 1979). The MAUS study area comprised the Anchorage Bowl and the area northeast to the town of Eklutna (Figure 1-1).

The projected future water demand increases, determined in the MAUS, are shown in Figure 1-2. It is expected that by the year 2025 an additional 81.5 million gallons per day (mgd) of water will be needed to meet the increased demands in the area.

The MAUS report identified many potential sources of supply: Eagle River Valley groundwater; Anchorage Bowl groundwater; and surface water from Campbell Creek, Ship Creek, Eagle River, and Eklutna Lake. Two plans were recommended by MAUS for future study. Plan IV, which ranked first environmentally and socially, included a combination of supply from Ship Creek, Anchorage Bowl groundwater, and Eklutna Lake. Plan VI, which ranked first on an economic basis, included an increased supply from Ship Creek, winter diversion from Eagle River, further development of Anchorage Bowl groundwater, and exploration for Eagle River Valley ground water.

To implement portions of these plans, the Municipality increased the existing water supply from within the Anchorage Bowl by recently constructing a 36-inch supply main to its water treatment plant from the military diversion facility on Ship Creek. Future developments are expected to include new wells to increase groundwater supply and the expansion of the capabilities of the plant that treats Ship Creek water. However, rapidly growing demands in Anchorage will require development of a new source outside the Anchorage Bowl within the next 10 years. The Eagle River-Chugiak-Eklutna area, northeast of Anchorage, needs a new source now.

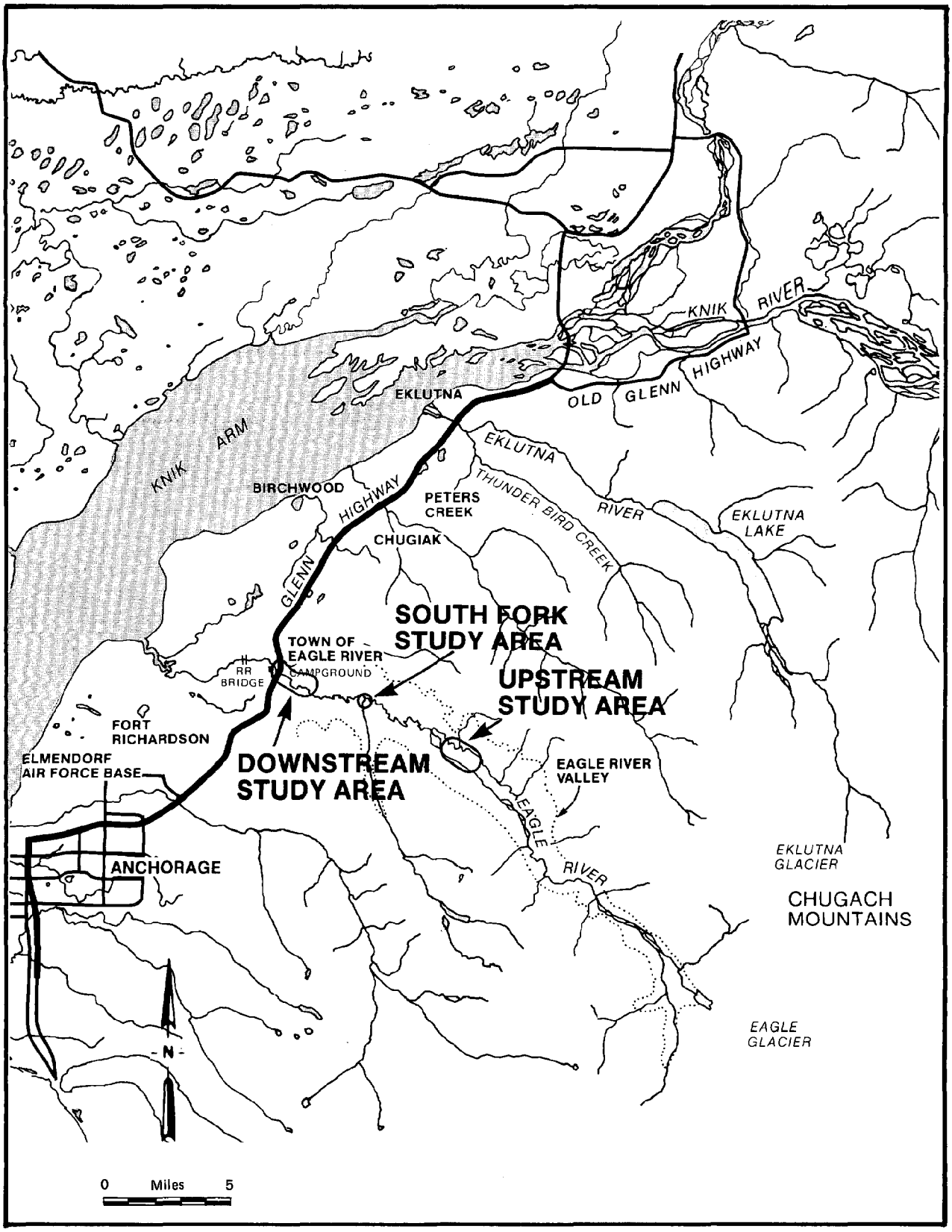
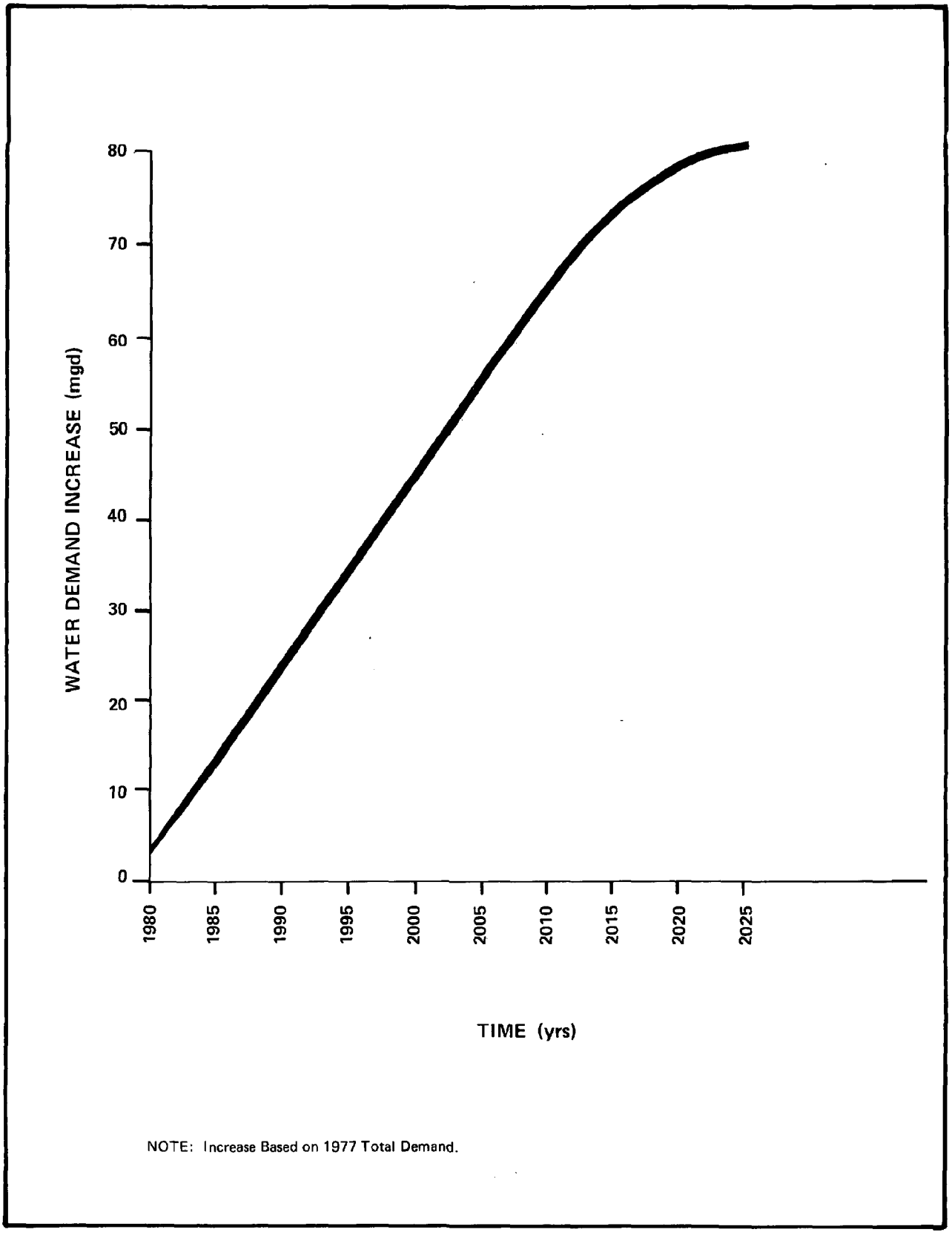


Figure 1-1
Vicinity Map



SOURCE: U.S. Corps of Engineers. 1979.

Figure 1-2
Projected Water Demand Increase 1980-2025

As a result of the MAUS findings, the Municipality decided to investigate potential sources outside the Anchorage Bowl that could supply 70 mgd of water. On the basis of the MAUS population projection, this diversion would satisfy the demands of the entire study area through the year 2012. The future increases in water supply capacity that are expected to be developed within the Anchorage Bowl will delay the need for the full 70-mgd capacity of the new water source outside the Bowl until approximately the year 2020 or later.

The Eagle River Valley is one possible source of water from outside the Anchorage Bowl that was suggested in the MAUS, Plan VI. To investigate the potential of this valley to supply the 70-mgd requirement, the Municipality engaged CH2M HILL to conduct the Eagle River Water Resource Study. The original scope of the study comprised four separate tasks:

- Task 1, a well drilling program to study the feasibility of developing the Eagle River Valley as a groundwater source
- Task 2, a preliminary damsite investigation to determine the feasibility of developing the Eagle River as a surface water source
- Task 3, an investigation to determine if the glacial rock flour in the Eagle River water is removable by conventional treatment processes
- Task 4, a preliminary design of a pipeline to transport groundwater or surface water from the Eagle River Valley to Anchorage

Each task was conducted independently.

The results of the first four tasks clearly indicate that a substantial dam and reservoir are required to develop Eagle River as a water source. Before committing itself to this dam and reservoir project, the Municipality of Anchorage increased the study scope to include Task 5, Eklutna Lake Alternative Water Source Evaluation. Task 5 analyzed the capability of Eklutna Lake to supply the 70 mgd of water to the area. Eklutna Lake is included in Plan IV of the MAUS. The lake is 30 miles northeast of downtown Anchorage and 16 miles northeast of the Eagle River (Figure 1-1).

PURPOSE AND SCOPE

During the MAUS the Corps of Engineers considered recommending a deep and shallow groundwater exploration program in the Eagle River Valley as a possible future action. However, the Corps recommended against developing deep groundwater because it doubted that deep groundwater production, even if available, would be economically feasible.

The Corps believed that induced infiltration (shallow groundwater) development could provide a summer water supply to augment a proposed winter river diversion. This combination would provide a dependable year-round water supply to Anchorage. The Corps recommended a hydrogeological survey to determine the potential for development of an induced infiltration source as a summer water supply.

The U.S. Geological Survey (USGS) conducted a surface geophysical survey of an area in the Eagle River Valley 4 miles upstream of the South Fork (see the Upstream Study Area in Figure 1-3). The 1981 report on this work states:

> Interpretation of electrical resistivity and seismic refraction data collected in one area of the middle reach of the Eagle River valley indicates that at most points along the exploration lines, the depth to bedrock below the valley floor varies between 350 and 450 feet. Two, and perhaps three, major unconsolidated sedimentary layers are inferred to overlie bedrock. Other significant layers may exist that are not recognizable from the sounding data.

As a result of the MAUS recommendation, the USGS interpretation, and the Anchorage Water and Sewer Utilities' (AWSU) desire to obtain a quantitative assessment of the availability of groundwater in the Eagle River Valley, AWSU included a comprehensive drilling and testing program as part of the Eagle River Water Resource Study. This program was the study's first and most important task, Task 1, Well Drilling Program.

For the Task 1 drilling program, CH2M HILL was contracted to define geologic materials above bedrock and to aid the USGS by making the CH2M HILL boreholes accessible for geophysical logging, facilitating the sampling of groundwater, and providing wells for aquifer pumping tests. The program was designed to be conducted under two drilling schedules:

- Schedule A. The AWSU and the USGS specified that 12 test sites be drilled to explore for aquifers. These sites were located along and between two cross-valley traverses that were previously identified by the USGS. These traverses are near the center of the valley, 7 to 8 miles upstream of Glenn Highway. See Figure 1-3, Lines A and B.

- Schedule B. Two test production wells and four observation wells were to be installed if developable aquifers were found during the Schedule A activities. These wells were to be located near the individual Schedule A test wells that encountered aquifers with a potential of over 300 gallons per minute.

CH2M HILL provided the engineering management services, field inspection, and engineering for this task. This included the selection and retention of a drilling contractor; the field supervision of percussion (cable-tool) and air-rotary drilling; coordination with Eklutna, Inc. (the land owner), AWSU, and USGS; the formulation of and recommendations for variations in the original Task 1 scope; and the preparation of this report.

CH2M HILL was to provide the following deliverable products for Task 1:

- Map indicating the location and identity of wells drilled for this task
- Driller's log of each well
- USGS geophysical logs and notes
- Induced infiltration analysis
- Production test results
- Water quality analyses
- Positive and/or negative conclusions and recommendations

These products are included in this report, except for the production test results and the water quality analyses. No developable quantities of water were found on which to obtain these data.

This report analyzes the previously collected data as well as data collected in this task and provides conclusions regarding the viability of developing groundwater in the Eagle River Valley to meet the future demands of the Municipality of Anchorage.

SITE DESCRIPTION

The Eagle River Valley runs generally east-west and is located approximately 18 miles northeast of Anchorage within the Chugach mountain range (Figure 1-1). The Eagle River begins at Eagle Glacier and flows northwest through the valley for approximately 35 miles to the Knik Arm. The valley is characterized by a typical U-shaped cross section formed by past episodes of glaciation.

Alluvial, glacioalluvial, lacustrine, and deltaic sedimentary deposits fill the valley basin. The steep mountain walls along the valley are composed of varying types of bedrock, including undifferentiated older metamorphic and assorted nonmarine sedimentary units. The valley floor is characterized by a low-relief flood plain consisting of alluvial sediments including gravels, sands, silts, and clays.

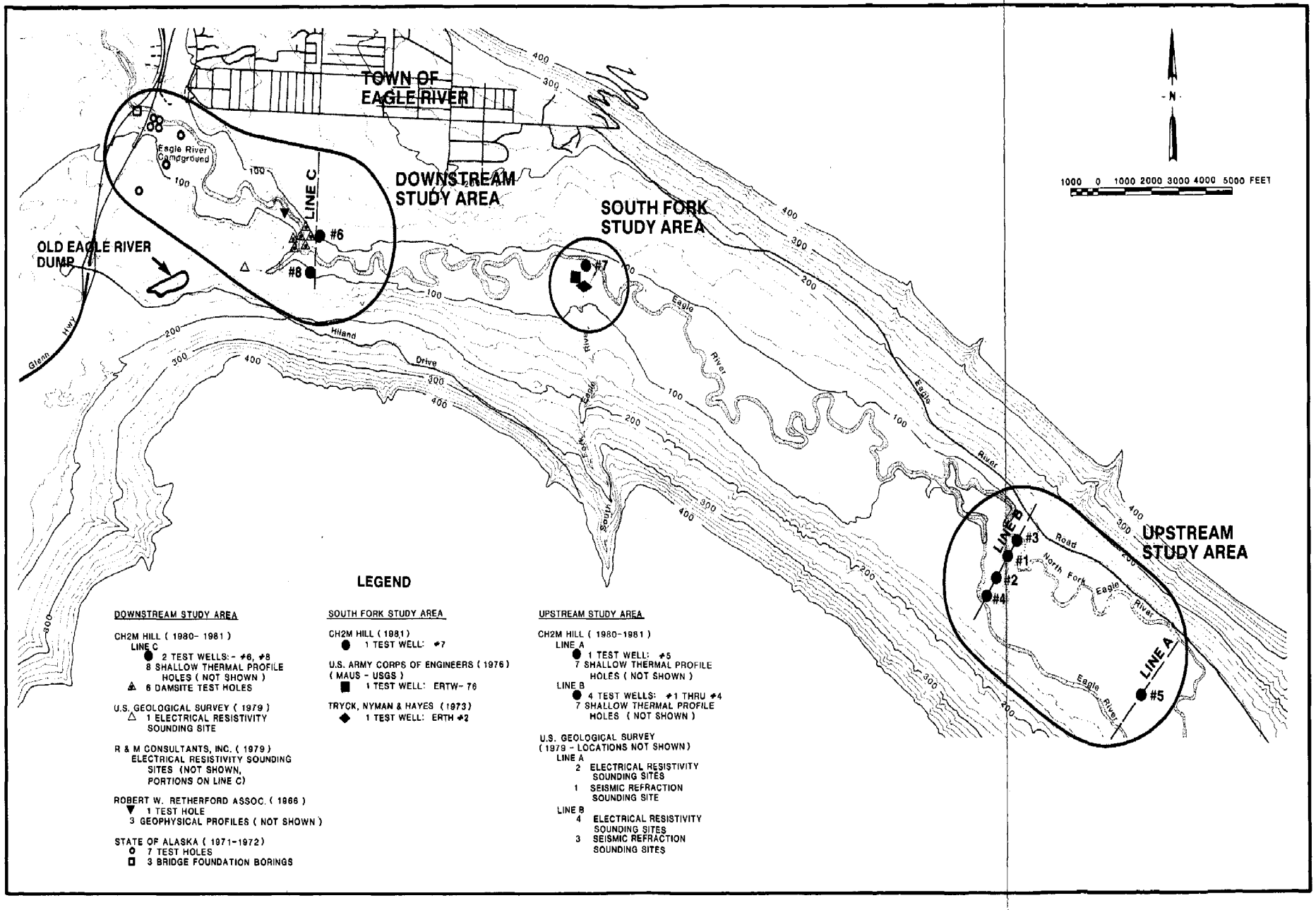


Figure 1-3
Eagle River Valley Test Wells and Other Subsurface Explorations

Task 1, Well Drilling Program, was designed and undertaken specifically to address the capability of the glacial valley sediments to provide an adequate supply of groundwater to the Anchorage area.

LIMITATIONS

This report was prepared for the use of the Anchorage Water and Sewer Utilities for specific application to the Eagle River Water Resource Study, Well Drilling Program, in accordance with generally accepted engineering practice. No other warranty, expressed or implied, is made. The wells indicate only the subsurface conditions at the well locations. Interpolation between wells was used for conclusions. Variations from the predicted results might exist. Should such variations be found, the findings and recommendations of this report will no longer pertain unless CH2M HILL is given the opportunity to reevaluate them in light of the new findings and report on the reevaluation in writing.

Chapter 2
PREVIOUS STUDIES

There has been limited exploration for groundwater in the Eagle River Valley prior to this study. Studies have been conducted that have speculated on the overall well-yield capacity of the valley. Two studies included the drilling of deep test wells.

SYNOPSIS OF PREVIOUS STUDIES

The following studies in the Eagle River Valley, which relate to this task, are listed in chronological order:

1. R. W. Retherford Associates and Adams, Corthell, Lee, Wince and Associates, 1966. Preliminary Engineering Report, Eagle River Project, Anchorage, Alaska. For the City of Anchorage Municipal Light and Power Utility. Federal Power Commission Project No. 2045.

2. Tryck, Nyman & Hayes; Dames & Moore; and Leeds, Hill & Jewett, Inc., 1973. Anchorage Water Sources. For the Anchorage Water Utility and the Central Alaska Utilities.

3. U.S. Geological Survey, 1974. Geology and Groundwater for Land Use Planning in the Eagle River-Chugiak Area, Alaska. Open File Report 74-57. Prepared for the Greater Anchorage Area Borough.

4. U.S. Geological Survey, 1977. Ground Water Investigation at the Alluvial Fan of the South Fork Eagle River, Anchorage, Alaska - Results of Test Drilling, 1976. Open File Report 77-493. Prepared for the Municipality of Anchorage.

5. Quadra Engineering, Inc., 1977. The Eagle River Community Water Supply and Distribution Plan. Prepared for Alaska Department of Environmental Conservation.

6. R&M Consultants, Inc., 1979. Eagle River Water Supply Study, Meadow Creek Area, Alaska, Final Report. Prepared for the State of Alaska, Department of Environmental Conservation.

7. U.S. Army Corps of Engineers, Alaska District, in conjunction with the Municipality of Anchorage, 1979. Metropolitan Anchorage Urban Study, Volume 2, Water Supply.

8. U.S. Geological Survey, 1981. Surficial Geophysical Data for Two Cross-Valley Lines in the Middle Eagle River Valley. Open File Report 80-2000. Prepared in cooperation with the Municipality of Anchorage.

The remainder of this chapter is a discussion of these studies and their pertinence to this Task 1 study.

1. Preliminary Engineering Report, Eagle River Project, Anchorage, Alaska (Retherford)

This report describes five potential hydroelectric power sites within the Eagle River drainage basin. Two of these sites are on Eagle River. The lower of the two sites was studied in more detail than the other site. It is located in the southeast corner of Section 13, Range 1 W, Township 14 N, about 1-1/2 miles southeast of the town of Eagle River (1,000 feet downstream of the damsite that was proposed in Task 2 of this study).

The geologic portion of the investigation of this site includes information gained from seismic profiles and one 240-foot-deep test boring that included a materials log and field permeability tests (Figure 2-1). The report emphasizes subsurface geologic conditions, including estimates of the depth to bedrock. On the basis of three seismic profiles and the test boring, the Retherford report states:

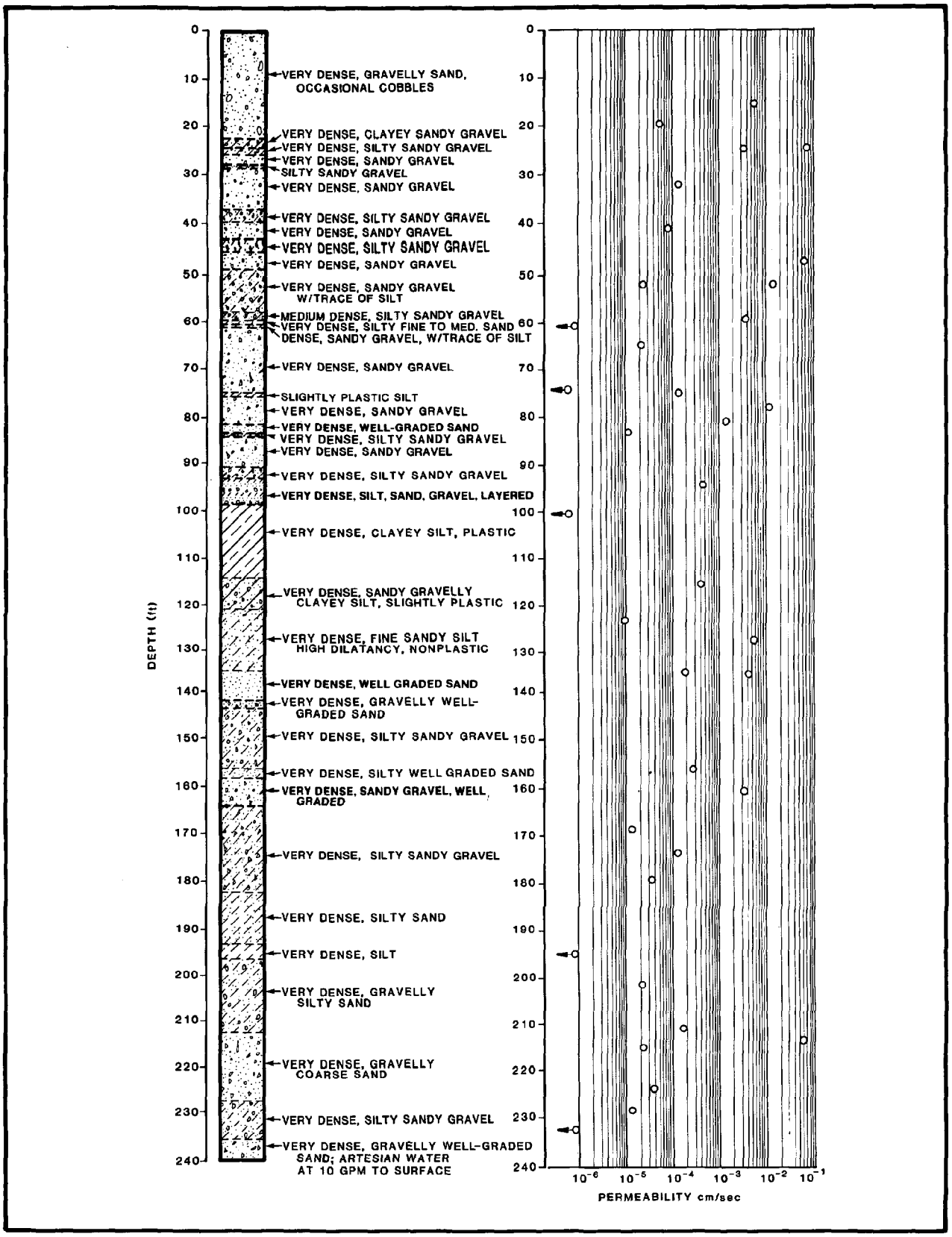
> The site is generally characterized by fairly deep and heterogeneous deposits of sands, gravels, clays, and silts exhibiting a complex stratigraphy. The only subsurface correlation available is with test hole no. 1 (the 240-foot boring) which showed a sequence of undifferentiated, very dense, alluvial deposits, primarily gravels.

Noting that bedrock was not encountered in the test hole, the report states that the top of the rock, which was estimated by seismic surveys to be approximately 240 feet deep at the test hole location, is uncorrelated with known rock depths and is subject to revision. This test hole is located in Figure 1-3.

Although the report did not consider groundwater capabilities, it mentioned artesian flow from the test boring at 10 gpm. Field permeabilities ranged from 10^{-1} cm/sec (gravels) to less than 10^{-6} cm/sec (sand, silt, and clay mixture). No conclusions about groundwater potential could be made from the report.

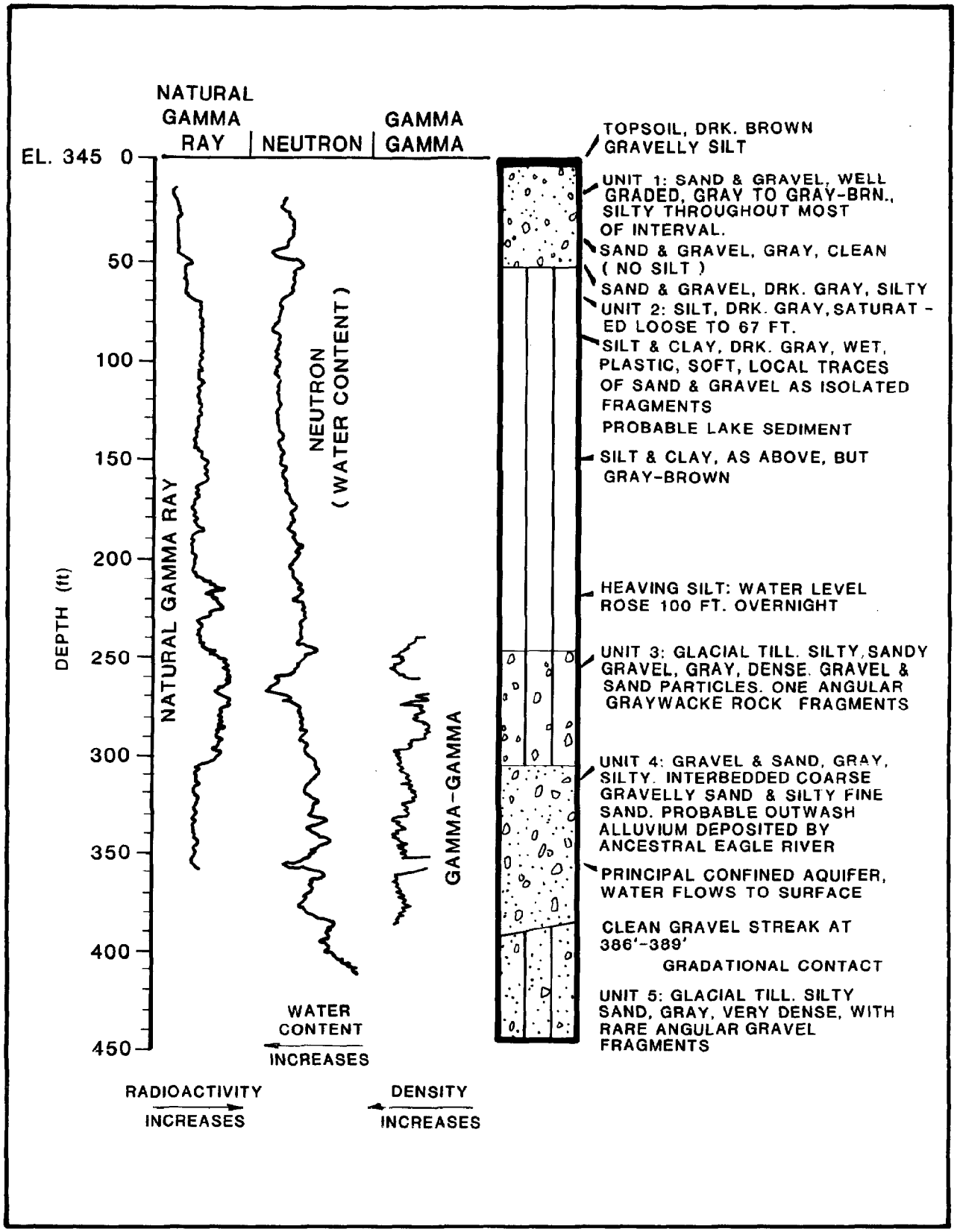
2. Anchorage Water Sources (TNH Study)

Chapter 7, Eagle River Wells, of Anchorage Water Sources, indicates that a shallow aquifer and a deep aquifer exist near the confluence of the Eagle River and the South Fork. A 445-foot-deep test hole (see Figure 1-3, Well ERTH No. 2) encountered the shallow aquifer between 33 and 42.5 feet and the deeper aquifer at depths greater than 300 feet (Figure 2-2).



SOURCE: R.W. Retherford Assoc. 1966.

Figure 2-1
R.W. Retherford Associates
Test Hole Boring Log



SOURCE: Tryck, Nyman, and Hayes, et al. 1973.

Figure 2-2
Tryck, Nyman, and Hayes
Test Well No. 2 Boring Log

This report contains the most positive evidence and conclusions to support the existence of substantial groundwater potential for municipal use in the Eagle River Valley. On the basis of a 24-hour pumping test of the shallow aquifer, the report indicates an initial specific capacity of the shallow aquifer to be 31 gpm per foot of drawdown. The report states, "A water yield of approximately 775 gpm (1.1 mgd) should be possible if the drawdown were increased to 25 feet."

The report indicates that, from 14-minute and 16-minute bailer tests, the specific capacities of the deeper aquifer at 344 feet and 346 feet were found to be 4 gpm per foot and 16 gpm per foot, respectively. The deeper aquifer is noted as a series of outwash sands and gravels interlayered with silty sand.

This report states in its analysis of the test hole and the pumping and bailer tests that "properly developed large diameter wells may yield water in excess of 1 mgd from Unit 1 (the shallow aquifer) and over 3 mgd from Unit 4 (the deeper aquifer)."

It says the pumping and bailer tests indicate that the aquifers have sufficient potential to warrant consideration of Eagle River groundwater as a potential water supply for the Anchorage area.

Additionally:

> It is quite reasonable to expect specific yields of 10 to 20 % in Eagle River alluvium but if it is assumed that the surficial aquifer in Eagle River has a specific yield of 5 % only 3.8 square miles 30 feet thick would be required (for a 40-mgd yield). Either the surficial or deep aquifer alone, therefore, should be able to provide the Anchorage area's needs for additional water.

Finally:

> The analysis of the Eagle River well project is based on the assumption that sustained yields will average 1.3 mgd per well from the deep aquifer. The single test well drilled in conjunction with this project provides inadequate information upon which to design and evaluate this project; however, until additional information is available, it must be used.
>
> Thirty wells in the Eagle River Valley of 2-mgd capacity would be required to furnish the area needs in the design year. This provides a capacity of approximately 1.5 times the annual average demand of 40 mgd. A possible well field arrangement is shown on Figure 254 (in the TNH report) for cost analysis, but actual locations must be based on test drilling.

3. Geology and Ground Water for Land Use Planning in the Eagle River-Chugiak Area, Alaska (USGS)

This report indicates that, because large alluvial fans generally contain deposits favorable for groundwater exploration, the greatest potential for ground-water development exists in the larger alluvial fans. Specifically mentioned is the Meadow Creek fan. This USGS report was based on existing well logs and production data, and it contains little information about the groundwater potential in the area studied in Task 1 of the Eagle River Water Resource Study.

The report does show several wells located near the Glenn Highway bridge and the Eagle River Campground. Most of these were installed by the State of Alaska and have low yields, from 1 to 72 gpm. Bedrock near the river ranges from 40 to 107 feet below ground level. A bedrock outcrop is shown in the river about 1/2 mile upstream of the Glenn Highway bridge.

4. Ground Water Investigation at the Alluvial Fan of the South Fork Eagle River (USGS)

This investigation was conducted as a phase of the water availability and water supply element of MAUS. Its primary purpose was to evaluate the potential of the aquifers described in the 1973 report of Tryck, Nyman & Hayes (TNH). A test well, ERTW-76, was drilled into bedrock at a depth of 487 feet, approximately 195 feet down-valley from the TNH well. The well location is shown in Figure 1-3.

According to the USGS, the lithologic sequence of the test hole drilled for this project was similar to that logged in the 1973 TNH test hole (Figure 2-3). However, the shallow aquifer found in the TNH test hole between 33 and 42.5 feet correlated with only 1 foot of relatively permeable aquifer material (at a depth of 48 to 49 feet) in the USGS test hole. This led the USGS to conclude that the shallow aquifer, tested by TNH to have a specific capacity of 31 gpm per foot of drawdown, has a limited areal extent. Test pumping by the USGS of individual aquifer zones below 300 feet indicated that no water-bearing strata capable of sustaining moderate-to-large yield public supply wells (200 gallons per minute or more) are present.

The report states:

> The well penetrated four sand and gravel strata of low water-yielding capacity.... Each water stratum was pumped for several hours, and the best aquifer yield was found to be 1.7 gal/min/ft of drawdown. These test results support the conclusion, previously inferred from drilling data at a nearby test hole drilled in 1973 (TNH), that larger yield, confined aquifers are not present in the subsurface at this locality.

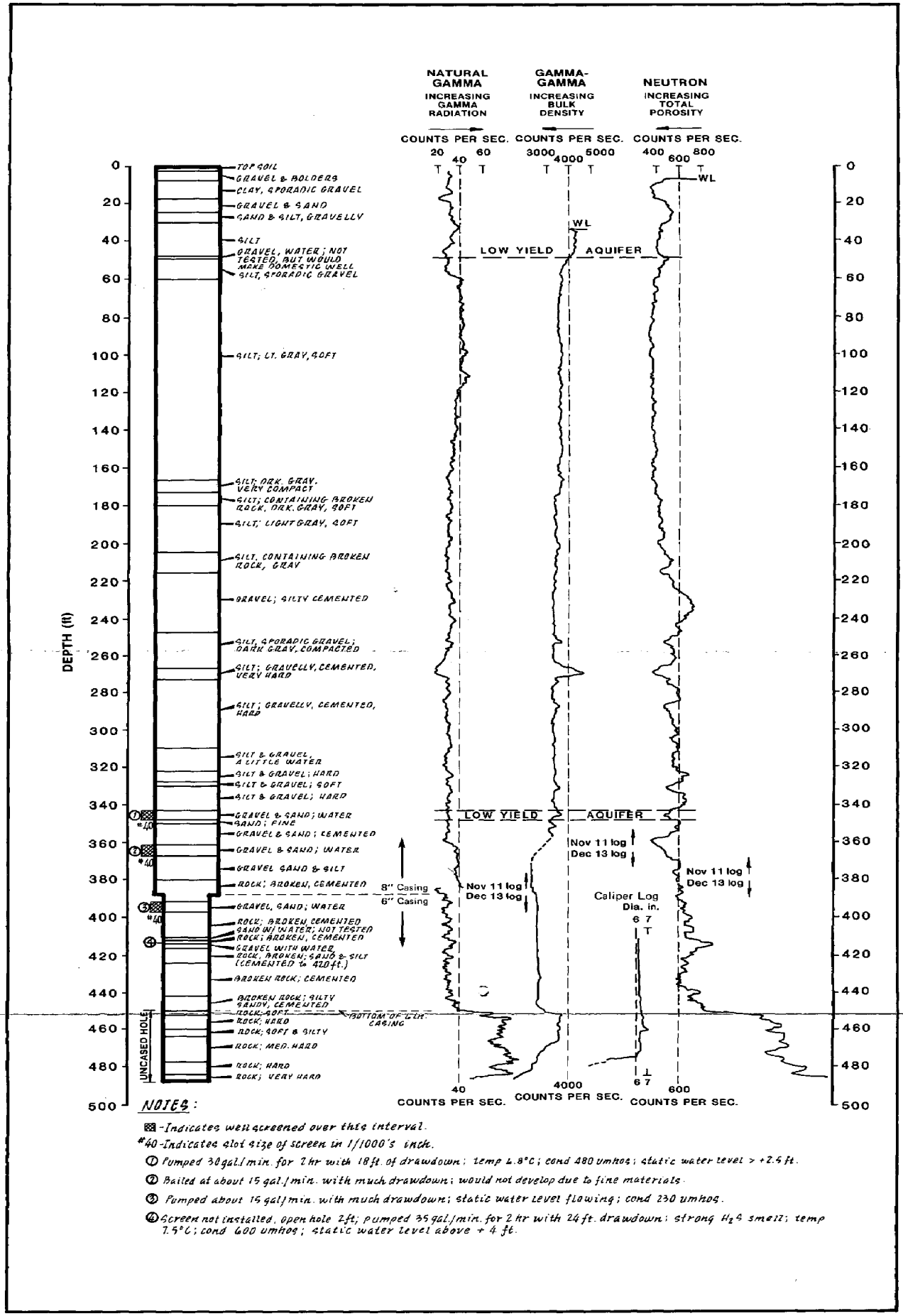


Figure 2-3
MAUS-USGS Test Well
Boring Log

SOURCE: U.S. Geological Survey, 1977.

As a part of the conclusions of this report, the USGS noted:

> Also, because only 1 foot of relatively permeable aquifer material (at a depth of 48 to 49 ft.) was penetrated in the unconfined system in ERTW-76, the extent of the shallow aquifer tested at well ERTH #2 is questionable. However, a surprisingly large yield (60 gal/min) was pumped from a 12-ft-deep, open-end casing beside the new test well, which suggests an abundance of very shallow groundwater here.

5. The Eagle River Community Water Supply and Distribution Plan (Quadra)

The purpose of this report was to compile and analyze existing data on the potential water supply sources for the Community of Eagle River. No field exploration was conducted.

This report notes that:

> ...the data (are) inconsistent and often conflicting (from previous studies in the area of Eagle River). Additional field work will be required before the true capabilities of the Eagle River aquifers can be determined.

On the basis of previous reports, Quadra chose to assume for the purpose of its study that the underflow of Eagle River will produce sufficient quantities of good-quality water to meet the needs of the community. The report further assumed that a shallow-aquifer well field could be located adjacent to the Eagle River in Sections 17 and 18 of T14N, R1W, with each well having a potential production capacity of 450 to 500 gpm.

6. Eagle River Water Supply Study, Meadow Creek Area, Alaska (R&M)

The emphasis of this study is on the surface water and groundwater potential in the Meadow Creek area, north of the Eagle River Valley. The study includes detailed hydrologic and geologic investigations of the Meadow Creek area, including geophysical surveys, well drilling, and test pumping.

No test holes or wells were drilled to test the aquifer characteristics or well production capabilities in the Eagle River Valley. Geophysical surveys run in the Meadow Creek area and the Eagle River area suggest that subsurface geologic conditions in the lower Eagle River Valley are similar to the Meadow Creek fan area to the north.

In its conclusions, the R&M report states:

> Interpretations developed in this study support the contention that aquifers within the glacial till including the Meadow Creek Fan, are discontinuous and restricted.

Relative to this comparison, the report states in its description of a test pumping of a well on the Meadow Creek fan that:

> The most significant result of this pump test is the discovery that the producing formation has physical limits at the test pumping rate (165 gpm). This observation supports the (R&M) concept that the good producing zones in this area are discontinuous and vary greatly in lithology from place to place.

7. Metropolitan Anchorage Urban Study (MAUS), Volume 2, Water Supply (Corps of Engineers)

Section 4, Groundwater - Eagle River Valley, of Appendix 3, Potential Water Resource Development, of this MAUS report contains a discussion of previous study in the Eagle River Valley, the 1976 MAUS-USGS test well, its recommendation for a future testing program, the feasibility of groundwater development in the Eagle River Valley, and the impacts of groundwater development.

Because the results of the TNH (1973) and MAUS-USGS (1976) test wells have not provided conclusive results on the potential for development of Eagle River groundwater, this MAUS report notes the need for a future testing program:

> Ground water aquifers in the Eagle River valley warrant continued consideration as a potential water supply for the Anchorage area. However, explorations to date have not been sufficient to determine overall aquifer characteristics.... these characteristics should be determined by a comprehensive field exploratory program.

The Corps suggested a deep, confined aquifer testing program consisting of four wells drilled to bedrock. Locations for these wells are shown in Figure 3-154 of the MAUS report. It also suggested that a shallow aquifer testing program be conducted, consisting of one test well drilled 4 miles upstream of the confluence of Eagle River and South Fork. This test well's location is also shown in Figure 3-154. If a shallow aquifer were found, numerous observation wells and seismic data would be required for definition of the aquifer.

However, the report recommends against an extensive drilling and testing program:

> The estimated cost of approximately $65,000,000 for a (groundwater) project, which would supply an average of 40 mgd to the Anchorage area is clearly excessive.... Therefore, it must be concluded that development of deep groundwater in the Eagle River Valley would not be feasible, regardless of whether or not the assumptions made about its availability are correct. Accordingly, an extensive drilling and testing program would not be justified.

The MAUS report does suggest that it may be prudent to conduct an analysis of shallow induced infiltration potential:

> If the formation beneath Eagle River should prove to be of sufficient permeability to make the use of the induced infiltration method practical, a considerable reduction in the cost of development would be possible. Because of the relatively low surface flow in Eagle River during the winter, it is possible that this method would be productive only in the summer months.

8. Surficial Geophysical Investigation Data for Two Cross-Valley Lines in the Middle Eagle River Valley, (USGS)

The work for this report was conducted in the area of the middle Eagle River Valley because in this reach, Eagle River and the North Fork meander on a flat, broad valley bottom that is swampy in places and that probably has a shallow water table. Seepage into small tributary channels had been noted by USGS. Because of these features this area was expected to have a greater groundwater potential than areas downstream.

Six vertical electrical resistivity soundings and four seismic refraction soundings were made along two cross-valley traverses (Lines A and B, Figure 1-3).

The following quotes summarize this report:

> The work described in this report appears to have served well as a means of supplying basic subsurface information in a small segment of the Eagle River valley. Geophysical sounding data for the valley bottom, alluvial reach that extends 3 miles upstream and downstream of the survey lines used in this study probably would be equally beneficial....
>
> Interpretation of electrical resistivity and seismic refraction data collected in one area of the middle reach of the Eagle River valley indicates that at most points along the exploration lines the depth to bedrock below the valley floor varies between 350 to 450 ft. Two, and perhaps three, major unconsolidated sedimentary layers are inferred to overlie bedrock.

This report refers to this Task 1, Well Drilling Program, and suggests that bedrock may be deeper and that revised values will be reported when more information becomes available.

SUMMARY OF PREVIOUS STUDIES

The TNH study contains the most positive evidence and conclusions to support the existence of substantial groundwater potential in the Eagle River Valley. Unfortunately, sufficient funds were not available to properly complete and test-pump the only well drilled.

A substantial Eagle River exploratory drilling program was then developed by the U.S. Corps of Engineers and USGS. Again, sufficient funds were not available, and only one well could be drilled. This one well was located 195 feet from the TNH well to determine the extent of the aquifers that the TNH well had encountered. The results of this limited program were quite disappointing, since developable groundwater was not found.

Because the South Fork area did not show potential for significant quantities of groundwater, the USGS then investigated other areas for groundwater. The limited time and budget allowed for an investigation of a small portion of the valley using surface geophysical methods only rather than test drilling. The data from these reports led USGS and AWSU to undertake the concentrated Task 1 Well Drilling Program for the middle of the Eagle River Valley. The program was developed to evaluate the groundwater potential of the Eagle River Valley on a scale much larger than any previous investigation. It was to be conducted along and between the USGS cross-valley geophysical lines, Lines A and B of Figure 1-3. The results of this drilling program are discussed in Chapter 3.

Chapter 3
TEST HOLE DRILLING

The Task 1 drilling program was designed to obtain an accurate description of the lithologic materials above bedrock and to aid the USGS by providing access for aquifer pumping tests and borehole geophysical logging and by facilitating sampling of groundwater quality.

Site access and necessary permits were obtained through the Municipality of Anchorage. Special cooperation by the land owners, Eklutna, Inc., and state permitting agencies allowed timely decisions regarding the execution of and changes in the direction of the drilling program.

DRILLING PROGRAM

CH2M HILL was authorized to begin the test hole drilling in July 1980 and subcontracted M-W Drilling, Inc., of Anchorage to supply the necessary drilling equipment and personnel to complete the task. Drilling did not begin until September 3, 1980. Delays resulted from site access problems caused by high streamflows and a desire to minimize the impact on the local environment caused by moving equipment and materials.

The original plan specified that in the first phase of the drilling program, Schedule A, 12 wells were to be drilled at sites along the two cross-valley traverses, which were previously identified by the USGS. These cross-valley traverses are shown as Lines A and B on Figure 1-3 and are within the Upstream Study Area of the drilling program. Two other areas of study are identified in the figure: the South Fork Study Area and Downstream Study Area.

Initial drilling began on Line B. Two percussion rigs (cable-tool) were used because they produce good formation samples and are lighter than truck-mounted air-rotary-type rigs. The lighter rigs have a minimal impact on the environment.

Six-inch and eight-inch steel casings were driven as drilling progressed. Eight-inch casing was used in the upper portion of Test Well Nos. 1 and 2 because these holes were expected to exceed 300 feet in depth. Telescoping 6-inch casing through the already installed 8-inch casing would allow the continuation of the holes to total depth. This system reduces the difficulty of driving casing at greater depths.

Schedule A focused on the drilling of 8-inch- and 6-inch-diameter test holes to identify potential aquifer zones. Cuttings were examined, and if the cuttings had indicated a potential aquifer, drive samples would have been collected to more accurately define

aquifer zones and materials. If any zones had been identified as having potential for significant water production (several feet of permeable sands and gravels), they would have been pump tested. Individual zones would have been screened using the "casing pull-back" method and pump tested.

The sequence of events and the findings of each hole drilled are described in the following paragraphs (see Figure 1-3 for the locations of the individual test wells).

Test Well No. 1

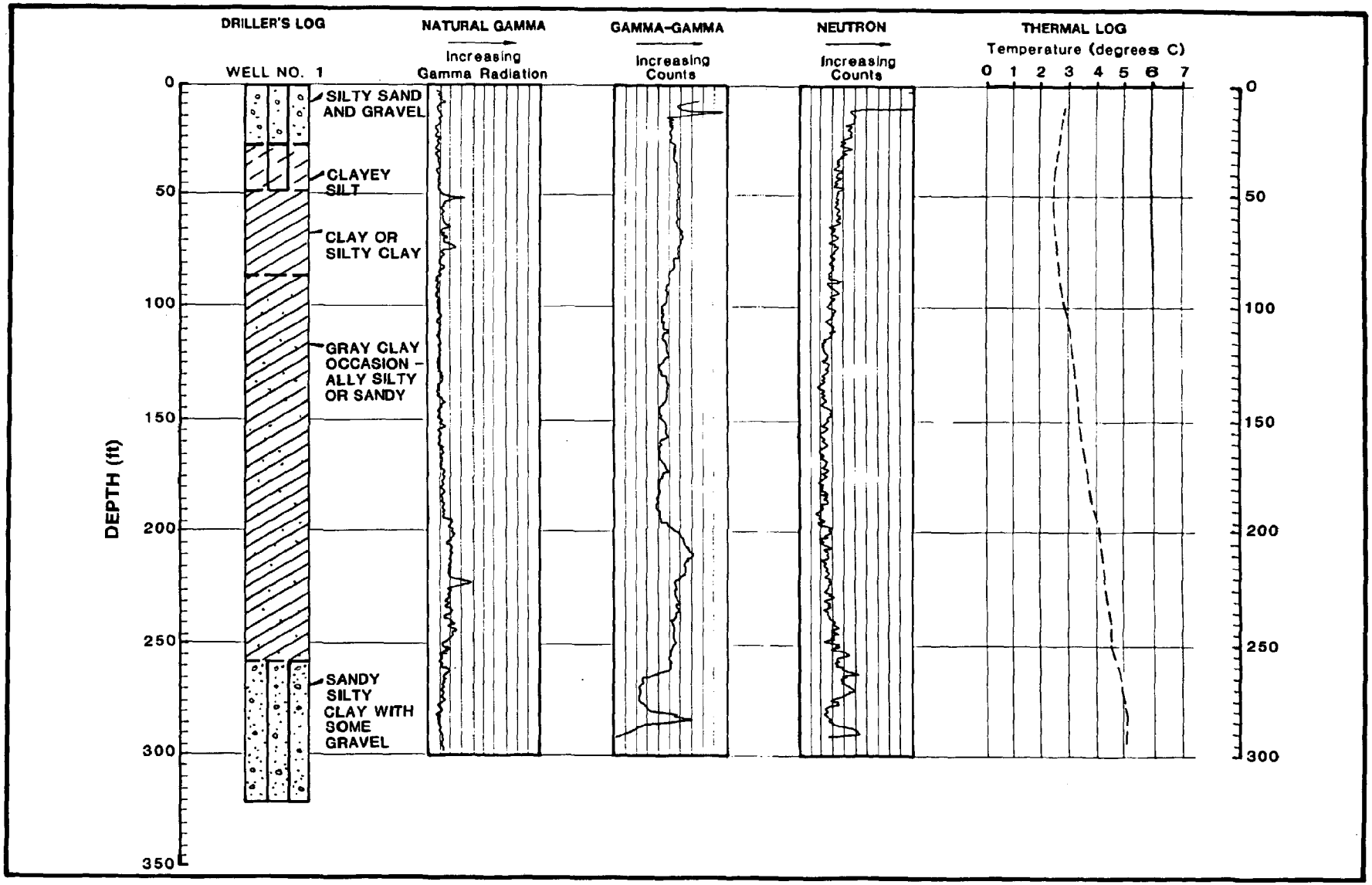
The drilling of Test Well No. 1 along Line B began on September 3, 1980. One hundred ninety-nine feet of 8-inch casing was installed; the boring was then reduced to 6-inch diameter. The drilling was terminated at a depth of 314 feet on September 22, 1980, when the casing could not be driven any further. Metal cuttings that were retrieved along with rock chips showed that the casing had bent and perhaps a large boulder or bedrock had been reached. It was decided, with the approval of the AWSU and USGS, to leave Test Well No. 1 uncompleted at 314 feet.

The decision included the possibility of returning to the site and continuing to drill if the other test holes along Line B encountered bedrock or potential aquifers at a depth greater than 315 feet. Subsequent completion of nearby Test Well No. 2 at 765 feet indicated that the rock chips retrieved at a depth of 314 feet in Test Well No. 1 were probably from a glacial till boulder rather than from bedrock. However, because no promising aquifers were found elsewhere, Test Well No. 1 was not continued to bedrock, as had been planned.

The sediments encountered in Test Well No. 1 were predominately low permeability silts and clays. Gravelly and sandy horizons were thin and rarely encountered, and those that were encountered had low permeability silts and clays as matrix. The sediments at this site have little potential for storage and transmission of groundwater (see Figure 3-1).

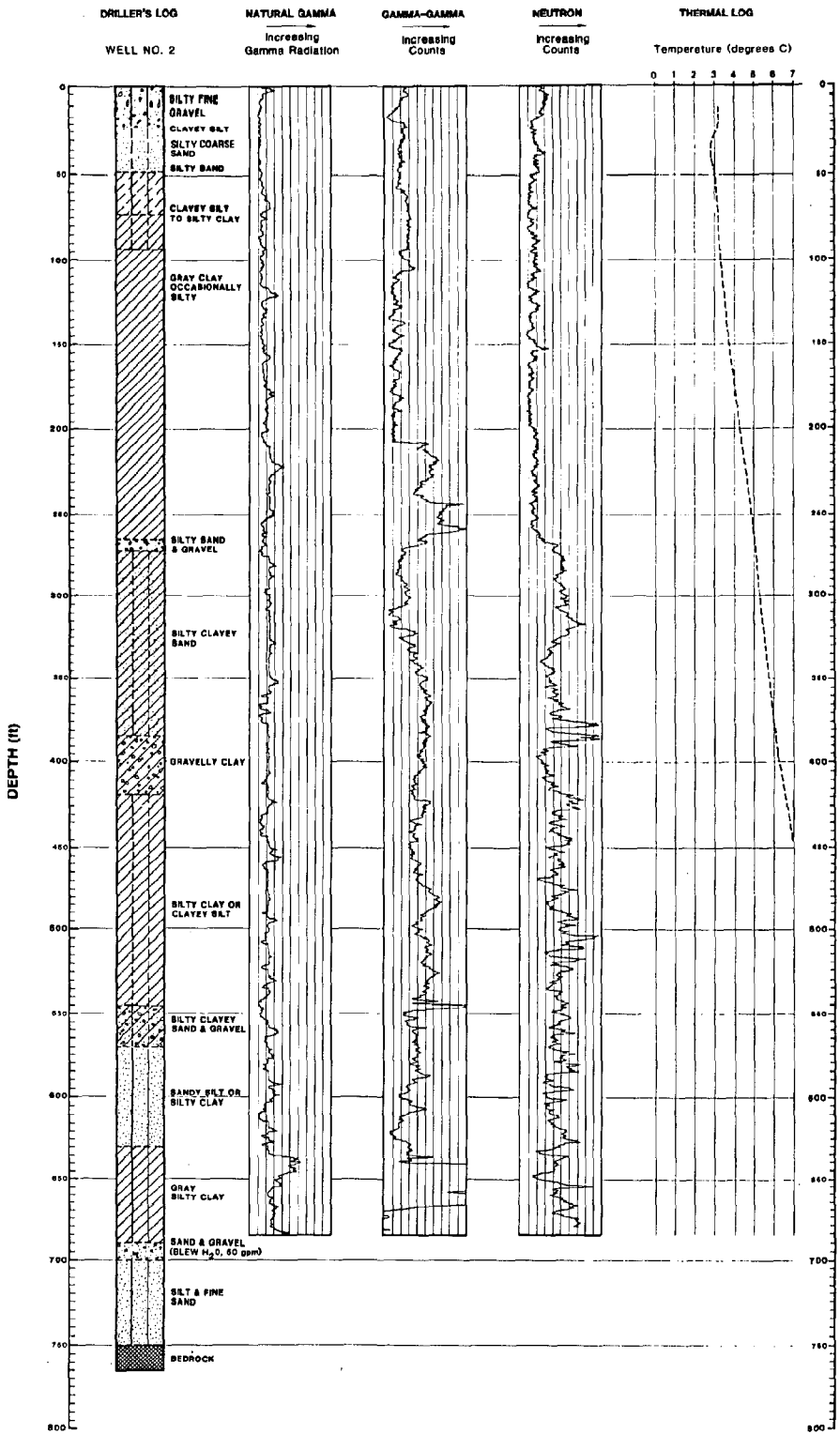
Test Well No. 2

The drilling of Test Well No. 2 on Line B by a cable-tool rig began on September 5, 1980. Eight-inch casing was installed to approximately 208 feet, and 6-inch casing was installed to 634 feet. In mid-October progress was stopped at 634 feet because the casing could not be driven further. Drilling was resumed on March 17, 1981, with an air-rotary rig. Revert mud was used to complete the open hole to a depth of 765 feet. Bedrock was encountered at 750 feet. The sediments and lithologic sequence encountered at Test Well No. 2 were similar to those encountered at Test Well No. 1. Thick sequences of silts and clays predominated the material above bedrock (see Figure 3-2). No significant aquifer material was encountered that warranted pump testing.



SOURCE: Geophysical Logging: U.S. Geological Survey
Thermal Log: Geothermal Surveys, Inc.

Figure 3-1
CH2M HILL Test Well No. 1
Boring and Geophysical Logs



SOURCE: Geophysical Logging: U.S. Geological Survey
Thermal Log: Geothermal Surveys, Inc.

Figure 3-2
CH2M HILL Test Well No. 2
Boring and Geophysical Logs

Test Well No. 3

The drilling of Test Well No. 3 on Line B by a cable-tool rig began on September 25, 1980, and was completed on October 3, 1980. Well No. 3 was completed entirely with 6-inch-diameter casing. The drilling was terminated at approximately 350 feet, prior to encountering bedrock, because the lithology encountered was similar to that found in Test Well Nos. 1 and 2. These test wells were dominated by thick sequences of low permeability silts and clays that are unsuitable for test pumping or development (see Figure 3-3).

Test Well No. 4

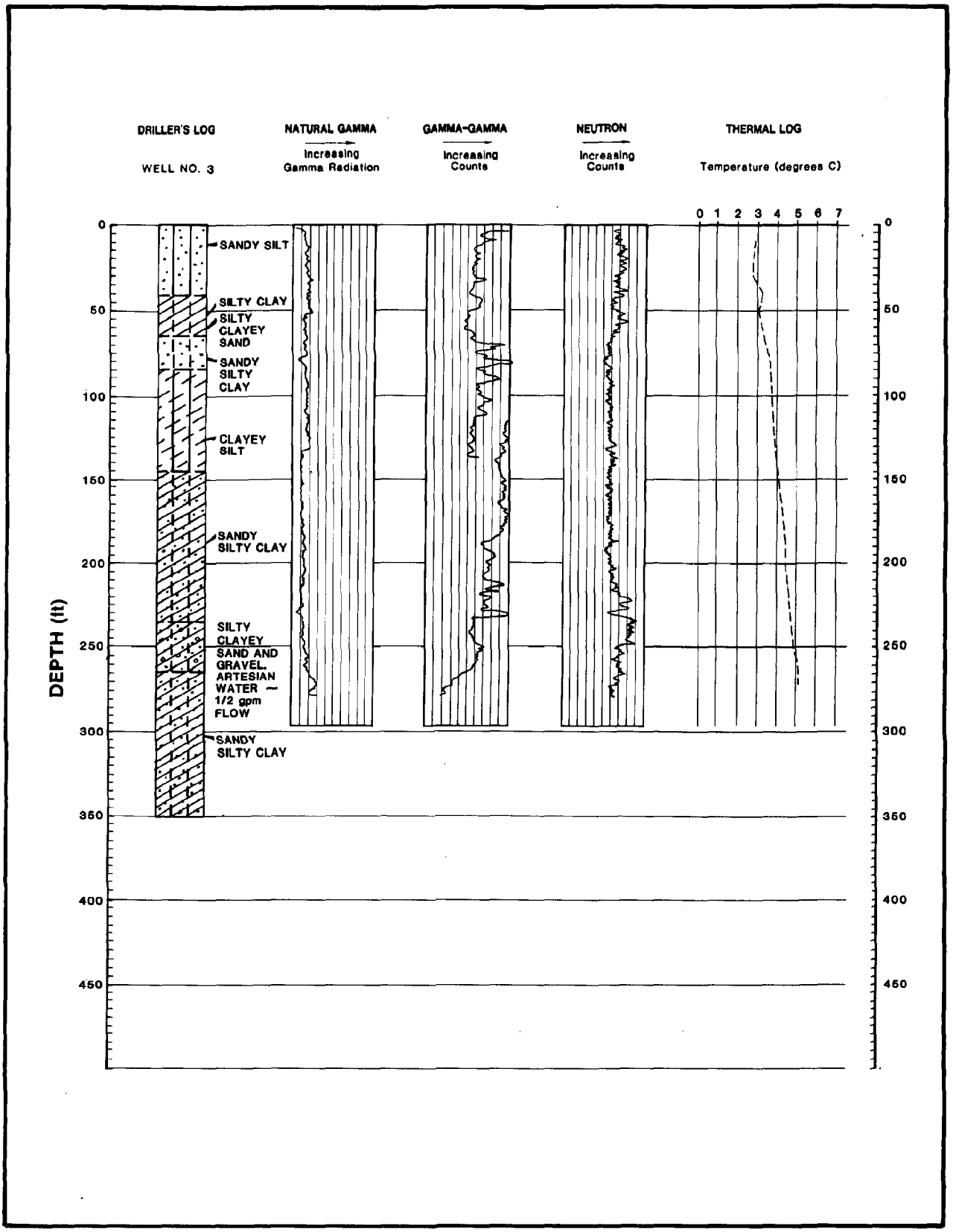
Test Well No. 4 on Line B was drilled by a cable-tool rig near the south boundary of the valley. This well completed the drilling necessary for a valley cross section along Line B. Drilling began on October 6, 1980, and was completed on October 8, 1980. Drillling was terminated at approximately 130 feet because the lithology correlated with the low groundwater potential materials encountered in the other wells along this cross section (see Figure 3-4).

Test Well No. 5

The information gathered from the drilling of the four test holes along cross-valley traverse, Line B, indicates extensive lake deposits, and it was concluded that the potential for encountering significant water-bearing horizons along Line A also was very small (Figure 3-5). The environment for deposition of the low permeability clays and silts encountered in Test Well Nos. 1 through 4 on Line B can be extrapolated throughout much of the Eagle River Valley. The same conditions almost certainly existed upstream, beyond Line A. A deep glacial lake probably extended throughout a significant portion of the Eagle River Valley. Because groundwater potential along Line A was considered low, it was recommended that supplemental surface geophysical work be done in the valley to assess the potential along Line A prior to drilling.

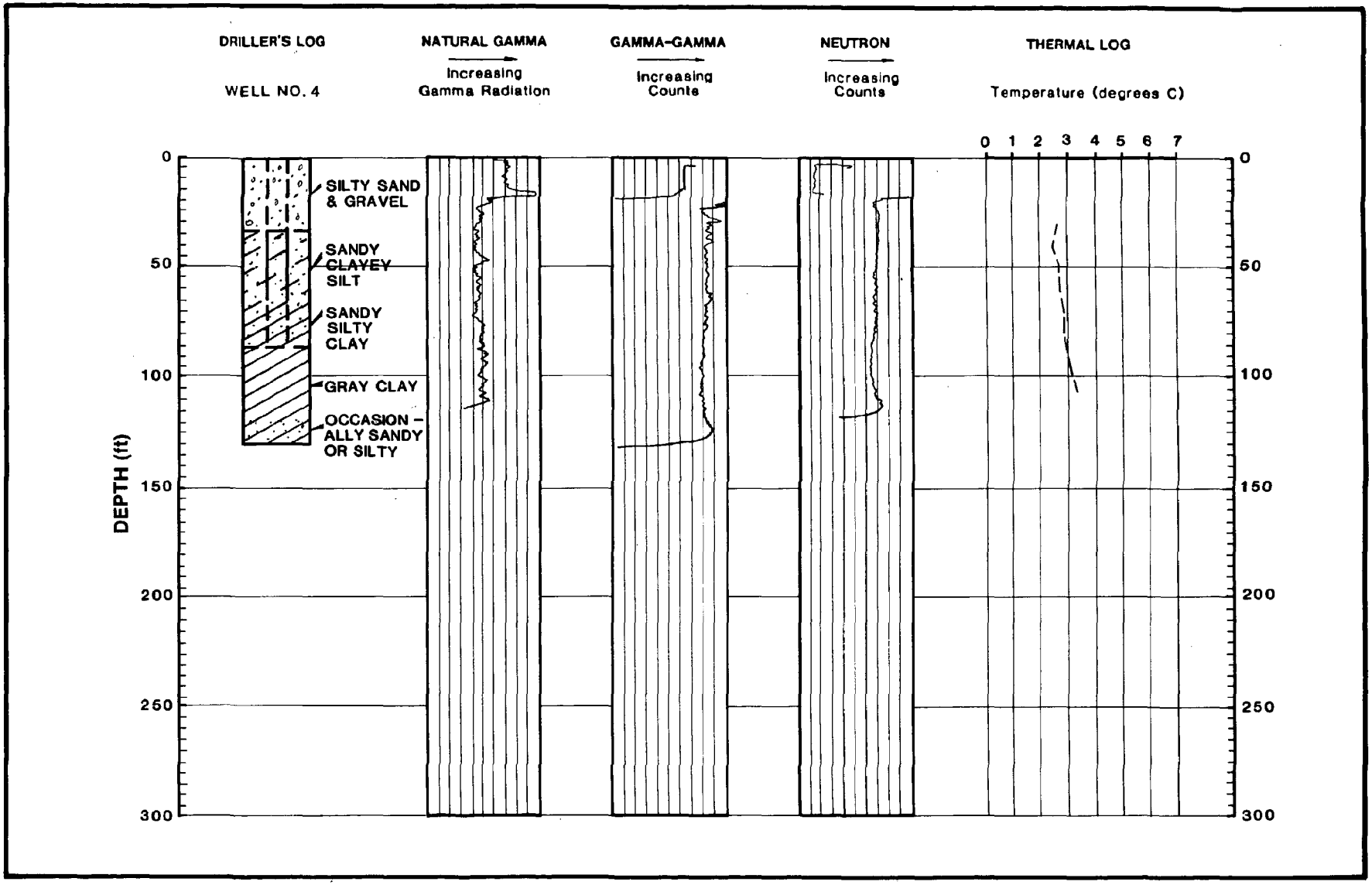
A thermal survey was conducted by Geothermal Surveys, Inc. (GSI). This survey indicated that Line A was not "particularly promising" as having significant groundwater flow beneath the site. However, because the AWSU wanted to ensure that no sizable groundwater source existed in this area, a test hole was drilled along Line A. One of the thermal holes along Profile A (No. 5) indicated the best groundwater potential and was selected to be the site for Test Well No. 5, which was drilled with a cable-tool rig.

Test Well No. 5 also encountered low permeability silts and clays similar to those found at the sites of Test Well Nos. 1 through 4



SOURCE: Geophysical Logging: U.S. Geological Survey
Thermal Log: Geothermal Surveys, Inc.

Figure 3-3
CH2M HILL Test Well No. 3
Boring and Geophysical Logs



SOURCE: Geophysical Logging: U.S. Geological Survey
Thermal Log: Geothermal Surveys, Inc.

Figure 3-4
CH2M HILL Test Well No. 4
Boring and Geophysical Logs

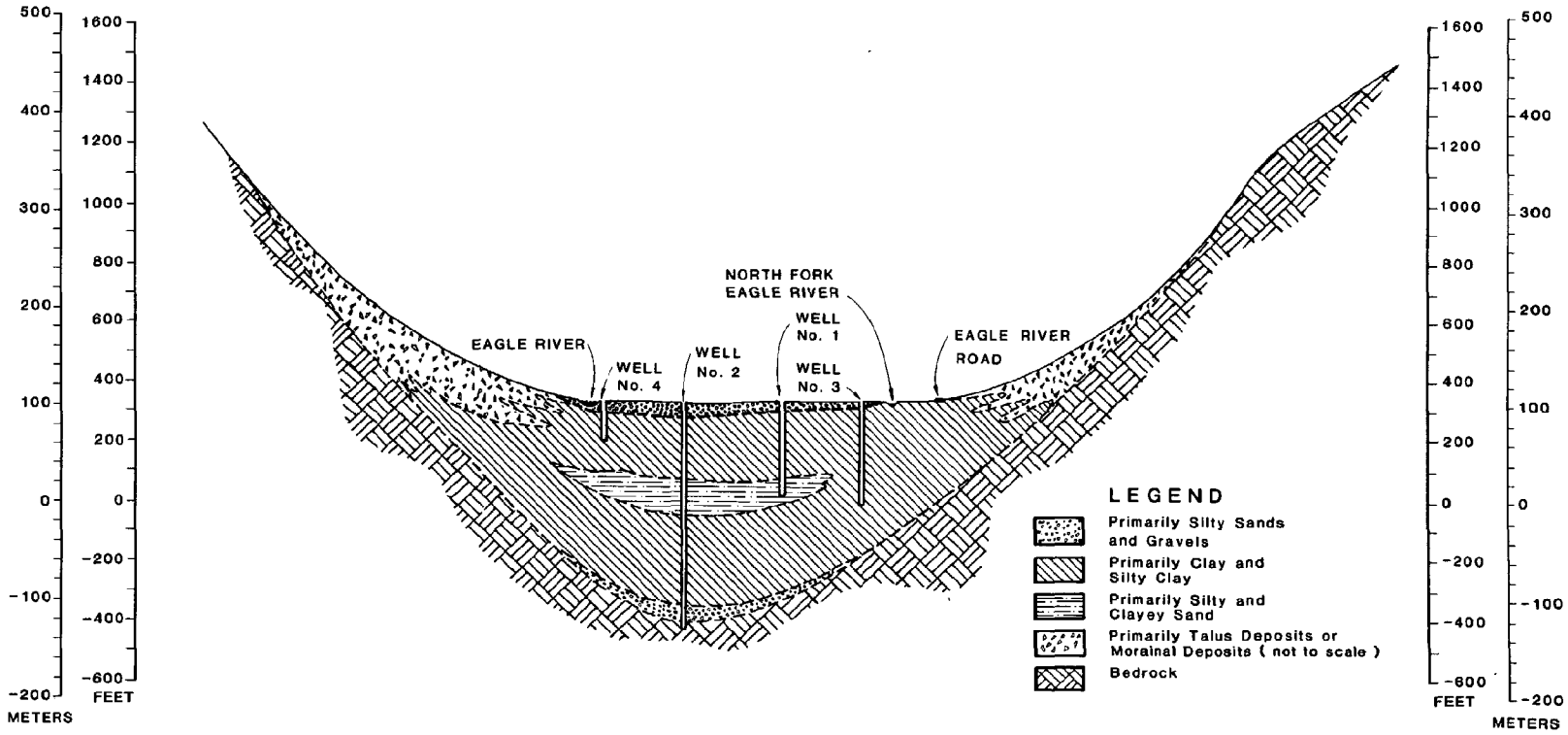


Figure 3-5
Middle Eagle River Valley
Geologic Cross Section

(Figure 3-6). The drilling of Test Well No. 5 was halted at a depth of 305 feet because the possibility of encountering a potential aquifer was considered remote. The drilling program was discontinued in the Upstream Study Area after Test Well No. 5 was abandoned.

Based on the data collected from the drilling of the first five test holes, the groundwater potential in the Upstream Study Area is not adequate for potential municipal water supply.

EXPLORATION AND EXAMINATION OF ALTERNATIVES

Geophysical Survey

Under the direction of CH2M HILL, GSI reassessed the existing geophysical data and proposed to do additional thermal sensing in the Eagle River Valley. GSI concluded that a "very accurate thermal loop" of the existing four test holes and a surface thermal grid of Line A and of the outwash deposits along Line C would be beneficial in locating additional drill sites. To conduct the borehole thermal survey, the following field work was required: down-hole temperature profiles were run both in the four test holes drilled for CH2M HILL along Line B and, for a background comparison, in an existing well down-valley at the Eagle River Campground.

Also, shallow surface thermal profiles, which consisted of monitoring ground temperatures from depths of approximately 10 feet below surface, required the drilling of 22 10-foot-deep holes along three valley profiles. Two of the three profiles coincided with Lines A and B. Profile C was run down-valley below the confluence of Eagle River and the South Fork at Line C (see Figure 1-3). GSI completed its field work the last week of November 1980.

Line C had temperatures and temperature drift that indicated a potential for groundwater. Probe sites C-1 and C-2 were chosen as having the greatest potential for groundwater flow beneath the site.

Test Well No. 6

Site C-2 was chosen as Test Well Site No. 6 at GSI's recommendation. Drilling at Site No. 6 began January 2, 1981, and was completed January 12, 1981. Test Well No. 6, drilled by the air-rotary method, encountered what appeared to be bedrock at 135 feet below ground surface. This is about 25 feet below the level of the river. The anticipated depth to bedrock, based on logs from nearby wells and on geophysical work, had been more than 300 feet. The drilling of the well continued to a depth of 160 feet, still in what proved to be bedrock. Drilling was discontinued at 160 feet. No potential aquifers were encountered (see Figure 3-7).

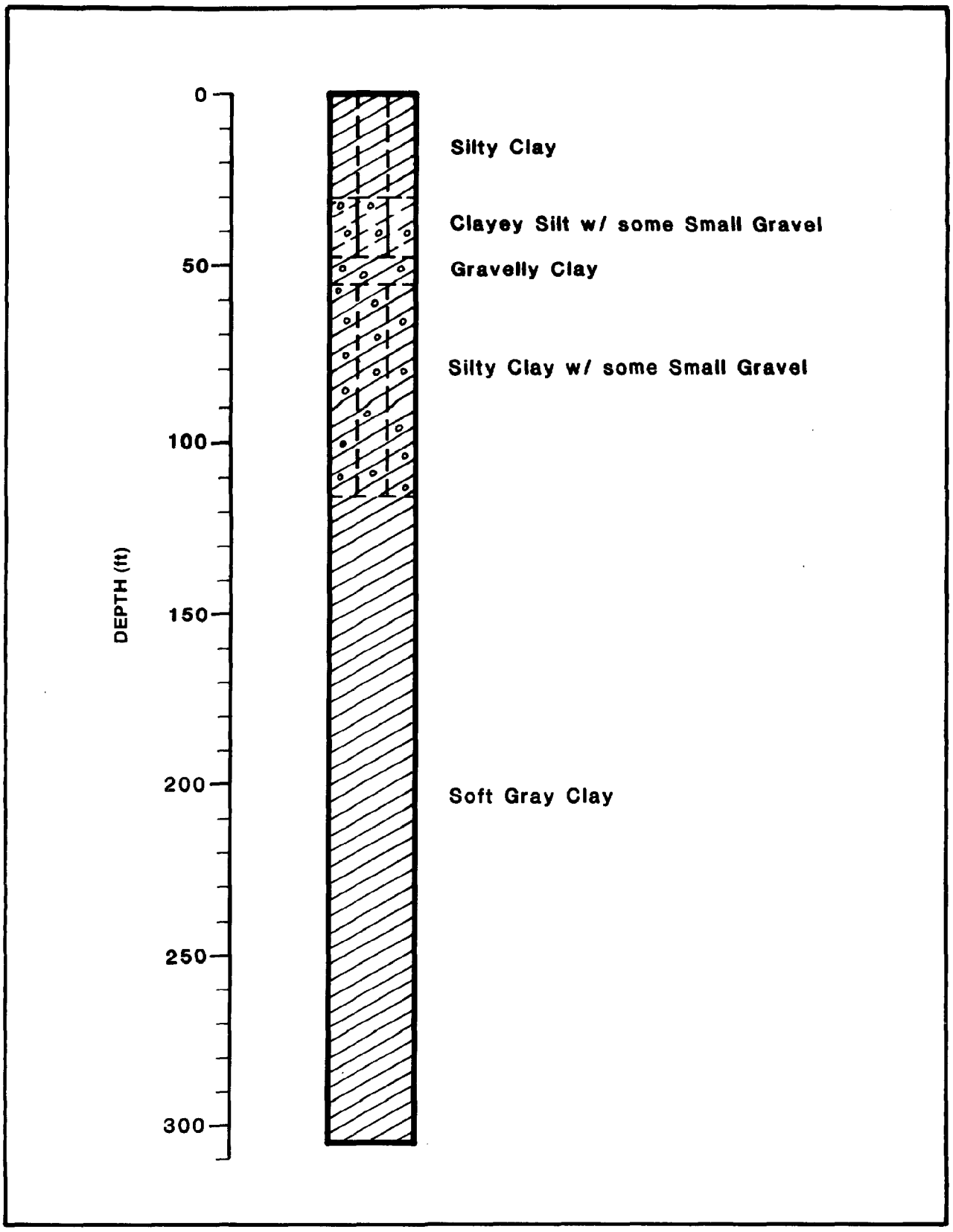


Figure 3-6
CH2M HILL Test Well No. 5
Boring Log

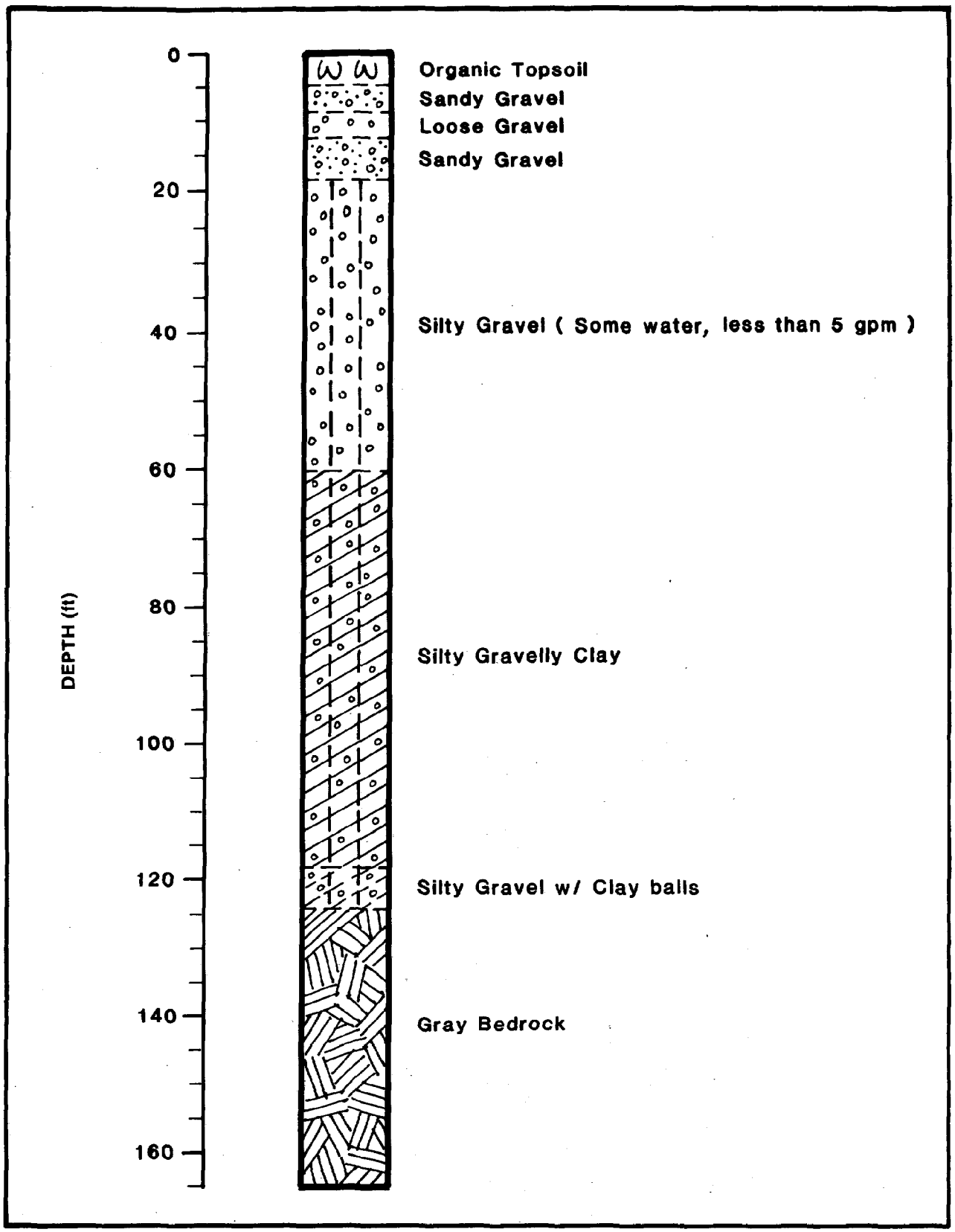


Figure 3-7
CH2M HILL Test Well No. 6
Boring Log

This finding of shallow bedrock and no aquifer material resulted in a reassessment of the groundwater exploration program. GSI, after reviewing the shallow bedrock data from Test Well No. 6, submitted a preliminary draft report that indicated data originally thought to be anomalous or incorrect (a high temperature drift) was actually correct. High drift in temperature over a short period of time is normally the result of shallow bedrock.

The GSI report included a geologic interpretation of the occurrence of shallow bedrock at the Test Well No. 6 site. Based on field visits, air photos, and nearby well logs, the shallow bedrock appears to be the result of a ridge formed as the main glacier bifurcated and gouged around a postulated bedrock knob in the vicinity of Test Well No. 6. According to GSI, the effects of such a ridge would be the erosion of areas on either side of the ridge and subsequent deposition of outwash gravels in the eroded channels. Evidence from Thermal Probe C-1 indicated a potential for groundwater flow in the location of an anticipated outwash channel south of Test Well No. 6. The groundwater potential suggested by the thermal survey at C-1 resulted in the drilling of Test Well No. 8.

Test Well No. 8

The air-rotary drilling rig began drilling Test Well No. 8 at the C-1 location on March 25, 1981. Drilling was completed on March 26, 1981, at 88 feet; bedrock was encountered at a depth of 74 feet. This bedrock level is about 25 feet below the level of the river, as encountered in Test Well No. 6. With the exception of a 5-foot sand and gravel zone between 69 and 74 feet, the subsurface materials consisted of low permeability silts and clays. The 5-foot-thick sand and gravel zone between 69 and 74 feet was too thin to justify further investigation as a source of large-volume water supply and was not pump tested (see Figure 3-8).

Shallow Groundwater Potential

To develop a shallow groundwater supply system, the subsurface materials need to be well-sorted sands and gravels in hydraulic communication with the river. The capacity and duration of a shallow groundwater supply system is also dependent upon its areal extent. Assuming a 3-month duration of use during low-flow winter months at a demand of 70 mgd, a 20-square-mile area with a minimum of 30 feet of sand and gravel would be required. This estimate assumes a specific yield of 5 percent. A larger specific yield would reduce the required land area. Some additional thickness also would be required to make up for the extraction system characteristics and the freezing of surface and near-surface materials.

Substantial recharge of the shallow surface materials cannot be assumed during low-flow winter months. Recharge could affect

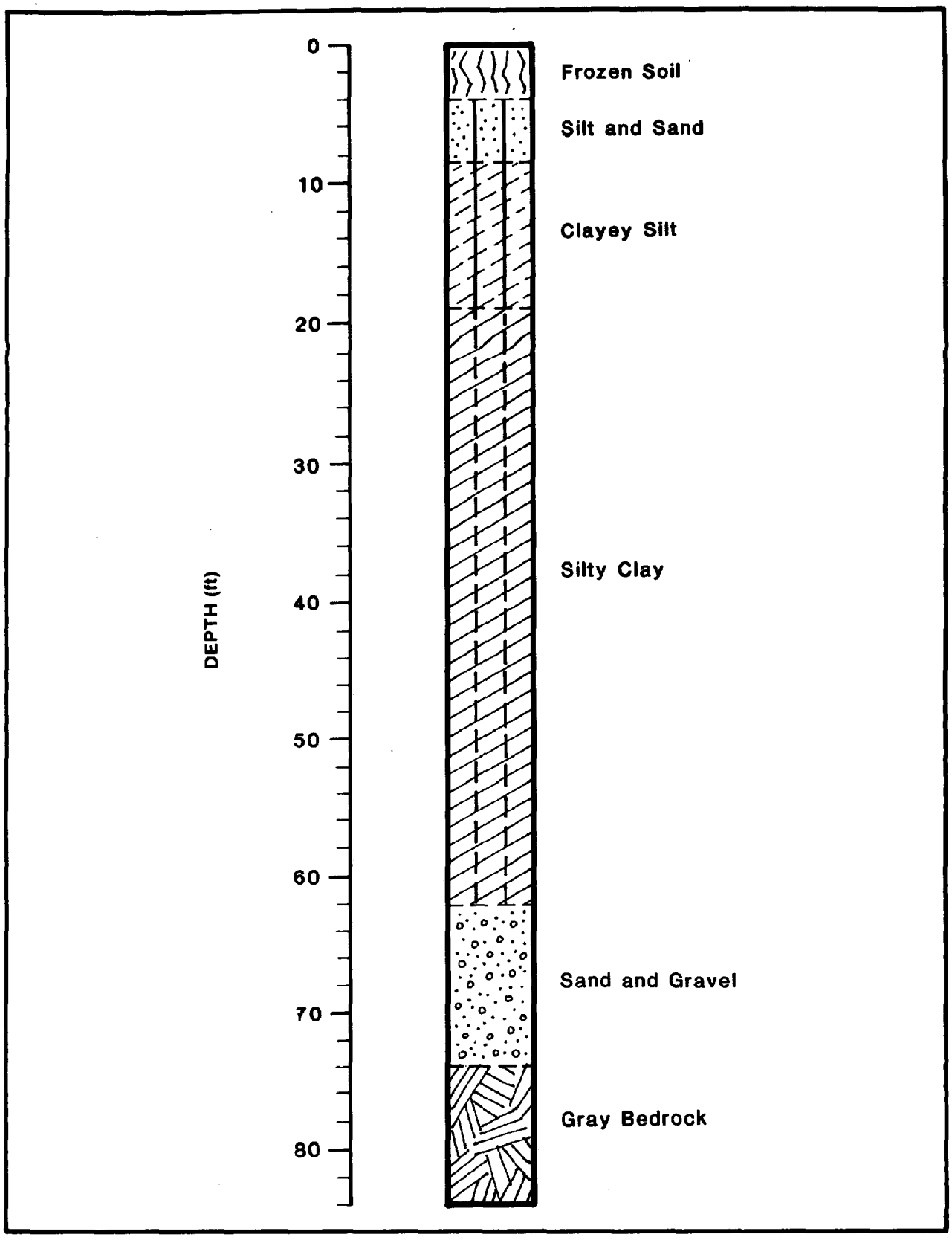


Figure 3-8
CH2M HILL Test Well No. 8
Boring Log

the existing fisheries. The impact on fisheries was addressed in a letter from the State of Alaska Department of Fish and Game (concerning a dam on Eagle River--See Appendix II, Preliminary Damsite Investigation). This letter had the following comments:

- o If no significant fisheries are found below the damsite, a minimum river flow of 20 mgd will have to be maintained. Studies may prove that larger minimum river flows are required to protect existing fisheries.

- o Changes in water surface on the North Fork of Eagle River could affect anadromous fish spawning habitat.

Recharge of shallow subsurface materials during the low-flow winter months could reduce the downstream river flows significantly and also affect the level of water in North Fork and the mouth of South Fork. This would affect the fisheries.

Table 3-1 is a compilation of land area requirements for various demands and specific yields.

Table 3-1
LAND AREA REQUIRED FOR SHALLOW GROUNDWATER SUPPLY
(30 Feet of Drainable Gravel)

Specific Yield (%)	Area Required (sq mi) 47-mgd Demand	70-mgd Demand
5	13.5	20.1
10	6.8	10.0

A subconsultant, Ranney Method Western Corporation, reviewed the borehole information from this Task 1 program, previous reports, and other data relative to development of shallow groundwater in the Eagle River Valley. (The Ranney report is included as an exhibit to this appendix.) Ranney concluded that the lower portion of the Eagle River Valley, beginning at the South Fork alluvial fan and extending downstream to the Glenn Highway bridge, was potentially suitable for the development of a shallow groundwater supply. Specifically, the report recommended further test drilling and test pumping in the South Fork alluvial fan and at selected sites downstream to the Glenn Highway bridge.

This recommendation was used in the selection of Test Well No. 7, near the Eagle River on the alluvial fan of the South Fork, and in the selection of Test Well No. 8, near the proposed damsite location. Test Well No. 8 was described in a previous section of this chapter.

Test Well No. 7

Test Well No. 7 was drilled with a cable-tool rig on March 24-25, 1981. This well was located near the TNH and the MAUS-USGS wells to confirm the reported presence of significant quantities of shallow groundwater. Shallow groundwater should be less available in March than in the summer and fall. Therefore, this drilling would confirm if a year-round shallow groundwater supply is available and if induced infiltration is possible from Eagle River. Drilling was terminated at a depth of 50 feet after encountering very little water and 34 feet of clay (see Figure 3-9).

Braided Channels

A section of the Eagle River about three miles upstream of Line A consists of braided channels. This area was identified by AWSU as a potential shallow groundwater source. CH2M HILL and Ranney Method Western Corporation considered this area, but no test holes were drilled. Shallow groundwater is not expected to be developable from this area for the following reasons.

1. Sufficient pervious materials are not expected to exist in this area to provide sufficient storage for required demands (Table 3-1).

2. Low flows in this area will be less than those recorded at the stream gage, making storage requirements greater than those calculated for downstream areas.

3. Braided streams tend to change frequently, making consistent reliable recharge to the shallow aquifer dependent on changing stream patterns. The success of a collector well is in direct relation to its distance from the stream from which the collector induces infiltration.

4. This area is eleven miles from the Glenn Highway and the cost per gallon to deliver water to the Municipality is expected to be high.

Additionally, the water may require treatment because of the small particle size of glacial flour, which could allow the flour to move through the formation. Ninety percent of the particles are smaller than 2 microns (a micron is one-millionth of a meter), 13 percent smaller than 0.5 micron.

SUMMARY

Table 3-2 summarizes the drilling program.

In general, no developable aquifers were found in the eight test wells drilled.

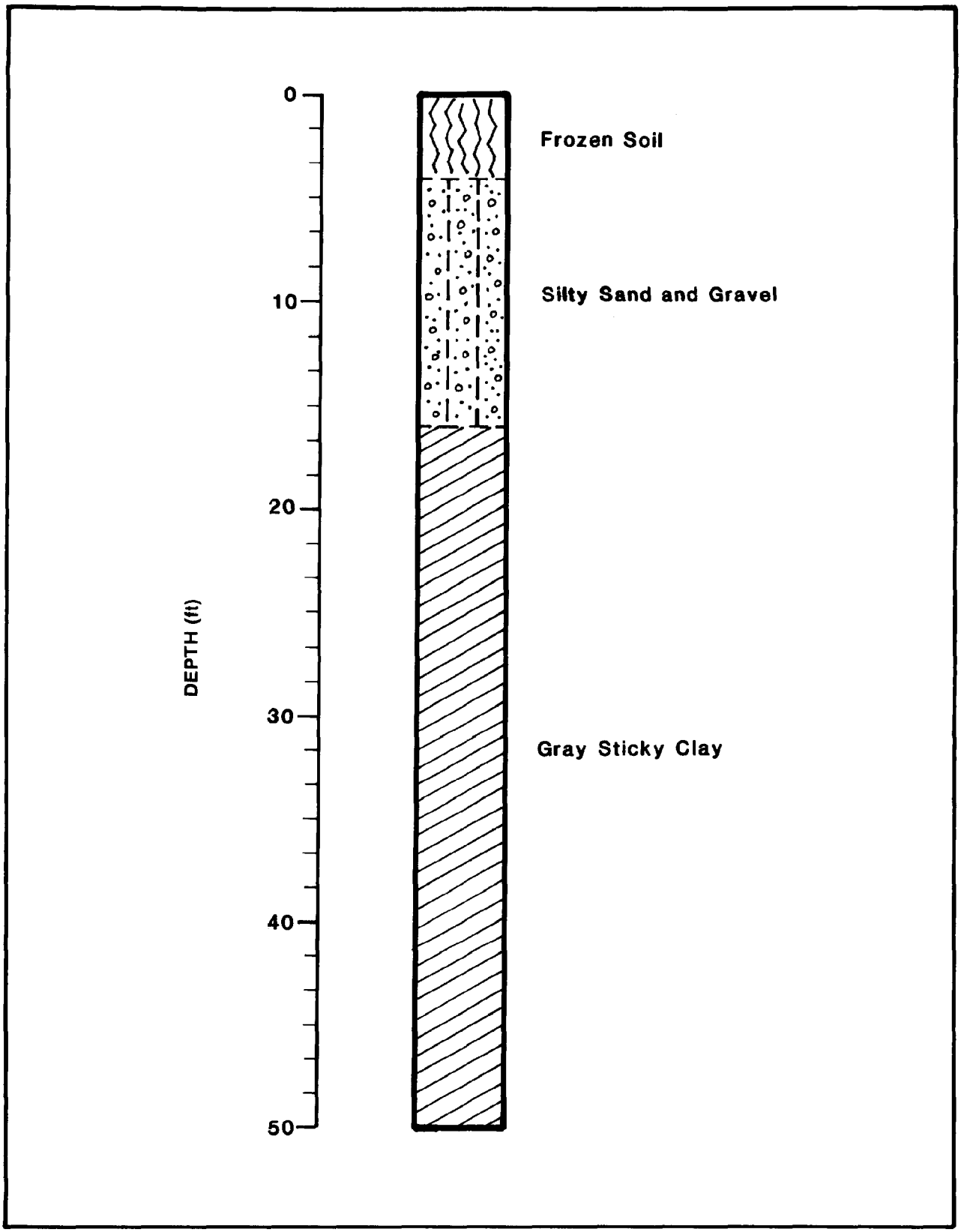


Figure 3-9
CH2M HILL Test Well No. 7
Boring Log

Table 3-2
TEST WELL DATA

Well No.	Location[a]	Depth of Well	Depth to Bedrock	Aquifers
1	Upstream Study Area	314[b]		Poor or None Found
2	Upstream Study Area	765	750	Poor or None Found
3	Upstream Study Area	350		Poor or None Found
4	Upstream Study Area	130		Poor or None Found
5	Upstream Study Area	305		Poor or None Found
6	Downstream Study Area	160	130	Poor or None Found
7	South Fork Study Area	50		Poor or None Found
8	Downstream Study Area	88	74	Fair

[a] See Figure 1-3.

[b] Depth at which glacial till boulder was encountered.

The four wells across the middle valley along Line B provided data that indicate this portion of the valley was formed by the backfilling of a deep glacial lake with fine sediments. These sediments provide low potential for groundwater development. Bedrock is very deep. Test Well No. 2 was drilled into bedrock at a depth of 750 feet. Some silty clays and gravels were found over the bedrock, but not in quantities sufficient for development.

Test Well No. 5 (Figure 1-3, Line A, upstream of Line B) and Test Well No. 7 (near the mouth of the South Fork, downstream of Line B) confirmed that the backfilled glacial lake extended throughout much of the valley.

Test Wells No. 6 and 8 were drilled several miles downstream of the middle valley as a result of additional field work and data analysis. Outwash channels were expected in this area. Both of these wells hit bedrock at a depth of about 25 feet below the

level of the nearby river channel. Little water-bearing material was found over the bedrock and no aquifer pumping tests were performed.

No areas were found that would justify development of an induced infiltration system. The drilling program was stopped because the data from the eight test wells were sufficient to conclude that aquifers in the Eagle River Valley are not sufficient to meet the Municipality of Anchorage's future demands.

Chapter 4
RECOMMENDATIONS

The following recommendations for groundwater development in the Eagle River Valley are made as a result of the Task 1 Well Drilling Program:

- o Abandon the prospect of developing groundwater in the Eagle River Valley as a source to help meet the Municipality of Anchorage's future demands.

- o If smaller demands in the immediate area require a nearby groundwater source, investigate the outwash channels that may exist in the lower Eagle River Valley.

The second recommendation is based on the assumption that glacial outwash channels do exist and should yield moderate volumes of water. However, this area can be compared geologically to the Meadow Creek fan area (R&M Consultants, Inc., 1979) and although individual wells may be capable of significant production, the geologic conditions are such that total production from several wells might be limited.

Additionally, shallow bedrock lies upstream and downstream of the Eagle River Campground. Shallow bedrock and low permeability silts and clays were found upstream of the proposed damsite (Figure 1-3, Line C). A bedrock outcrop exists in the river at the upstream end of the campground. Downstream of the campground at the Glenn Highway bridge, bedrock is very shallow (see attached exhibit). Shallow bedrock can limit the amount of water that is available. Therefore, the availability of groundwater may be limited in the lower Eagle River Valley.

Chapter 5
BIBLIOGRAPHY

Anchorage Water Sources. Prepared for the Anchorage Water Utility and the Central Alaska Utilities. Anchorage, Alaska: Tryck, Nyman & Hayes; Dames & Moore; and Leeds, Hill & Jewett, Inc. 1973.

The Eagle River Community Water Supply and Distribution Plan. Prepared for Alaska Department of Environmental Conservation. Anchorage, Alaska: Quadra Engineering, Inc. 1977.

Eagle River Water Supply Study, Meadow Creek Area, Alaska, Final Report. Prepared for the State of Alaska, Department of Environmental Conservation. Anchorage, Alaska: R&M Consultants, Inc. 1979.

Preliminary Engineering Report, Eagle River Project, Anchorage, Alaska. Prepared for the City of Anchorage Municipal Light and Power Utility. Anchorage, Alaska: R.W. Retherford Associates and Adams, Corthell, Lee, Wince and Associates. Federal Power Commission Project No. 2045. 1966.

U.S. Army Corps of Engineers, Alaska District, in conjunction with the Municipality of Anchorage. Metropolitan Anchorage Urban Study, Volume 2, Water Supply. 1979.

U.S. Geological Survey. Geology and Ground Water for Land Use Planning in the Eagle River-Chugiak Area, Alaska. Open File Report 74-57. Prepared for the Greater Anchorage Area Borough by C. Zenone, H.R. Schmoll, and E. Dobrovolny. Denver, Colorado (published by the Anchorage Area Borough). 1974.

U.S. Geological Survey. Ground Water Investigation at the Alluvial Fan of the South Fork Eagle River, Anchorage, Alaska - Results of Test Drilling, 1976. Open File Report 77-493 for the Municipality of Anchorage. 1977.

U.S. Geological Survey. Surficial Geophysical Data for Two Cross-Valley Lines in the Middle Eagle River Valley, Alaska. Open File Report 80-2000. Prepared in cooperation with the Municipality of Anchorage by Larry Dearborn and Donald H. Schaefer. 1981.

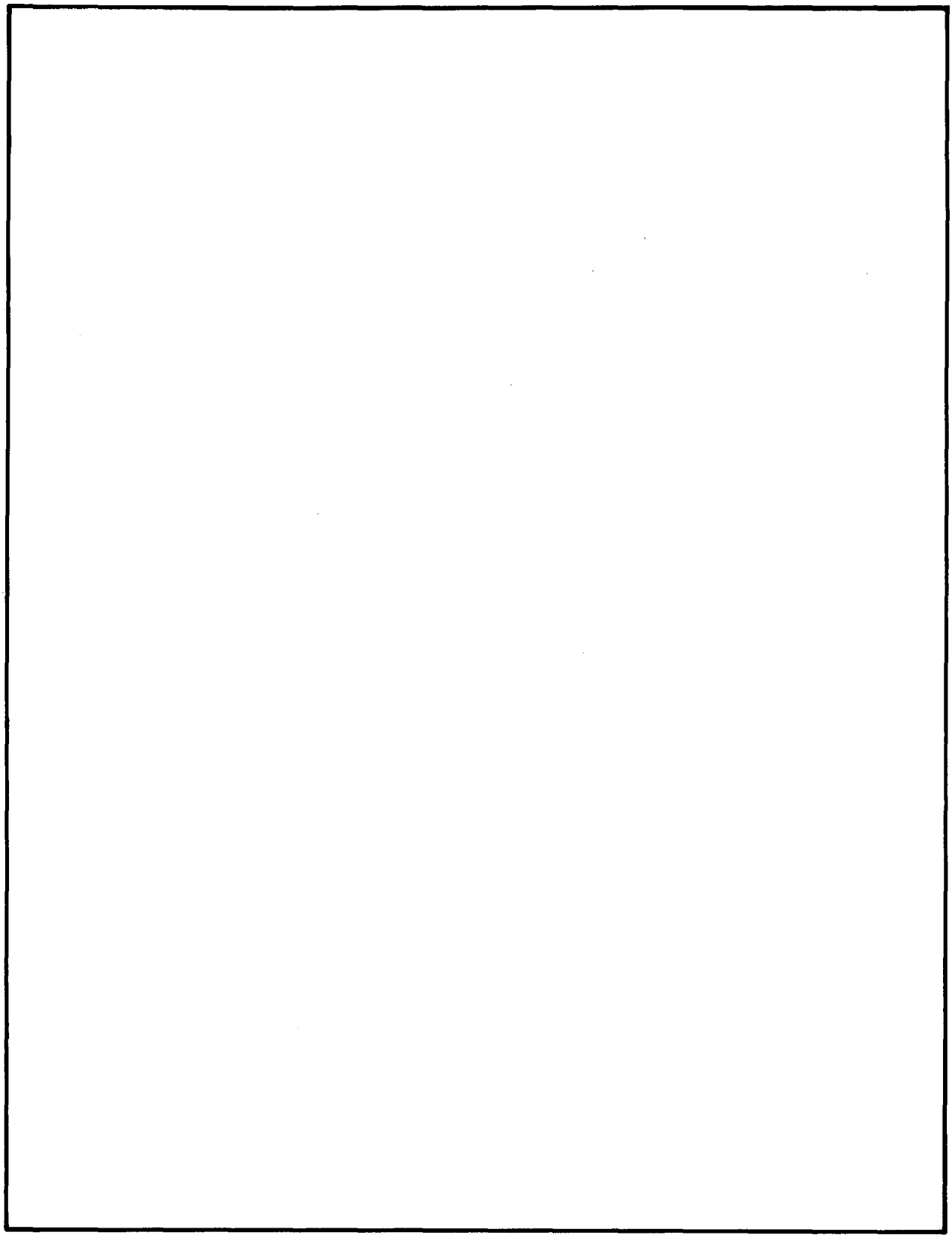


Exhibit
Ranney Method Western Corporation Report

RANNEY METHOD WESTERN CORPORATION

RANNEY METHOD

WATER SUPPLY ENGINEERS AND CONTRACTORS

RANNEY COLLECTORS
SURFACE WATER INTAKES
ARTIFICIAL RECHARGING
CONSTRUCTION DEWATERING

P. O. BOX 6387
KENNEWICK, WASHINGTON 99336
TELEPHONE: (509) 586-6447

March 9, 1981

CH2M Hill
P.O. Box 2088
Redding, California 96099

COPY

Attention: Mr. Ramond L. Moresco
Chief Hydrogeologist

Re: Municipality of Anchorage, Alaska
- Eagle River Shallow Ground-Water Study

Gentlemen:

We have reviewed the existing information, reports and data recently transmitted to us and are setting forth our preliminary evaluation and recommendations regarding the development of a shallow ground-water supply from the alluvial deposits adjacent to and underlying the Eagle River.

(1) Location and Hydrogeology:

The locations of existing wells and test holes within the study area are shown on the Location Map in Figure SW-95-P1 and the upper portions of their logs are given in Figure SW-95-P2. In general, the lower valley of the Eagle River is underlain by shallow deposits of sands, gravels, cobbles and/or boulders, extending from ground surface to a maximum observed depth of about 50 feet. These sand and gravel deposits are quite variable in character, containing clay zones at some wells and being described as "silty," at others. Underlying these shallow sands and gravels is a rather thick zone of impermeable material, generally described as grey silt or grey clayey silt. It is, of course, only the shallow deposits above this zone that are of interest for a shallow ground-water development.

It is probable that these shallow sands and gravels are in hydraulic contact with the Eagle River and that free interchange of water between the river and the aquifer occurs. Thus, a shallow ground-water development could rely upon a dependable source of recharge by induced infiltration from the river. The specific areas where geologic data are available are described in detail as follows.

(2) Eagle River (Ford) Campground:

This area is located along the South bank of the Eagle River just upstream from the Glenn Highway bridge. Bridge borings at the Glenn Highway bridge encountered bedrock, described as claystone, at depths of only 4 to 6 feet below ground level (1 to 6 feet below river level). However, three wells drilled by the State of Alaska in the Eagle River Campground (Wells 14-3, 14-4, and 14-5) showed bedrock occurring at depths of 47 and 107 feet. The logs of these wells show water-bearing sands, gravels and boulders extending to depths of 45 feet, with the most favorable material appearing to extend to a depth of 24 to 26 feet. The Quadra Engineering Inc. report describes two of these wells as follows: "Both wells are 30 to 35 feet deep and are producing 200 to 250 gallons per minute without substantial drawdown." Based upon the foregoing, it would appear that this area is potentially suitable for a shallow ground-water supply. It is noted, however, that bedrock outcrops in the riverbed at the upstream end of the campground, thereby limiting the area available for development.

(3) Proposed Damsite:

The proposed damsite is about 1 mile upstream from the Eagle River Campground. Retherford Test Hole 1 showed sand and gravels extending from ground surface to a depth of 49 feet, the materials encountered appearing to be somewhat similar to those encountered at the campground and therefore potentially suitable for development. However, CH2M Hill damsite boring B-5, located adjacent to the river and on the north bank, showed only 8 feet of silty sand and gravel underlain by silty sands, clay, and clayey gravels.

(4) South Fork Alluvial Fan:

In 1973, Tryck, Nyman & Hayes drilled a 6-inch diameter test hole, referred to as ERTH-2, to explore the materials underlying the South Fork Alluvial Fan. The log of this test hole revealed the existence of a shallow ground-water aquifer, extending from ground surface to a depth of 52 feet. The materials encountered consisted of silty sand, gravels and cobbles, with a silt free zone occurring from 33 to 42.5 feet. A slotted well screen was installed in the zone from 33 to 38 feet and the well was pumped continuously, at a constant rate of 350 gallons per minute, for a period of 24 hours. The drawdown stabilized at 11.3 feet after 5 hours of pumping. This is considered to be a highly favorable production for a 6-inch diameter well and would

indicate an aquifer having a moderately high permeability. If the aquifer is proven to be in hydraulic contact with the river, the probable yield of a single radial collector well (Ranney Collector) could be expected to be in the order of magnitude of 5 MGD.

A subsequent test hole drilled in 1976 by the USGS, referred to as ERTW-76, showed silts, sands and gravels extending from ground surface to a depth of 49 feet. However, a silt zone occurred in the interval from 30 to 48 feet, i.e., that zone which was indicated as being most productive at ERTH-2. Although the USGS test hole did not confirm the areal extend of the aquifer shown to exist at ERTH-2, the USGS report contains the added comment, "a surprisingly large yield (60 gal/min) was pumped from a 12-ft. deep, open-end casing beside the new test well, which suggests an abundance of very shallow ground water here."

The South Fork Alluvial Fan is considered to be the most favorable area encountered, based upon existing well data. Preliminary geologic mapping by the USGS shows that this alluvial fan has a width, along the river, of over 2000 feet. This would be sufficient distance for 4 to 5 radial collector wells (Ranney Collectors) or a potential yield of 20 to 25 MGD.

(5) CH2M Hill Lines B & A:

At Line B, Wells 4, 2 and 1 showed silty sands and gravel extending from ground surface to depth of 20 to 30 feet while Well 3 showed only sandy silt. Similarly, Well 5 on Line A did not show any shallow water-bearing materials, the materials encountered consisting of silty clays and clayey silts. It is concluded that this area is not suitable for the development of a shallow ground water supply.

(6) Summary and Recommendations:

Based upon the foregoing geologic data, it appears that the lower portion of the Eagle River Valley is potentially suitable for the development of a shallow ground-water supply, although present well data are insufficient to confirm the magnitude of such a development. Specifically, we recommend further test drilling and test pumping in the South Fork Alluvial Fan and at selected sites in the valley extending downstream from the alluvial fan to the Glenn Highway bridge.

This test drilling and test pumping program is generally outlined as follows:

a. The test holes should be a minimum of 8-inches in diameter and should be drilled with a cable tool rig using the "drive and bail" technique.

b. The test holes should be located as close as practicable to the Eagle River and carried to a depth of 50 feet or until the first significant layer of impermeable material is encountered.

c. Where water-bearing materials are encountered, small rate testing should be carried for preliminary (field kit) determinations of water quality.

d. An experienced hydrogeologist should be on the site throughout the test drilling program to select drilling sites, visually observe and log the test holes, and direct all drilling activities.

e. At sites selected from the results of the test drilling, detailed pumping tests should be conducted to determine the permeability of the aquifer, the infiltration rate of the river bed, and all other data necessary to the evaluation of the ground-water potential of the site.

f. As a minimum, each detailed pumping test should consist of the drilling of a 10 or 12-inch diameter pumping well, equipped with a suitable screen, and three 8-inch diameter observation wells. The pumping well will be pumped continuously, at a constant rate, for a period of at least 48 hours or until water levels have become sufficiently stabilized to make the neccessary hydraulic determinations. Water levels in observation wells and changes in river stage will be recorded continuously, by means of automatic water level recorders, throughout the test period. Near the end of the test, water samples will be collected for laboratory determinations of water quality.

We believe the testing program, as outlined above, will provide the data required for determining the feasibility of a shallow ground-water supply in the lower Eagle River Valley. If you have any questions or wish to discuss this program in further detail, please let us know. We are returning your reports under separate cover.

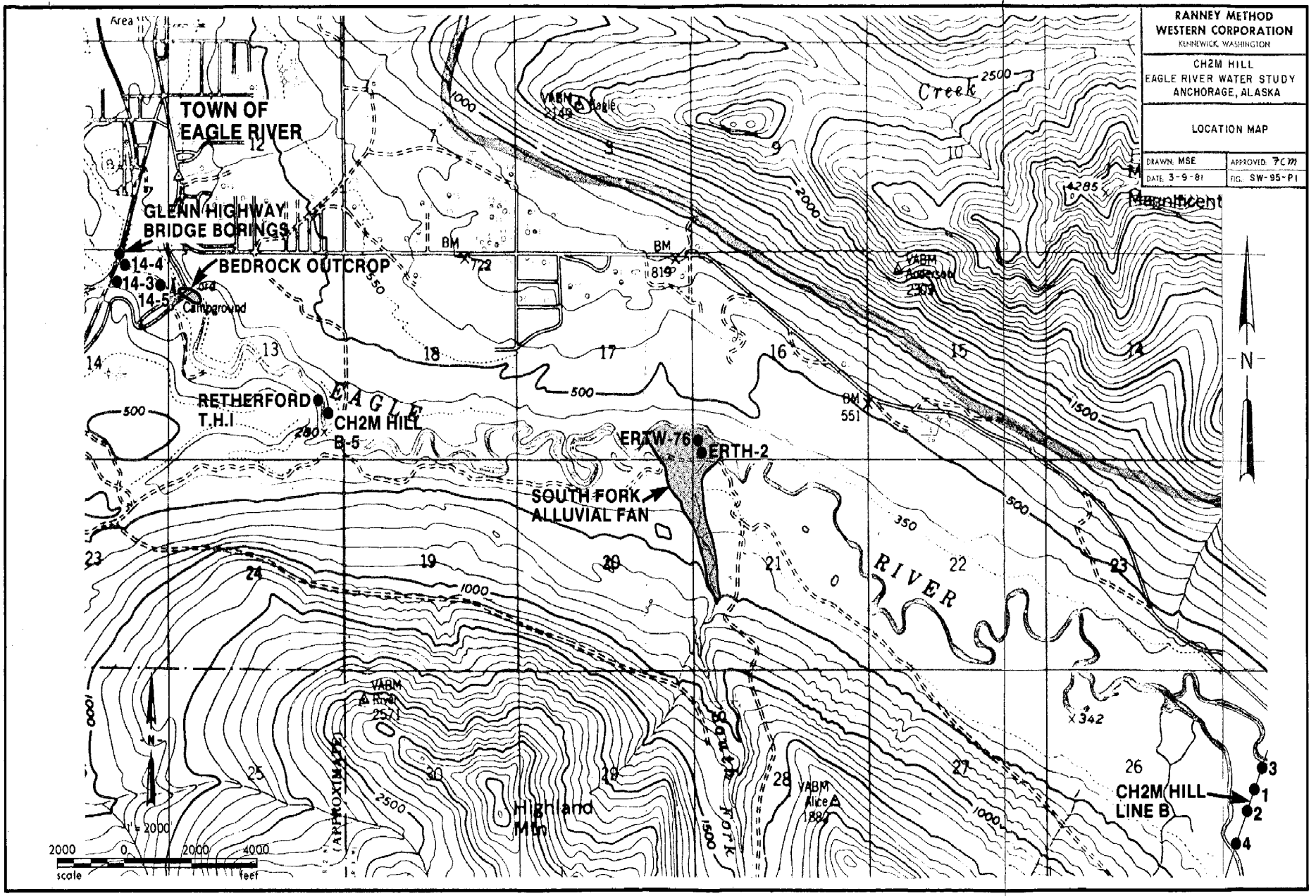
Very truly yours,

RANNEY METHOD WESTERN CORPORATION

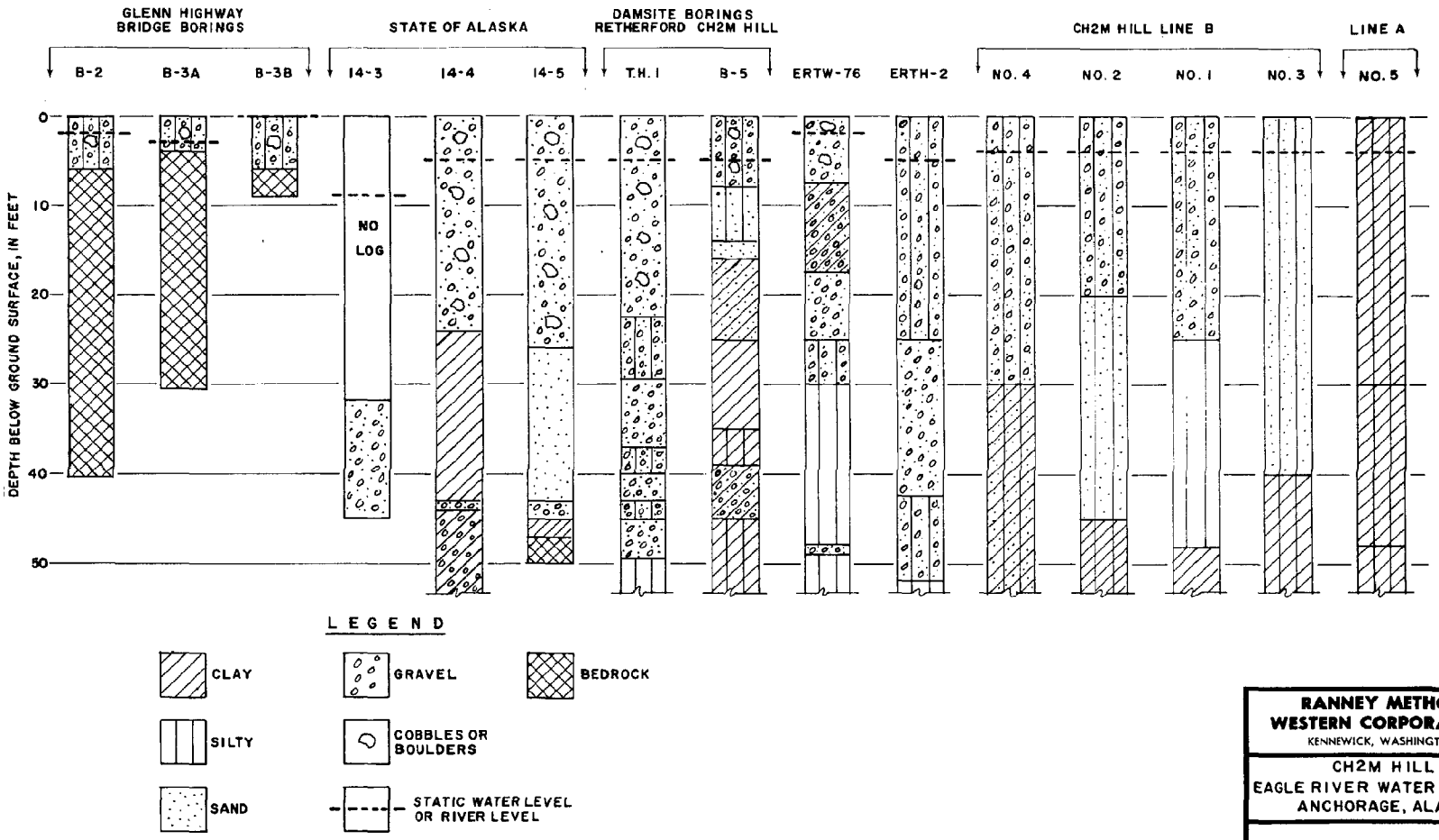
Frederick C. Mikels

Frederick C. Mikels, P.E.
President & Chief Engineer

FMC/sk



Location Map



RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

CH2M HILL
EAGLE RIVER WATER STUDY
ANCHORAGE, ALASKA

LOGS OF WELLS

DRAWN: MSE	APPROVED: FCM
DATE: 3-9-81	FIG.: SW-95-P2

Logs of Wells