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SEMIANNUAL TECHNICAL REPORT

FOR ARPA CONTRACT H0210035
REVIEW AND CRITICAL ANALYSIS OF THE STATE-OF-THE-ART
IN UNDERGROUND WORKS CONSTRUCTION
SEPT. 1971

FOUNDATION-CONSULTANTS

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13. ABSTRACT

Under the ARPA Contract No. HO210035, Foundation Sciences, Inc. is determining the feasibility of collecting information on the construction of underground works, especially those of the last twenty years. The gathering and quantitizing of this type of information is being performed for the Oregon and Washington areas as a pilot project.

The first phase of the study is the collection of as much of the data as available about the geology, design, construction and performance of existing underground rock excavations and the tabulation of this knowledge for a data bank. To date, all information contained in the "general data" forms for 256 projects have been entered into the computer.

Four general computer programs are employed to obtain accurate ansers to specific inquiries and report writing demands. The Inquire and Print program is the only program necessary for the data user and is available to all terminal users at any location in the United States. Detailed operating instructions are included for this program plus a brief discussion of three other programs used to enter the information into the computer.

The second phase of the study is the evaluation of data available iwth special reference to those items of design and construction affecting supports. Two projects have been selected for intensive study, Boundary Dam and Vista Ridge

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SEMIANNUAL TECHNICAL REPORT

for ARPA Contract HO210035

Review and Critical Analysis of the State-of-the-Art

In Underground Works Construction

FOUNDATION SCIENCES, INC.

Portland, Oregon

September, 1971

SEMIANNUAL TECHNICAL REPORT
Review and Critical Analysis of the State-of-the-Art
In Underground Works Construction

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APPENDIX

APPENDIX (cont.)

SUMMARY

Under the Advanced Research Projects Agency (ARPA) Contract Number HO210035, Foundation Sciences, Inc. is determining the feasibility of collecting information on the construction of underground works, especially those of the last twenty years. The gathering and quantitizing of this type of information is being performed for the Oregon and Washington areas as a pilot project.

The first phase of the study is the collection of as much of the data as available about the geology, design, construction and performance of existing underground rock excavations and the tabulation of this knowledge for a data bank. To date, all information contained in the "general data" forms for 256 projects have been entered into the computer.

Four general computer programs are employed to obtain accurate answers to specific inquiries and report writing demands. The Inquire and Print program is the only program necessary for the data user and is available to all terminal users at any location in the United States. Detailed operating instructions are included for this program plus a brief discussion of three other programs used to enter the information into the computer.

The second phase of the study is the evaluation of data available with special reference to those items of design and construction affecting supports. Two projects of special interest have been selected for intensive study, during a review of all tunneling data, by the project officer and principal investigator.

It was decided to study in detail the Boundary and Vista Ridge tunnels and, if time and funds permit, to also obtain more detail on the Carmen-Smith Diversion and Power tunnels and the Green Peter Dam Diversion tunnel.

SEMIANNUAL TECHNICAL REPORT
for ARPA Contract HO210035
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In Underground Works Construction

Introduction

During the construction of underground works, especially those of the last twenty years, a large amount of experience has been gained and data generated. Unfortunately, very little of this knowledge has ever been organized, evaluated, and made readily available for the improvement of the industry. Under this contract Foundation Sciences, Inc. is determining the feasibility of collecting this information, quantitizing it, and making it available as an experience bank. The gathering and quantitizing of this type of information is being performed on a small scale in the Washington and Oregon areas as a pilot project. As an additional phase of the work, two selected underground projects are being subjected to a detailed evaluation of major parameters affecting the work in general, and ground support in particular.

The basic objectives of the work are to:

1. summarize available experience in underground works,
2. isolate those factors which have had the greatest influence on ground support, construction, economy, safety, and performance,
3. determine if generally applicable and useful relationships or rules can be established for underground support, excavation procedures, layout and design methods,

4. critically review existing projects where known problems occurred so future mistakes can be avoided,

5. point out the most potentially fruitful research areas for the development of improved excavation and support methods,

6. produce a microfilm and computer-controlled data bank on significant underground excavations.

One of the basic difficulties of a study such as this is the manipulation of an enormous mass of raw data. Much of the data is being handled by computers and the work is organized in phases that will permit a yearly review of the results and their worth. The general conclusions reached to date are as follows:

1. significant amounts of data are available,

2. storage and retrieval of the information in a large time-sharing computer bank is practical,

3. access to the information requires small financial outlays to the potential user,

4. many colleges, government organizations, and private business firms already have the necessary access equipment,

5. nationwide access is available,

6. more useful test data on physical properties has been generated in the last few years,

7. gathering data is more time consuming than originally anticipated.

PHASE I WORK

The aim of the first phase of the Advanced Research Projects Agency (ARPA) Contract No. HO210035, is the collection of as much of the data as

available about the geology, design, construction and performance of existing underground rock excavations and the tabulation of this knowledge for a data bank.

The program proceeded through the following steps to accomplish the goal of Phase I.

1. a search of published information on underground projects,
2. a canvas of those agencies in Oregon and Washington who had engaged in underground works in rock,
3. follow-up visits by project personnel to the offices of the most promising sources of information to enlist their support and to gather available data,
4. preparation and utilization of the necessary computer programs to compile and evaluate these data.

As required by the Contract, contact was made with two Department of Defense-sponsored Information Analysis Centers to help guide specific aspects of the research and to avoid duplication of previously published work. The United States Defense Atomic Support Agency Data Center (DASA) advised that no other projects have been completed or are now in progress that duplicates the present work. However, the reply from Oak Ridge National Laboratory included a listing of railroad tunnels which they had identified as part of a civil defense study; the list of tunnels was added to the computer data bank.

Data Collection

As the first step in the survey of potential data sources, a form letter and questionnaire (see the Appendix) soliciting cooperation and data from

various organizations which may have built tunnels or other underground caverns was sent to forty-four offices, broken down as follows:

A. Federal, State and County Offices	6
B. Private, Municipal and Public Utility Districts	26
C. Highway Departments, Railroads	5
D. Irrigation Districts	7
Total	44

The reply of the agencies contacted by the initial contact letter (see the Appendix) included thirty responses, eighteen of which indicated projects of value to the study. From the eighteen agencies with projects of possible value, a listing of 140 tunnels and 1 underground powerhouse was received; the breakdown follows:

	Responses	Tunnels
A. Federal, State and County Offices	6 of 6	63
B. Private, Municipal and Public Utility Districts	17 of 26	30
C. Highway Departments, Railroads	3 of 5	47
D. Irrigation Districts	4 of 7	0
Totals	30 of 44	140

At this stage of preliminary data gathering, more difficulty in receiving project information was experienced than was originally anticipated. The problem generally resulted from the large mass of unclassified information available about a project, and not from an agency's reluctance to make the

information available. It was difficult for them to decide what information to select. Consequently, an additional contact letter was sent (see the Appendix) and a series of personal visits to owner's offices was begun to select pertinent data for the files.

Personal visits were made to 9 agencies, including Southern Pacific Railroad Company, Bechtel Corporation, the North Pacific Division of the Corps of Engineers, the Portland Water Bureau, the Portland District of the Corps of Engineers, Eugene Water and Electric Board, Seattle City Light, Burlington Northern Railroad Company and the Oregon State Highway Department.

The additional contact letter was mailed to eleven organizations who indicated, in their questionnaire reply, construction of structures of sufficient size and interest to be included in the detailed analysis of the study. In this contact letter these organizations were asked to make available, or to give the location of Design Memoranda, Bidding Documents, Completion Reports, Inspection or Performance Reports and Construction Daily Shift Reports.

Through the personal visits and contact letters, a total of forty-five firms and agencies were contacted and 242 significant projects located. General data on 256 projects have been filed in the computer (see the Appendix).

Throughout the process of data collection, the gathered information varied greatly in completeness and in quality. In many cases the required information is available, but is not easily accessible. As a result, continuing personal visits are being made to project owners' offices to search their dead

files for pertinent information.

Organization and Computerization of Data

Preliminary data were accumulated by several different methods. Many of the tunnel information documents were duplicate copies which the project owners were willing to release permanently. However, a large portion of the currently tabulated data was either utilized on a loan basis or, at the owner's request, remained in the project office.

Due to the above-mentioned circumstances and the large accumulation of data, it was decided to employ a microfilm data retrieval system. Microfilm equipment, which includes a Starfile camera and a reader-printer, was utilized to record all documents which were not already on file in hard copy. Filming was done on 16-millimeter roll film, which may be easily converted to a computer-indexed aperture card system.

In the computer-indexed system, each of the various pieces of microfilmed data is given a unique file number which identifies the project, the type of data, and the page number. These numbers are then placed in the computer file bank. In an individual search for information on a certain project, or for a specific question, the computer can be questioned as to the availability of the data. The computer will then be able to respond with the microfilm file number. By reference to the file number, copies of the document can then be obtained upon request to the control agency.

Formulation of computer data sheets began data organization for rapid access by the use of computer storage and retrieval. Four data forms were designed: general data, exploration data, construction data, and design data (see the Appendix). Data forms could be designed as well for inspection, maintenance, operation, cost or any other subjects of interest. The forms are designed to minimize judgment decisions during form completion so that non-technical personnel may be utilized to gather the data.

The General Data form lists twelve items of general interest and is established primarily to maintain control on incoming data and to demonstrate the workability of the system on the other more complicated files. The data files are designed for computer access which utilizes a teletype terminal and Omnitec phone couplet to a local interchange with the computer located in Seattle, Washington. All programs have been developed under the guidelines of a simplified programming language; and, because knowledge of computer programming is not a prerequisite for operation and program development, general office personnel have demonstrated their ability to successfully manipulate the data.

Computer Programs

All information contained in the General Data form has been entered into the computer. In order to maintain up-to-date computer diles enabling the user to obtain accurate answers to specific inquiries and report writing demands, four general computer programs are employed.

1. File Maintenance Program - performs the functions of file creation and maintenance.

2. Inquire and Print Program - is designed specifically for applications that range from the quick extraction of specific data to the preparation of detailed printed reports.

3. Transaction Update Program - aids the control agency in updating master files and performs deletion, addition, and change operations.

4. Sort and Merge Program - enables the control agency to define and execute sort, merge, and file copying functions.

The data file, in order to be manipulated by any of the four general programs, must have a particular structure for efficient operation. The file structure for the General Data form (see the Appendix) illustrates how a 12-field record can be organized. Each "record" of the file, which is represented by one line on the table, describes a single project. Twelve data fields comprise the record; each column in the figure represents a "field". The requirements of the general programs are that every record in a given data file must contain the same number of fields, arranged in the same order. Information has been supplied for each of the twelve data fields on 256 tunneling projects. These data have been entered into the computer as illustrated by the computer printout (see the Appendix).

The Inquire and Print program is the only program necessary for the data user and is available to all terminal users at any location in the United States. Through the use of basic computer commands (see the Appendix) and the Inquire and Print routine, the tunnel information held in the data bank may

be manipulated to answer specific inquiry problems. For this reason detailed instructions for the operation of the Inquire and Print program are included in this report. A brief discussion of the other three programs follows the Inquire and Print operation instructions. This discussion describes, in a general manner, how the information contained in the General Data form was entered into the computer.

INQUIRE AND PRINT PROGRAM - The Inquire and Print program operates on one specific data file at a time; i.e., the General Data file. A data file consists of data records, each of which contains a maximum of 100 fields of information. Each field in a given data record contains either alphabetic or numeric information. Whether a field has alphabetic or numeric characters dictates how the information in the field is to be processed in subsequent programs.

When the user defines his specific inquiry problem, he is ready to use the Inquire and Print program. The program operates on a data file to perform the following functions:

1. select all or some of the data records from the files,
2. take field totals on any numeric field in the selected records,
3. print all or some of the selected records or alternatively transfer control to user-supplied routines for printing and additional calculations.

To process the data file, the user must supply the Inquire and Print

program with control information which describes the data records of his files and the work to be done. The Inquire and Print program may be executed by entering the necessary control information from a previously created control file or by responding to specific questions which are asked by the computer during the initial operation of the Inquire and Print program.

For each Inquire and Print run, the user must indicate which method of supplying control information is to be used. He does this by entering a FILES statement as soon as the Inquire and Print program is loaded. The format of this statement is:

> 89 FILES, cntl, input
>
> where the lower case words indicate portions of the statement that the user supplies:
>
> "cntl" is the name of the control file containing the control information. If the control information is to be entered by the total prompting method (no control file used), the name PROMPT or the symbol # should be used.
>
> "input" is the name of the data file to be processed.

If the user does not enter the 89 FILES statement the computer will ask for the names of those files before continuing.

Control Information - Whether the control information is entered into the Inquire and Print program by the control files, control statements (prompting), or a combination of the two, it must contain four types of information.

1. Record structure - the number of fields in each record of the data file, and whether each is alphabetic or numeric.

2. Field totals - the numeric fields on which field totals are to be taken.

3. Record selection - the criteria for selecting records for printing.

4. Printing instructions - the method to be used for printing the the selected records.

Prompting - If no control file is used, the Inquire and Print program prompts the user for the four types of control information. By responding to the questions of the Inquire and Print program, the user directly supplies the necessary information and controls the operation of the Inquire and Print program.

Record Structure Specification - In order to read the records in the input file, the Inquire and Print program must know the structure of the record, including the number of fields it contains and whether each field is numeric or alphabetic. This information is constant with each file and can be provided the user in table form.

The Inquire and Print program prompts for the record structure specification by requesting the user to enter the total number of fields in a record. The following message appears:

TOTAL NUMBER OF FIELDS IN A RECORD?

The user enters the number of fields immediately after the question mark; his answer is followed by a carriage return, (R). The system then responds with:

ENTER N FOR NUMERIC FIELDS, A FOR ALPHABETIC FIELDS

n_1 TO n_2

where n_1 and n_2 are the beginning and ending field numbers for which the Inquire and Print program needs specification.

The user enters N or A for each field in the specified range (n_1 to n_2) which is set up in groups of five or fewer. The entries are made on the line following the question mark; consecutive entries are separated by a comma or a blank. If only one field remains, the message will be:

FIELD n_1
?

In the case of the General Data file, there are twelve fields with field 1 as numeric, fields 2 through 5 alphabetic, field 6 numeric, field 7 alphabetic, fields 8 through 10 numeric, and fields 11 through 12 alphabetic. The following is an example of the user computer exchange for this file.

Example 1

The control information for a sample record structure specification is given below (underlining indicates user response):

Total Number Of Fields In A Record? 12 (R)

Enter N for Numeric Field, A For Alphabetic

Fields 1 to 5
? N,A,A,A,A (R)
Fields 6 to 10
? N,A,N,N,N (R)
Fields 11 to 12
? A,A (R)

Field Totals Specifications - As the Inquire and Print program selects records for printing, totals may be accumulated for any or all

numeric fields in the selected records. The user has the option of selecting the numeric fields on which he wished to accumulate totals. The Inquire and Print program prompts the user for the field totals specification by asking him if field totals are to be taken. The user responds to:

FIELD TOTALS?

with YES or NO. If he answers NO, no field totals will be taken. If he answers YES, a series of question marks are written. After each question mark, the user enters the field number of a numeric field to be totaled; only one field number may be entered after each question mark. The user enters zero (0) to indicate that all the desired field numbers have been entered.

Example 2

Field Totals? YES (R)
? 8 (R)
? 10 (R)
? 0 (R)

In this example, field totals are to be accumulated on fields 8 and 10. Note the entry of 0 to end the input of field numbers.

Record Selection Specification - The user specifies the criteria which govern the record selection. The selection of a record is determined by comparing the value of one of its fields with a test value supplied by the user. Selection criteria can be composed of up to 100 different "and/or" statements chosen from the following list of logical operators.

1. EQ - Field value equals test value.

2. NE - Field value does not equal test value.

3. LT - Field value is less than test value.

4. GT - Field value is greater than test value.

5. LE - Field value is less than or equal to test value.

6. GE - Field value is greater than or equal to test value.

It is possible to specify multiple relational tests in which the contents of several fields of a record are compared with specified test values. These multiple relational tests, called "logical groups", specify both AND or OR conditions. In an OR condition, a record is selected if any one of the relational tests is passed. In and AND condition, a record is selected only if each of the relational tests connected by the AND relation are passed.

In building the selection criteria for the selection of records, there are certain rules to follow. These rules apply particularly to the formation of multiple logical groups:

"IF" is the word used for the logical OR when multiple logical groups or tests are involved. "AND" is the word for the logical AND.

Example 3
If field 3 equals "CORPS OF ENGINEERS". If field 9 equals 15. In logical terms, these two tests mean that if either field 3 equals "CORPS OF ENGINEERS" or field 9 equals 15, select the record.
If field 3 equals "CORPS OF ENGINEERS" and field 9 equals 15. This logical group means only if field 3 equals "CORPS OF ENGINEERS" and field 9 equals 15, select the record.

"IF" must start each selection criterion. Each selection criterion is called a "logical OR group".

Example 4

If field 6 equals 1945
And field 7 does not equal "HORSESHOE"
And field 3 does not equal "CORPS OF ENGINEERS"
} Logical OR group

If field 9 equals 15
And field 8 is less than 1500
} Logical OR group

This example shows two "logical OR groups" linked together to make up two selection criteria. A record is selected if field 6 equals 1945 and field 7 is not equal to "HORSESHOE" and field 3 is not equal to "CORPS OF ENGINEERS", or if field 9 equals 15 and field 8 is less than 1500.

If any "logical OR groups" develop a true condition, the record will be selected.

Example 5

If field 10 is greater than or equal to 0

Any record with the value of field 10 greater than or equal to zero will be selected.

If field 6 equals 1930
And field 11 equals "RAILROAD"
} Logical OR group

If field 9 is greater than or equal to 0 } Logical OR group

Any record with either field 6 equal to 1930 and field 11 equal to RAILROAD, or field 9 greater than or equal to 0 will be selected. The same rule would apply if there were more than two logical OR groups; if any one group developed a true condition, the record would be selected.

Each record in the file is compared with the record selection criteria. A record is compared with each logical OR group (in the order it is specified) until it meets a true condition; it is then selected and the next record is compared. If a record does not satisfy any logical group in the criterion, it is not selected.

The Inquire and Print program prompts the user for the record selection specifications by asking him if he wishes to enter selection criteria:

SELECTION CRITERIA:

The user responds YES or NO. A response of NO causes all records to be selected. If the response is YES, the Inquire and Print program prints a series of question marks; after each question mark the user enters part of his selction criteria. His selection can contain up to 100 relational tests.

A criterion consisting of a single relational test is entered as:

?IF, field number, relational operator (R)

? test value (R)

Each relational test in the selection criteria is entered on two lines following the question marks.

To indicate the end of the selection criteria the user types:

?END, number, word

where "number" is any numeric value and "word" is any alphabetic string following the question mark. Thus, if the record selection specification contains a single relational test, it is entered as:

?IF, field number, relational operator (R)

? test value (R)

?END, number, word (R)

Example 6

Select records if the name appearing in field 3 is equal to "CORPS OF ENGINEERS".

```
Selection Criteria? YES (R)
? IF,5,EQ (R)
? "CORPS OF ENGINEERS" (R)
? END,0,END (R)
```

If an alphabetic string contains blanks or commas, the string must be enclosed in quotes when it is entered.

For multiple relational tests, the format of the selection criteria is:

Example 7

Select records if the value of field 8 is greater than 0 and less than 9000, or if the value of field 8 is less than 0 and the value of field 9 is greater than 0, or if the value of field 9 is equal to 0.

```
Selection Criteria? YES (R)
? IF,8,GT (R)          }
? 0 (R)                } First logical OR group
? AND,8,LT (R)         }
? 9000 (R)             }
? IF,8,LT (R)          }
? 0 (R)                } Second logical OR group
? IF,9,GT (R)          }
? 0 (R)                }
? IF,9,EQ (R)          } Third logical OR group
? 0 (R)                }
? END,0,END (R)        } End of selection criteria
```

In the above example a record is selected if it satisfies any one of the logical OR groups.

Printing Instruction Specification - Three printing options are provided by the Inquire and Print program. By the first option every field of

the selected record will be printed. By the second option, only the fields of the selected records in the order specified by the user will be printed. By the third option, the user can specify the format in which the selected records are to be printed, including column headings and explanatory remarks. The third option also allows the user the opportunity to perform computations with the data and print the results.

If the user selects the first or second option, he has the choice of whether the fields are to be printed in packed-zone or in full-zone format. If the user chooses the packed-zone format, the fields printed out will be joined together; no spacing is provided between consecutive fields. A numeric value printed under this format does have a trailing blank character and may have a preceding space; no plus sign (+) is printed. However, if the value is negative, there is no space; a minus sign (-) is printed. By the full-zone format, all the fields are zone aligned. Each zone contains 15 character positions (columns), and every fifteenth column is the start of a new zone. By this format, the field values can be printed in a neat, readable form. Any numeric field can be contained in a 15-column zone; blanks are printed following the number to fill the zone. For alphabetic fields, any field containing 15 characters or less can be printed in one zone. However, if the field contains more than 15 characters, the field value will occupy two consecutive zones; the column alignment may be affected.

Examples of a packed-zone and a full-zone printout are as follows:

Packed Zone

Blue River Dam1795 Circular
Mud Mountain1991 Circular

Full Zone

Blue River Dam	1795	Circular
Mud Mountain	1991	Circular

The Inquire and Print program prompts for printing instruction specification by asking the user if he wishes to print the entire selected record. The user responds to:

PRINT ENTIRE RECORD?

If the user responds with YES, the program will then type:

PACK OR FULL ZONE PRINT?

The user enters PACK for packed zone format; he enters either FULL or ZONE for full zone format.

If the user responds with NO, to the question, "PRINT ENTIRE RECORD?", then the Inquire and Print program types:

LIST FIELDS IN SEQUENCE
?

The user responds by indicating whether he wants the program to use his own inserted print routines or to print only specified fields. If he wishes to use his print routine or if he wishes no printing at all, he enters 102 after the question mark. If he wants only certain fields of the selected records printed, he enters the field number of the first field to be printed. The Inquire and

Print program then prints a series of question marks, and the user responds to each with a field number. The field values will be printed, left to right, in the order in which their field numbers are specified. To end the field sequence specification, the user types zero (0). The Inquire and Print program then responds:

PACK OR FULL ZONE PRINT?

The user enters PACK for packed zone printing of the fields; he enters FULL or ZONE for full zone printing.

Example 8
Print only the first, second, eighth, and tenth fields of selected records using packed zone printing. Print Entire Record? NO (R) List Fields In Sequence ? 1 (R) ? 2 (R) ? 8 (R) ? 10 (R) ? 0 (R) Pack or Full Zone Print? PACK (R)

Control File Program - This program builds a control file for use in an Inquire and Print program run. The use of a pre-constructed control file would save time where the same or similar type search of the files was frequently performed. The control file may contain all or part of the required control information. The user creates the control file by answering specific questions asked by the Control File program. These questions are essentially

the same questions asked by the Inquire and Print program in the fully prompted mode. If the user wishes to enter all of the control information through the control file, his responses to the Control File program questions are identical to his responses to the Inquire and Print program questions. However, if he wishes some prompting during the execution, his responses to the Control File questions are different; these responses are described in the following paragraphs.

To prepare the program for a run, the user must first load the Control File processor into his work area and then enter a FILES statement in the following form:

89 FILES cntl

where:

"cntl" is the name of the control file to be created.

The FILES statement is followed by a RUN command and the Control File Program begins operating. If the 89 FILES statement is omitted by the user the computer will ask for the name of the control file. The questions generated and the user's responses (for prompting by the Inquire and Print program) are as follows:

The first question asked by the Control File program is:

RUN TYPE?

For a control file to be used with the Inquire and Print program, the user must enter INQUIRY after the question mark.

Record Structure Specification - The user must enter the record structure for the data file to be processed by the Inquire and Print pro-

gram. The user cannot request prompting by the Inquire and Print program for this control information; it must be entered during the execution of the Control File program. This information is the same as the record structure information explained earlier under the Inquire and Print Program.

Field Totals Specification - If the user wishes to be prompted in the Inquire and Print program he responds with YES. The Control File program then types a question mark on the next line and the user enters a zero. If the user wishes to have specific fields totaled, he types YES and the numbers of those fields; otherwise, he types NO.

Record Selection Specification - The Control File program types:

SELECTION CRITERIA?

To be prompted by the Inquire and Print program, the user enters YES and a carriage return (R). The Control File program then responds with a question mark and the user enters: END, number, word - where number is any numeric value and word is any character string. If the user has specific selection criteria these are entered in the same manner as explained under the Inquire and Print Program.

Example 9

Selection Criteria? YES (R)
? END,0,END (R)

These responses cause the Inquire and Print program to prompt the user for the record selection specification.

Printing Instruction Specification - For the printing instruction information, the Control File program types:

PRINT ENTIRE RECORD?

If YES is typed, the whole record will be typed. To be prompted, or to select specific criteria in the Inquire and Print program, the user enters a NO and the Control File program types:

LIST FIELDS IN SEQUENCE
?

If the user wishes to list fields he does so in the same manner described earlier under the Inquire and Print Program. If he wishes to be prompted the user enters a zero after the question mark.

The control file created as described above and used by the Inquire and Print program is an external (symbolic) file. Thus, it is possible for the user to construct his control files from the terminal without using the Control File program.

Terminal Control File Construction - In the symbolic control file, a line number precedes each group of data in the file. These data represent the control information; and must always appear in the following order:

1. record structure specification,
2. field totals specification,
3. record selection specification,
4. printing instruction specification.

If the user chooses to construct his own control file, he enters a line number "n" followed by a logical grouping of the control information. "n" can be any number from 1 to 99999. Successive line numbers and data are entered until the required control specifications have been supplied. The user then assigns the file a name and saves the file; it can then be used with the Inquire and Print program at any time.

Record Structure Specification - The record structure specification must always be the first control information contained in the control file. This information is entered in the form:

$c, s_1, s_2, \ldots, s_c$

where:

"c" is the number of fields in each record.

"s" is a code representing either a numeric or alphabetic field. "s" is 0 if the field is numeric; it is 1 if the field is alphabetic. The user must enter the appropriate code for each field in a record. There must be exactly "c" entries.

Example 10

```
1000  12
1010  0,1,1,1,1,0,1,0,0,0,1,1

or

1000  12,0,1,1,1,1,0,1,0,0,0,1,1
```

Both of the examples are record structure specifications for a record containing 12 fields, the first numeric, the next four alphabetic, the sixth numeric, the seventh alphabetic, the next three numeric and the last two alphabetic. Note that in this case, there must be 12 ones or zeros following the count specification.

The user may enter zero (0) for the record structure specification. This will cause the Inquire and Print program to prompt the user for the control information.

Field Totals Specification - The field totals specification must follow the record structure specification in the control file. If the user wishes to take field totals, he can specify this control information in his control file. It is entered as:

$$c, f_1, f_2, \ldots, f_c$$

where:

"c" is the number of fields to be totaled.

"$f_1, f_2, \ldots, f_c$" are the field numbers of the fields to be totaled. The user must enter exactly "c" field numbers.

Example 11	
1100 2 1150 8, 10	two fields to be totaled fields 8 and 10
or	
1100 2,8,10	

An entry of zero for the field totals specification in the control file causes the Inquire and Print program to prompt the user for the control statements. An entry of 101 indicates that no field totals are to be taken.

Example 12	
1100 0	specifies prompting for field totals specification
1100 101	specifies no field totals

Record Selection Specification - Record selection specification must always follow the field totals specification in the control file. If the user enters zero for this specification, he requests to be prompted for the control information by the Inquire and Print program. By entering 101, he indicates that no records are to be selected; all the records are to be printed.

Example 13	
1200 0	specifies prompting for record selection specification
1200 101	specifies selection of all records

If the record selection criteria are to be contained in the control file, the complete record selection specification must be generated as follows:

The number of "logical OR groups" in the criteria

The number of relational tests followed by the specification of the actual relational tests for each "logical OR group"

The relational test, which is the basic element of a record selection criterion, has the following format:

f,r,v

where:

"f" is the field number to be tested

"r" is the relational operator code number

"v" is the test value (numeric or alphabetic)

Following is a listing of allowable relational operators and the corresponding relational operator codes, "r":

r	Relational Operator
1	EQ
2	NE
3	LT
4	GE
5	GT
6	LE

To construct a "logical OR group" the user must first supply the number of relational tests in the OR group, then list the actual relational tests. The format for a "logical OR group" with more than one relational test is:

$$c,f_1,r_1,v_1,f_2,r_2,v_2,\ldots f_c,r_c,v_c$$

where "c" is the number of relational tests in the "logical OR group", "f_1" is the field number for the first relational test, "r_1" is the first relational operator code, and "v_1" is the first test value, "f_c,r_c, and v_c" correspond to the last field number, operator code, and test value in the OR group. The user must enter "c" relational tests.

If the selection criteria contain one or more "logical OR groups", the user must first supply the number of "logical OR groups" in the criteria followed by the OR groups, listed according to the format above. Thus, the selection criterion for one "logical OR group" must appear as:

$$n,c,f_1,r_1,v_1,f_2,r_2,v_2,\ldots,f_c,r_c,v_c$$

where "n" is the number of "logical OR groups" (n=1), and c, f_1, r_1, etc., as defined in the preceeding paragraph. Multiple OR groups must appear in the control file as follows:

$$n, c_1 \ldots, c_2 \ldots, c_3 \ldots, c_n$$

where "n" is the count of "logical OR groups" in the criteria and "c_1, c_2, c_3, and c_n" are the first, second, third and last OR groups, respectively.

Example 14

If field 8 is not equal to 0

And field 9 is greater than 15

And field 3 is not equal to "CORPS OF ENGINEERS"

Or if field 6 is greater than 1900

Or if field 7 is equal to CIRCULAR

And field 11 is not equal to HIGHWAY

And field 10 is less than 1100000

1200 3	3 OR groups
1210 3	3 relational tests in group one
1220 8,2,0	If field 8 not equal to 0
1230 9,5,15	And if field 9 greater than 15
1240 3,2,"Corps of Engineers"	And if field 3 not equal to Corps or Engr.
1250 1	1 relational test in group two
1260 6,5,1900	If field 6 greater than 1900
1270 3	3 relational tests in group three
1280 7,1,Circular	If field 7 is equal to Circular
1290 11,2,Highway	And field 11 not equal to Highway
1300 10,3,1100000	And field 10 less than 1100000

or

1200 3,3,8,2,0,9,5,15,3,2,"Corps of Engineers"
1210 1,6,5,1900,3,7,1,Circular,11,2,Highway,10,3,1100000

Printing Instruction Specification - Printing instruction specification must always follow the record selection specification in the control file. The user has four printing options from which he may choose; he may request:

1. prompting from the Inquire and Print program,
2. use of his own inserted print routines,
3. printing of all fields in the selected records,
4. printing of only specified fields in the records.

If the user wants to be prompted, an entry of zero causes the Inquire and Print program to prompt for the print instructions. If the user enters the value 102, the Inquire and Print program turns control of printing over to user-supplied printing routines.

If the user enters the value 101, all of the fields of selected records will be printed just as if he had answered YES to the question "PRINT ENTIRE RECORD?" using control statements. The user must then specify whether packed-zone or full-zone printing of alphabetic fields is desired; to do this the user enters a 1 for full zone printing or a 0 for packed zone printing.

If the user wishes to print only certain fields of selected records, he must enter the following information for the printing specification in the control file:

$c, z, f_1, f_2, \ldots, f_c$

where:

"c" is the total number of fields to be printed.

"z" is 1 or 0 and specifies the zone printing format.

"$f_1, f_2, \ldots, f_c$" are the actual numbers of the fields to be printed. There must be exactly c field numbers entered.

Example 15

Construct the control file in order to print the first, ninth, second, fifth, and thirteenth fields of selected records using full zone printing. Print the fields in the above order.

```
1400  5
1410  1
1420  1,9,2,5,12
```

or

```
1400  5,1,1,9,2,5,12
```

User Exits - To enhance the data presentation capabilities, the Inquire and Print program allows the user to enter his own printing and processing routines. The user-coded routines may be inserted into the Inquire and Print program at four user exits. The coded routines are coded in standard Basic computer language, and all the Basic commands can be used except "restore" or "backspace". All of the user exits become active during an Inquire and Print run. These exits are located at lines 4000-4999 (Exit 2); lines 5000-5999 (Exit 1); lines 6000-6999 (Exit 3); and lines 7000-7999 (Exit 4).

User Exit 1 is referenced after control information has been read and all the files have been opened. User Exit 1 is ideal for inserting routines

which print titles and initial column headings.

User Exit 2 becomes available before each record is read. Because the Inquire and Print field totals are accumulative only on selected records, this exit may be used to accumulate totals on every record read.

User Exit 3 is given control each time a record is selected. All fields of the selected record, field totals (as specified in the control information), and record counts are available for use in the user-supplied routine. All totals and counts are current through the record just selected.

At this exit, the user can insert his own-code routine which may control the following types of processing:

1. printing fields of the record in any format and order,
2. causing spacing and column positioning,
3. performing intermediate calculations,
4. printing results of intermediate calculations.

This exit can also be used to count print lines and to print headers, when needed, for special fixed-page-length reports.

User Exit 4 becomes active after all records have been read. All final totals and record counts are available for use in user-supplied routines at this exit. Exit 4 can be used as a final processor to print final totals, the results of final calculations, and final messages. After control is returned from this exit the Inquire and Print program prints an end of run message which consists of field totals (if requested), record counts, and the message NOW

AT END. If the user wished to have the end of run message eliminated, he could end his user-supplied routine at Exit 4 with a STOP or END statement.

It is the user's decision whether or not to take advantage of the user exits. If the user exits are utilized, the user should observe the following rules:

1. Each user-supplied routine inserted at Exit 1, Exit 2, or Exit 3 must end with a RETURN statement to return control to the Inquire and Print program.

2. The routine inserted at Exit 4 must contain a RETURN statement unless the option of eliminating the end of run message is used. In this case, the RETURN statement is replaced by the use of the STOP and END statement. The STOP and END statements should only be used at this exit.

3. The commands, RESTORE and BACKSPACE, should not be used in the user-coded routines. All other basic commands are acceptable.

4. Particular care must be taken in choosing the variable and array names to be coded in the user's routines. These names are described in the Appendix.

Variables and Arrays - Through user exits, the data handled by the Inquire and Print program during execution is available to the user. These data are contained in variables and arrays. A list of the variables and arrays, which are made available to the user for his own-code routines, is shown in the Appendix.

User Exit Procedure - Once the user has decided to utilize the Inquire and Print user exit capabilities, he must observe the following procedure:

1. Enter his user-coded routines at the terminal. These routines must be entered prior to the execution of the Inquire and Print program and must be named (NAME command) and saved (SAVE command) in the user's computer library.

2. Load the Inquire and Print program into his work area by using a LOAD command.

3. Merge the user-supplied routines with the Inquire and Print program. The MERGE command is used to produce this result.

Examples of User-Coded Routines - The user wants to print a listing of all tunnel projects contained in the General Data file that are over 500 feet in length with spans greater than 15 feet. He would also like an appropriate heading for the report, a listing of project name, shape, and cost for each project. In addition, he would like to know the average cost per linear foot for both arched roof and circular shaped tunnels.

Three user exits will be used in the above described program (5000-5999, 6000-6999, and 7000-7999). The user will specify his selection criteria based on field 8 (tunnel length - tunnels with a length greater than 500 feet), and on field 9 (tunnel diameter or span - tunnels with a span greater than 15 feet). Following is a sample of the user-inserted coding at the three user exits required to perform the desired function.

Print Heading - User Exit 1

```
5000 Print"  This Program Selects Specific Tunnels Over 500 Feet"
5010 Print"  In Length Having Spans Greater Than 15 Feet And Cal-"
5020 Print"  culates Their Cost Per Linear Foot And Finds The"
5030 Print"  Average Cost For Each Type Of Tunnel Selected."
5040 Print
5050 Print Using 5060
5060 (15 spaces) Name (21 spaces) Shape (18 spaces) Cost
5070 Print
5080 Return
```

Lines 5000-5030 print the desired title heading. Lines 5050 and 5060 print the appropriate column headings. Lines 5040 and 5070 skip lines between printing. Line 5080 is necessary to return control to the Inquire and Print program.

Print Selected Records - User Exit 3

```
6000  X1 = A(10)/A(8)
6010  IF A(7)$EQ "Circular" GOTO 6050
6020  X2 = X2 + X1
6030  Z1 = Z1 + 1
6040  GOTO 6070
6050  X3 = X3 + X1
6060  Z2 = Z2 + 1
6070  Print Using 6080, A(2)$, A(7)$, X1
6080: ################## (10 sps) ################## (15 sps) ####
6090  Return
```

Line 6000 divides the cost by the length of each tunnel. Line 6010 checks to see if A(7) is equal to Circular (A(7) holds the contents of field 7 in the currently selected record). Field 7 contains the shape of the tunnel; a shape equal to circular identifies a particular tunnel. Line 6020 totals the cost per linear foot of arched roof shaped tunnels selected. Line 6030 counts the number of arched roof shaped tunnels selected. Line 6040 gives control to line 6070 to print the currently selected record (a project with an arched roof shape). If the project had a circular shaped tunnel, line 6010 would have given control to line 6050 to total the cost per linear foot of circular tunnels and count the number of circular tunnels, (see lines 6020 and 6030). Line 6070 prints the name, shape, and cost for every selected record (selected if tunnels have an

arched roof or circular tunnel shape). Line 6080 is how the printing in line 6070 will be formatted. Line 6090 returns control to the Inquire and Print program.

Print Final Totals - User Exit 4

```
7000  X4 = X2/Z1
7010  X5 = X3/Z2
7020  Print
7030  Print
7040  Print
7050  Print Using 7060,Z1,X4
7060: Average Costs Per Linear Foot For ## Arched Roof Tunnels $#####
7070  Print Using 7080,Z2,X5
7080: Average Costs Per Linear Foot For ## Circular Tunnels $#####
7090  End
```

Line 7000 computes the average cost per linear foot of the arched roof tunnels; line 7010 computes the average cost per linear foot for circular tunnels (the totals were accumulated in User Exit 3). Line 7050 prints the number of arched roof tunnels and the average cost per linear foot. Line 7070 prints the number of circular tunnels and the average cost per linear foot. Lines 7060 and 7080 are how the printing will be formatted. Line 7090 ends execution of the Inquire and Print program. This statement is used to suppress the printing of the normal end of run messages.

The complete user-supplied routines would then look as follows:

```
5000  Print"    This Program Selects Specific Tunnels Over 500 Feet"
5010  Print"    In Length Having Spans Greater Than 15 Feet and Cal-"
5020  Print"    culated Their Cost Per Linear Foot And Finds The"
5030  Print"    Average Cost For Each Type Of Tunnel Selected."
```

```
5040  Print
5050  Print Using 5060
5060                Name                    Shape                    Cost
5070  Print
5080  Return
6000  X1 = A(10)/A(8)
6010  IF A(7)$EQ"Circular" GOTO 6050
6020  X2 = X2 + X1
6030  Z1 = Z1 + 1
6040  GOTO 6070
6050  X3 = X3 + X1
6060  Z2 = Z2 + 1
6070  Print Using 6080, A(2)$, A(7)$, X1
6080: ##################    ##################    #####
6090  Return
7000  X4 = X2/Z1
7010  X5 = X3/Z2
7020  Print
7030  Print
7040  Print
7050  Print Using 7060,Z1,X4
7060: Average Costs Per Linear Foot For ## Arched Roof Tunnels $#.####
7070  Print Using 7080,Z2,X5
7080: Average Costs Per Linear Foot For ## Circular Tunnels $#####
7090  End
```

This program, when merged with the Inquire and Print program, produces the following results:

This Program Selects Specific Tunnels Over 500 Feet In Length Having Spans Greater Than 15 Feet and Calculates Their Cost Per Linear Foot and Finds The Average Cost For Each Type Of Tunnel Selected.

Name	Shape	Cost
Blue River Dam Div	Circular	316
Cougar Main Div	Arched Roof	167
Cougar Reg Outlet	Circular	355
Green Peter Div	Arched Roof	781

Big Cliff Div	Arched Roof	428
Knowles Creek	Arched Roof	431
Sunset	Arched Roof	177
Vista Ridge West	Arched Roof	4166
Vista Ridge East	Arched Roof	4352

Average Cost Per Linear Foot For 7 Arched Roof Tunnels $ 1500

Average Cost Per Linear Foot For 2 Circular Tunnels $ 335

The remaining three programs, File Maintenance, Transaction Update, and Sort and Merge, are used basically by the control agency to process and update the various files. The explanation of these three programs will be very brief, as the user needs only to be aware of their general existence.

FILE MAINTENANCE PROGRAM - The File Maintenance program is designed to help the control agency perform the necessary creation and file maintenance tasks. As a generalized, file-oriented program, it can be executed under one of three options:

Create - permits the creation of a new data file.

Update - permits the updating of an existing data file through the deletion of records, the modification of fields of records and the addition of new records.

Copy - permits copying of records from one data file to another.

Data Files - The data files processed by the File Maintenance program are internally formatted files; they contain fixed-length records of up to 100 fields. The fields are either numeric or alphabetic.

Control Information - Because the File Maintenance program is a gen-

eralized program, control information is necessary to direct the run operation. This information may be supplied either by "total prompting" or "control files" methods, or a combining of both into a "prompting/control file" method.

If the "total prompting" method is used, the control information is supplied during the execution of the File Maintenance program. When using the "control file" method, a file containing the control information is created and saved before executing the File Maintenance program. This control file, an external (symbolic) format, is constructed by using the same Control File program explained under Inquire and Print Program.

When the control information for several File Maintenance program runs is similar but not identical, a combination "prompting/control file" method can be used. A control file that contains all of the control information that is constant for the File Maintenance program run is created, and prompting can be requested at execution time for any control information that varies.

For each File Maintenance program run, the method of supplying control information must be indicated. This identification is made in the FILES statement similar to the 89 FILES statement described earlier. The following examples show the various file statements for the different options available.

•Create Option

Example 16
When making a CREATE run, a FILES statement must be used to designate the method of entering control information and the name assigned to the

data file being created. The format of this FILES statement must be as follows:

```
89 FILES cntl, input, output, #
```

where the lower case words indicate portions of the statement that the user supplies:

"cntl" is the name of the control file containing control information. If the control information is to be entered by the total prompting method (no control file used), the name PROMPT or the symbol # should be used.

"input" is a temporary file name. Even though no input file is used during a CREATE run, the user must enter a name or the symbol # in this position of the statement.

"output" is the name assigned to the data file being created.

"#" is a symbol representing a temporary file used by the File Maintenance program. It may be omitted if the records to be added to the new file are contained in the control file, "cntl".

*Update Option

Example 17

Whenever a data file is processed for updating, the File Maintenance program constructs a new file which contains the undeleted records and their modifications, as well as the added records. A FILES statement must be used in an UPDATE run to identify the file being processed and the new file being constructed. This FILES statement is also used to designate the user's method of entering control information. Its format must be as follows:

```
89 FILES cntl, input, output, #
```

where the lower case words indicate portions of the statement that the user supplies:

"cntl" is the name of the control file containing control information. If no control file is used, the name PROMPT or the symbol # should be used.

"input" is the name of the data file to be processed.

"output" is the name assigned to the new updated file. The user may designate the input file and output file to be the same ("input" and "output" are the same name). However, this is not recommended; if the user should make an error in specifying the conditions for deletions or modifications, he would no longer have a file containing his original data records after the UPDATE run.

"#" is a symbol representing a temporary file used by the File Maintenance program. It may be omitted if the records to be added to the update file are contained in a control file.

•Copy Option

Example 18

The COPY option of the File Maintenance program is used to copy records of one data file onto another data file. The FILES statement used is of the following format:

89 FILES cntl, input, output, #

where the lower case words indicate portions of the statement that the user supplies:

"cntl" is the name of the control file. If no control file is used, "cntl" is the name of a temporary file. In this case, the name PROMPT or the symbol "#" should be used.

"input" is the name of the file to be copied.

"output" is the name of the file created by the COPY operation.

"#" is optional. "#" is a symbol representing a temporary file.

User Exits - The File Maintenance program allows the user to enter his own processing routines if necessary, to handle the nonstandard file. The user-coded routines may be inserted in the File Maintenance program in two user exits located at lines 4000-4999 (Exit 2) and lines 5000-5999 (Exit 1).

Exit 1 becomes available after control information has been read and all the files have been opened. This exit is used when the data records of the input file are preceded by records. The routine inserted at this exit is used to read in the header label and to position the file at the first field of its first data record.

Exit 2 becomes available before each record is read. Special read routines can be inserted at this exit to read variable-length records. Exit 2 can also be used during the UPDATE option to take field totals on every record read. A routine to accumulate the totals, count how many records have been read, and print the field total results before the end of the file is encountered can be inserted.

TRANSACTION UPDATE - The Transaction Update program aids the control agency in updating master files and permits the use of one or two transaction files containing records to perform deletion, addition, and change operations. The program also permits the control agency to insert own-code routines in the program to fulfill unique processing requirements.

The Transaction Update program uses three types of files to update a master file:

1. An input master file that can be either an internal- or external-format file created and maintained by the File Maintenance program or the Transaction Update program.

2. A transaction file that can be either an internal- or external-format file created and maintained by the File Maintenance pro-

gram or the Transaction Update program. Either one or two transaction files can be used to update a master file.

3. A control file that is an external-format file created by the Transaction Specifications program containing information describing the records in the input master file and in the transaction files. It also describes the specifications for the master file update by the Transaction Update program. The control file is created by running the Transaction Specifications program.

Control Information - The Transaction Update program is a general program and the control information must be supplied. The control information is supplied for each type of update to the Transaction Update program in the form of the control file created during the operation of Transaction Specifications. The Transaction Specifications program, which operates in a fully prompted mode, builds the control file from the responses to questions asked during the run. A control file, which is in external (symbolic) format, contains all the information required to direct the Transaction Update program to use its transaction update capabilities.

User Exits - The transaction update program provides 10 user exits to allow the insertion of code routines to perform any of a variety of special processing functions that are beyond the normal scope of the Transaction Update program's generalized processing. All 10 exits, or any combination of the 10 can be used to provide the update capabilities required. All 10 of the user exits become active during a Transaction Update run. The exits are located as follows:

1	1000 through 1999	Before any files are opened

2	2000 through 2999	After the control file is read and stored
3	3000 through 3999	Before each record is read
4	4000 through 4999	After each record is read
5	5000 through 5999	After an out-of-sequence condition occurs on a transaction file
6	6000 through 6999	After a matching condition occurs prior to update
7	7000 through 7999	After each operation step of an addition or change transaction occurs
8	8000 through 8999	Before each output master record is written
9	9000 through 9999	After each output master record is written
10	10000 through 10999	After program processing is completed

The data processed during the execution of the Transaction Update program is available through the user exits.

SORT AND MERGE PROGRAM - The Sort and Merge program enables the control agency to define and execute sort, merge, and file copying functions. The Sort and Merge program contains four separate processors or sub-programs: CONTROL, SORT, MERGE, and COPY. The CONTROL processor allows the specification of requirements for the SORT, MERGE or COPY processors in a conversational mode. The CONTROL processor then translates these requirements and stores them as specifi ations in a control file, which is assigned

a name and saved for immediate or subsequent use.

The SORT processor permits the user to sort data files into any sequence. As many as 10 data files, in either symbolic or internal format, can be used as input to this processor. The output file from the SORT processor can be in either symbolic or internal format. Up to 25 data fields can be used to control the SORT. These sequence control fields, or sort keys, can be any combination of alphabetic/numeric characters, in either ascending or descending sequence, or in both.

The MERGE processor allows the user to merge two or three data files, each in the same sequence, into one data file. Like the SORT processor, the MERGE processor can control as many as 25 fields in either ascending or descending sequence. The input file to the MERGE processor and the merged output data file can be in either symbolic or internal format.

The COPY processor enables the user to copy one file and create a second one. The processor does not require any sequence control fields. The input and output files can be in either symbolic or internal format. This processor can be used to rename internal or symbolic format files that are too large to load and name.

The Sort and Merge program can accept either symbolic or internal format files. If more than one file is input to the SORT or MERGE processors, the files can be of different formats. The output file from any of the processors can be in either symbolic or internal format and does not have to correspond to

the input file format.

Computer Equipment

The equipment necessary to obtain access to the data bank is as follows:

1. standard teletype terminal,
2. standard telephone,
3. telephone computer coupler.

The monthly rental on this equipment is under $90.00; however, there is a large variety of faster and more complex terminals available. The data bank may also be accessed directly by other in-house computers and those computers may, in turn, be used as a terminal.

The telephone connection in most large cities in the United States is to a local line. The total cost would be a minimum of about $120.00 per month including the charge for computer connection time which is based on actual time used. This charge should be well within the ability of numerous design firms, schools, contractors, government agencies and other interested parties throughout the country.

Personnel Training

The training necessary for the use of the data bank ranges from none to two days depending upon the individuals intelligence, past experience, and the complexity of the search and data manipulation. The average engineer or technical individual should be able to operate the program with just the aid of the operation manual and prompting by the computer. A few hours of explanation on the use of Basic computer language will allow complete utilization of

the more complex options available in the user exit capacity of the program.

PHASE II WORK

Preliminary Analysis of Data

The second phase of the ARPA contract is the intensive study of two projects of special interest in the Oregon and Washington areas. This study is intended to provide a detailed analysis of the records of a particular project and determine the methods of exploration, design and construction, and to determine whether these methods produce the desired end product. This portion of the program is to highlight the use of any exceptional methods, to indicate where better methods could have been used and to determine if full advantage was taken of available data and technology.

In order to obtain a list of prospective tunnels, the present list contained in the computer was searched by the computer for all the underground projects which fulfilled the requirements of this portion of the study. The projects on the list produced by the computer were then screened in more detail by the personnel of Foundation Sciences, Inc. The results of this screening produced the following list of six tunnels.

1. Vista Ridge Tunnel
2. Boundary Dam Equipment Chamber and Tunnels
3. Mossy Rock Diversion Tunnels
4. Carmen-Smith Diversion and Power Tunnels
5. Green Peter Dam Diversion Tunnel

6. La Grande Power Tunnel

Vista Ridge Tunnel, Multnomah County, Oregon - The Vista Ridge Tunnels are two, parallel, 54-foot span highway tunnels driven through a fractured volcanic ridge. The eastbound tunnel is 1,001.5 feet long and the westbound tunnel is 1,048 feet long. They are built on a 5 percent grade with an 8 degree curve. The tunnel section consists of a concrete liner 2.5 feet thick supported by two concrete sills 10 to 15 feet high and 6 feet wide at the base. Rock support and arch reinforcement is provided by 14-inch wide flange cold-rolled ribs. Weight of the ribs varies from 48 to 103 pounds per foot with a spacing of from 2 to 4 feet. Extensive blasting and seismic records were kept due to the dense residential development on Vista Ridge.

The Oregon State Highway Department performed the exploration and design of the tunnel. Drake-Winston, a joint venture, was the contractor. The cost of the project was $8,735,000.00 and was completed in 1969.

Boundary Dam Equipment Chamber and Tunnels, Pend Oreille County, Washington - The Boundary Dam Project includes an underground powerhouse and several associated tunnels. The main cavern is 477 feet long, 76 feet wide and 170 feet high. The tunnels include 4,300 linear feet of a 22-foot diameter tunnel, 910 linear feet of a 42-foot diameter tunnel, and various other shafts and tunnels. The project is located in a limestone and dolomite formation and is one of the few suitable underground structures in the Oregon-Washington area not constructed in volcanic rock.

The main cavities are supported by rock bolts with a maximum length of 20 feet, sixty steel sets, 8 WF 31, were used together with rock bolts for support in the smaller tunnels. Shotcrete and concrete were used as lining. A special support problem developed necessitating the use of large cable tendons to hold the rock in place.

Extensive instrumentation and rock mechanics studies were performed during design and construction. The program consisted mainly of flat jack tests and plate loading tests. An instrumentation program to monitor the performance of the cantilever is in progress and records are available from 1966 to the present from the owner, Seattle City Light.

Mossy Rock Diversion Tunnels, Lewis County, Washington - The Mossy Rock Diversion Tunnels are two, parallel, 40-foot span, gothic arch tunnels, 1300± feet in length. The uncommon shape of these tunnels was a result of an attempt to produce a more stable arch. Support was designed for steel sets or rockbolts at the contractor's option. The project is located on the Cowlitz River and was completed in 1964 for a cost of $1,520,700.00.

Carmen-Smith Diversion and Power Tunnels, Lane County, Oregon - The Carmen-Smith Diversion and Power Tunnels are small-diameter tunnels varying from 13.5 feet to 16.0 feet in diameter. They are located in eastern Lane County and are constructed in basalt flows. The Carmen Diversion Tunnel is 11,381 feet long and the Smith Power Tunnel is 7 272 feet long. The tunnels were completed in 1962 and 1963 at the cost well over the esti-

mate because of serious water problems. During construction a large amount of water was encountered and during the first dewatering of the tunnel, uplift pressure buckled the invert. Detailed geologic mapping was carried out in the tunnel. The small diameter and ease of support limit the usefulness of this tunnel for purposes of the detailed study. However, it is included here because of the interesting and severe water problem plus the failure of the lining.

Green Peter Dam Diversion Tunnel, Linn County, Oregon - The diversion tunnel at Green Peter Dam is located on the Santiam River and was built by the Portland District Corps of Engineers for a cost of $820,200.00. The tunnel is a horseshoe-shaped tunnel with a span of 30 feet and a length of 1,050 feet. It was driven in basalt and tuff and through nine shear zones with a maximum overburden of 150 feet. A major fallout problem occurred near the upstream portal. The support design was changed from rock bolts to steel ribs because the labor union refused to allow men to work under rock supported only by bolts. The tunnel was finished in 1965.

La Grande Power Tunnel, Pierce County, Washington - The La Grande Power Tunnel is located on the Nisqually River. The tunnel is 6,236 feet long and has a circular section with a diameter of 15 feet. It was included despite the fact that it was completed almost 30 years ago, because the shape, support, span and lining were modified to fit whatever geologic conditions were encountered. There were a total of thirteen different section designs, twelve of which

were used in construction. While the flexibility of the design and construction contract probably would not be applicable to current construction methods, it presents an opportunity to study efficiency of various sections. It was completed in 1942 at a cost of $1,307,000.00 by the City of Tacoma PUD.

This summary was reviewed by the project officer and principal investigator, in a meeting at Portland, Oregon. As a result of that meeting it was decided to study Boundary and Vista Ridge tunnels in detail and, if time and funds permit, to also obtain more detail on Carmen-Smith Diversion and Power Tunnels and the Green Peter Dam Diversion Tunnel.

Data Gathering

Vista Ridge - The data for the Vista Ridge project is kept on file in Salem, Oregon at the Oregon State Highway Department, Building #17. The material, while quite complete, is not well indexed and requires considerable searching. The material consists of the last remaining copies of the data and the Oregon State Highway Department does not wish to let it leave the building; therefore, the material must be microfilmed on the premises. The contractor, Drake-Winston, still has an office located in Portland where records are available, again, for inhouse reviewing. The personnel who worked on the job, both as contractor and engineer, are available for interviews.

Boundary Dam - The data for the Boundary project is located in Seattle, Washington at the offices of Seattle Power and Light. Bechtel Corporation, located in San Francisco, has most of the design computation and a visit to

that office is planned in the near future. Visits to the Seattle Power and Light offices have been made and considerable microfiliming has been performed.

Secondary Projects - Data from Green Peter Dam Diversion Tunnel has been supplied by the Corps of Engineers in Portland. The Portland Corps has a policy of compiling all their data and publishing it in several reports all of which have been collected and microfilmed. Data from Carmen-Smith was supplied by Eugene Power and Electric Board in Eugene, Oregon and by Bechtel Corporation in San Francisco, California. A visit to Eugene was made to obtain copies of the Carmen-Smith data.

In general, the data collecting phase has been more time consuming and more costly than originally estimated. The problem resulted from the large mass of information generally located in indifferent or nonexistent archive file systems, and it, therefore, required large expenditures of time to locate the desired information. The contacted agency generally was willing to allow us access to their files but unwilling to spend any great time searching them. It was also difficult for the contacted agency to know which of the particular unbound data volumns, such as design calculation, would be of interest to the study. This phase of the data gathering is essentially 80 percent complete and searching and analyzing have begun.

Intensive Study of Pilot Projects

The intensive study program on the Vista Ridge and Boundary projects will follow an outline guide, but the report will be shaped as the history of the

job unfolds. The outline guide for the Vista Ridge tunnel is shown below as an example.

A. Introduction

1. Location general description

2. Justification

B. Exploration Program

1. Drilling from the surface

2. Exploration drift
   a. total cost
   b. cost as a percentage of the job
   c. drilling and mapping program
   d. seismic study of blasting
   e. material testing and rock engineering

C. Design of the Tunnel

1. Requirements of the structure
   a. traffic load
   b. alignment
   c. grade
   d. spiral

2. Tunnel support design
   a. design assumptions
   b. factor of safety
   c. computation of roof loads
   d. design of steel ribs
   e. design of concrete liner
   f. design of rib foundations

3. Portal location and design
   a. natural slopes
   b. depth to rock
   c. slope stability

4. Cut and cover tunnel design
   a. roof load

b. rib design
c. lining design
d. foundation design
e. redesign during construction

5. Drainage design

6. Ventilation, lighting and appurtenances

D. Construction of the Tunnel

1. Schedule of operation
   a. side drift excavation
   b. sill construction
   c. top heading and arch excavation
   d. bench excavation
   e. cut and cover excavations
   f. portal wing wall redesign
   g. cut and cover section excavation
   h. lining construction
   i. ceiling construction

2. Operation in the side drifts
   a. excavation
   b. support of the side drifts
   c. construction of the sills

3. Top heading and rib construction
   a. excavation
   b. placement and spacing of the ribs
   c. overbreak problems

4. Bench removal

5. Lining construction

6. Seismic studies

7. Machinery and labor

E. Cost of the Tunnel

1. Engineer's estimate and bid price

2. Cost of change work orders

3. Final contract payment

4. Cost of claims and damages

5. Highway department overhead

F. Evaluation of the Project

1. Use of exploration in design and construction

2. Comparison of methods with state-of-the-art today

3. Use of rock mechanics

4. Potential savings

5. Monitoring of completed project

6. Value of this project to future projects

7. Conclusions and recommendations

The Boundary outline is similar to that the the Vista Ridge tunnel. The studies on the Green Peter and Carmen-Smith tunnels will be abbreviated accounts of the support failures and problems encountered in each of the tunnels. The amount of detail on the Green Peter and Carmen-Smith projects will depend upon the time available after the completion of the two primary project studies.

APPENDIX

Initial Form Letter
to Potential Data Sources

Dear

Foundation Sciences, Inc. has signed a contract with the U. S. Bureau of Mines to do a critical analysis study on all tunnels and chambers excavated in rock in Oregon and Washington. If the study produces practical results it will be expanded to the whole United States and eventually to other countries.

The purpose of the study is to provide an experience-based data bank on all factors which appear to have a significant bearing on (1) construction, (2) economics, (3) safety, (4) performance, and (5) maintenance of such underground excavation. The data bank will be computerized and made readily available to all data contributors, and summary reports on the project will be published at the time of its completion. It is hoped by both the U. S. Bureau of Mines and Foundation Sciences, Inc. that the data bank and reports will provide answers to the frequent vital questions raised by the various industries involved in this type of work.

A list of 75 organizations and companies involved with tunnel and chamber excavation work in Oregon and Washington has been compiled by us and the name of your firm has been included in it. We would be pleased if you could contribute to the program. If you can at this time or in the near future provide us with information of the kind shown on the enclosed questionnaire, would you please fill it out and return it to us in the enclosed self-addressed envelope.

Very truly yours,

FOUNDATION SCIENCES, INC.

R. Kenneth Dodds
President

Initial Contact Questionnaire

1. Has your firm or organization ever constructed, or had constructed for it, a tunnel, adit, or chamber greater than 10 feet in diameter?

2. Would you be willing to make the design and construction data of your tunnels, etc. available for our study and for the proposed data bank? If you are willing, any restrictions that you wish to impose will be honored.

3. If so, would you please indicate how many tunnels, adits, and chambers larger than 10 feet in diameter you have completed and/or have under construction.

4. If a firm other than yours did either the construction or the design work, would you please give us their name and address.

5. If you are willing to make the indicated data available, is it all in your files, in the other firm's files, or some in both? Would you please indicate which firm has what part of the data.

6. Can we make personal contact with you or another representative of your firm or organization as a follow-up on this query?

Agencies Replying To Initial Contact Letter

I. Federal, State, and County Organizations

Corps of Engineers
North Pacific Division
210 Custom House
Portland, Oregon 97209
Mr. Wm. Harold Stuart

Portland District
2850 S. E. 82nd Avenue
Portland, Oregon
Mr. D. H. Basgen

Seattle District
1519 Alaskan Way, S.
Seattle, Washington 98134
Mr. Edwin Derrick

Walla Walla District
City-County Airport
Walla Walla, Washington 99362
Col. Richard M. Connell

Bonneville Power and Light Administration
P. O. Box 3621
Portland, Oregon 97208
Mr. George S. Bingham

Bureau of Reclamation
Denver District
Denver Federal Center
Denver, Colorado 80225
Mr. B. P. Bellport

Boise District
P. O. Box 8008
Boise, Idaho 83707
Chief Engineer

II. Private, Municipal, and Co-op Organizations

City of Ashland
City Hall
Ashland, Oregon 97520
Mr. Allen A. Alsing

Central Lincoln Peoples Utility District
255 S. W. Coast Highway
Newport, Oregon 97365
Mr. John E. Schriner

Coos-Curry Electric Cooperative
P. O. Box 460
Coquille, Oregon 97423
Mr. Ray Shavere

Eugene Water and Electric Board
500 E. Fourth
Eugene, Oregon 97401
Mr. Herbert H. Hunt

Pacific Power and Light
920 S. W. 6th Avenue
Portland, Oregon 97204
Mr. Jack Stiles

Portland General Electric Company
621 S. W. Alder
Portland, Oregon 97204
Mr. Robert A. Blakeney

Portland Water Bureau
1800 S. W. 6th Avenue
Portland, Oregon 97204
Mr. Ken Anderson

Chelan County PUD
327 North Wenatchee Avenue
Wenatchee, Washington 98801
Mr. E. C. Metcalf

Cowlitz County PUD
960 Commerce
Longview, Washington 98632
Mr. Carl H. Evans

Douglas County PUD
1151 North Main Street
East Wenatchee, Washington 98801
Mr. John A. Gregg

Franklin County PUD
1411 West Clark Street
Pasco, Washington 99302
Mr. Harold Haake

Grant County PUD
P. O. Box 878
Ephrata, Washington 98823
Mr. R. R. Ries

Mason County PUD No. 3
P. O. Box 490
Shelton, Washington 98594
Mr. Richard L. Thompson

Seattle City and Light Company
1015 Third Avenue
Seattle, Washington 98104
Mr. C. R. Hoidal

Skagit County PUD
313 Kincaid Street
Mt. Vernon, Washington 98273
Mr. Robert A. Yale

City of Tacoma PUD
P. O. Box 11007
Tacoma, Washington 98411
Mr. Carl E. Heenan

The Washington Water Power Company
P. O. Drawer 1445
Spokane, Washington 99210
Mr. R. H. Benker

Washington Public Power Supply Company
130 Vista Way
Kennewick, Washington 99336
Mr. S. K. Billingsley

III. Highway Departments and Railroads

Oregon State Highway Department
State Highway Building
Salem, Oregon 97310
Mr. Tom Edwards

Washington State Highway Department
Highway License Building
Olympia, Washington 98501
Mr. Larry Robertson

Burlington Northern Railroad Company
American Bank Building
621 S. W. Morrison
Portland, Oregon 97204
Mr. H. F. Moy

Southern Pacific Railway Company
65 Market Street
San Franscisco, California 94105
Mr. H. M. Williamson

Union Pacific Railway Company
1460 Dodge Street
Room 1012
Omaha, Nebraska 68102
Mr. R. M. Brown

Second Form Letter
to Potential Data Sources

Re: Advanced Research Projects Agency, State-of-the-Art Review
Underground Projects; Initial Questionnaire

Dear

Thank you for you previous letter of response to the above-referenced questionnaire. To date, through similar responses, we have located more than 100 tunnels and chambers in the states of Oregon and Washington. We are now in the process of collecting Design Memoranda, Bidding Documents, Completion Reports, and subsequent Inspection or Performance Reports on these projects. At a later date, it may be of great assistance if we could see Construction Daily Shift Reports. Therefore, we would appreciate information on where they can be obtained.

In your response, you indicated tunneling projects of sufficient size and interest to be included in the detailed analysis for our study; therefore, we would like to have the above-listed reports in order to record pertinent data. All data supplied to us will be recorded here and returned promptly. The data will be handled statistically and no project will be specifically identified in our study report.

Thank you for your cooperation.

Respectfully yours,

FOUNDATION SCIENCES, INC.

Paul W. Howell
Project Scientist

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE I

NAME	OWNER	LOCATION
BLUE RIVER DAM DIV	COE PORTLAND	LANE ORE
COUGAR MAIN DIV	COE PORTLAND	LANE ORE
COUGAR PENSTOCK	COE PORTLAND	LANE ORE
COUGAR REG OUTLET	COE PORTLAND	LANE ORE
COUGAR RUSH CREEK	COE PORTLAND	LANE ORE
GREEN PETER DIV	COE PORTLAND	LINN ORE
BIG CLIFF DIV	COE PORTLAND	LINN ORE
DETROIT DAM DIV	COE PORTLAND	MARION ORE
HANSON DAM OUTLET	COE SEATTLE	KING WASH
EAGLE GORGE OUTLET	COE SEATTLE	UNKNOWN
MUD MOUNTAIN 23D	COE SEATTLE	PIERCE WASH
MUD MOUNTAIN 9D	COE SEATTLE	PIERCE WASH
DWORSHAK DAM DIV	COE WALLA WALLA	BONNER IDA
LUCKY PEAK OUTLET	COE WALLA WALLA	BONNER IDA
CARMEN-SMITH POWER	EUG WAT & ELEC BD	LANE ORE
CARMEN DIV	EUG WAT & ELEC BD	LANE ORE
KNOWLES CREEK	ORE STATE HIWAY	LANE ORE
SUNSET	ORE STATE HIWAY	TILLAMOOK ORE
TOOTH ROCK	ORE STATE HIWAY	MULTNOMAH ORE
ELK CREEK	ORE STATE HIWAY	DOUGLAS ORE
CAPE CREEK	ORE STATE HIWAY	LANE ORE
ARCH CAPE	ORE STATE HIWAY	CLATSOP ORE
VISTA RIDGE WEST	ORE STATE HIWAY	MULTNOMAH ORE
VISTA RIDGE EAST	ORE STATE HIWAY	MULTNOMAH ORE
J C BOYLE PROJECT	PAC POWER & LIGHT	UNKNOWN
TOKETEE PROJECT	PAC POWER & LIGHT	UNKNOWN
SWIFT TUNNEL	PAC POWER & LIGHT	UNKNOWN
FARADAY DIV	PORTLAND GE	CLACKAMAS ORE
OAK GROVE	PORTLAND G E	CLACKAMAS ORE
OAK GROVE #2	PORTLAND GE	CLACKAMAS ORE
OAK GROVE #3	PORTLAND G E	CLACKAMAS ORE
ROUND BUTTE POWER	PORTLAND GE	JEFFERSON ORE
ROUND BUTTE DIV	PORTLAND G E	JEFFERSON ORE
ROUND BUTTE SPILL	PORTLAND G E	JEFFERSON ORE
ROUND BUTTE LL GRT	PORTLAND GE	JEFFERSON ORE
ROUND BUTTE LL ACC	PORTLAND G E	JEFFERSON ORE
ROUND BUTTE UL GRT	PORTLAND G E	JEFFERSON ORE
ROUND BUTTE UL ACC	PORTLAND G E	JEFFERSON ORE
ROUND BUTTE LR GRT	PORTLAND G E	JEFFERSON ORE
ROUND BUTTE UR ACC	PORTLAND G E	JEFFERSON ORE
ROUND BUTTE UR GRT	PORTLAND G E	JEFFERSON ORE
BULL RUN #0	PORTLAND GE	CLACKAMAS ORE

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE I

NAME	OWNER	LOCATION
BULL RUN #1	PORTLAND G E	CLACKAMAS ORE
BULL RUN #2	PORTLAND GE	CLACKAMAS ORE
BULL RUN #4	PORTLAND G E	CLACKAMAS ORE
ROUND BUTTE LR ACC	PORTLAND G E	JEFFERSON ORE
BULL RUN@DIV	PORTLAND WATER BUR	CLACKAMAS ORE
BULL RUN LEFT ABT	PORTLAND WATER BUR	CLACKAMAS ORE
CAS#4 ABERNETHY	SP TRANSP CO	LANE ORE
CAS#16 FIELDS	SP TRANSP CO	LANE ORE
CAS#17 FIELDS	SP TRANSP CO	LANE ORE
CAS#11 FRAZIER	SP TRANSP CO	LANE ORE
CAS#12 FRAZIER	SP TRANSP CO	LANE ORE
CAS#13 FRAZIER	SP TRANSP CO	LANE ORE
CAS#14 FRAZIER	SP TRANSP CO	LANE ORE
CAS#23 LOOKOUT	SP TRANSP CO	LANE ORE
CAS#24 LOOKOUT	SP TRANSP CO	LANE ORE
CAS#21 MCCREDIE	SP TRANSP CO	LANE ORE
CAS#22 WESTFIR	SP TRANSP CO	LANE ORE
CAS#3 CASCADE SUMT	SP TRANSP CO	LANE ORE
CAS#18 WICOPEE	SP TRANSP CO	LANE ORE
CAS#19 WICOPEE	SP TRANSP CO	LANE ORE
CAS#20 WICOPEE	SP TRANSP CO	LANE ORE
COOS#16 CANARY	SP TRANSP CO	LANE ORE
COOS#15 CUSHMAN	SP TRANSP CO	LANE ORE
COOS#14 RICHARDSON	SP TRANSP CO	LANE ORE
COOS#17 KROLL	SP TRANSP CO	DOUGLAS ORE
COOS#18 KROLL	SP TRANSP CO	DOUGLAS ORE
COOS#19 REEDSPORT	SP TRANSP CO	DOUGLAS ORE
COOS#20 LAKESIDE	SP TRANSP CO	COOS ORE
CAS#5 CRUZATTE	SP TRANSP CO	LANE ORE
COOS#21 LAKESIDE	SP TRANSP CO	COOS ORE
COOS#13 VAUGHN	SP TRANSP CO	LANE ORE
SIS#1 CORNUTT	SP TRANSP CO	DOUGLAS ORE
SIS#2 GLENDALE	SP TRANSP CO	DOUGLAS ORE
SIS#3 GLENDALE	SP TRANSP CO	DOUGLAS ORE
SIS#4 GLENDALE	SP TRANSP CO	DOUGLAS ORE
SIS#5 GLENDALE	SP TRANSP CO	DOUGLAS ORE
SIS#6 GLENDALE	SP TRANSP CO	DOUGLAS ORE
SIS#7 GLENDALE	SP TRANSP CO	DOUGLAS ORE
SIS#9 HUGO	SP TRANSP CO	JOSEPHINE ORE
CAS#6 CRUZATTE	SP TRANSP CO	LANE ORE
SIS#8 WOLFCREEK	SP TRANSP CO	JOSEPHINE ORE
SIS#13 SISKIYOU	SP TRANSP CO	JOSEPHINE ORE

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TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE I

NAME	OWNER	LOCATION
SIS#14 SISKIYOU	SP TRANSP CO	JACKSON ORE
SIS#15 SISKIYOU	SP TRANSP CO	JACKSON ORE
TIL#26 COCHRAN	SP TRANSP CO	WASHINGTON ORE
TIL#27 COCHRAN	SP TRANSP CO	WASHINGTON ORE
TIL#28 ENRIGHT	SP TRANSP CO	TILLAMOOK ORE
TIL#29 ENRIGHT	SP TRANSP CO	TILLAMOOK ORE
TIL#30 ENRIGHT	SP TRANSP CO	TILLAMOOK ORE
TIL#32 ENRIGHT	SP TRANSP CO	TILLAMOOK ORE
CAS#7 CRUZATTE	SP TRANSP CO	LANE ORE
TIL#34 ENRIGHT	SP TRANSP CO	TILLAMOOK ORE
TIL#35 ENRIGHT	SP TRANSP CO	TILLAMOOK ORE
TIL#36 ENRIGHT	SP TRANSP CO	TILLAMOOK ORE
TIL#25 TIMBER	SP TRANSP CO	WASHINGTON ORE
TOL#24 EDDYVILLE	SP TRANSP CO	LINCOLN ORE
JEF#38 WILSONIA	SP TRANSP CO	MULTNOMAH ORE
CAS#8 CRUZATTE	SP TRANSP CO	LANE ORE
CAS#9 CRUZATTE	SP TRANSP CO	LANE ORE
CAS#10 CRUZATTE	SP TRANSP CO	LANE ORE
CAS#15 FIELDS	SP TRANSP CO	LANE ORE
MAYFIELD POWER	CITY OF TACOMA	LEWIS WASH
MAYFIELD DIV	CITY OF TACOMA	LEWIS WA
MOSSY ROCK DIV #1	CITY OF TACOMA	LEWIS WASH
MAYFIELD DIV #2	CITY OF TACOMA	LEWIS WASH
LA GRANDE POWER	CITY OF TACOMA	THURSTON WASH
CUSHMAN #2	CITY OF TACOMA	MASON WASH
CUSHMAN DIV	CITY OF TACOMA	MASON WASH
PORT-HUNNING #1	UNION PACIFIC RR	MULTNOMAH ORE
PORT-SPOK #12	UNION PACIFIC RR	WHITMAN WA
PORT-SPOK #13	UNION PACIFIC RR	WHITMAN WA
PORT-SPOK #14	UNION PACIFIC RR	WHITMAN WA
PORT-SPOK #15	UNION PACIFIC RR	WHITMAN WA
PORT-SPOK #16	UNION PACIFIC RR	ADAMS WA
PORT-SPOK #17	UNION PACIFIC RR	ADAMS WA
OLYMPIA BR MP 5.23	UNION PACIFIC RR	THURSTON WA
OLYMPIA BR MP 5.76	UNION PACIFIC RR	THURSTON WA
ORE EAST BR #16	UNION PACIFIC RR	MALHEUR ORE
ORE EAST BR #17	UNION PACIFIC RR	UNKNOWN
PORT-HUNNING #1.25	UNION PACIFIC RR	MULTNOHAH OR
PORT-HUNNING #1.50	UNION PACIFIC RR	HOODRIVER OR
PORT-HUNNING #3.50	UNION PACIFIC RR	UMATILLA OR
PORT-HUNNING #6	UNION PACIFIC RR	BAKER OR
PORT-SEA MP 4.50	UNION PACIFIC RR	MULTNOMAH OR

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE I

NAME	OWNER	LOCATION
PORT-SPOK #7	UNION PACIFIC RR	WALLA WALLA WA
PORT-SPOK #10	UNION PACIFIC RR	WHITMAN WA
PORT-SPOK #11	UNION PACIFIC RR	WHITMAN WA
2/108 TUNNEL #1	WASH HWY DEPT	CHELAN WASH
14/216	WASH HWY DEPT	UNKNOWN
20/108	WASH HWY DEPT	CHELAN WASH
20/111	WASH HWY DEPT	CHELAN WASH
20/113N	WASH HWY DEPT	CHELAN WASH
97/24 MT BAKER	WASH HWY DEPT	UNKNOWN
97/359 KNAPPS HILL	WASH HWY DEPT	UNKNOWN
101/23 FORT COL	WASH HWY DEPT	UNKNOWN
123/106	WASH HWY DEPT	UNKNOWN
12/308 RIMROCK	WASH HWY DEPT	YAKIMA WASH
14/128 TUNNEL #1	WASH HWY DEPT	UNKNOWN
14/129 TUNNEL #2	WASH HWY DEPT	UNKNOWN
14/130 TUNNEL #3	WASH HWY DEPT	UNKNOWN
14/133 TUNNEL #4	WASH HWY DEPT	UNKNOWN
14/134 TUNNEL #5	WASH HWY DEPT	UNKNOWN
14/206 BINGEN	WASH HWY DEPT	UNKNOWN
14/215	WASH HWY DEPT	UNKNOWN
YAKIMA MAIN CANAL	BU REC BOISE	KITTITAS ORE
KLAMATH CANAL A	BU REC BOISE	KLAMATH ORE
BLACK CANYON T#1	BU REC BOISE	GEM IDA
BLACK CANYON T#2	BU REC BOISE	GEM IDA
BLACK CANYON T#2A	BU REC BOISE	GEM IDA
BLACK CANYON T#3	BU REC BOISE	GEM IDA
BLACK CANYON T#4	BU REC BOISE	GEM IDA
BLACK CANYON T#5	BU REC BOISE	GEM IDA
BLACK CANYON T#6	BU REC BOISE	GEM IDA
BLACK CANYON T#7	BU REC BOISE	GEM IDA
BLACK CANYON T#8	BU REC BOISE	GEM IDA
COLU BASIN BACON	BU REC BOISE	UNKNOWN
FRENCHMAN HILLS	BU REC BOISE	UNKNOWN
SNOW LAKE	BU REC BOISE	UNKNOWN
DESCHUTES T#1	BU REC BOISE	WASCO ORE
DESCHUTES T#2	BU REC BOISE	WASCO ORE
OWHYEE APPRH N CAN	BU REC BOISE	MALHEUR ORE
OWYHEE LATRL N CAN	BU REC BOISE	MALHEUR ORE
OWYHEE T#1 N CAN	BU REC BOISE	MALHEUR ORE
OWYHEE T#3 N CAN	BU REC BOISE	MALHEUR ORE
OWYHEE T#4 N CAN	BU REC BOISE	MALHEUR ORE
OWYHEE T#5 S CAN	BU REC BOISE	MALHEURORE

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE I

NAME	OWNER	LOCATION
OWYHEE T#6 X CAN	BU REC BOISE	MALHEUR ORE
OWYHEE T#7 S CAN	BU REC BOISE	MALHEUR ORE
ROGUE RIV CAS DIV	BU REC BOISE	KLAMATH ORE
ROGUE RIV S FORK	BU REC BOISE	JACKSON ORE
ROGUE RIV G S POWR	BU REC BOISE	JACKSON ORE
VALE T#1	BU REC BOISE	MALHEUR ORE
VALE T#2	BU REC BOISE	MALHEUR ORE
VALE T#3	BU REC BOISE	MALHEUR ORE
VALE T#4	BU REC BOISE	MALHEUR ORE
VALE T#5	BU REC BOISE	MALHEUR ORE
YAKIMA KITTITAS MC	BU REC BOISE	KITTITAS WASH
T#2 S BRANCH CANAL	BU REC BOISE	KITTITAS WASH
ROZA DIV	BU REC BOISE	KITTITAS ORE
T#3 YAKIMA RIDGE	BU REC BOISE	KITTITAS ORE
T#5 YAKIMA RIDGE	BU REC BOISE	KITTITAS ORE
T#7 YAKIMA RIDGE	BU REC BOISE	KITTITAS ORE
T#8 YAKIMA RIDGE	BU REC BOISE	KITTITAS ORE
YAKIMA PROJECT	BU REC BOISE	KITTITAS, WASH
YAKIMA ROCKY POINT	BU REC BOISE	KITTITAS ORE
YAKIMA RIVER	BU REC BOISE	KITTITAS ORE
T#1 N BRANCH CANAL	BU REC BOISE	KITTITAS ORE
T#2 N BRANCH CANAL	BU REC BOISE	KITTITAS ORE
T#3 N BRANCH CANAL	BU REC BOISE	KITTITAS ORE
T#4 N BRANCH CANAL	BU REC BOISE	KITTITAS ORE
T#5 N BRANCH CANAL	BU REC BOISE	KITTITAS ORE
T#1 S BRANCH CANAL	BU REC BOISE	KITTITAS ORE
PRINEVILLE U/S DIV	BU REC BOISE	CROOK ORE
PRINEVILLE D/S DIV	BU REC BOISE	COOK ORE
KLAMATH CANAL A	BU OF REC BOISE	KLAMATH OR
CAPE HORN #1	BURLINGTON NORTH	CAPE HORN WASH
CAPE HORN #10	BURLINGTON NORTH	KLICKITAT WASH
CAPE HORN #11	BURLINGTON NORTH	KLICKITAT WASH
CAPE HORN #12	BURLINGTON NORTH	KLICKITAT WASH
CAPE HORN #13	BURLINGTON NORTH	FRANKLIN WASH
CAPE HORN #15	BURLINGTON NORTH	FRANKLIN WASH
CAPE HORN #16	BURLINGTON NORTH	FRANKLIN WASH
CAPE HORN #17	BURLINGTON NORTH	FRANKLIN WASH
CAPE HORN #18	BURLINGTON NORTH	WHITMAN WASH
FORT WRIGHT #19	BURLINGTON NORTH	SPOKANE WASH
O T RY #1	BURLINGTON NORTH	WASCO ORE
CAPE HORN #2	BURLINGTON NORTH	SKAMANIA WASH
O T RY #2	BURLINGTON NORTH	WASCO ORE

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE I

NAME	OWNER	LOCATION
O T RY@#3	BURLINGTON NORTH	WASCO ORE
O T RY #4	BURLINGTON NORTH	WASCO ORE
GATEWAY #5	BURLINGTON NORTH	JEFFERSON ORE
MAYGER #3	BURLINGTON NORTH	COLUMBIA ORE
CORNELIUS	BURLINGTON NORTH	MULTNOMAH ORE
TUNNEL #1 OTR	BURLINGTON RR	OREGON
TUNNEL #3 OTR	BURLINGTON RR	OREGON
TUNNEL #4 OTR	BURLINGTON RR	OREGON
TUNNEL #2 OTR	BURLINGTON RR	OREGON
CAPE HORN #3	BURLINGTON NORTH	SKAMANIA WASH
BLUE SLIDE	BURLINGTON RR	WASHINGTON
JOHNSON CR #45	BURLINGTON RR	WASHINGTON
WOLF CREEK	BURLINGTON RR	WASHINGTON
FASTON	BURLINGTON RR	WASHINGTON
HORLICK #1	BURLINGTON RR	WASHINGTON
HORLICK #2	BURLINGTON RR	WASHINGTON
TANCUM	BURLINGTON RR	WASHINGTON
SNOQUALMIE #50	BURLINGTON RR	WASHINGTON
VAIL	BURLINGTON RR	WASHINGTON
WOLF CREEK	BURLINGTON RR	WASHINGTON
CAPE HORN #4	BURLINGTON NORTH	SKAMANIA WASH
ROCK LAKE	BURLINGTON RR	WASHINGTON
PALISADES	BURLINGTON RR	WASHINGTON
ROCKLAKE #43	BURLINGTON RR	WASHINGTON
WATTS #41	BURLINGTON RR	WASHINGTON
•2 MII E SPOKANE	BURLINGTON RR	WASHINGTON
EASTON	BURLINGTON RR	WASHINGTON
VAIL #2	BURLINGTON RR	WASHINGTON
WHITTIER	BURLINGTON RR	WASHINGTON
WHITTIER #2	BURLINGTON RR	WASHINGTON
CASCADE	BURLINGTON RR	WASHINGTON
CAPE HORN #5	BURLINGTON NORTH	SKAMANIA WASH
EVERETT #15	BURLINGTON RR	WASHINGTON
OROVILLE #7	BURLINGTON RR	WASHINGTON
SAMISH #18	BURLINGTON RR	WASHINGTON
SEATTLE #17	BURLINGTON RR	WASHINGTON
WINSTON #14	BURLINGTON RR	WASHINGTON
STAMPEDE #1	BURLINGTON RR	WASHINGTON
STAMPEDE #4	BURLINGTON RR	WASHINGTON
OSTRANDER	BURLINGTON RR	WASHINGTON
NELSON-BENNETT	BURLINGTON RR	WASHINGTON
RUSTON	BURLINGTON RR	WASHINGTON

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE I

NAME	OWNER	LOCATION
CAPE HORN #6	BURLINGTON NORTH	SKAMANIA WASH
CAPE HORN #7	BURLINGTON NORTH	KLICKITAT WASH
CAPE HORN #8	BURLINGTON NORTH	KLICKITAT WASH
CAPE HORN #9	BURLINGTON NORTH	KLICKITAT WASH

256 RECORDS READ
256 RECORDS SELECTED

RUN COMPLETED

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE II

NAME	ENGINEER	CONTRACTOR
BLUE RIVER DAM DIV	COE PORTLAND	RADCO & AUSUM CONS
COUGAR MAIN DIV	COE PORTLAND	NORTHWOOD INC
COUGAR PENSTOCK	COE PORTLAND	BELMONT CONST INC
COUGAR REG OUTLET	COE PORTLAND	BELMONT CONST INC
COUGAR RUSH CREEK	COE PORTLAND	BELMONT CONST INC
GREEN PETER DIV	COE PORTLAND	PAUL HARDEM AN INC
BIG CLIFF DIV	COE PORTLAND	CONSOLIDATED BLDS
DETROIT DAM DIV	COE PORTLAND	UNKNOWN
HANSON DAM OUTLET	COE SEATTLE	UNKNOWN
EAGLE GORGE OUTLET	COE SEATTLE	UNKNOWN
MUD MOUNTAIN 23D	COE SEATTLE	UNKNOWN
MUD MOUNTAIN 9D	COE SEATTLE	UNKNOWN
DWORSHAK DAM DIV	COE WALLA WALLA	PETER KIEWITT
LUCKY PEAK OUTLET	COE WALLA WALLA	UNKNOWN
CARMEN-SMITH POWER	BECHTEL	UNKNOWN
CARMEN DIV	BECHTEL	UNKNOWN
KNOWLES CREEK	ORE STATE HIWAY	GIBBONS & REED
SUNSET	ORE STATE HIWAY	KERNS & KIBBE
TOOTH ROCK	UNKNOWN	UNKNOWN
ELK CREEK	ORE STATE HIWAY	UNKNOWN
CAPE CREEK	ORE STATE HIWAY	UNKNOWN
ARCH CAPE	ORE STATE HIWAY	UNKNOWN
VISTA RIDGE WEST	ORE STATE HIWAY	DRAKE-WINSTON
VISTA RIDGE EAST	ORE STATE HIWAY	DRAKE-WINSTON
J C BOYLE PROJECT	PIONEER SERV & ENG	MORRISON & KNUDSEN
TOKETEE PROJECT	PIONEER SERV & ENG	L E DIXON
SWIFT TUNNEL	UNKNOWN	UNKNOWN
FARADAY DIV	EBASCO	G. F. ATKINSON
OAK GROVE	EBASCO	UNKNOWN
OAK GROVE #2	EBASCO	UNKNOWN
OAK GROVE #3	EBASCO	UNKNOWN
ROUND BUTTE POWER	BECHTEL	PETER KIEWITT
ROUND BUTTE DIV	BECHTEL	PETER KIEWITT
ROUND BUTTE SPILL	BECHTEL	PETER KIEWITT
ROUND BUTTE LL GRT	BECHTEL	PETER KIEWITT
ROUND BUTTE LL ACC	BECHTEL	PETER KIEWITT
ROUND BUTTE UL GRT	BECHTEL	PETER KIEWITT
ROUND BUTTE UL ACC	BECHTEL	PETER KIEWITT
ROUND BUTTE LR GRT	BECHTEL	PETER KIEWITT
ROUND BUTTE UR ACC	BECHTEL	PETER KIEWITT
ROUND BUTTE UR GRT	BECHTEL	PETER KIEWITT
BULL RUN #0	C. P. DUNN	UNKNOWN

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE II

NAME	ENGINEER	CONTRACTOR
BULL RUN #1	J. G. WHITE	UNKNOWN
BULL RUN #2	J.G. WHITE	UNKNOWN
BULL RUN #4	J.G.WHITE	UNKNOWN
ROUND BUTTE LR ACC	BECHTEL	PETER KIEWITT
BULL RUN DIV	STEVENS THOMPSON	GATES & FOX
BULL RUN LEFT ABT	STEVENS THOMPSON	GATES & FOX
CAS#4 ABERNETHY	SP TRANSP CO	UTAH CONSTR CO
CAS#16 FIELDS	SP TRANSP CO	UTAH CONSTR CO
CAS#17 FIELDS	SP TRANSP CO	UTAH CONSTR CO
CAS#11 FRAZIER	SP TRANSP CO	UTAH CONSTR CO
CAS#12 FRAZIER	SP TRANSP CO	UTAH CONSTR CO
CAS#13 FRAZIER	SP TRANSP CO	UTAH CONSTR CO
CAS#14 FRAZIER	SP TRANSP CO	UTAH CONSTR CO
CAS#23 LOOKOUT	SP TRANSP CO	SP TRANSP CO
CAS#24 LOOKOUT	SP TRANSP CO	SP TRANSP CO
CAS#21 MCCREDIE	SP TRANSP CO	UTAH CONSTR CO
CAS#22 WESTFIR	SP TRANSP CO	SP TRANSP CO
CAS#3 CASCADE SUMT	SP TRANSP CO	UTAH CONSTR CO
CAS#18 WICOPEE	SP TRANSP CO	UTAH CONSTR CO
CAS#19 WICOPEE	SP TRANSP CO	UTAH CONSTR CO
CAS#20 WICOPEE	SP TRANSP CO	UTAH CONSTR CO
COOS#16 CANARY	SP TRANSP CO	SP TRANSP CO
COOS#15 CUSHMAN	SP TRANSP CO	SP TRANSP CO
COOS#14 RICHARDSON	SP TRANSP CO	SP TRANSP CO
COOS#17 KROLL	SP TRANSP CO	SP TRANSP CO
COOS#18 KROLL	SP TRANSP CO	SP TRANSP CO
COOS#19 REEDSPORT	SP TRANSP CO	SP TRANSP CO
COOS#20 LAKESIDE	SP TRANSP CO	SP TRANSP CO
CAS#5 CRUZATTE	SP TRANSP CO	UTAH CONSTR CO
COOS#21 LAKESIDE	SP TRANSP CO	SP TRANSP CO
COOS#13 VAUGHN	SP TRANSP CO	SP TRANSP CO
SIS#1 CORNUTT	SP TRANSP CO	SP TRANSP CO
SIS#2 GLENDALE	SP TRANSP CO	SP TRANSP CO
SIS#3 GLENDALE	SP TRANSP CO	SP TRANSP CO
SIS#4 GLENDALE	SP TRANSP CO	SP TRANSP CO
SIS#5 GLENDALE	SP TRANSP CO	SP TRANSP CO
SIS#6 GLENDALE	SP TRANSP CO	SP TRANSP CO
SIS#7 GLENDALE	SP TRANSP CO	SP TRANSP CO
SIS#9 HUGO	SP TRANSP CO	SP TRANSP CO
CAS#6 CRUZATTE	SP TRANSP CO	UTAH CONSTR CO
SIS#8 WOLFCREEK	SP TRANSP CO	SP TRANSP CO
SIS#13 SISKIYOU	SP TRANSP CO	SP TRANSP CO

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE II

NAME	ENGINEER	CONTRACTOR
SIS#14 SISKIYOU	SP TRANSP CO	SP TRANSP CO
SIS#15 SISKIYOU	SP TRANSP CO	SP TRANSP CO
TIL#26 COCHRAN	SP TRANSP CO	SP TRANSP CO
TIL#27 COCHRAN	SP TRANSP CO	SP TRANSP CO
TIL#28 ENRIGHT	SP TRANSP CO	SP TRANSP CO
TIL#29 ENRIGHT	SP TRANSP CO	SP TRANSP CO
TIL#30 ENRIGHT	SP TRANSP CO	SP TRANSP CO
TIL#32 ENRIGHT	SP TRANSP CO	SP TRANSP CO
CAS#7 CRUZATTE	SP TRANSP CO	UTAH CONSTR CO
TIL#34 ENRIGHT	SP TRANSP CO	SP TRANSP CO
TIL#35 ENRIGHT	SP TRANSP CO	SP TRANSP CO
TIL#36 ENRIGHT	SP TRANSP CO	SP TRANSP CO
TIL#25 TIMBER @	SP TRANSP CO	SP TRANSP CO
TOL#24 EDDYVILLE	SP TRANSP CO	SP TRANSP CO
JEF#38 WILSONIA	SP TRANSP CO	SP TRANSP CO
CAS#8 CRUZATTE	SP TRANSP CO	UTAH CONSTR CO
CAS#9 CRUZATTE	SP TRANSP CO	UTAH CONSTR CO
CAS#10 CRUZATTE	SP TRANSP CO	UTAH CONSTR CO
CAS#15 FIELDS	SP TRANSP CO	SP TRANSP CO
MAYFIELD POWER	CITY OF TACOMA	UNKNOWN
MAYFIELD DIV	HARZA ENGINEERING	ARUNDEL CORP
MOSSY ROCK DIV #1	HARZA ENGINEERING	UNKNOWN
MAYFIELD DIV #2	HARZA ENGINEERING	UNKNOWN
LA GRANDE POWER	UNKNOWN	L.E. DIXON CO
CUSHMAN #2	UNKNOWN	YOUDALL CONST
CUSHMAN DIV	CITY OF TACOMA	A GUTHRIE CO
PORT-HUNNING #1	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #12	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #13	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #14	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #15	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #16	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #17	UNION PACIFIC RR	UNION PACIFIC RR
OLYMPIA BR MP 5.23	UNION PACIFIC RR	UNION PACIFIC RR
OLYMPIA BR MP 5.76	UNION PACIFIC RR	UNION PACIFIC RR
ORE EAST BR #16	UNION PACIFIC RR	UNION PACIFIC RR
ORE EAST BR #17	UNION PACIFIC RR	UNION PACIFIC RR
PORT-HUNNING #1.25	COE PORTLAND	UNKNOWN
PORT-HUNNING #1.50	UNION PACIFIC RR	UNION PACIFIC RR
PORT-HUNNING #3.50	UNION PACIFIC RR	UNION PACIFIC RR
PORT-HUNNING #6	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SEA MP 4.50	UNION PACIFIC RR	UNION PACIFIC RR

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE II

NAME	ENGINEER	CONTRACTOR
PORT-SPOK #7	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #10	UNION PACIFIC RR	UNION PACIFIC RR
PORT-SPOK #11	UNION PACIFIC RR	UNION PACIFIC RR
2/108 TUNNEL #1	UNKNOWN	MYERS & GOULTER
14/216	UNKNOWN	MORRISON KNUDSEN
20/108	UNKNOWN	HWY CONST CO LTD
20/111	UNKNOWN	HWY CONST LTD
20/113N	UNKNOWN	UNKNOWN
97/24 MT BAKER	UNKNOWN	UNKNOWN
97/359 KNAPPS HILL	UNKNOWN	ELLIOTT & CO
101/23 FORT COL	WASH HWY DEPT	MORRISON-KNUDSEN
123/106	UNKNOWN	FED HWY ADMIN
12/308 RIMROCK	UNKNOWN	BJORK BROS
14/128 TUNNEL #1	UNKNOWN	MIRENE CO
14/129 TUNNEL #2	UNKNOWN	MIRENE CO
14/130 TUNNEL #3	UNKNOWN	MIRENE CO
14/133 TUNNEL #4	UNKNOWN	COLONIAL CONST CO
14/134 TUNNEL #5	UNKNOWN	COLONIAL CONST CO
14/206 BINGEN	UNKNOWN	DORMAN & KAMPE
14/215	UNKNOWN	MORRISON-KNUDSEN
YAKIMA MAIN CANAL	BU REC BOISE	UNKNOWN
KLAMATH CANAL A	BU REC BOISE	UNKNOWN
BLACK CANYON T#1	BU REC BOISE	UNKNOWN
BLACK CANYON T#2	BU REC BOISE	UNKNOWN
BLACK CANYON T#2A	BU REC BOISE	UNKNOWN
BLACK CANYON T#3	BU REC BOISE	UNKNOWN
BLACK CANYON T#4	BU REC BOISE	UNKNOWN
BLACK CANYON T#5	BU REC BOISE	UNKNOWN
BLACK CANYON T#6	BU REC BOISE	UNKNOWN
BLACK CANYON T#7	BU REC BOISE	UNKNOWN
BLACK CANYON T#8	BU REC BOISE	UNKNOWN
COLU BASIN BACON	BU REC BOISE	UNKNOWN
FRENCHMAN HILLS	BU REC BOISE	UNKNOWN
SNOW LAKE	BU REC BOISE	UNKNOWN
DESCHUTES T#1	BU REC BOISE	UNKNOWN
DESCHUTES T#2	BU REC BOISE	UNKNOWN
OWHYEE APPRH N CAN	BU REC BOISE	UNKNOWN
OWYHEE LATRL N CAN	BU REC BOISE	UNKNOWN
OWYHEE T#1 N CAN	BU REC BOISE	UNKNOWN
OWYHEE T#3 N CAN	BU REC BOISE	UNKNOWN
OWYHEE T#4 N CAN	BU REC BOISE	UNKNOWN
OWYHEE T#5 S CAN	BU REC BOISE	UNKNOWN

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE II

NAME	ENGINEER	CONTRACTOR
OWYHEE T#6 X CAN	BU REC BOISE	UNKNOWN
OWYHEE T#7 S CAN	BU REC BOISE	UNKNOWN
ROGUE RIV CAS DIV	BU REC BOISE	UNKNOWN
ROGUE RIV S FORK	BU REC BOISE	UNKNOWN
ROGUE RIV G S POWR	BU REC BOISE	UNKNOWN
VALE T#1	BU REC BOISE	UNKNOWN
VALE T#2	BU REC BOISE	UNKNOWN
VALE T#3	BU REC BOISE	UNKNOWN
VALE T#4	BU REC BOISE	UNKNOWN
VALE T#5	BU REC BOISE	UNKNOWN
YAKIMA KITTITAS MC	BU REC BOISE	UNKNOWN
T#2 S BRANCH CANAL	BU REC BOISE	UNKNOWN
ROZA DIV	BU REC BOISE	UNKNOWN
T#3 YAKIMA RIDGE	BU REC BOISE	UNKNOWN
T#5 YAKIMA RIDGE	BU REC BOISE	UNKNOWN
T#7 YAKIMA RIDGE	BU REC BOISE	UNKNOWN
T#8 YAKIMA RIDGE	BU REC BOISE	UNKNOWN
YAKIMA PROJECT	BU REC BOISE	UNKNOWN
YAKIMA ROCKY POINT	BU REC BOISE	UNKNOWN
YAKIMA RIVER	BU REC BOISE	UNKNOWN
T#1 N BRANCH CANAL	BU REC BOISE	UNKNOWN
T#2 N BRANCH CANAL	BU REC BOISE	UNKNOWN
T#3 N BRANCH CANAL	BU REC BOISE	UNKNOWN
T#4 N BRANCH CANAL	BU REC BOISE	UNKNOWN
T#5 N BRANCH CANAL	BU REC BOISE	UNKNOWN
T#1 S BRANCH CANAL	BU REC BOISE	UNKNOWN
PRINEVILLE U/S DIV	BU REC BOISE	SCHRADER CONSTR
PRINEVILLE D/S DIV	BU REC BOISE	SCHRADER CONSTR
KLAMATH CANAL A	BU REC BOISE	UNKNOWN
CAPE HORN #1	UNKNOWN	UNKNOWN
CAPE HORN #10	UNKNOWN	UNKNOWN
CAPE HORN #11	UNKNOWN	UNKNOWN
CAPE HORN #12	UNKNOWN	UNKNOWN
CAPE HORN #13	UNKNOWN	UNKNOWN
CAPE HORN #15	UNKNOWN	UNKNOWN
CAPE HORN #16	UNKNOWN	UNKNOWN
CAPE HORN #17	UNKNOWN	UNKNOWN
CAPE HORN #18	UNKNOWN	UNKNOWN
FORT WRIGHT #19	UNKNOWN	UNKNOWN
O T RY #1	UNKNOWN	UNKNOWN
CAPE HORN #2	UNKNOWN	UNKNOWN
O T RY #2	UNKNOWN	UNKNOWN

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE II

NAME	ENGINEER	CONTRACTOR
O T RY #3	UNKNOWN	UNKNOWN
O T RY #4	UNKNOWN	UNKNOWN
GATEWAY #5	UNKNOWN	UNKNOWN
MAYGER #3	UNKNOWN	UNKNOWN
CORNELIUS	UNKNOWN	UNKNOWN
TUNNEL #1 OTR	UNKNOWN	UNKNOWN
TUNNEL #3 OTR	UNKNOWN	UNKNOWN
TUNNEL #4 OTR	UNKNOWN	UNKNOWN
TUNNEL #2 OTR	UNKNOWN	UNKNOWN
CAPE HORN #3	UNKNOWN	UNKNOWN
BLUE SLIDE	UNKNOWN	UNKNOWN
JOHNSON CR #45	UNKNOWN	UNKNOWN
WOLF CREEK	UNKNOWN	UNKNOWN
FASTON	UNKNOWN	UNKNOWN
HORLICK #1	UNKNOWN	UNKNOWN
HORLICK #2	UNKNOWN	UNKNOWN
TANCUM	UNKNOWN	UNKNOWN
SNDQUALMIE #50	UNKNOWN	UNKNOWN
VAIL	UNKNOWN	UNKNOWN
WOLF CREEK	UNKNOWN	UNKNOWN
CAPE HORN #4	UNKNOWN	UNKNOWN
ROCK LAKE	UNKNOWN	UNKNOWN
PALISADES	UNKNOWN	UNKNOWN
ROCKLAKE #43	UNKNOWN	UNKNOWN
WATTS #41	UNKNOWN	UNKNOWN
•2 MII E SPOKANE	UNKNOWN	UNKNOWN
EASTON	UNKNOWN	UNKNOWN
VAIL #2	UNKNOWN	UNKNOWN
WHITTIER	UNKNOWN	UNKNOWN
WHITTIER #2	UNKNOWN	UNKNOWN
CASCADE	UNKNOWN	UNKNOWN
CAPE HORN #5	UNKNOWN	UNKNOWN
EVERETT #15	UNKNOWN	UNKNOWN
OROVILLE #7	UNKNOWN	UNKNOWN
SAMISH #18	UNKNOWN	UNKNOWN
SEATTLE #17	UNKNOWN	UNKNOWN
WINSTON #14	UNKNOWN	UNKNOWN
STAMPEDE #1	UNKNOWN	UNKNOWN
STAMPEDE #4	UNKNOWN	UNKNOWN
OSTRANDER	UNKNOWN	UNKNOWN
NELSON-BENNETT	UNKNOWN	UNKNOWN
RUSTON	UNKNOWN	UNKNOWN

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE II

NAME	ENGINEER	CONTRACTOR
CAPE HORN #6	UNKNOWN	UNKNOWN
CAPE HORN #7	UNKNOWN	UNKNOWN
CAPE HORN #8	UNKNOWN	UNKNOWN
CAPE HORN #9	UNKNOWN	UNKNOWN

256 RECORDS READ
256 RECORDS SELECTED

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE III

NAME	DATE	USE	COST	KEY NO
BLUE RIVER DAM DIV	40066	WATER	566340	12-1
COUGAR MAIN DIV	20057	WATER	306647	12-2-1
COUGAR PENSTOCK	20060	WATER	336240	12-2-2
COUGAR REG OUTLET	59	WATER	341640	12-2-3
COUGAR RUSH CREEK	20060	WATER	0	12-2-4
GREEN PETER DIV	30064	WATER	820200	12-3
BIG CLIFF DIV	50	WATER	270124	12-4
DETROIT DAM DIV	49	WATER	1132000	12-5
HANSON DAM OUTLET	61	WATER	0	13-1
EAGLE GORGE OUTLET	0	WATER	0	13-2
MUD MOUNTAIN 23D	48	WATER	0	13-3
MUD MOUNTAIN 9D	47	WATER	0	13-4
DWORSHAK DAM DIV	70066	WATER	0	14-1
LUCKY PEAK OUTLET	80050	WATER	0	14-2
CARMEN-SMITH POWER	0	WATER	0	17-1-1
CARMEN DIV	60062	WATER	0	17-1-2
KNOWLES CREEK	58	HIGHWAY	616641	26-1
SUNSET	41	HIGHWAY	141685	26-2
TOOTH ROCK	36	HIGHWAY	0	26-3
ELK CREEK	0	HIGHWAY	0	26-4
CAPE CREEK	0	HIGHWAY	0	26-5
ARCH CAPE	37	HIGHWAY	0	26-6
VISTA RIDGE WEST	69	HIGHWAY	4171982	26-7
VISTA RIDGE EAST	67	HIGHWAY	4562674	26-8
J C BOYLE PROJECT	58	WATER	714500	29-1
TOKETEE PROJECT	49	WATER	1484520	29-2
SWIFT TUNNEL	0	WATER	0	29-3
FARADAY DIV	31157	WATER	0	31-01-0
OAK GROVE	25	WATER	0	31-02-0
OAK GROVE #2	25	WATER	0	31-02-0
OAK GROVE #3	25	WATER	0	31-02-0
ROUND BUTTE POWER	41063	WATER	924217	31-03-0
ROUND BUTTE DIV	121961	WATER	1161960	31-03-0
ROUND BUTTE SPILL	21762	WATER	216514	31-03-0
ROUND BUTTE LL GRT	30962	OTHER	189628	31-03-0
ROUND BUTTE LL ACC	21262	OTHER	178208	31-03-0
ROUND BUTTE UL GRT	11262	OTHER	66620	31-03-0
ROUND BUTTE UL ACC	121961	OTHER	76428	31-03-0
ROUND BUTTE LR GRT	20162	OTHER	142757	31-03-0
ROUND BUTTE UR ACC	110361	OTHER	81054	31-03-1
ROUND BUTTE UR GRT	120161	OTHER	39734	31-03-1
BULL RUN #0	52726	WATER	29500	31-04-0

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE III

NAME	DATE	USE	COST	KEY NO
BULL RUN #1	11	WATER	11[illegible]	31-04-0
BULL RUN #2	12	WATER	9[illegible]	31-04-0
BULL RUN #4	12	WATER	55000	31-04-0
ROUND BUTTE LR ACC	11262	OTHER	179873	32-03-0
BULL RUN DIV	61	WATER	1200000	32-1-1
BULL RUN LEFT ABT	61	WATER	916000	32-1-2
CAS#4 ABERNETHY	26	RAILROAD	0	36-1
CAS#16 FIELDS	26	RAILROAD	0	36-10
CAS#17 FIELDS	26	RAILROAD	0	36-11
CAS#11 FRAZIER	26	RAILROAD	0	36-12
CAS#12 FRAZIER	26	RAILROAD	0	36-13
CAS#13 FRAZIER	26	RAILROAD	0	36-14
CAS#14 FRAZIER	26	RAILROAD	0	36-15
CAS#23 LOOKOUT	26	RAILROAD	0	36-16
CAS#24 LOOKOUT	26	RAILROAD	0	36-17
CAS#21 MCCREDIE	26	RAILROAD	0	36-18
CAS#22 WESTFIR	26	RAILROAD	0	36-19
CAS#3 CASCADE SUMT	26	RAILROAD	0	36-2
CAS#18 WICOPEE	26	RAILROAD	0	36-20
CAS#19 WICOPEE	26	RAILROAD	0	36-21
CAS#20 WICOPEE	26	RAILROAD	0	36-22
COOS#16 CANARY	83	RAILROAD	0	36-23
COOS#15 CUSHMAN	83	RAILROAD	0	36-24
COOS#14 RICHARDSON	83	RAILROAD	0	36-25
COOS#17 KROLL	83	RAILROAD	0	36-26
COOS#18 KROLL	83	RAILROAD	0	36-27
COOS#19 REEDSPORT	83	RAILROAD	0	36-28
COOS#20 LAKESIDE	83	RAILROAD	0	36-29
CAS#5 CRUZATTE	26	RAILROAD	0	36-3
COOS#21 LAKESIDE	83	RAILROAD	0	36-30
COOS#13 VAUGHN	83	RAILROAD	0	36-31
SIS#1 CORNUTT	83	RAILROAD	0	36-32
SIS#2 GLENDALE	83	RAILROAD	0	36-33
SIS#3 GLENDALE	83	RAILROAD	0	36-34
SIS#4 GLENDALE	83	RAILROAD	0	36-35
SIS#5 GLENDALE	83	RAILROAD	0	36-36
SIS#6 GLENDALE	83	RAILROAD	0	36-37
SIS#7 GLENDALE	83	RAILROAD	0	36-38
SIS#9 HUGO	83	RAILROAD	0	36-39
CAS#6 CRUZATTE	26	RAILROAD	0	36-4
SIS#8 WOLFCREEK	83	RAILROAD	0	36-40
SIS#13 SISKIYOU	83	RAILROAD	0	36-41

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE III

NAME	DATE	USE	COST	KEY NO
SIS#14 SISKIYOU	83	RAILROAD	0	36-42
SIS#15 SISKIYOU	83	RAILROAD	0	36-43
TIL#26 COCHRAN	12	RAILROAD	0	36-44
TIL#27 COCHRAN	12	RAILROAD	0	36-45
TIL#28 ENRIGHT	12	RAILROAD	0	36-46
TIL#29 ENRIGHT	12	RAILROAD	0	36-47
TIL#30 ENRIGHT	12	RAILROAD	0	36-48
TIL#32 ENRIGHT	12	RAILROAD	0	36-49
CAS#7 CRUZATTE	26	RAILROAD	0	36-5
TIL#34 ENRIGHT	12	RAILROAD	0	36-50
TIL#35 ENRIGHT	12	RAILROAD	0	36-51
TIL#36 ENRIGHT	12	RAILROAD	0	36-52
TIL#25 TIMBER	12	RAILROAD	0	36-53
TOL#24 EDDYVILLE	1	RAILROAD	0	36-54
JEF#38 WILSONIA	20	RAILROAD	0	36-55
CAS#8 CRUZATTE	26	RAILROAD	0	36-6
CAS#9 CRUZATTE	26	RAILROAD	0	36-7
CAS#10 CRUZATTE	26	RAILROAD	0	36-8
CAS#15 FIELDS	26	RAILROAD	0	36-9
MAYFIELD POWER	0	WATER	0	37-1
MAYFIELD DIV	55	WATER	2457342	37-2
MOSSY ROCK DIV #1	64	WATER	1520700	37-2
MAYFIELD DIV #2	0	WATER	831215	37-3
LA GRANDE POWER	0	WATER	1306836	37-4
CUSHMAN #2	29	WATER	0	37-5
CUSHMAN DIV	24	WATER	185853	37-6
PORT-HUNNING #1	9	RAILROAD	0	40-1
PORT-SPOK #12	12	RAILROAD	0	40-10
PORT-SPOK #13	12	RAILROAD	0	40-11
PORT-SPOK #14	12	RAILROAD	0	40-12
PORT-SPOK #15	12	RAILROAD	0	40-13
PORT-SPOK #16	12	RAILROAD	0	40-14
PORT-SPOK #17	12	RAILROAD	0	40-15
OLYMPIA BR MP 5.23	21	RAILROAD	0	40-16
OLYMPIA BR MP 5.76	46	RAILROAD	0	40-17
ORE EAST BR #16	37	RAILROAD	0	40-18
ORE EAST BR #17	37	RAILROAD	0	40-19
PORT-HUNNING #1.25	35	RAILROAD	0	40-2
PORT-HUNNING #1.50	22	RAILROAD	0	40-3
PORT-HUNNING #3.50	48	RAILROAD	0	40-4
PORT-HUNNING #6	28	RAILROAD	0	40-5
PORT-SEA MP 4.50	9	RAILROAD	0	40-6

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE III

NAME	DATE	USE	COST	KEY NO
PORT-SPOK #7	99	RAILROAD	0	40-7
PORT-SPOK #10	12	RAILROAD	0	40-8
PORT-SPOK #11	12	RAILROAD	0	40-9
2/108 TUNNEL #1	110536	HIGHWAY	0	42-1
14/216	11833	HIGHWAY	0	42-10
20/108	52262	HIGHWAY	0	42-11
20/111	52262	HIGHWAY	0	42-12
20/113N	0	HIGHWAY	0	42-13
97/24 MT BAKER	39	HIGHWAY	0	42-14
97/359 KNAPPS HILL	31667	HIGHWAY	0	42-15
101/23 FORT COL	32	HIGHWAY	0	42-16
123/106	35	HIGHWAY	0	42-17
12/308 PIMROCK	21836	HIGHWAY	0	42-2
14/128 TUNNEL #1	91735	HIGHWAY	0	42-3
14/129 TUNNEL #2	91735	HIGHWAY	0	42-4
14/130 TUNNEL #3	91735	HIGHWAY	0	42-5
14/133 TUNNEL #4	91035	HIGHWAY	0	42-6
14/134 TUNNEL #5	91035	HIGHWAY	0	42-7
14/206 BINGEN	24	HIGHWAY	0	42-8
14/215	10833	HIGHWAY	0	42-9
YAKIMA MAIN CANAL	29	WATER	0	44-07-1
KLAMATH CANAL A	7	WATER	0	44-09-0
BLACK CANYON T#1	37	WATER	0	44-1-1
BLACK CANYON T#2	37	WATER	0	44-1-2
BLACK CANYON T#2A	38	WATER	0	44-1-3
BLACK CANYON T#3	37	WATER	0	44-1-4
BLACK CANYON T#4	37	WATER	0	44-1-5
BLACK CANYON T#5	37	WATER	0	44-1-6
BLACK CANYON T#6	37	WATER	0	44-1-7
BLACK CANYON T#7	37	WATER	0	44-1-8
BLACK CANYON T#8	32	WATER	0	44-1-9
COLU BASIN BACON	50	WATER	0	44-2-1
FRENCHMAN HILLS	53	WATER	0	44-2-2
SNOW LAKE	39	WATER	0	44-2-3
DESCHUTES T#1	45	WATER	0	44-3-1
DESCHUTES T#2	45	WATER	0	44-3-2
OWHYEE APPRH N CAN	35	WATER	0	44-4-1
OWYHEE LATRL N CAN	32	WATER	0	44-4-2
OWYHEE T#1 N CAN	32	WATER	0	44-4-3
OWYHEE T#3 N CAN	34	WATER	0	44-4-4
OWYHEE T#4 N CAN	34	WATER	0	44-4-5
OWYHEE T#5 S CAN	33	WATER	0	44-4-6

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
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NAME	DATE	USE	COST	KEY NO
OWYHEE T#6 X CAN	35	WATER	0	44-4-7
OWYHEE T#7 S CAN	35	WATER	0	44-4-8
ROGUE RIV CAS DIV	59	WATER	0	44-5-1
ROGUE RIV S FORK	58	WATER	0	44-5-2
ROGUE RIV G S POWR	59	WATER	0	44-5-3
VALE T#1	29	WATER	0	44-6-1
VALE T#2	30	WATER	0	44-6-2
VALE T#3	29	WATER	0	44-6-3
VALE T#4	30	WATER	0	44-6-4
VALE T#5	30	WATER	0	44-6-5
YAKIMA KITTITAS MC	29	WATER	0	44-7-1
T#2 S BRANCH CANAL	29	WATER	0	44-7-10
ROZA DIV	38	WATER	0	44-7-11
T#3 YAKIMA RIDGE	38	WATER	0	44-7-12
T#5 YAKIMA RIDGE	39	WATER	0	44-7-13
T#7 YAKIMA RIDGE	39	WATER	0	44-7-14
T#8 YAKIMA RIDGE	39	WATER	0	44-7-15
YAKIMA PROJECT	39	WATER	0	44-7-16
YAKIMA ROCKY POINT	29	WATER	0	44-7-2
YAKIMA RIVER	31	WATER	0	44-7-3
T#1 N BRANCH CANAL	28	WATER	0	44-7-4
T#2 N BRANCH CANAL	29	WATER	0	44-7-5
T#3 N BRANCH CANAL	29	WATER	0	44-7-6
T#4 N BRANCH CANAL	30	WATER	0	44-7-7
T#5 N BRANCH CANAL	31	WATER	0	44-7-8
T#1 S BRANCH CANAL	28	WATER	0	44-7-9
PRINEVILLE U/S DIV	102659	WATER	123569	44-8-1
PRINEVILLE D/S DIV	102659	WATER	77324	44-8-2
KLAMATH CANAL A	7	WATER	0	44-9-1
CAPE HORN #1	6	RAILROAD	142814	5-1
CAPE HORN #10	6	RAILROAD	78342	5-10
CAPE HORN #11	6	RAILROAD	12892	5-11
CAPE HORN #12	6	RAILROAD	75007	5-12
CAPE HORN #13	8	RAILROAD	12983	5-13
CAPE HORN #15	8	RAILROAD	35382	5-14
CAPE HORN #16	8	RAILROAD	257897	5-15
CAPE HORN #17	8	RAILROAD	333152	5-16
CAPE HORN #18	8	RAILROAD	44737	5-17
FORT WRIGHT #19	10	RAILROAD	303245	5-18
O T RY #1	10	RAILROAD	245797	5-19
CAPE HORN #2	6	RAILROAD	6452	5-2
O T RY #2	10	RAILROAD	84758	5-20

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
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NAME	DATE	USE	COST	KEY NO
O T RY #3	10	RAILROAD	127588	5-21
O T RY #4	10	RAILROAD	155447	5-22
GATEWAY #5	11	RAILROAD	0	5-23
MAYGER #3	98	RAILROAD	9576	5-24
CORNELIUS	11	RAILROAD	790801	5-25
TUNNEL #1 OTR	10	RAILROAD	0	5-26
TUNNEL #3 OTR	10	RAILROAD	0	5-27
TUNNEL #4 OTR	10	RAILROAD	0	5-28
TUNNEL #2 OTR	10	RAILROAD	0	5-29
CAPE HORN #3	6	RAILROAD	53915	5-3
BLUE SLIDE	10	RAILROAD	113129	5-30
JOHNSON CR #45	8	RAILROAD	205859	5-31
WOLF CREEK	0	RAILROAD	0	5-32
FASTON	8	RAILROAD	26151	5-33
HORLICK #1	0	RAILROAD	0	5-34
HORLICK #2	8	RAILROAD	160432	5-35
TANCUM	8	RAILROAD	70722	5-36
SNDQUALMIE #50	8	RAILROAD	2504968	5-37
VAIL	10	RAILROAD	67155	5-38
WOLF CREEK	10	RAILROAD	5946	5-39
CAPE HORN #4	6	RAILROAD	36786	5-4
ROCK LAKE	0	RAILROAD	0	5-40
PALISADES	8	RAILROAD	55210	5-41
ROCKLAKE #43	8	RAILROAD	52626	5-42
WATTS #41	8	RAILROAD	391649	5-43
.2 MII E SPOKANE	0	RAILROAD	0	5-44
EASTON	0	RAILROAD	0	5-45
VAIL #2	0	RAILROAD	0	5-46
WHITTIER	0	RAILROAD	0	5-47
WHITTIER #2	8	RAILROAD	61073	5-48
CASCADE	28	RAILROAD	*******	5-49
CAPE HORN #5	6	RAILROAD	59254	5-5
EVERETT #15	0	RAILROAD	369410	5-50
OROVILLE #7	6	RAILROAD	12,987	5-51
SAMISH #18	2	RAILROAD	114276	5-52
SEATTLE #17	6	RAILROAD	1042536	5-53
WINSTON #14	28	RAILROAD	818061	5-54
STAMPEDE #1	86	RAILROAD	1922024	5-55
STAMPEDE #4	87	RAILROAD	98552	5-56
OSTRANDER	10	RAILROAD	192359	5-57
NELSON-BENNETT	13	RAILROAD	849354	5-58
RUSTON	14	RAILROAD	167770	5-59

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE III

NAME	DATE	USE	COST	KEY NO
CAPE HORN #6	6	RAILROAD	78833	5-6
CAPE HORN #7	6	RAILROAD	154957	5-7
CAPE HORN #8	6	RAILROAD	113043	5-8
CAPE HORN #9	6	RAILROAD	52209	5-9

256 RECORDS READ
256 RECORDS SELECTED

RUN COMPLETED

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE IV

NAME	SHAPE	LENGTH	SPAN	USE
BLUE RIVER DAM DIV	CIRCULAR	1795	25	WATER
COUGAR MAIN DIV	ARCHED ROOF	1834	20	WATER
COUGAR PENSTOCK	ARCHED ROOF	1043	15	WATER
COUGAR REG OUTLET	CIRCULAR	963	23	WATER
COUGAR RUSH CREEK	ARCHED ROOF	630	8	WATER
GREEN PETER DIV	ARCHED ROOF	1050	29	WATER
BIG CLIFF DIV	ARCHED ROOF	631	22	WATER
DETROIT DAM DIV	HORSESHOE	1364	34	WATER
HANSON DAM OUTLET	ARCHED ROOF	886	23	WATER
EAGLE GORGE OUTLET	ARCHED ROOF	0	23	WATER
MUD MOUNTAIN 23D	CIRCULAR	1991	27	WATER
MUD MOUNTAIN 9D	ARCHED ROOF	1800	11	WATER
DWORSHAK DAM DIV	HORSESHOE	1722	53	WATER
LUCKY PEAK OUTLET	CIRCULAR	1161	23	WATER
CARMEN-SMITH POWER	HORSESHOE	7284	14	WATER
CARMEN DIV	ARCHED ROOF	11381	11	WATER
KNOWLES CREEK	ARCHED ROOF	1430	36	HIGHWAY
SUNSET	ARCHED ROOF	800	39	HIGHWAY
TOOTH ROCK	ARCHED ROOF	837	40	HIGHWAY
ELK CREEK	ARCHED ROOF	1090	30	HIGHWAY
CAPE CREEK	ARCHED ROOF	714	34	HIGHWAY
ARCH CAPE	ARCHED ROOF	1228	36	HIGHWAY
VISTA RIDGE WEST	ARCHED ROOF	1001	58	HIGHWAY
VISTA RIDGE EAST	ARCHED ROOF	1049	58	HIGHWAY
J C BOYLE PROJECT	HORSESHOE	1662	16	WATER
TOKETEE PROJECT	UNKNOWN	5400	17	WATER
SWIFT TUNNEL	UNKNOWN	0	0	WATER
FARADAY DIV	HORSESHOE	2426	23	WATER
OAK GROVE	CIRCULAR	170	14	WATER
OAK GROVE #2	CIRCULAR	250	14	WATER
OAK GROVE #3	CIRCULAR	1300	12	WATER
ROUND BUTTE POWER	CIRCULAR	1520	23	WATER
ROUND BUTTE DIV	CIRCULAR	2093	21	WATER
ROUND BUTTE SPILL	CIRCULAR	390	21	WATER
ROUND BUTTE LL GRT	RECTANGULAR	797	9	OTHER
ROUND BUTTE LL ACC	RECTANGULAR	963	7	OTHER
ROUND BUTTE UL GRT	RECTANGULAR	280	9	OTHER
ROUND BUTTE UL ACC	RECTANGULAR	413	7	OTHER
ROUND BUTTE LR GRT	RECTANGULAR	600	9	OTHER
ROUND BUTTE UR ACC	RECTANGULAR	438	7	OTHER
ROUND BUTTE UR GRT	RECTANGULAR	167	9	OTHER
BULL RUN #0	HORSESHOE	457	11	WATER

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE IV

NAME	SHAPE	LENGTH	SPAN	USE
BULL RUN #1	HORSESHOE	4702	9	WATER
BULL RUN #2	HORSESHOE	1550	13	WATER
BULL RUN #4	HORSESHOE	2180	13	WATER
ROUND BUTTE LR ACC	RECTANGULAR	972	7	OTHER
BULL RUN DIV	CIRCULAR	1000	15	WATER
BULL RUN LEFT ABT	CIRCULAR	1700	7	WATER
CAS#4 ABERNETHY	ARCHED ROOF	698	22	RAILROAD
CAS#16 FIELDS	ARCHED ROOF	2213	22	RAILROAD
CAS#17 FIELDS	ARCHED ROOF	267	22	RAILROAD
CAS#11 FRAZIER	ARCHED ROOF	779	22	RAILROAD
CAS#12 FRAZIER	ARCHED ROOF	360	21	RAILROAD
CAS#13 FRAZIER	ARCHED ROOF	875	22	RAILROAD
CAS#14 FRAZIER	ARCHED ROOF	2121	21	RAILROAD
CAS#23 LOOKOUT	ARCHED ROOF	654	22	RAILROAD
CAS#24 LOOKOUT	ARCHED ROOF	394	22	RAILROAD
CAS#21 MCCREDIE	ARCHED ROOF	561	22	RAILROAD
CAS#22 WESTFIR	ARCHED ROOF	1999	21	RAILROAD
CAS#3 CASCADE SUMT	ARCHED ROOF	3655	21	RAILROAD
CAS#18 WICOPEE	ARCHED ROOF	640	22	RAILROAD
CAS#19 WICOPEE	ARCHED ROOF	363	22	RAILROAD
CAS#20 WICOPEE	ARCHED ROOF	436	22	RAILROAD
COOS#16 CANARY	ARCHED ROOF	624	22	RAILROAD
COOS#15 CUSHMAN	ARCHED ROOF	2143	21	RAILROAD
COOS#14 RICHARDSON	ARCHED ROOF	473	22	RAILROAD
COOS#17 KROLL	ARCHED ROOF	1200	21	RAILROAD
COOS#18 KROLL	ARCHED ROOF	1556	21	RAILROAD
COOS#19 REEDSPORT	ARCHED ROOF	4183	21	RAILROAD
COOS#20 LAKESIDE	ARCHED ROOF	870	22	RAILROAD
CAS#5 CRUZATTE	ARCHED ROOF	964	22	RAILROAD
COOS#21 LAKESIDE	ARCHED ROOF	475	22	RAILROAD
COOS#13 VAUGHN	ARCHED ROOF	2489	21	RAILROAD
SIS#1 CORNUTT	ARCHED ROOF	264	22	RAILROAD
SIS#2 GLENDALE	ARCHED ROOF	423	22	RAILROAD
SIS#3 GLENDALE	ARCHED ROOF	433	22	RAILROAD
SIS#4 GLENDALE	ARCHED ROOF	332	22	RAILROAD
SIS#5 GLENDALE	ARCHED ROOF	341	22	RAILROAD
SIS#6 GLENDALE	ARCHED ROOF	517	22	RAILROAD
SIS#7 GLENDALE	ARCHED ROOF	128	22	RAILROAD
SIS#9 HUGO	ARCHED ROOF	2105	21	RAILROAD
CAS#6 CRUZATTE	ARCHED ROOF	566	21	RAILROAD
SIS#8 WOLFCREEK	ARCHED ROOF	2812	21	RAILROAD
SIS#13 SISKIYOU	ARCHED ROOF	3108	21	RAILROAD

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GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE IV

NAME	SHAPE	LENGTH	SPAN	USE
SIS#14 SISKIYOU	ARCHED ROOF	1192	22	RAILROAD
SIS#15 SISKIYOU	ARCHED ROOF	258	22	RAILROAD
TIL#26 COCHRAN	ARCHED ROOF	414	22	RAILROAD
TIL#27 COCHRAN	ARCHED ROOF	412	22	RAILROAD
TIL#28 ENRIGHT	ARCHED ROOF	240	21	RAILROAD
TIL#29 ENRIGHT	ARCHED ROOF	292	22	RAILROAD
TIL#30 ENRIGHT	ARCHED ROOF	262	21	RAILROAD
TIL#32 ENRIGHT	ARCHED ROOF	500	22	RAILROAD
CAS#7 CRUZATTE	ARCHED ROOF	3164	22	RAILROAD
TIL#34 ENRIGHT	ARCHED ROOF	303	22	RAILROAD
TIL#35 ENRIGHT	ARCHED ROOF	251	22	RAILROAD
TIL#36 ENRIGHT	ARCHED ROOF	179	22	RAILROAD
TIL#25 TIMBER	ARCHED ROOF	1417	21	RAILROAD
TOL#24 EDDYVILLE	ARCHED ROOF	682	21	RAILROAD
JEF#38 WILSONIA	ARCHED ROOF	1396	22	RAILROAD
CAS#8 CRUZATTE	ARCHED ROOF	671	22	RAILROAD
CAS#9 CRUZATTE	ARCHED ROOF	1144	21	RAILROAD
CAS#10 CRUZATTE	ARCHED ROOF	467	22	RAILROAD
CAS#15 FIELDS	ARCHED ROOF	150	21	RAILROAD
MAYFIELD POWER	HORSESHOE	830	45	WATER
MAYFIELD DIV	HORSESHOE	548	**	WATER
MOSSY ROCK DIV #1	ARCHED ROOF	1794	33	WATER
MAYFIELD DIV #2	ARCHED ROOF	1488	33	WATER
LA GRANDE POWER	UNKNOWN	6236	14	WATER
CUSHMAN #2	UNKNOWN	0	17	WATER
CUSHMAN DIV	UNKNOWN	0	0	WATER
PORT-HUNNING #1	ARCHED ROOF	654	32	RAILROAD
PORT-SPOK #12	ARCHED ROOF	494	21	RAILROAD
PORT-SPOK #13	ARCHED ROOF	958	21	RAILROAD
PORT-SPOK #14	ARCHED ROOF	593	21	RAILROAD
PORT-SPOK #15	ARCHED ROOF	909	21	RAILROAD
PORT-SPOK #16	ARCHED ROOF	667	22	RAILROAD
PORT-SPOK #17	ARCHED ROOF	426	21	RAILROAD
OLYMPIA BR MP 5.23	ARCHED ROOF	108	22	RAILROAD
OLYMPIA BR MP 5.76	ARCHED ROOF	665	22	RAILROAD
ORE EAST BR #16	ARCHED ROOF	2537	22	RAILROAD
ORE EAST BR #17	ARCHED ROOF	138	22	RAILROAD
PORT-HUNNING #1.25	ARCHED ROOF	635	34	RAILROAD
PORT-HUNNING #1.50	ARCHED ROOF	418	34	RAILROAD
PORT-HUNNING #3.50	ARCHED ROOF	610	22	RAILROAD
PORT-HUNNING #6	ARCHED ROOF	518	22	RAILROAD
PORT-SEA MP 4.50	ARCHED ROOF	5436	22	RAILROAD

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
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NAME	SHAPE	LENGTH	SPAN	USE
PORT-SPOK #7	ARCHED ROOF	623	22	RAILROAD
PORT-SPOK #10	ARCHED ROOF	994	21	RAILROAD
PORT-SPOK #11	ARCHED ROOF	1760	21	RAILROAD
2/108 TUNNEL #1	UNKNOWN	184	20	HIGHWAY
14/216	UNKNOWN	233	15	HIGHWAY
20/108	UNKNOWN	603	21	HIGHWAY
20/111	UNKNOWN	88	21	HIGHWAY
20/113N	UNKNOWN	361	16	HIGHWAY
97/24 MT BAKER	UNKNOWN	1466	19	HIGHWAY
97/359 KNAPPS HILL	UNKNOWN	740	16	HIGHWAY
101/23 FORT COL	UNKNOWN	800	18	HIGHWAY
123/106	UNKNOWN	510	19	HIGHWAY
12/308 RIMROCK	UNKNOWN	577	17	HIGHWAY
14/128 TUNNEL #1	UNKNOWN	130	18	HIGHWAY
14/129 TUNNEL #2	UNKNOWN	408	18	HIGHWAY
14/130 TUNNEL #3	UNKNOWN	257	18	HIGHWAY
14/133 TUNNEL #4	UNKNOWN	261	19	HIGHWAY
14/134 TUNNEL #5	UNKNOWN	212	19	HIGHWAY
14/206 BINGEN	UNKNOWN	118	18	HIGHWAY
14/215	UNKNOWN	389	15	HIGHWAY
YAKIMA MAIN CANAL	HORSESHOE	305	12	WATER
KLAMATH CANAL A	UNKNOWN	3300	14	WATER
BLACK CANYON T#1	HORSESHOE	825	14	WATER
BLACK CANYON T#2	HORSESHOE	475	14	WATER
BLACK CANYON T#2A	HORSESHOE	422	14	WATER
BLACK CANYON T#3	HORSESHOE	1375	14	WATER
BLACK CANYON T#4	HORSESHOE	1270	14	WATER
BLACK CANYON T#5	HORSESHOE	640	14	WATER
BLACK CANYON T#6	HORSESHOE	870	14	WATER
BLACK CANYON T#7	HORSESHOE	1630	14	WATER
BLACK CANYON T#8	HORSESHOE	3170	9	WATER
COLU BASIN BACON	HORSESHOE	10037	23	WATER
FRENCHMAN HILLS	HORSESHOE	9280	14	WATER
SNOW LAKE	UNKNOWN	2560	6	WATER
DESCHUTES T#1	HORSESHOE	3443	11	WATER
DESCHUTES T#2	HORSESHOE	3361	11	WATER
OWHYEE APPRH N CAN	HORSESHOE	440	12	WATER
OWYHEE LATRL N CAN	HORSESHOE	350	5	WATER
OWYHEE T#1 N CAN	HORSESHOE	18723	17	WATER
OWYHEE T#3 N CAN	HORSESHOE	1354	14	WATER
OWYHEE T#4 N CAN	HORSESHOE	1990	12	WATER
OWYHEE T#5 S CAN	HORSESHOE	21948	9	WATER

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
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NAME	SHAPE	LENGTH	SPAN	USE
OWYHEE T#6 X CAN	HORSESHOE	1040	8	WATER
OWYHEE T#7 S CAN	HORSESHOE	4325	7	WATER
ROGUE RIV CAS DIV	CIRCULAR	2100	6	WATER
ROGUE RIV S FORK	HORSESHOE	3553	6	WATER
ROGUE RIV G S POWR	CIRCULAR	4833	6	WATER
VALE T#1	HORSESHOE	2150	11	WATER
VALE T#2	HORSESHOE	5007	11	WATER
VALE T#3	HORSESHOE	1312	11	WATER
VALE T#4	HORSESHOE	500	10	WATER
VALE T#5	HORSESHOE	286	10	WATER
YAKIMA KITTITAS MC	HORSESHOE	179	12	WATER
T#2 S BRANCH CANAL	HORSESHOE	1390	5	WATER
ROZA DIV	HORSESHOE	8231	17	WATER
T#3 YAKIMA RIDGE	HORSESHOE	9588	17	WATER
T#5 YAKIMA RIDGE	HORSESHOE	3983	14	WATER
T#7 YAKIMA RIDGE	HORSESHOE	755	13	WATER
T#8 YAKIMA RIDGE	HORSESHOE	1475	13	WATER
YAKIMA PROJECT	HORSESHOE	1475	13	WATER
YAKIMA ROCKY POINT	HORSESHOE	305	12	WATER
YAKIMA RIVER	CIRCULAR	3640	9	WATER
T#1 N BRANCH CANAL	HORSESHOE	1686	12	WATER
T#2 N BRANCH CANAL	HORSESHOE	1025	12	WATER
T#3 N BRANCH CANAL	HORSESHOE	2276	12	WATER
T#4 N BRANCH CANAL	HORSESHOE	482	11	WATER
T#5 N BRANCH CANAL	HORSESHOE	3470	7	WATER
T#1 S BRANCH CANAL	HORSESHOE	2000	6	WATER
PRINEVILLE U/S DIV	CIRCULAR	529	11	WATER
PRINEVILLE D/S DIV	ARCHED ROOF	331	11	WATER
KLAMATH CANAL A	UNKNOWN	3300	14	WATER
CAPE HORN #1	ARCHED ROOF	2369	16	RAILROAD
CAPE HORN #10	ARCHED ROOF	576	16	RAILROAD
CAPE HORN #11	ARCHED ROOF	269	16	RAILROAD
CAPE HORN #12	ARCHED ROOF	385	16	RAILROAD
CAPE HORN #13	ARCHED ROOF	203	16	RAILROAD
CAPE HORN #15	ARCHED ROOF	323	16	RAILROAD
CAPE HORN #16	ARCHED ROOF	2494	16	RAILROAD
CAPE HORN #17	ARCHED ROOF	2220	16	RAILROAD
CAPE HORN #18	ARCHED ROOF	369	16	RAILROAD
FORT WRIGHT #19	ARCHED ROOF	2134	16	RAILROAD
O T RY #1	ARCHED ROOF	814	16	RAILROAD
CAPE HORN #2	ARCHED ROOF	122	16	RAILROAD
O T RY #2	ARCHED ROOF	810	16	RAILROAD

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE IV

NAME	SHAPE	LENGTH	SPAN	USE
O T RY #3	ARCHED ROOF	480	16	RAILROAD
O T RY #4	ARCHED ROOF	384	16	RAILROAD
GATEWAY #5	ARCHED ROOF	242	16	RAILROAD
MAYGER #3	ARCHED ROOF	175	16	RAILROAD
CORNELIUS	ARCHED ROOF	4111	16	RAILROAD
TUNNEL #1 OTR	UNKNOWN	814	16	RAILROAD
TUNNEL #3 OTR	UNKNOWN	480	16	RAILROAD
TUNNEL #4 OTR	UNKNOWN	584	16	RAILROAD
TUNNEL #2 OTR	UNKNOWN	810	16	RAILROAD
CAPE HORN #3	ARCHED ROOF	416	16	RAILROAD
BLUE SLIDE	UNKNOWN	1093	15	RAILROAD
JOHNSON CR #45	UNKNOWN	1973	15	RAILROAD
WOLF CREEK	UNKNOWN	90	0	RAILROAD
FASTON	UNKNOWN	203	15	RAILROAD
HORLICK #1	UNKNOWN	496	0	RAILROAD
HORLICK #2	UNKNOWN	1239	17	RAILROAD
TANCUM	UNKNOWN	496	16	RAILROAD
SNDQUALMIE #50	UNKNOWN	11890	15	RAILROAD
VAIL	UNKNOWN	810	15	RAILROAD
WOLF CREEK	UNKNOWN	90	17	RAILROAD
CAPE HORN #4	ARCHED ROOF	267	16	RAILROAD
ROCK LAKE	UNKNOWN	704	0	RAILROAD
PALISADES	UNKNOWN	704	15	RAILROAD
ROCKLAKE #43	UNKNOWN	756	18	RAILROAD
WATTS #41	UNKNOWN	2559	16	RAILROAD
.2 MII E SPOKANE	UNKNOWN	863	0	RAILROAD
EASTON	UNKNOWN	203	0	RAILROAD
VAIL #2	UNKNOWN	810	0	RAILROAD
WHITTIER	UNKNOWN	528	0	RAILROAD
WHITTIER #2	UNKNOWN	528	15	RAILROAD
CASCADE	UNKNOWN	41152	16	RAILROAD
CAPE HORN #5	ARCHED ROOF	395	16	RAILROAD
EVERETT #15	UNKNOWN	2440	16	RAILROAD
OROVILLE #7	UNKNOWN	1761	18	RAILROAD
SAMISH #18	UNKNOWN	1113	16	RAILROAD
SEATTLE #17	UNKNOWN	5142	30	RAILROAD
WINSTON #14	UNKNOWN	4059	16	RAILROAD
STAMPEDE #1	UNKNOWN	9834	16	RAILROAD
STAMPEDE #4	UNKNOWN	649	16	RAILROAD
OSTRANDER	UNKNOWN	1165	28	RAILROAD
NELSON-BENNETT	UNKNOWN	4391	28	RAILROAD
RUSTON	UNKNOWN	323	28	RAILROAD

GENERAL DATA FILE FOR
TUNNELS IN THE OREGON AND WASHINGTON AREA
TABLE IV

NAME	SHAPE	LENGTH	SPAN	USE
CAPE HORN #6	ARCHED ROOF	657	16	RAILROAD
CAPE HORN #7	ARCHED ROOF	966	16	RAILROAD
CAPE HORN #8	ARCHED ROOF	755	16	RAILROAD
CAPE HORN #9	ARCHED ROOF	392	16	RAILROAD

256 RECORDS READ
256 RECORDS SELECT

General Data Form

Key Number _____

Project Name _____

Owner _____

Engineer _____

Contractor _____

Date Finished _____

Shape:
- ☐ Circular
- ☐ Horseshoe
- ☐ Rectangular
- ☐ Square
- ☐ Trapezoidal
- ☐ Arched Roof
- ☐ Oval

Length _____

Diameter or Span _____

Cost _____

Use:
- ☐ Railroad
- ☐ Highway
- ☐ Water
- ☐ Other

Location _____
(County) (State)

Exploration Data Form

Field #1 Key Number_____

Field #2 Type of Reconnaissance

☐ Aerial ☐ Field

☐ Map

Field #3 Reconniassance Performed by

☐ Geologist ☐ In House

☐ Engineer ☐ Consultant

Field #4 Years Experience_____

DRILLING PROGRAM

Field #5 Number of Holes_____

Field #6 Type of Drill

☐ Auger ☐ Wash Boring

☐ Diamond Rotary Drill ☐ Churn Drill

Core Drill ☐ Jetting

Field #7 Diameter of Holes_____ inches

Field #8 Penetration Tests_____

Field #9 Water Pressure Tests_____

Field #10 Drill Log Available ☐ Yes ☐ No

Field #11 RQD ☐ Yes ☐ No

Field #12 Location of Holes ☐ Portal Areas Only

☐ Throughout Tunnel Length

☐ Random Spacing

Field #13 Regular Spacing

Intervals of holes_____ feet

Field #14 Located by Geologist

Field #15 Cost _____ dollars

PILOT BORE

Field #16 Contractor_____

Field #17 Length_____ linear feet

Field #18 Shape

☐ Round ☐ Oval

☐ Rectangular ☐ Horseshoe

Field #19 Diameter of Span_____ feet

Field #20 Location of Pilot Bore with Respect to Main Bore

☐ Off Alignment ☐ Bottom of Heading

☐ Top of Heading ☐ Edge of Heading

☐ Center of Heading

Field #21 Use of Pilot Bore During Construction

☐ None ☐ Blasting Improvement

☐ Ventilation ☐ Access

☐ Muck Hauling

Field #22 Geologic Map Available ☐ Yes ☐ No

Field #23 Cost of Pilot Tunnel_____ dollars

LAB TESTING

Soil Tests

Field #24 Specific Gravity_____

Field #25 Atterberg Limits_____

Shear Tests

Field #26 Direct_____

Field #27 Triaxial_____

Field #28 Consolidated_____

Field #29 Unconfined_____

Field #30 Drained_____

Field #31 Consolidation_____

Field #32 Other_____

Rock Tests

Modulus of Elasticity

Field #33 Static_____

Field #34 Dynamic_____

Strength Tests

Field #35 Unconfined_____

Field #36 Triaxial_____

Field #37 Tensile_____

Field #38 Direct Shear_____

Water Tests

Field #39 Sulfide Reactive_____

Field #40 Other_____

Field #41 Cost of Lab Testing_____ dollars

FIELD TESTS

Field #42 Prop Load Cells _____ number

Field #43 Rock Bolt Load Cells _____ number

Field #44 Extensometer:

- ☐ Single Position
- ☐ 8 Position
- ☐ Multiple other than 8, what _____

Field #45 Readout:

- ☐ Electric
- ☐ Mechanical
- ☐ Rod
- ☐ Wire

Field #46 Anchorage:

- ☐ Expandable Packer
- ☐ Grout Anchor
- ☐ Mechanical Anchor

Field #47 Length _____ feet

Field #48 Number _____

Rock Bolt Tests

Field #49 Pull Tests _____

Field #50 Load Retention _____

Field #51 Diameter of Bolt _____ inches

Field #52 Type of Anchor:

- ☐ Slot and Wedge
- ☐ Cone and Wedge
- ☐ Fingered and Wedge
- ☐ Grout
- ☐ Bail and Wedge
- ☐ Other

Field #53 Type of Bolt:

☐ Hollow ☐ Solid

Field #54 Plate Loading Test_____

Field #55 Type

☐ Horizontal ☐ Vertical

☐ Rock ☐ Soil

Field #56 Area of Plate_____ square inches

Field #57 Maximum Load_____ pounds

Field #58 Flat Jack Tests_____

Field #59 Type

☐ Horizontal ☐ Vertical

☐ Other

Field #60 Jack Size_____ square inches

Field #61 Overcoring

Field #62 Exterior Hole Diameter_____ inches

Field #63 Interior Hole Diameter_____ inches

Field #64 Number of Axes on Gauge_____

Field #65 Pressure Chamber Tests_____

Field #66 In Situ Shear Tests_____

Field #67 Surface Subsidence Measurements_____

Field #68 Tunnel Shape Change Monitoring_____

Field #69 Cost of_____ dollars

SIESMIC SURVEY

Field #70 Number of Lines_____

Field #71 Total Length of Lines_____linear feet

Field #72 Cost of Survey___ _____ dollars

Construction Data Form

Field #1 Key Number_____

Field #2 Type of Contract

☐ Prime ☐ Sub

EXCAVATION

Field #3 Soft Ground

☐ Full Face ☐ Fore Poling

☐ Shield ☐ Breast Boards

☐ Compressed Air ☐ Multiple Drifts

Field #4 Multiple Drift Types:

☐ American ☐ Italian

☐ English ☐ Australian

☐ Belgian ☐ German

Field #5 Rock

☐ Full Face ☐ Top Heading and Bench

☐ Bottom Heading

Field #6 Type of Round:

☐ Vee Cut ☐ Draw Cut

☐ Burn Hole ☐ Pyramid Cut

☐ Double V or Wedge

Field #7 Length of Round_____ feet

Field #8 Number of Holes per Round_____

Field #9 Number of Drills Used_____

Field #10 Average Bit Lift_____ hours

Field #11 Average Drill Time_____ minutes

Field #12 Minimum Drill Time_____ minutes

Field #13 Type of Explosives:

☐ Black Powder

Field #14 Grade of Black Powder:

☐ Grade A ☐ Grade B

☐ Granulation ☐ Pellet Powder

☐ Dynamite

Description of Dynamite:

Field #15 % of Nitro_____

Field #16 Density_____

Field #17 Diameter of Cartridge_____ inches

Field #18 Length of Cartridge_____ inches

Field #19 Type of Dynamite:

☐ Straight ☐ Special Gelatin

☐ Red Cross Extra ☐ Gelex

☐ Red Cross ☐ Duobel

☐ Extra ☐ Monobel

☐ Hi Cap ☐ Lump Coal

☐ Gelatin ☐ Gelobel

☐ Hi Velocity Gelatin

Type of Explosives (cont):

☐ Nitramon

☐ Nitramex

☐ Free Running

Field #20 Type of Ignition System:

☐ Ignitacord ☐ Squibs

☐ Safety Fuse ☐ Caps

☐ Primacord

Field #21 Powder Factor_____

Field #22 Stemming:

Field #23 Average Load Time_____ minutes

Field #24 Minimum Load Time_____ minutes

Field #25 Type of Boring Machine:

☐ Roller Cutter ☐ Disc Cutter

☐ Solid Cutter

MUCKING

Field #26 Type of Mucking:

☐ Hand

☐ Mechanical

Field #27 Type of Mechanical Mucking:

☐ Rubber Tired ☐ Diesel Operated

☐ Track Mounted ☐ Electrically Operated

Field #28 Air Operated

Field #29 Bucket Size_____ yard

Field #30 Hp Power_____ hp

Field #31 Car Capacity_____ yard

Field #32 Type of Haulage:

☐ Electric ☐ Animal

☐ Diesel ☐ Air

Field #33 Average Mucking Time_____ minutes

Field #34 Minimum Mucking Time_____ minutes

VENTILATION

Field #35 Type of Ventilation

☐ Blower ☐ Open Compressed Air Line

☐ Exhaust ☐ None

☐ Both

Field #36 Diameter of Fan Line_____ inches

Field #37 Average Ventilation Time_____ minutes

Field #38 Minimum Ventilation Time_____ minutes

RATE OF ADVANCE

Field #39 Number of Headings_____

Field #40 Average Daily_____ feet

Field #41 Best Daily_____ feet

Field #42 Worst Daily_____ feet

Field #43 Best Weekly_____ feet

Field #44 Best Monthly_____ feet

UNUSUAL CONDITIONS

Excessive Water:

Field #45 Maximum Inflow of Water_____ cfm

Field #46 Average Inflow of Water_____ cfm

Field #47 Maximum Press_____ psi

Field #48 Average Press_____ psi

Field #49 Ground Temperature_____ °F

Field #50 Gas:

☐ Poisonous ☐ Explosive

☐ Both

TEMPORARY SUPPORTS

Field #51 Type of Temporary Supports:

Timber:

Field #52 Length Supported_____ linear feet

Field #53 Types of Timber Sets:

☐ Post and Cap ☐ 4 Piece

☐ Arch Set ☐ Cap and Hitches

Field #54 Average Spacing_____ feet

Field #55 Minimum Spacing_____ feet

Field #56 Size_____

Field #57 Number of Pieces_____

Steel:

Field #58 Type of Steel Sets

☐ Wall Plates ☐ Struts

☐ Full Circle Rib

Rock Bolts:

Field #59 Type of Rock Bolts

☐ Pattern Bolts ☐ Random

☐ Both

Field #60 Length Bolted_____ linear feet

Field #61 Spacing_____ feet

Field #62 Bolt Length_____ feet

Field #63 Type of Anchor

☐ Slot and Wedge ☐ Cone and Wedge

☑ Wedge and Bail ☐ Grout

☐ Finger and Wedge

Field #64 Surface Preparation:

☐ Pads

☐ Chipping

Field #65 Tensioned by:

☐ Untensioned ☐ Torquing

☐ Pulling

Field #66 Rock Bolt Accessories

☐ Channels ☐ Chain Line Fence

☐ Weld Wire Mesh

Shotcrete:

Field #67 Length of Support_____ linear feet

Field #68 Thickness_____ inches

Field #69 ☐ Full Circle

PERMANENT LINING

Field #70 Length of Permanent Lining_____ linear feet

Reinforcing:

Field #71 Size of Bars_____

Field #72 Spacing of Bars_____ inches

Field #73 Number of Mats_____

Concrete:

Field #74 Length of Concrete_____ linear feet

Field #75 Type of Forms:

☐ Telescopic Full Circle ☐ Non-telescopic

☐ Telescopic Arch ☐ Bulkhead

Field #76 Power Sequence:

☐ Full Circles ☐ Curb-Invert Arch

☐ Invert Arch ☐ Curb Arch Invert

☐ Arch Invert

Field #77 Sequence:

☐ Advance ☐ Retreat

Field #78 Jumbos:

☐ Form ☐ Pouring

☐ Finishing

Field #79 Masonry Length_____ linear feet

Field #80 Steel or Iron Length_____ linear feet

Field #81 Minimum Thickness of Lining_____ inches

UNEXPECTED PROBLEMS

Field #82 Loss of Heading_____ times

Rock Falls:

Field #83 Number of Rock Falls_____

Field #84 Size_____

Field #85 Injuries_____

Field #86 Deaths_____

LEGAL ACTIONS

Field #87 Number of Claims_____

Field #88 Amount of Claims Requested_____ dollars

Field #89 Amount of Claims Settled_____ dollars

COSTS

Field #90 Bid Price_____ dollars

Field #91 Actual Price_____ dollars

TIME

Field #92 Completed_____ days ahead of schedule

Field #93 Completed_____ days behind schedule

Design Data Form

Field #1 Key Number_____

Field #2 ☐ Plans Available

Microfilm number_____

SHAPE

Field #3 ☐ Circular ☐ Oval

☐ Rectangular ☐ Arched Roof

Field #4 Height_____ feet

Field #5 Width_____ feet

Field #6 Radius of Arch_____ feet

LINING

Field #7 Total length of lining_____ linear feet

Unlined

Field #8 Total length_____ linear feet

Field #9 No support_____ linear feet

Field #10 Ribs_____ linear feet

Field #11 Rock Bolts_____ linear feet

Concrete

Field #12 Total Length_____ linear feet

Supported section:

Field #13 Minimum thickness_____ inches

Field #14 Maximum thickness_____ inches

Unsupported section:

Field #15 Minimum thickness_____ inches

Field #16 Maximum thickness_____ inches

Reinforcement:

Field #17 Size of bars_____ inches

Field #18 Spacing of bars_____ inches

Field #19 Number of mats_____

Steel or Cast Iron

Field #20 Total length_____ linear feet

Field #21 Thickness_____ inches

Shotcrete

Field #22 Total length_____ linear feet

Field #23 Thickness_____ inches

Timber

Field #24 Total length_____ linear feet

Field #25 Thickness_____ inches

Brick or Masonry

Field #26 Total length_____ linear feet

Field #27 Thickness_____ inches

Field #28 Maximum overburden height_____ feet

Field #29 Design load_____ psi

Field #30 Load derived from:

- ☐ External hydro load
- ☐ Full rock load
- ☐ Triangle rock load
- ☐ Percent of full rock load
- ☐ Measurement

Field #31 Design computations available

Microfilm number_____

Field #32 Design method:

- ☐ Rock used as support member
- ☐ Thick walled cylinder
- ☐ Laminated cylinder
- ☐ Finite element
- ☐ Moment distribution
- ☐ Two-dimentional stress field
- ☐ Elastic theory for holes in stressed medium
- ☐ Time dependent strain considered

Field #33 Safety factor used_____

Field #34 Rock properties obtained from:

- ☐ Lab
- ☐ Field test
- ☐ Estimated
- ☐ Handbook

COST ESTIMATE

Field #35 Total_____ dollars

Field #36 Per linear foot_____ dollars

Field #37 Per cubic yard_____ dollars

Field #38 Lining cost per foot_____ dollars

SPECIFICATIONS

Field #39 ☐ Specs available

Microfilm number_____

Field #40 Liquidated damages_____dollars per day

Field #41 Payment

☐ Per foot ☐ Per yard

☐ Lump sum ☐ Cost plus

☐ Cost plus fixed fee

Field #42 Steel Support Payment:

☐ Per pound supplied

☐ Per pound installed

☐ Per pound supplied and installed

☐ Upset price

Field #43 ☐ Safety steel paid for

Field #44 Rock Bolt Payment:

☐ Each ☐ Per linear foot

☐ Lump sum

Field #45 ☐ Safety rock bolts paid for

Field #46 ☐ Contractor responsible for safety

Field #47 Passing Zones

☐ Not allowed

☐ Allowed outside design lines

☐ Allowed outside design lines but no pay

Field #48 Passing Zones Located:

☐ By engineer

Field #48 Passing Zones Located (cont):

☐ By contractor

☐ By contractor but approved by engineer

Field #49 Survey

☐ Engineer responsibility

☐ Contractor responsibility

Field #50 ☐ Feeler holes

Field #51 Excavation

☐ Tights allowed

☐ Overbreak paid for

Field #52 ☐ Excess water clause

Supports

Steel sets:

Field #53 Size --- Minimum_____

Maximum_____

Average_____

Field #54 Spacing - Minimum_____ feet

Maximum_____ feet

Average_____ feet

Field #55 Design of steel:

☐ Proctor and White

☐ Rule of thumb or handbook

Design of steel (cont):

☐ Past experience factor

☐ educated guess

Field #56 Number of different weights of sets:

☐ One ☐ Two

☐ Three to five ☐ More than five

Field #57 Set Fabrication:

☐ One piece ☐ Two piece

☐ Three piece ☐ Wall plate

☐ Full circle ☐ Struts

Field #58 Set installation:

☐ Overrun ☐ As designed

☐ Underrun ☐ Subject of claim

☐ Considered excessive by inspection

Rock Bolts:

Field #59 ☐ Rock Bolt Design Available

Microfilm number_____

Field #60 Diameter -- Minimum_____

Maximum_____

Average_____

Field #61 Spacing -- Minimum_____ feet

Maximum_____ feet

Average_____ feet

Field #62 How Tensioned:

☐ By torque

☐ By pulling

Field #63 Length_____ feet

Field #64 Tension_____ psi

Field #65 Exterior surface prepared by:

☐ Chipping

☐ Pad

Field #66 Design:

☐ Rule of thumb ☐ Experience factor

☐ Suspension ☐ Beam theory

☐ Pattern bolts ☐ Grouted

Field #67 Installation:

☐ Overrun ☐ As designed

☐ Underrun ☐ Subject of claim

Retorquing:

Field #68 Time limit_____ days

Field #69 Distance limit_____ feet

Field #70 ☐ As directed

Field #71 ☐ Grouted

Key Number	Project Name	Owner	Engineer	Contractor	Date Finished	Shape			
						Circular	Horse-shoe	Rectan-gular	Square
Field #1	Field #2	Field #3	Field #4	Field #5	Field #6	Field #7			

General Data
File Structure

lix

Shape			Length	Diameter or Span	Cost	Use				Location
Trapezoid	Arched Roof	Oval				Railroad	Highway	Water	Other	
Field #7			Field #8	Field #9	Field #10	Field #11				Field #12

LIBRARY RELATED COMMANDS

CATALOG
Prints the list of programs and files saved in a library

CATALOG [{ * / ** / *** }]

CATALOG ALL
Prints the list of programs and files saved in the user's private library along with descriptive information

CATALOG ALL

SAVE
Saves program work area in a user's private or *shared library

SAVE (file name)

REMOVE
Deletes a user's private or *shared library file from the library

REMOVE (file name)

PROTECT
Protects a user's private or *shared library file from destruction

PROTECT (file name)

UNPROTECT
Removes protected status of a user's private or *shared library file

UNPROTECT (file name)

PROGRAM EXECUTION COMMANDS

RUN
Starts execution of program

RUN [{ file name (, start line no.) / start line no. }]

RUN**ANNUIT,50

CONTINUE
Resumes execution of program at current execution point without reset of execution status

CONTINUE

EXECUTE
Executes a single program statement

EXECUTE (file no.)

Display Command
Prints value of a simple variable or array element at terminal. Subscripts must be integer constants.

variable name
A(1,2)

STATUS
Prints current execution status

STATUS

RESET
Changes execution state of program

RESET (ALL)

PROGRAMMER'S WORK AREA COMMANDS

CLEAR
Clears all or selected statements from program work area

$$\underline{\text{CLEAR}}\ \left[\left\{\begin{matrix}\text{line no.}\\ \text{line no. range}\end{matrix}\right\},\ldots,\left\{\begin{matrix}\text{line no.}\\ \text{line no. range}\end{matrix}\right\}\right]$$

CLEAR 10-30,50,110-170,320

LOAD
Loads the program work area with files saved in a library

$$\underline{\text{LOAD}}\ \left[(\text{file name}),\ldots,(\text{file name})\right]$$

LOAD PROG, SUB1,*SUB2

MERGE
Merges a saved file with the current content of the program area

$$\underline{\text{MERGE}}\ \left[\text{file name}\ \ (,\text{line no.})\right]$$

MERGE PROGA, 1000

LIST
Prints at the terminal all or selected statements of the program work area. Line numbers are not printed with the NN option.

$$\underline{\text{LIST}}\ (\underline{\text{NN}})\ \left[\left\{\begin{matrix}\text{line no.}\\ \text{line no. range}\end{matrix}\right\},\ldots,\left\{\begin{matrix}\text{line no.}\\ \text{line no. range}\end{matrix}\right\}\right]$$

LIST 100-150,210,300-

EDIT
Edits all or selected statements of the program work area

EDIT LIST [{line no. / line no. range} ,...., {line no. / line no. range}]
;[replaced string con.];[replacement string con.]

EDIT 50-100,150,WXYZ,"ABC"

RENUMBER
Renumbers lines of the program work area.

Values of 100 and 10 are assumed for new start line no. and increment if unspecified.

RENUMBER [start line no. [,new start line no.(,increment)]]

Renumber 325,1000,20

CHECK
Checks statements in the program work area for errors

CHECK

PUNCH
Punches on paper tape at the terminal all or selected statements of the program work area

PUNCH [{line no. / line no. range} ,...., {line no. / line no. range}]

PUNCH 50,100-200,1010-

NAME
Names the program work area

NAME (file name)

TAPE
Sets input mode to paper tape
TAPE

INFO
Prints information concerning program in work area
INFO

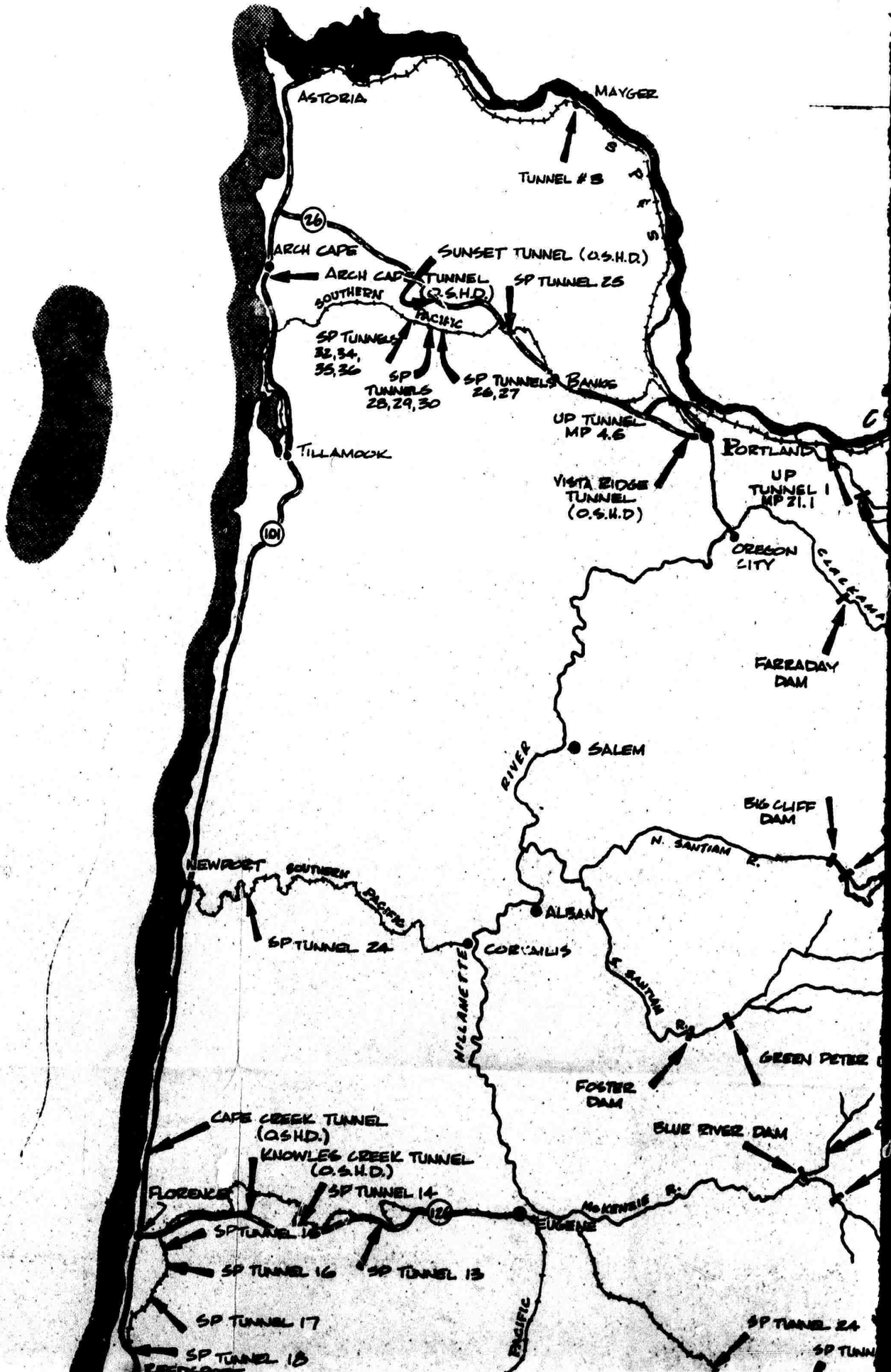
List of Available
Variables and Arrays

VARIABLE NAME	DESCRIPTION
A$ (array)	Contains the values of all the alphabetic field of the current record. If the i^{th} field of the record is alphabetic, it is stored in A$(i).
A (array)	Contains the values of all the numeric fields of the current record. If the i^{th} field of the record is numeric, it is stored in A(1).
B (array)	Contains codes indicating the numeric and alphabetic characteristics of each field of the record (i.e., 0 for numeric and and 1 for alphabetic). B(1) refers to the i^{th} field of the record.
C (array)	Contains the numbers of the fields on which totals are to be taken. For example, C(1) contains the field number for the first requested field total.
D (array)	Contains the accumulated field totals. The first element in the array, D(1), contains the totals for the first field listed in the field totals specification, the second element in the array, D(2), contains the totals for the second field listed in the field totals specification. At lines 6000-6999, this array contains subtotals, updated with the current selected record, and, at lines 7000-7999, it contains final totals, since all records have been read

VARIABLE NAME	DESCRIPTION
C1 (variable)	Contains the number of fields in a record.
C2 (variable)	Contains the number of fields to be totaled.
T2 (variable)	Contains a count on the number of records read. At lines 6000-6999, T2 has been updated by the currently read record and contains a subtotal. At lines 7000-7999, T2 contains a final count on the number of records read.
T4 (variable)	Contains a count on the number of records selected. At lines 6000-6999, T4 has been updated by the currently selected record and contains a subtotal. At lines 7000-7999, it contains a final count on the number of records selected. If the record selection is such that there is no specified record selection (all records selected), then T2 contains a count on both records read and records selected. T4 is not updated and should not be used.
Q1 (variable)	User read switch. Must be used only at lines 4000-4999.

A

1 B

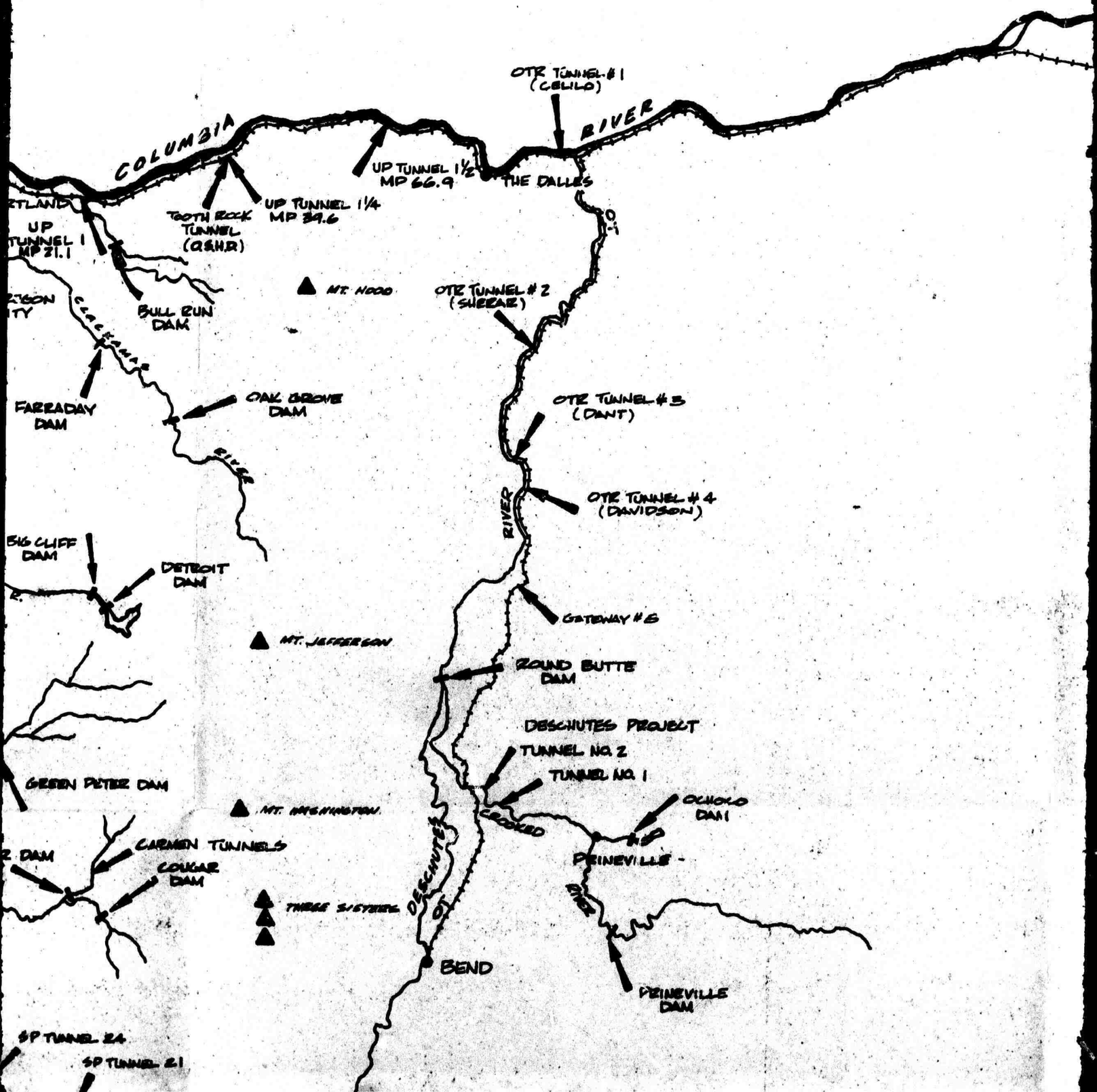

ASTORIA
MAYGER
TUNNEL # 5
CASCADES
26
ARCH CAPE
SUNSET TUNNEL (O.S.H.D.)
ARCH CAPE TUNNEL (O.S.H.D.)
SP TUNNEL 25
SOUTHERN PACIFIC
SP TUNNELS 32, 34, 35, 36
SP TUNNELS 28, 29, 30
SP TUNNELS 26, 27
BANKS
UP TUNNEL MP 4.6
PORTLAND
TILLAMOOK
VISTA RIDGE TUNNEL (O.S.H.D)
UP TUNNEL I MP 21.1
101
OREGON CITY
CLACKAMAS
FARRADAY DAM
SALEM
RIVER
BIG CLIFF DAM
N. SANTIAM R.
NEWPORT
SOUTHERN PACIFIC
ALBANY
SP TUNNEL 24
CORVALLIS
WILLAMETTE
S. SANTIAM R.
GREEN PETER
FOSTER DAM
CAPE CREEK TUNNEL (O.S.H.D.)
BLUE RIVER DAM
KNOWLES CREEK TUNNEL (O.S.H.D.)
FLORENCE
SP TUNNEL 14
126
McKENZIE R.
EUGENE
SP TUNNEL 15
SP TUNNEL 16
SP TUNNEL 13
SP TUNNEL 17
SP TUNNEL 18
PACIFIC
SP TUNNEL 24

1B

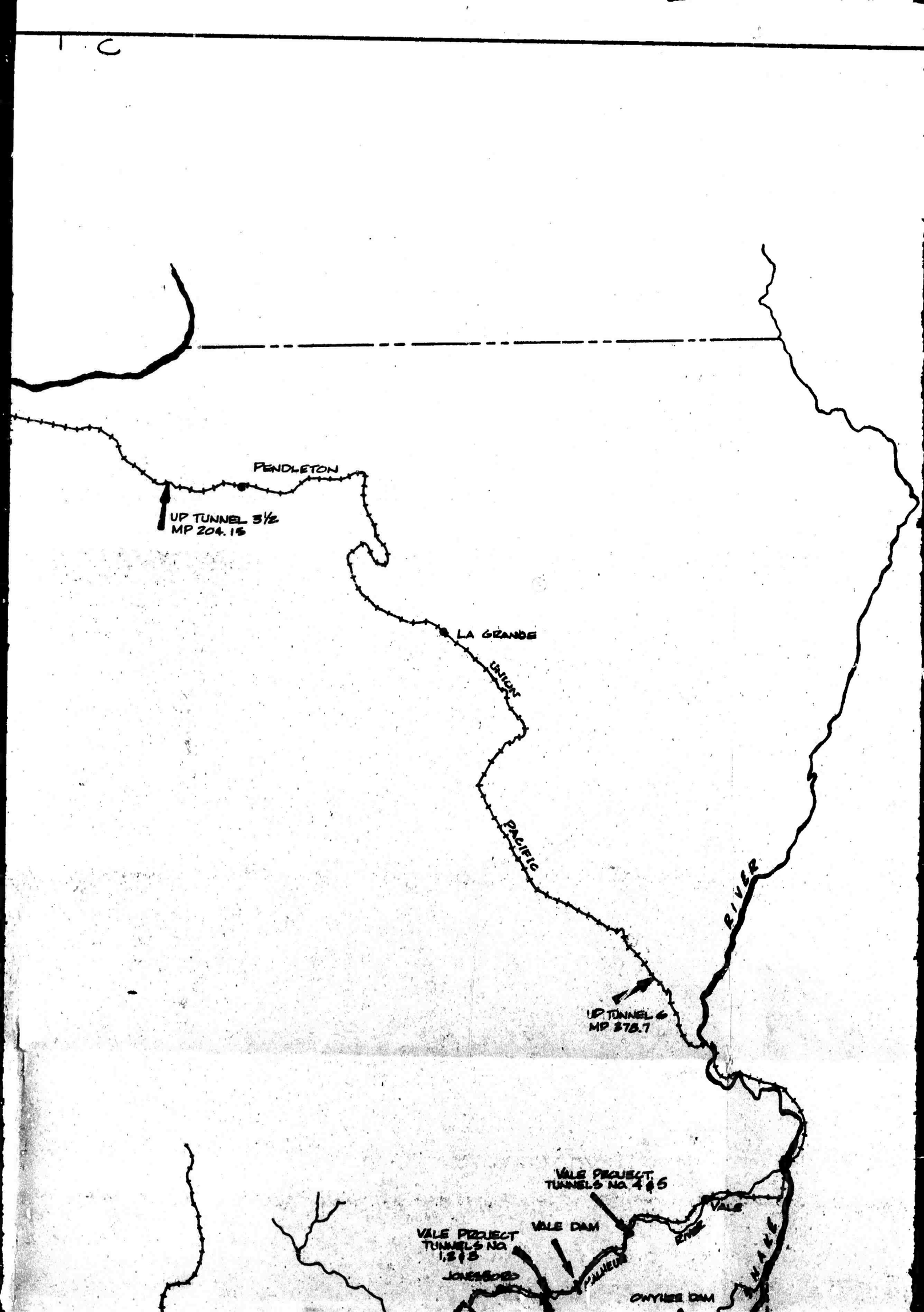
—OREGON—

SCALE: 1 INCH = 16 MILES

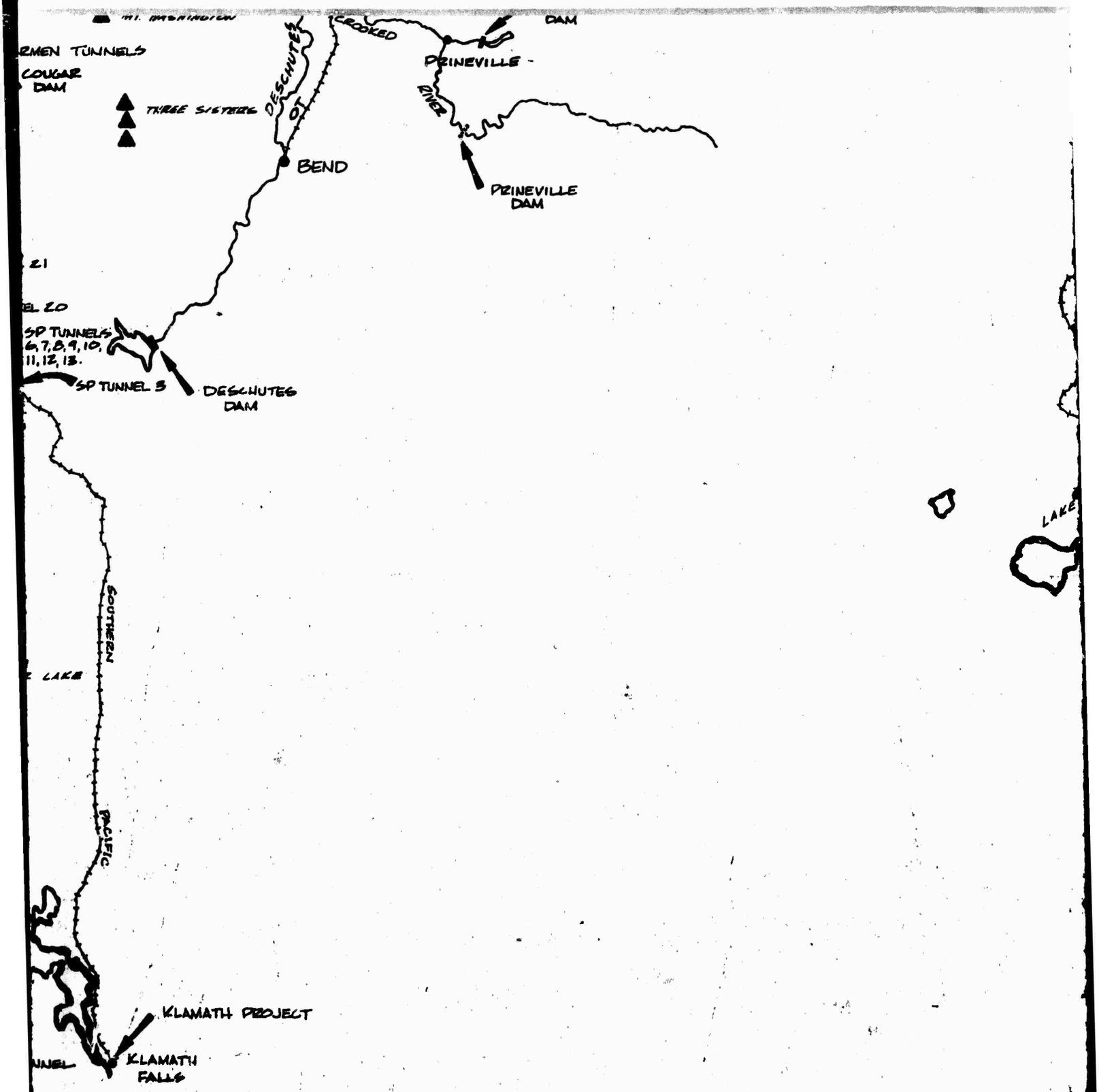
16 8 0 16 32

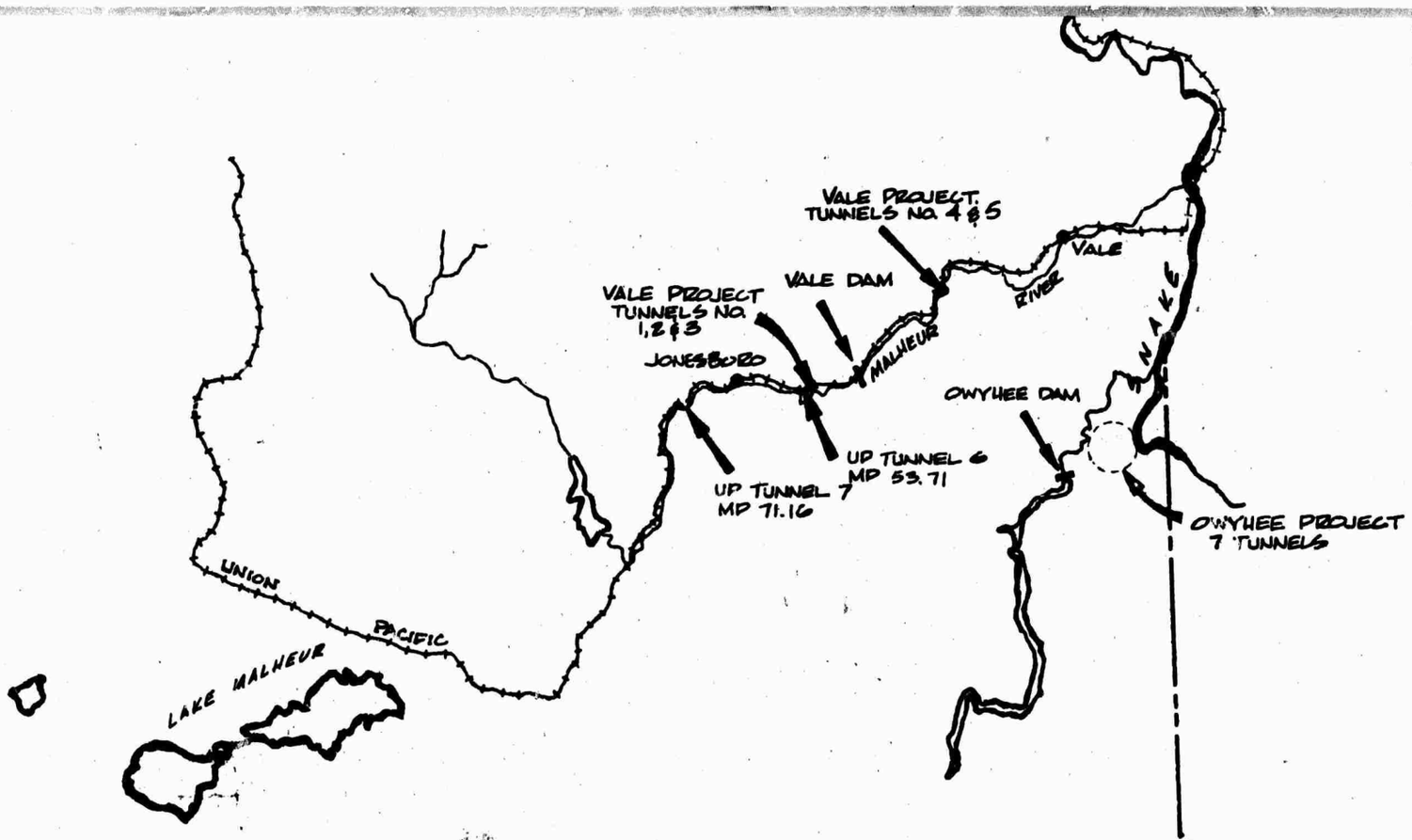


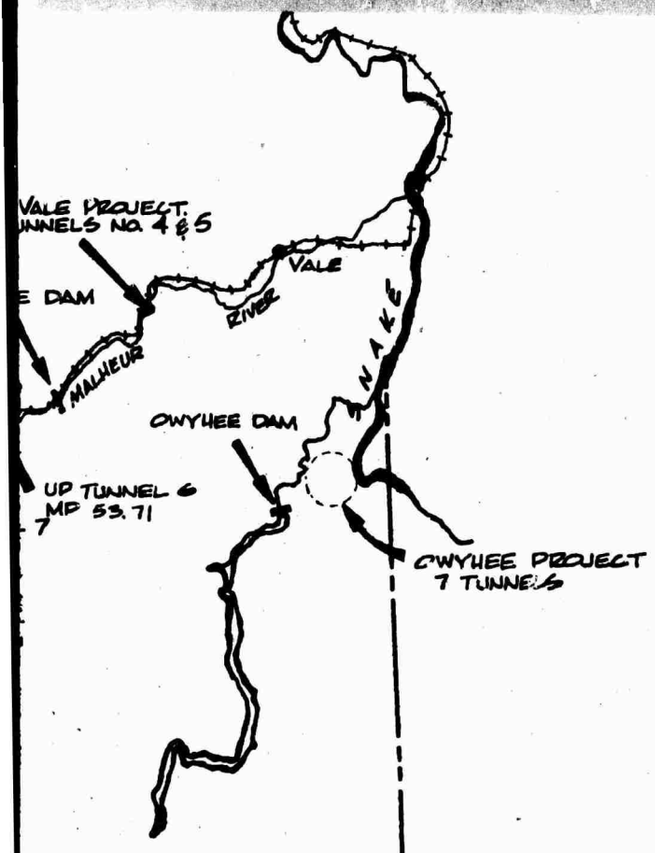
1 C


PENDLETON
UP TUNNEL 3½
MP 204.15
LA GRANDE
UNION
PACIFIC
RIVER
UP TUNNEL 6
MP 378.7
VALE PROJECT
TUNNELS NO. 4 & 5
VALE
VALE DAM
VALE PROJECT
TUNNELS NO.
1, 2 & 3
JONESBORO
OWYHEE DAM


FOSTER DAM
BLUE RIVER DAM
CAPE CREEK TUNNEL (O.S.H.D.)
KNOWLES CREEK TUNNEL (O.S.H.D.)
SP TUNNEL 14
FLORENCE
SP TUNNEL 15
SP TUNNEL 16
SP TUNNEL 13
SP TUNNEL 17
SP TUNNEL 18
REEDSPORT
SP TUNNEL 19
SD TUNNELS 20,21
ELK CREEK TUNNEL (O.S.H.D)
126
EUGENE
McKENZIE R.
PACIFIC
SP TUNNEL 24
SP TUNNEL 21
SP TUNNEL 23
SP TUNNEL 22
SP TUNNELS 16,17,18,19
SP TUNNELS 14,16
SP TUNNELS 4,5
38
COOS BAY
SOUTHERN PACIFIC
SOUTHERN
SP TUNNEL 1
SP TUNNELS 2,3
SP TUNNELS 4,6,6,7
SP TUNNEL 8
SP TUNNEL 9
ROGUE
RIVER
GRANTS PASS
MEDFORD
SP TUNNEL 14,15
SP TUNNEL 13
GREEN SPRINGS TUNN


MT. WASHINGTON
RMEN TUNNELS
COUGAR DAM
THREE SISTERS
DESCHUTES
CROOKED
DAM
PRINEVILLE
RIVER
BEND
PRINEVILLE DAM
21
EL 20
SP TUNNELS 6,7,8,9,10, 11,12,13.
SP TUNNEL 5
DESCHUTES DAM
SOUTHERN
LAKE
PACIFIC
KLAMATH PROJECT
KLAMATH FALLS
UNNEL
UNNEL
LAKE


VALE PROJECT
TUNNELS NO. 4 & 5
VALE
VALE DAM
VALE PROJECT
TUNNELS NO.
1, 2 & 3
RIVER
SNAKE
JONESBORO
MALHEUR
OWYHEE DAM
UP TUNNEL 6
MP 53.71
UP TUNNEL 7
MP 71.16
OWYHEE PROJECT
7 TUNNELS
UNION
PACIFIC
LAKE MALHEUR



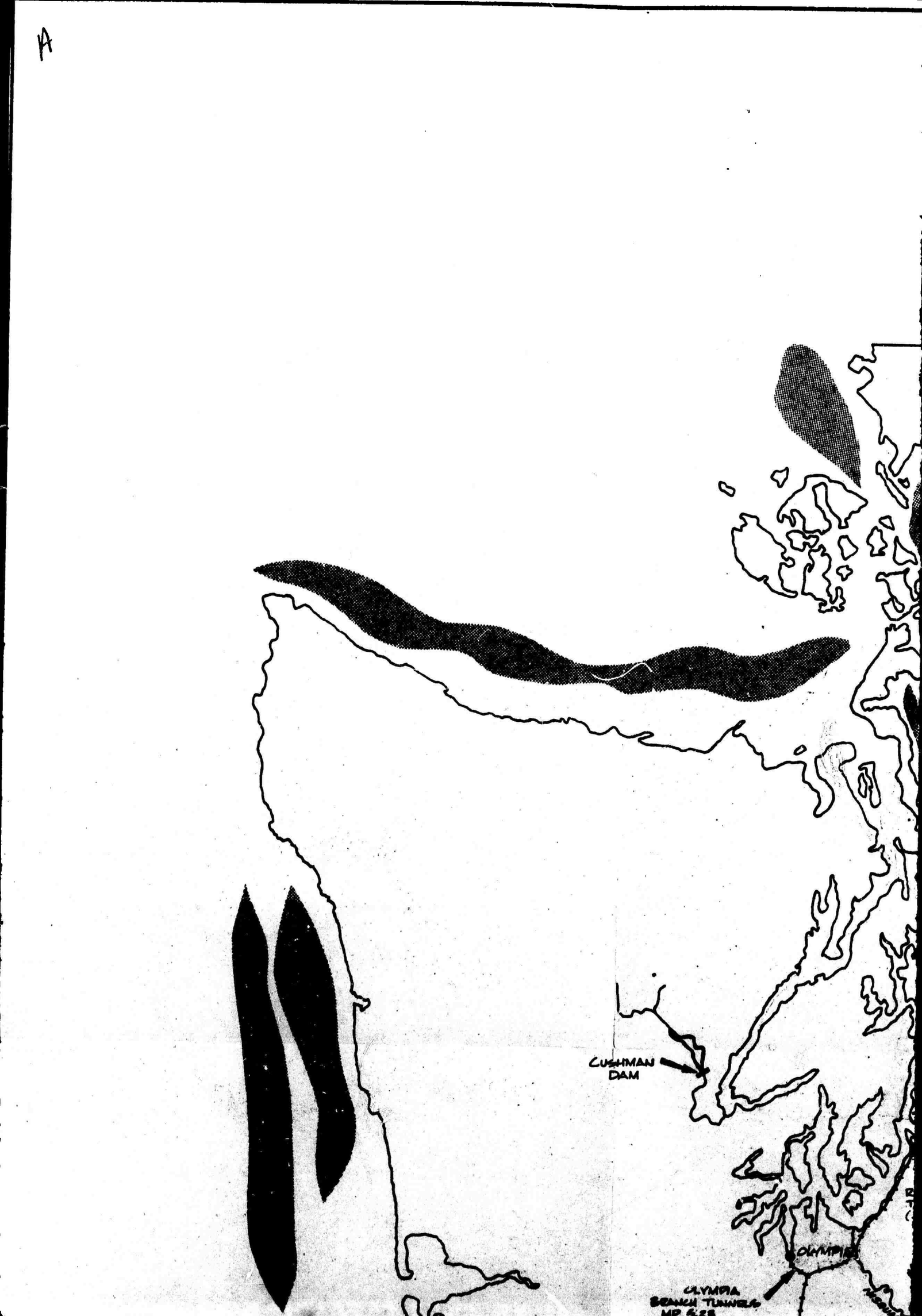
FOUNDATION SCIENCES, INC.
PORTLAND, OREGON

STATE-OF-THE-ART UNDERGROUND WORKS CONSTRUCTION

ARPA CONTRACT NO. H0210035

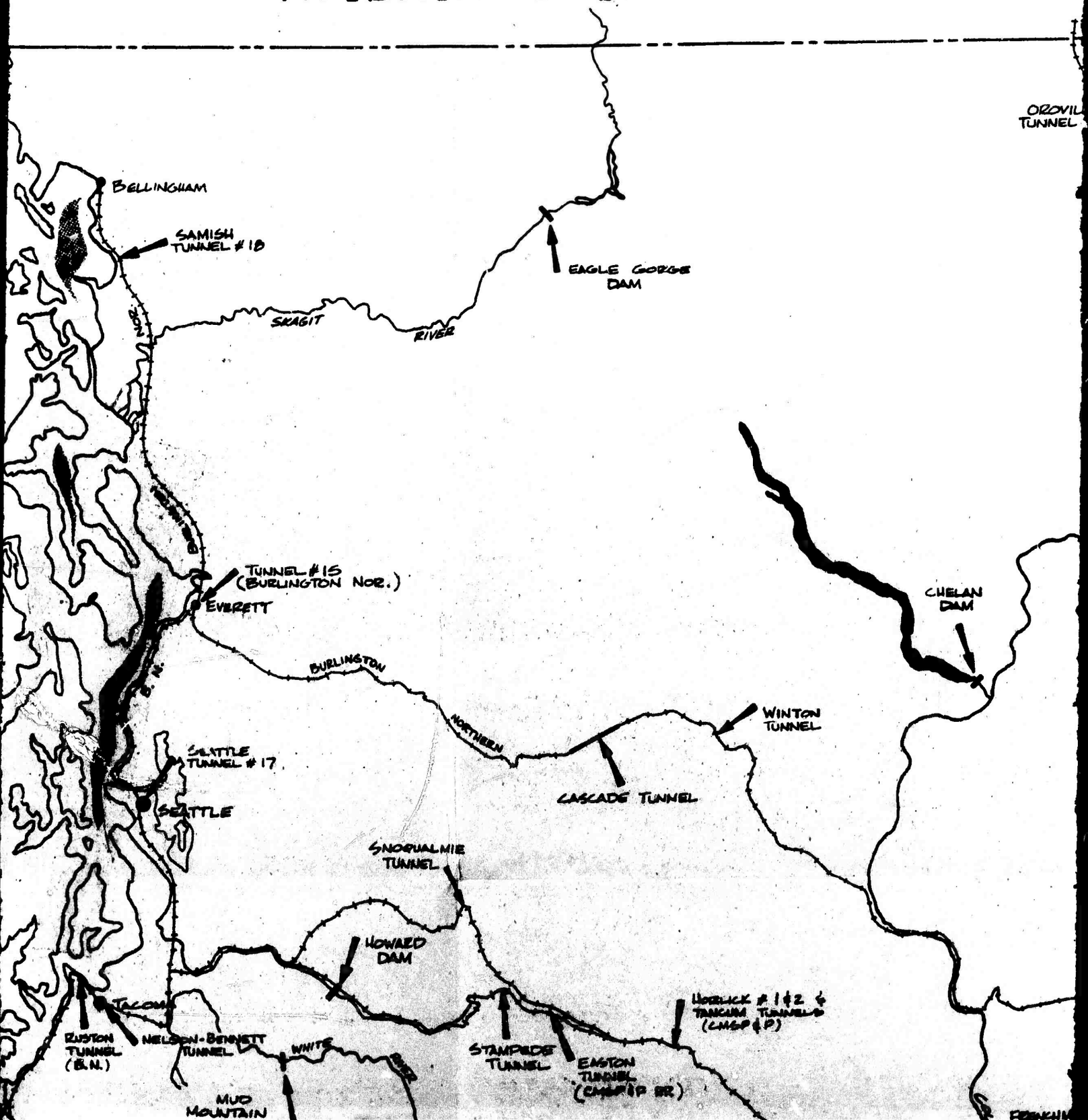
SCALE	DATE	NUMBER
SHOWN	MAY 1971	48-1-1

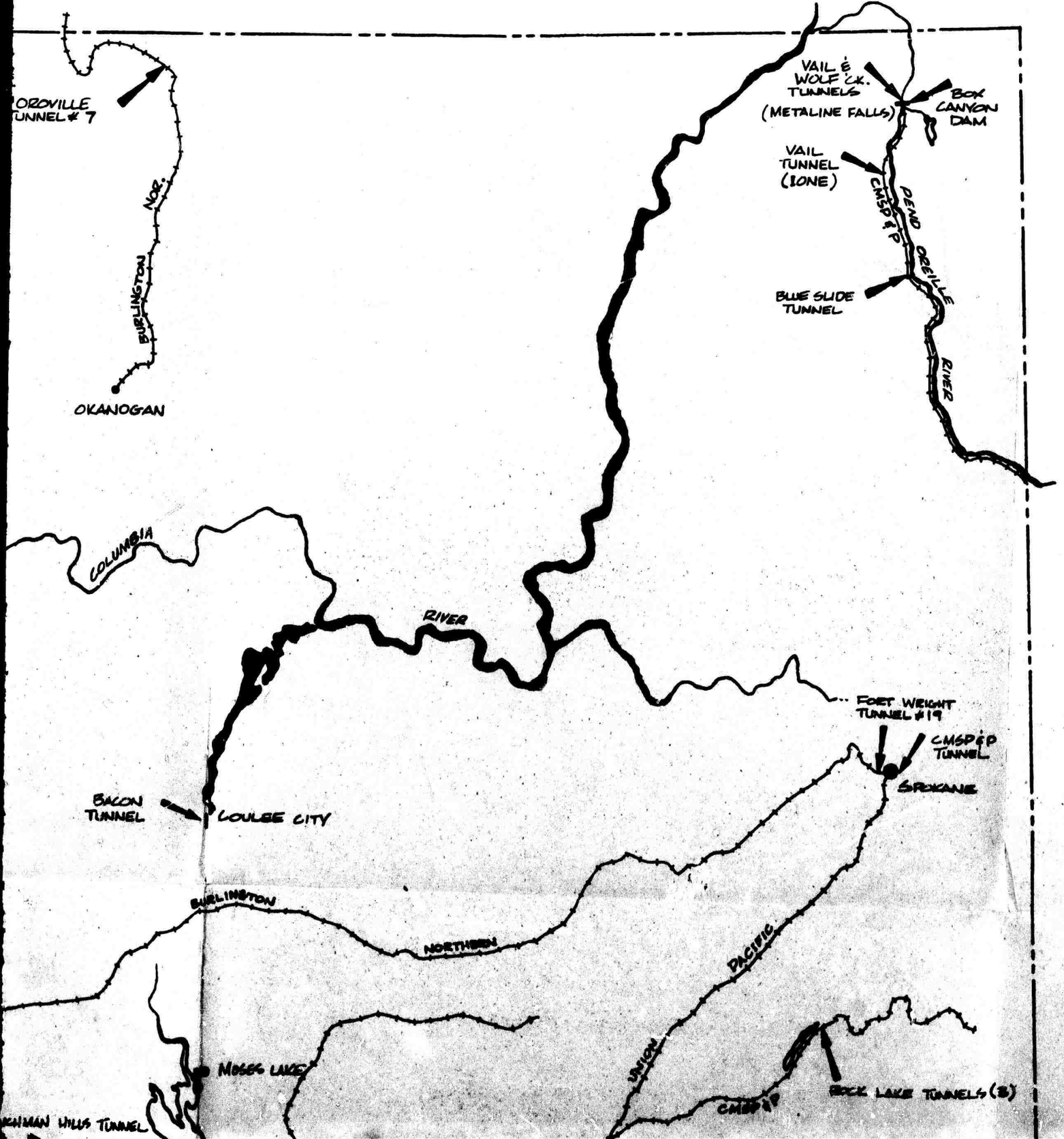
A

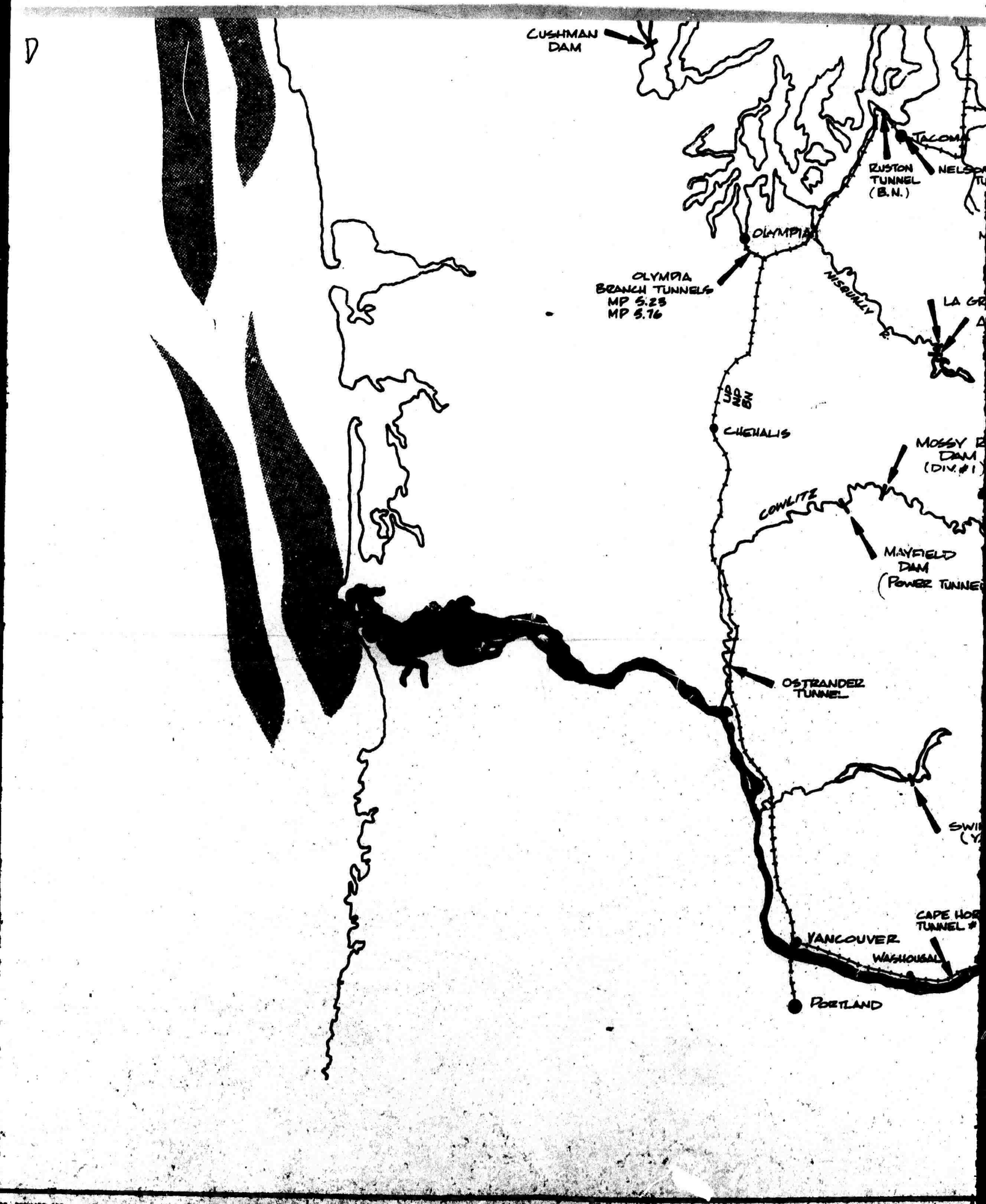


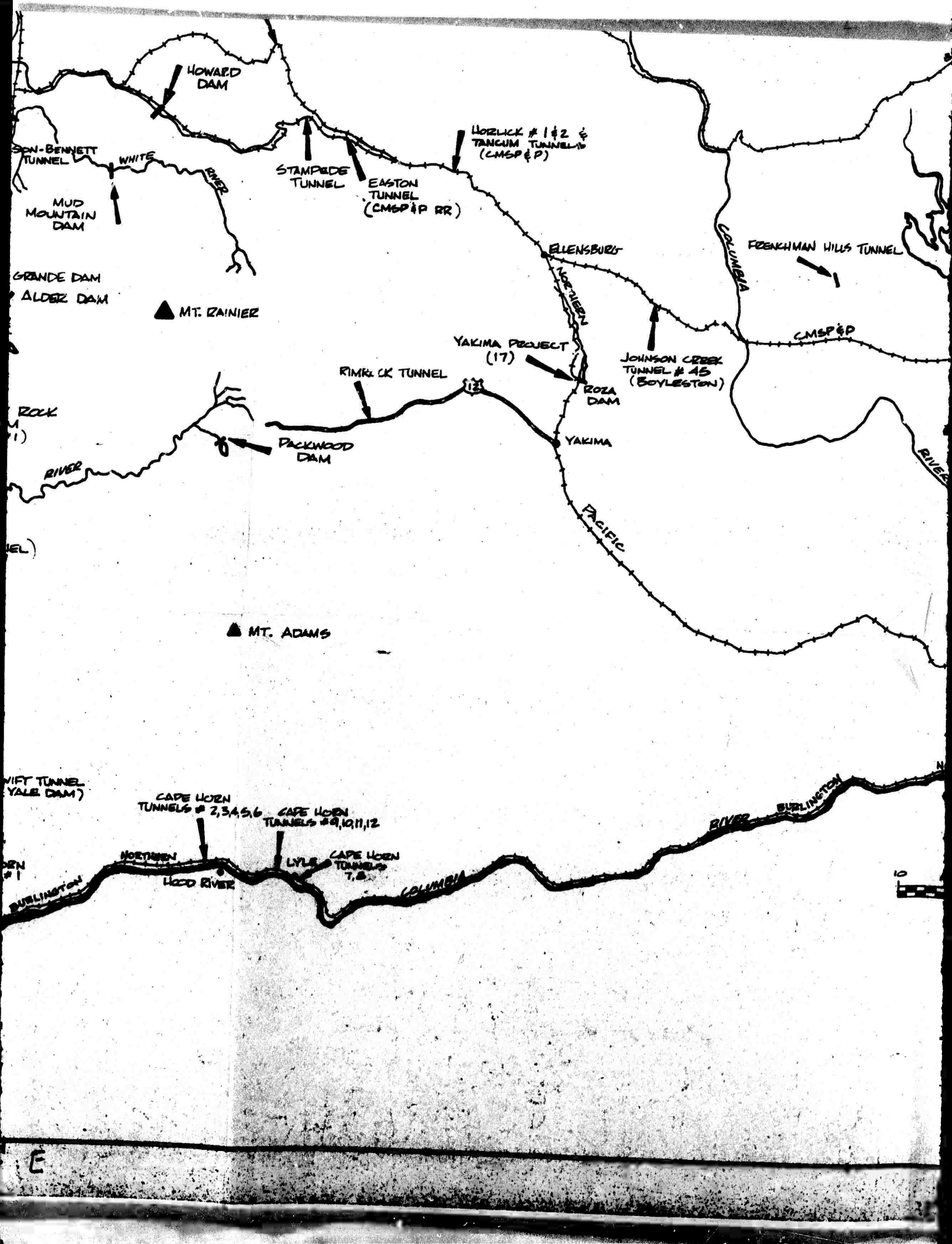
1B

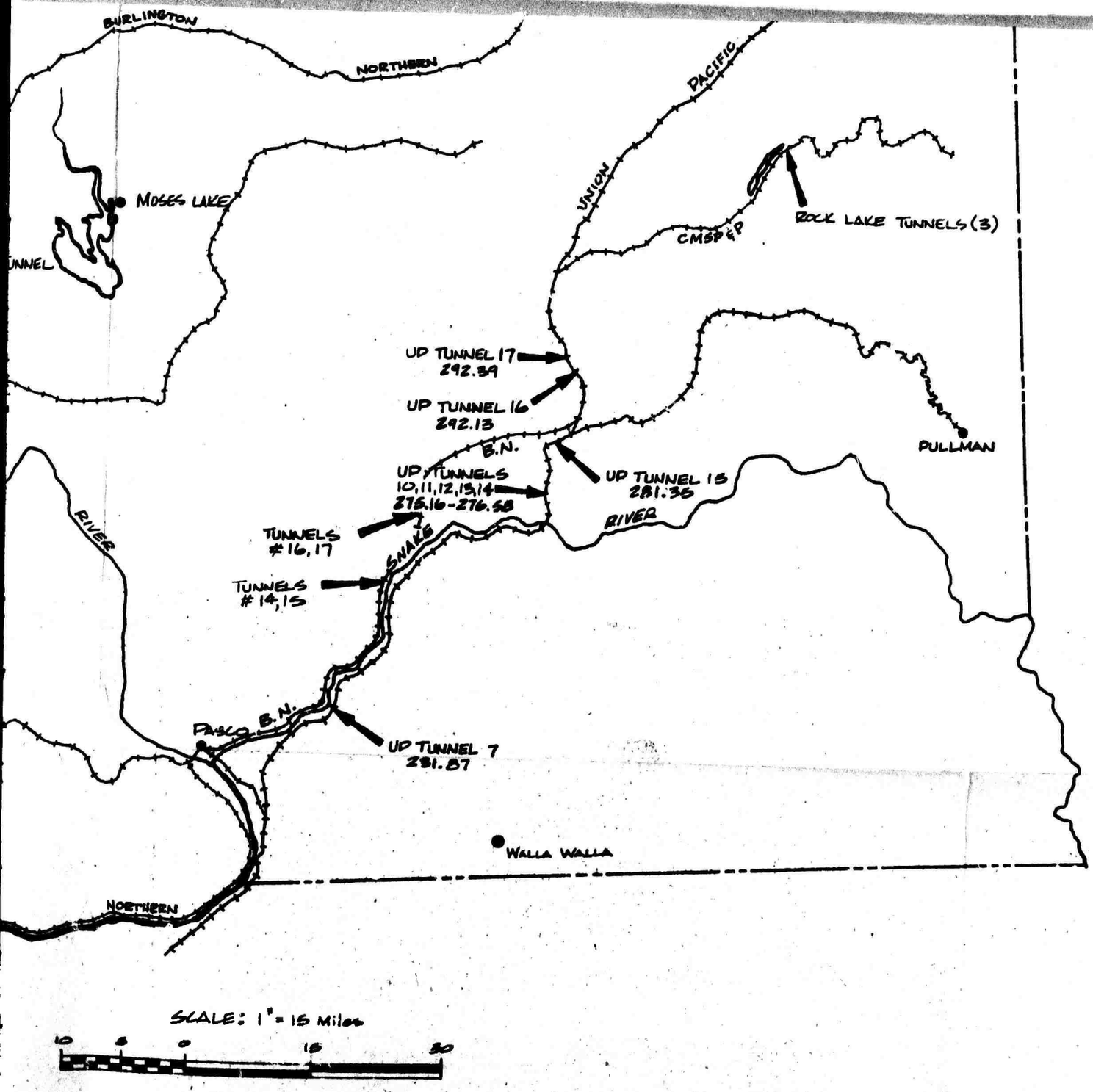
-WASHINGTON-

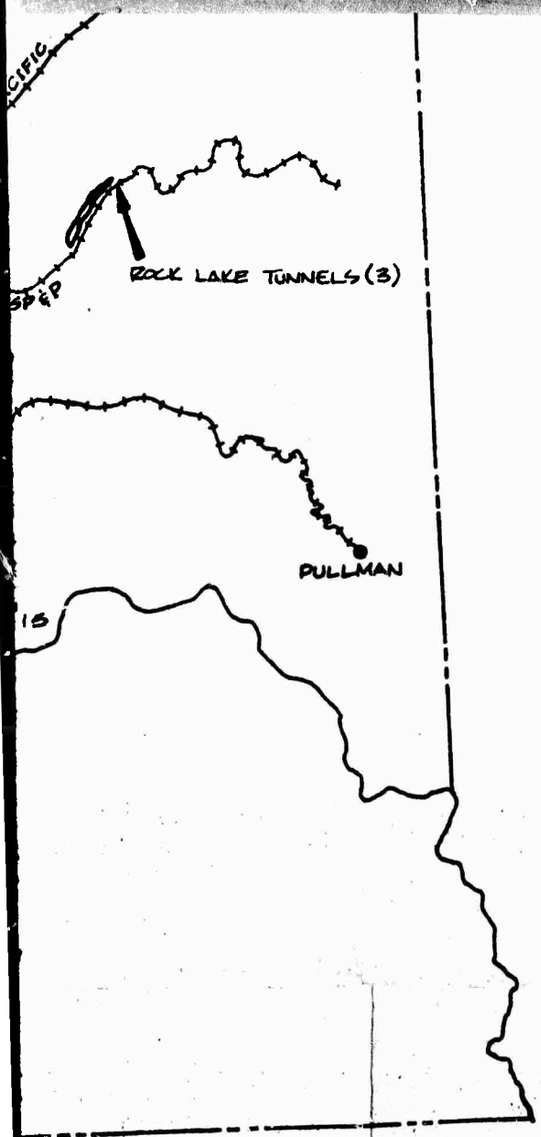



OROVILLE TUNNEL # 7
BURLINGTON NOR.
OKANOGAN
VAIL & WOLF CK. TUNNELS
(METALINE FALLS)
BOX CANYON DAM
VAIL TUNNEL (IONE)
CMSP & P
PEND OREILLE
BLUE SLIDE TUNNEL
RIVER
COLUMBIA
RIVER
FORT WRIGHT TUNNEL #19
CMSP&P TUNNEL
SPOKANE
BACON TUNNEL
COULEE CITY
BURLINGTON
NORTHERN
PACIFIC
UNION
MOSES LAKE
CMSP&P
ROCK LAKE TUNNELS (2)


D
CUSHMAN DAM
RUSTON TUNNEL (B.N.)
OLYMPIA
OLYMPIA BRANCH TUNNELS MP 5.23 MP 5.76
CHEHALIS
COWLITZ
OSTRANDER TUNNEL
VANCOUVER
PORTLAND


HOWARD DAM
SON-BENNETT TUNNEL
WHITE
RIVER
MUD MOUNTAIN DAM
STAMPEDE TUNNEL
EASTON TUNNEL (CMSP&P RR)
HORLICK #1 & 2 & TANCUM TUNNELS (CMSP&P)
ELLENSBURG
NORTHERN
COLUMBIA
FRENCHMAN HILLS TUNNEL
CMSP&P
GRANDE DAM
ALDER DAM
MT. RAINIER
YAKIMA PROJECT (17)
JOHNSON CREEK TUNNEL #45 (BOYLESTON)
RIMROCK TUNNEL
ROZA DAM
YAKIMA
PACKWOOD DAM
PACIFIC
MT. ADAMS
CAPE HORN TUNNELS #2,3,4,5,6
CAPE HORN TUNNELS #9,10,11,12
NORTHERN
LYLE
CAPE HORN TUNNELS 7,8
HOOD RIVER
BURLINGTON
COLUMBIA
RIVER
BURLINGTON
10


BURLINGTON
NORTHERN
MOSES LAKE
UNNEL
UNION
PACIFIC
CMSP&P
ROCK LAKE TUNNELS (3)
UP TUNNEL 17
292.59
UP TUNNEL 16
292.13
B.N.
PULLMAN
UP TUNNELS
10,11,12,13,14
275.16-276.58
UP TUNNEL 15
281.35
RIVER
TUNNELS
#16,17
SNAKE
TUNNELS
#14,15
PASCO
B.N.
UP TUNNEL 7
281.87
WALLA WALLA
NORTHERN
SCALE: 1" = 15 Miles
10
5
0
15
30



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