CRAG WATER PLAN

COLUMBIA REGION ASSOCIATION of GOVERNMENTS

429 S.W. 4TH AVENUE SUITE 500 PORTLAND, OREGON 97204 (503) 226-4331

CLACKAMAS COUNTY, OREGON — CITIES IN CLACKAMAS COUNTY
CLARK COUNTY, WASHINGTON — CITIES IN CLARK COUNTY
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CRAG

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SUMMARY

JULY 1969

THE PREPARATION OF THIS REPORT WAS FINANCIALLY AIDED THROUGH A FEDERAL GRANT UNDER THE URBAN PLANNING ASSISTANCE PROGRAM AUTHORIZED BY SECTION 701 OF THE HOUSING ACT OF 1954, AS AMENDED.

CLARK & GROFF ENGINEERS
CONSULTING ENGINEERS & PLANNERS, SALEM, OREGON

THE CRAG EXECUTIVE COMMITTEE - 1969

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This report was prepared by CLARK & GROFF ENGINEERS, INC. of Salem, Oregon. The CRAG staff and special consultants contributed to the report by supplying critical review and information upon which parts of the report are based.

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August 6, 1969

The CRAG Executive Committee
429 S. W. 4th Avenue
Portland, Oregon 97204

Gentlemen:

This will transmit for your consideration a summary of the report, "CRAG Water Plan" prepared for your Committee over the past fifteen months, pursuant to authorizations given by your Committee on April 19, 1968 and subsequently amended April 8, 1969.

Whereas the Technical Report is the complete compendium of all data, analyses, evaluations, maps and recommendations, this Summary is an assembly of sufficient information to permit a quick review of the important features of this study. In the interest of conserving time and cost, pages have been lifted from the Technical Report in their entirety. Thus, arrangement of the contents does not permit full utilization of all pages and titles of some illustrations are reversed.

It is hoped this abbreviated version will serve the purposes for which it is intended. At the same time, the reader with more than a passing interest will find much background material in the Technical Report.

As mentioned elsewhere, Clark & Groff Engineers appreciates this opportunity to be of service. We are grateful for the cooperation of the CRAG Executive Committee and its Assembly, and for the considerable assistance and pleasant relationship of Executive Director Homer C. Chandler, Engineer Homer V. Tunks and the staff.

Respectfully submitted,

CLARK & GROFF ENGINEERS, INC.

Lloyd K. Clark

Lloyd K. Clark, President

LKC/ey

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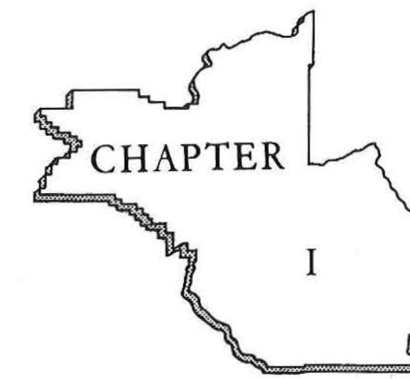
CHAPTER I

INTRODUCTION



PROJECT AUTHORIZATION

The Columbia Region Association of Governments (CRAG) is responsible for long-range comprehensive planning in the four-county area of Multnomah, Clackamas and Washington Counties in Oregon and Clark County in Washington. This area, for the purposes of this report, is designated as the CRAG study area.

One of the responsibilities of CRAG is the preparation of a comprehensive plan for water resource utilization within the study area. To assist in this endeavor CRAG engaged Clark & Groff Engineers, Inc. on April 19, 1968 to perform the professional engineering services necessary for such a study.

WATER PLANNING NEEDS

In the early days of Oregon there was little or no need for regional planning. There was an abundant supply of the basic natural resources necessary to sustain life. However, the situation is now different and is in a rapid state of change, particularly in the urbanized part of the CRAG study area. At present the area has approximately 970,000 people. Projections indicate a population of nearly 1,800,000 by year 2000. This rapid growth brings with it many complex and varied problems relating to water needs.

In many cases where agricultural centers have been situated on valley land, urban development is spreading out to cover a large part of this land with buildings and pavement.

Concurrently with the population increase has come industrial expansion. Though extremely valuable to the economy, this development has also brought into focus the importance of our water resource.

The concentration of population in the CRAG study area has intensified water distribution requirements. The bulk of the rain and snow occurs during winter months, while the summers are warm and dry. Stream flows closely follow the rainfall pattern while the need for water is greatest when rainfall and stream flows are lowest. In many cases, direct diversion of stream flow does not supply year-round water needs. This is particularly true of the Tualatin Valley and the Bull Run water system. Therefore, more and more storage during peak flows must be provided in order to distribute the supply throughout the year.

Agriculture in the CRAG area is competing with the municipal and industrial sectors for water. Changes in irrigation programs and cropping practices together with increased storage could well increase the agricultural water consumption.

Planning for water needs, therefore, must recognize the many demands and conflicts which arise in the wise utilization of this important resource.

PURPOSE AND SCOPE OF STUDY

The purpose of this study is the preparation of long-range plans for the urbanized regions of the CRAG area which will provide for more orderly and, hopefully, more economical development of water resources by local agencies to the year 2000.

The objectives of the study as set out in the agreement between CRAG and CLARK & GROFF ENGINEERS, INC. are as follows:

1. To identify and describe the present types and extent of water utilization within the CRAG area.

2. To identify and describe the total potential water resources in the project area and project said description to the year 2000.

3. To provide the information necessary to promote the efficient and orderly development of the collection and distribution of water resources by local agencies to the year 2000 A.D.

4. To provide the information necessary to avoid overlapping, duplication, under-design or over-design of water resources collection and distribution facilities which may be constructed within the CRAG study area.

The plan will be directed to the concept of comprehensive development of water resources within the CRAG study area. It will contain basic data and information which can serve as a basis for subsequent studies. It will provide a framework within which individual communities and other water agencies can plan long-range capital improvements on an area-wide basis. It will provide CRAG a basis for the evaluation of water plans where their approval is required for federal funding.

The scope of the study is to collect all available information from the various agencies having jurisdiction within their respective fields and to analyze and utilize this information to the fullest in the development of a comprehensive plan. The report includes recommendations for use by local and state agencies for implementing the projects to achieve the objectives of the plan.

CONCLUSIONS

Summary statements taken from the main body of the report may be found in brief sections preceding each chapter. These statements are limited to factual data collected or generated during the course of the study. Based on this data, conclusions can be drawn, and certain assumptions can be made with regard to the probable future course of events. The future can hardly be predicted with accuracy, but in the light of the knowledge developed in this study, the following conclusions or deductions seem warranted for the area within the present CRAG boundaries:

1. The small amount of precipitation during the summer months often creates water shortages affecting municipal and agricultural water supplies. This period of water shortage is also the period of greatest demand for municipal and agricultural water.

2. The population is expected to increase from 968,645 in 1968 to 1,188,000 by 1980, 1,450,000 by 1990, and 1,755,000 by 2000. The majority of the people will reside in what is now considered to be the urbanized portion of this area.

3. Residential land uses will continue to dominate development in the urban area and near commercial-industrial centers such as Milwaukie-Oak Grove, Tualatin-Lake Oswego-West Linn, Beaverton and Vancouver-Hazeldale. Commercial and industrial land uses will be scattered throughout the urban areas and near established commercial and industrial centers. Industrial land uses will also concentrate near the confluence of the Willamette and Columbia Rivers. Agricultural land-use acreage appears to be declining.

4. Present municipal water use averages about 135 MGD with peak days reaching about 350 MGD. By the year 2000, average day and peak day water usage is expected to be 276 MGD and 718 MGD respectively.

5. The water requirements of industries operating on private systems was approximately 212 MGD in 1965 and is estimated to be 423 MGD in 2000.

6. Agricultural water requirements based on land usage are estimated to be 2,310 MGD in 1970 and 1,980 MGD in 2000. This apparent decline is expected to be offset by changes in irrigation programs, cropping practices and the availability of stored water. Thus it is likely that agricultural needs in 2000 will not be less than presently estimated.

7. Only small quantities of water are currently consumed for recreational purposes. The use of water for this purpose is primarily nonconsumptive. Recreational water use is increasing rapidly and the trend is expected to continue for the foreseeable future.

8. Existing municipal facilities for the supply and transmission of water are capable of producing 338 MGD which is slightly less than the present peak day requirement of 350 MGD.

9. Properly utilized, there appears to be sufficient surface water and ground water to satisfy municipal, industrial, agricultural and recreational water requirements to the year 2000.

10. The primary sources of surface water which are currently available for diversion are the Columbia River (63,000 MGD), Willamette River below the Willamette Falls (2,800 MGD), Lewis River between the mouth and Ariel Dam (450 MGD), and Clackamas River near the mouth (220 MGD).

11. Sources of surface water which are currently being developed are the Trask River Project at 9 MGD and Lake Oswego's Clackamas River Project with treatment at 11.0 MGD and transmission facilities at 16 MGD. Ultimate development is expected to reach 32 MGD by 1985.

12. Sources of surface water currently in the planning stage for development are the Clark County PUD Lewis River project: 50-250 MGD; City of Canby, Molalla River or Willamette River Project: 2 MGD; City of Portland development of Bull Run: 350 MGD; Bureau of Reclamation Tualatin Project: 20-24 MGD. The Washington County Tualatin Basin Water Plan: 42 MGD is now being developed in part as the Trask River Project.

13. The primary sources of ground water and the estimated quantities currently available are the ground waters of the:
    Vancouver, Washington lowland area, 500 MGD,
    Camas-Washougal, Washington area, 250 MGD, and
    The Troutdale-Sauvies Island, Oregon area, 50 MGD.

14. Sources of ground water currently being planned for development are:
    City of Camas, Washington, 13.6 MGD,
    Clark County PUD, 5.7 MGD,
    City of Vancouver, Washington, 66 MGD, and
    City of Washougal, Washington, 12 MGD.

15. Ground water resources in the Tualatin Valley are limited and it is doubtful they could be developed to serve the municipal water requirements of the area to the year 2000.

16. There are presently 130 agencies serving water to local areas. There has been limited effort on the part of these agencies to develop regional plans to provide adequate supplies to meet future needs.

17. At the Willamette River Falls there are nonconsumptive water rights for power held by Portland General Electric Company and Publisher's Paper Company which amount to 19,490 MGD. Until these rights are adjudicated there will be a cloud on all appropriations for water upstream of Willamette Falls.

18. The Clackamas River, near its mouth, is one of the primary water resources considered in this report for municipal water supply. There is a sufficient quantity of water to serve the needs of only a portion of the CRAG study area to year 2000. Low flows could possibly be augmented by purchase of water from upstream storage. There should be an adjudication of water rights on the Clackamas River before final plans are made for the diversion of additional amounts of water near the mouth.

19. The systems approach showed the following alternatives to be the most economical for providing water supply to the urban portion of the CRAG study area to the year 2000.
    (A) Ground water for the Vancouver, Camas, Washougal area.
    (B) Bull Run (City of Portland) to supply the additional water requirements of Multnomah County east of Portland, City of Portland, and the Beaverton, Aloha, Tigard area of east Washington County.
    (C) Trask River Project to supply the additional water requirements of Hillsboro, Forest Grove and Cornelius.
    (D) The lower Clackamas River to supply the additional water requirements of the Milwaukie, Oregon City, Lake Oswego area of Clackamas County.

20. The total estimated cost (in 1969 dollars) of the proposed facilities listed in Paragraph 20 above is approximately $58 million with $25 million planned for implementation in the next ten years.

21. The Columbia Region Association of Governments appears to be the logical agency to act as the planning, coordinating and sponsoring agency in the implementation of the plan.

22. Implementation as to financing, constructing and operating on a more or less wholesale basis may be accomplished by
    a) a regional organization;
    b) an organization by subareas of the region; or
    c) an association of existing organizations.

23. The CRAG Water Plan should be updated on a routine basis by analyzing and evaluating changing conditions as they occur.

Note: The alternative methods of providing water from potential sources to water-use areas within the urban portion of the CRAG study area were explored by developing a systems analysis approach wherein the economic costs were evaluated on a relative basis. This approach takes into account all of the related cost factors such as source development, transmission, water treatment plant construction and operation, and pumping. Fixed costs such as administration were excluded.

RECOMMENDATIONS

The following is an outline of suggested steps to be taken by the Columbia Region Association of Governments in the near future to implement the CRAG Water Plan. They are stated in a suggested order of priority.

1. The CRAG General Assembly should adopt the CRAG Water Plan as the basic guideline for long-range water planning in the CRAG study area.

2. The Oregon State Board of Health, federal planning agencies, and all local planning agencies in the CRAG study area should be advised as to both the content of the CRAG Water Plan and the intent of CRAG to implement the plan. Comments and suggestions should be solicited from these agencies.

3. CRAG should sponsor meetings with officials of all local governments in the CRAG study area for the purpose of introducing the CRAG Water Plan.

4. CRAG should be given the authority by these officials to provide the planning, coordination, and initiative necessary to implement the CRAG Water Plan. With this authority CRAG could then take positive action whenever water needs arise.

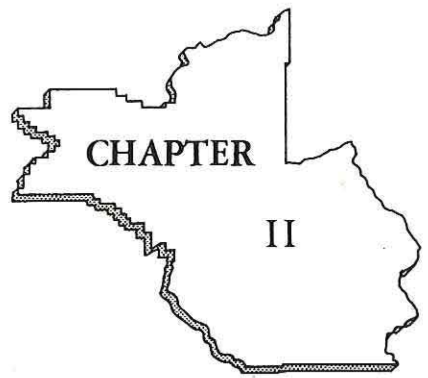
5. CRAG and the officials of all local governments should develop the optimum governmental arrangement for implementing the plan in each subarea. Detailed cooperative agreements should be established.

6. Following development of governmental arrangements, an equitable financial program should be developed. This includes type of financing, federal and state grants and loans, and equitable means of cost sharing.

7. After development of an equitable financial program, the construction program should be developed and implemented.

8. All aspects of the CRAG Water Plan, including governmental arrangements, cooperative agreements, financial program, construction program, and physical aspects, should be periodically reviewed and updated.

CRAG AREA SKETCH



SUMMARY

The CRAG study area consists of the four counties of Washington, Clackamas, and Multnomah in Oregon and Clark County in Washington, see Figure II-2. The area contains 3,699 square miles with a population of 968,645 residents in 1968.

The major topographic and geologic features are the Coast Range uplift which is made up of marine sedimentary rocks and associated volcanics; the Willamette trough; and the western and high Cascades which originated from anticlinal folding and volcanic activity. The major rivers running through the area are the Columbia River and the Willamette River.

The climate in the CRAG study area is characterized by mild, wet winters and warm, dry summers. Approximately 75 percent of the precipitation in the CRAG study area normally occurs during the six-month period from October 1 to March 31 with the remaining six months receiving 25 percent of the precipitation. The two-month period of July-August receives about 3 percent of the annual average precipitation. The small amount of precipitation during the summer months often creates water shortages which affect municipal and agricultural water supplies. This period of water shortage is also the period of greatest demand for municipal and agricultural water.

Both natural increase and in-migration have played prominent roles in the CRAG study area population growth. The average decennial population increase over the fifty-year period between 1910 and 1960 was 103,600 persons per decade; however, it varied from a low of 46,100 persons per decade between 1930-40 to a high of 203,200 between 1940-50. The area population is expected to increase from 968,645 in 1968 to 1,188,000 by 1980, 1,450,000 by 1990, 1,755,000 by year 2000.

Population projections are presented in this report for the years 1970, 1980, 1990 and 2000. These projections are presented by individual census tract to facilitate updating this report and use in subsequent supplementary reports.

The major natural resource based industries in the CRAG study area are agriculture, food processing, lumber and wood products, and paper and allied categories. A slow but steady decline in employment is expected in these industries. The non-resource based growth industries include manufacturing; fabricated metals, machinery, and transportation equipment, and non-manufacturing; trade, services, government, and finance-insurance-real estate. A steady increase in employment is expected in these industries. The diversity of industrial activities and the numerous small firms with wide areal distribution provides a "relatively stable, diversified and resilient" economy for the region.

Residential land use has been dominant within the urban area in the past, and, as indicated in Figure II-7 and Table II-8, is expected to continue to dominate in the future. Although much of this development will continue to occur within the urban area, a great deal of it will also extend out of the area on all sides, especially near established commercial-industrial centers such as Milwaukie-Oak Grove, Tualatin-Lake Oswego-West Linn, Beaverton and Vancouver-Hazeldale.

The ultimate extent of residential usage, in addition to what exists now, should extend to the areas north and east of Vancouver, south and east of Oregon City, south and west of Tigard and Lake Oswego, the area between and north of Beaverton and Hillsboro, and some east of Clackamas.

Commercial land uses will be scattered throughout the urban area much as they are now with consolidation of this use in or near established commercial centers. This is also true of the industrial uses but with a concentration near the confluence of the Willamette and Columbia Rivers on both the Oregon and Washington shores of the Columbia. The rest of the industrial land uses will be scattered through the area in strips and nodes.

The future agricultural land-use pattern in the CRAG study area appears to be tending toward the following: (1) total acreage will continue to decline and will be replaced by urban land uses; and (2) intensive agricultural land uses requiring irrigation will continue to decline. However, if large water storage projects such as McKay-Rock Creek, the Tualatin Project and the Gaston Project are constructed thus making large volumes of water available for irrigation, there will be a probable increase in agricultural land use.

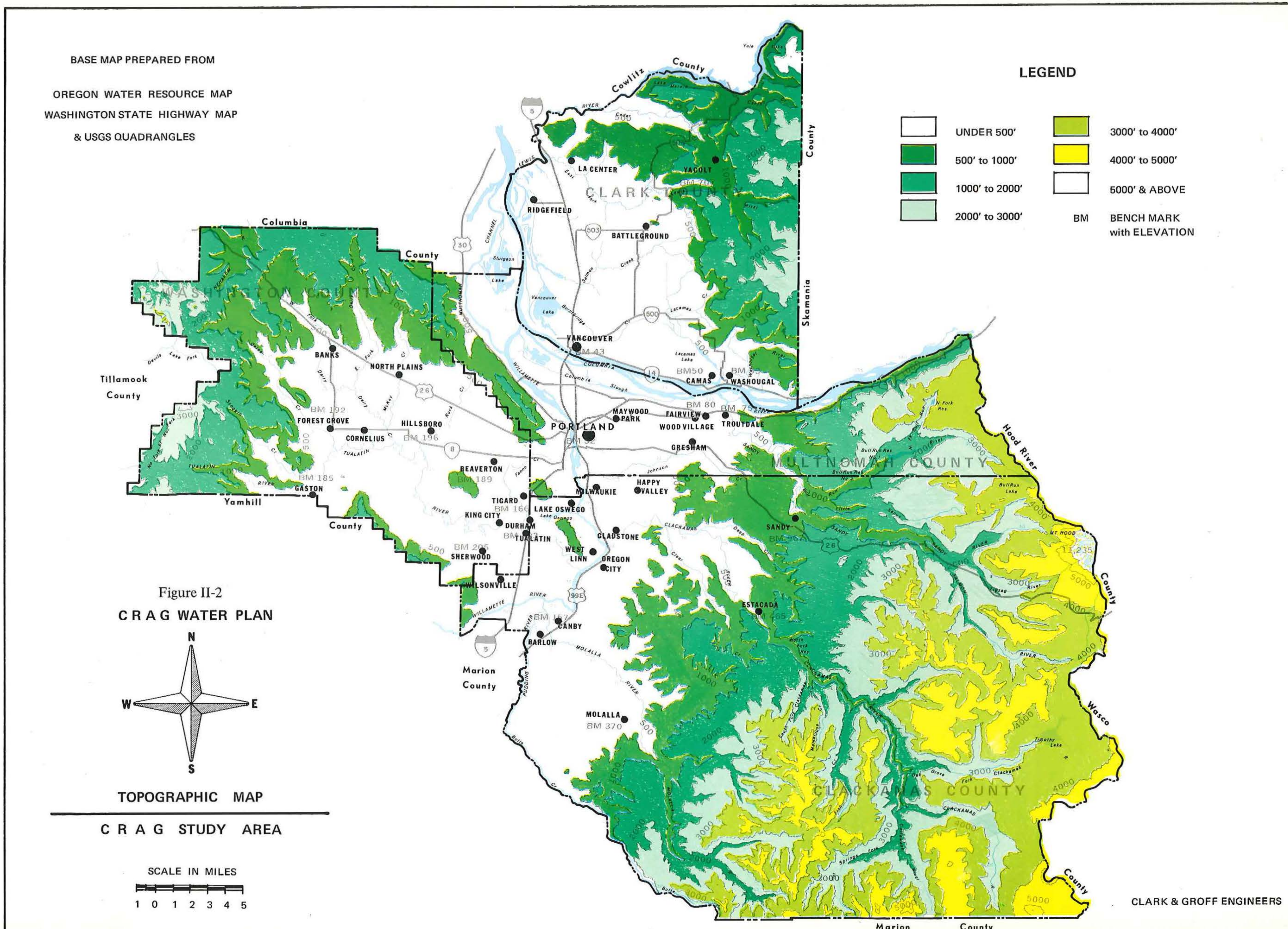


Figure II-2
C R A G WATER PLAN

TABLE II-8

LAND-USE DISTRIBUTION BY SUBAREA

(Acres and Tenths of Acres)

Urban Subarea	Residential	Commercial	Industrial	Public and Semi-Public	Transportation	Vacant	Total
Clark County, Washington							
1960	5,137.7	352.4	1,687.3	1,986.2	2,858.4	36,052.6	48,074.6
1990	10,882.0	640.0	3,351.0	2,430.0	4,907.0	25,864.6	48,074.6
Percent Increase	111.8	81.6	98.6	22.3	71.7	- 28.3	–
Washington County, Oregon[1]							
1960	7,652.8	330.6	711.8	2,634.2	4,086.1	50,871.7	66,287.2
1990	19,303.0	1,029.0	2,622.0	3,144.0	6,518.0	33,671.2	66,287.2
Percent Increase	114.5	211.5	270.8	19.4	59.5	- 33.8	–
Multnomah County, Oregon							
1960	28,133.2	2,197.4	4,130.8	9,305.0	17,938.8	57,854.0	119,559.2
1990	39,243.0	2,619.0	7,030.0	10,916.0	21,243.0	38,508.2	119,559.2
Percent Increase	42.0	19.2	70.1	17.3	18.4	-33.4	–
Clackamas County, Oregon							
1960	8,818.5	316.1	772.9	1,601.1	4,322.4	43,001.5	58,832.5
1990	17,135.0	796.0	1,712.0	2,020.0	6,603.0	30,566.5	58,832.5
Percent Increase	94.3	151.8	121.5	26.2	52.8	-28.9	–

[1]Includes small section of Multnomah County.

Source: Wilbur Smith & Associates, *Planning Analysis and Projections – Portland-Vancouver Metropolitan Transportation Study.*

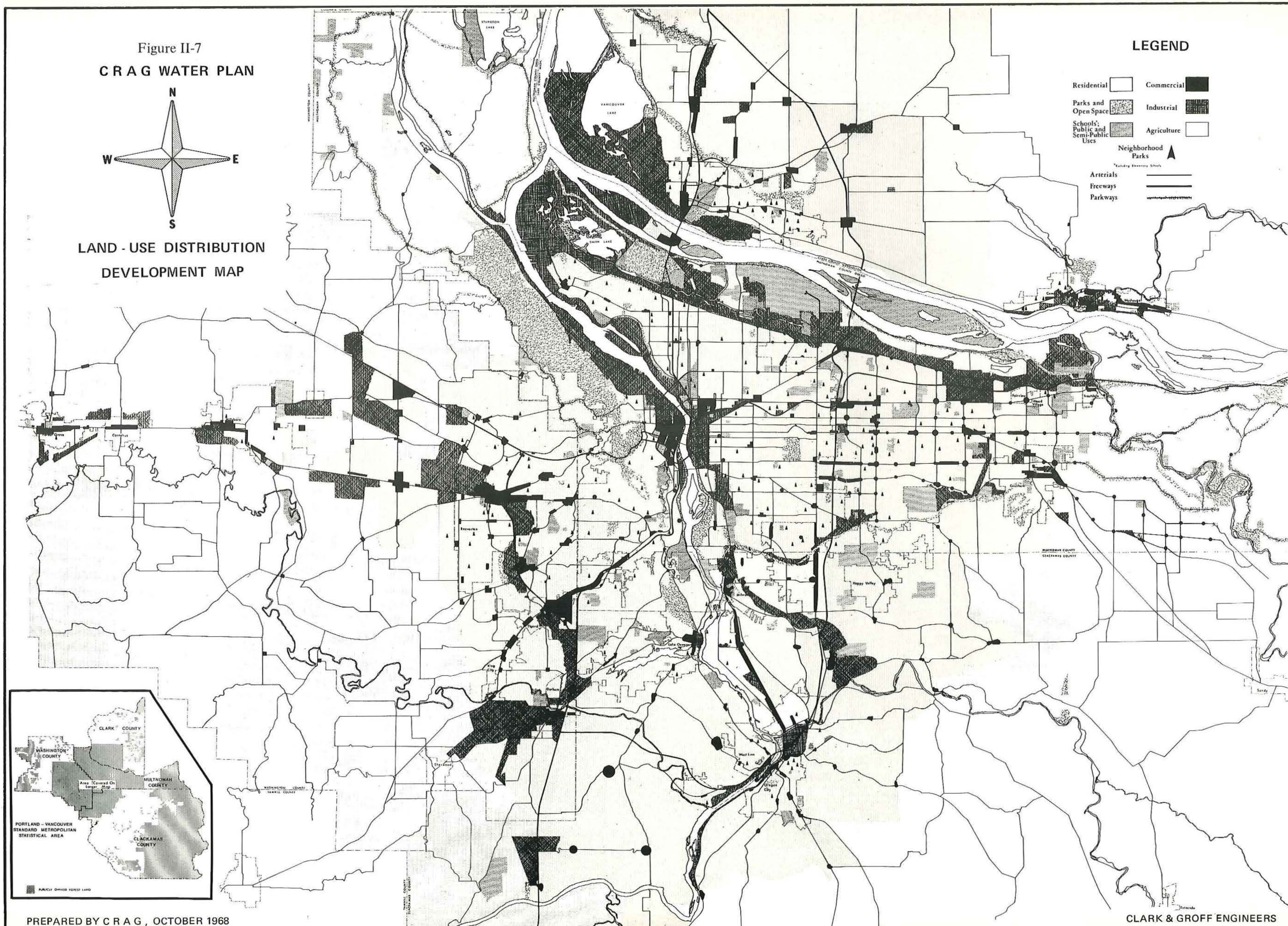
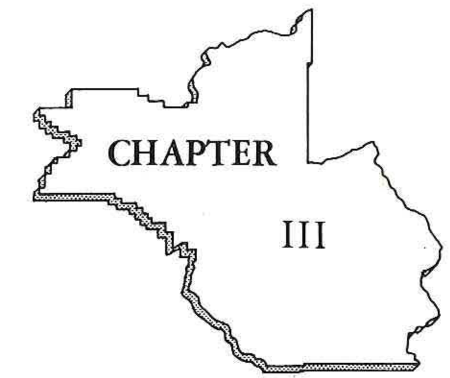


Figure II-7

CRAG WATER PLAN

LAND - USE DISTRIBUTION DEVELOPMENT MAP

WATER REQUIREMENTS



SUMMARY

The three general categories of water requirements investigated were municipal, private industrial, and agricultural. Recreational water use is discussed in a general manner. Included in municipal water requirements was an allowance for those industrial users that purchase water from municipal water systems. Private industrial water users are those who have their own source of large quantities of water from wells or a major stream. Agricultural water requirements are for the irrigation of farm lands. Primary emphasis in this chapter was placed on present and future requirements for municipal water.

An average of 135 million gallons of water per day (MGD) is presently used in the CRAG study area by municipal water users. The ratio of peak day water use to average day water use was found to be 2.60, therefore, during the warm summer months, peak day water use within the CRAG study area could total 350 million gallons per day (MGD). By the year 2000, average day and peak day usage is expected to double. Most of this increase in water usage will come from increased population, the remainder of the increase is expected to occur because of a growing use of water consuming appliances. Increased water usage generally accompanies a higher standard of livving.

By the year 2000, municipal water requirements for Washington County are expected to average 55 million gallons per day, well over three times the 17 million gallons per day needed at present. Clackamas County will need three times as much as the 20 million gallons it now consumes. Clark County can expect to see its future water requirements almost triple from their present level of 16 million gallons on an average day. Multnomah County, with a present usage of 82 million gallons per day, will experience an increased usage of only 50 percent.

Beginning with the census of 1960 the counties comprising the CRAG study area were divided into census tracts by the U.S. Bureau of Census, each tract containing approximately 4,000 persons. In order to reduce the number of computations required, and to present a more meaningful analysis, groups of census tracts have been consolidated into what will be referred to as "water-use areas."

Water-use areas consist of one or more census tracts with at least one of the following characteristics:

A. The area is now served by a single water system.
B. The area is the smallest unit that could become a part of a regional system.
C. The area should preferably be served by one system.
D. The area is growing at a different rate than the surrounding areas.
E. The area is so sparsely settled that community systems are impractical, yet the population trends should be reviewed for future updating and analysis. These areas are generally single census tracts.

Projected municipal water requirements for the CRAG study area, the four counties, and water-use areas are presented in tabular form in Table III-5 and are illustrated graphically in Figure III-1.

An average of 212 million gallons of water per day was consumed in the CRAG study area in 1965 by industrial water users operating on private systems. Industrial water use in the CRAG study area is primarily for pulp and paper production at Oregon City and West Linn in Clackamas County and Camas and Vancouver in Clark County. Other large users are aluminum plants at Troutdale in Multnomah County and Vancouver in Clark County, a hydrogen peroxide plant near Vancouver and a sawmill and plywood mill in northeastern Clark County. There are no large industrial water users operating on private systems in Washington County.

Industrial water requirement estimates for those industries operating on private systems have been made for the CRAG study area. It should be emphasized that numerous factors could change these estimates considerably. For example, the addition of one or more pulp and paper mills in the CRAG study area would increase future industrial water requirements substantially.

Estimated agricultural water requirements to year 2000 are presented in Table III-9 for each of the four counties in the study region. These requirements were derived from the total acreage of irrigated agriculture in each county and gross irrigation requirements estimated at 1.5 acre-feet per acre. It is estimated that total water requirements for irrigation will slowly decline to year 2000. However, if large water storage projects are constructed there could conceivably be an increase in water requirements for irrigation. Changes in irrigation programs and cropping practices such as double cropping, crop cooling and frost protection will tend to cause agricultural water requirements to increase. This is occurring now to limited extent and could increase by the year 2000.

Only small quantities of water are currently consumed for recreational activities in the CRAG study area. Important water-based recreation areas include the Clackamas, Sandy, Columbia, and Lewis Rivers and high mountain lakes in the upper stretches of the Clackamas and Sandy Rivers.

The future extent of water-based recreation activity cannot be precisely predicted. However, it is known that recreational water use is increasing rapidly with increased leisure time, rising personal incomes, and increasing population. This trend is expected to continue in the foreseeable future. Although recreational water use is increasing rapidly this water use is primarily nonconsumptive.

There is sufficient water in the CRAG study area to satisfy present and future water-use requirements to year 2000 for municipal, industrial, agricultural and recreational purposes. Total estimated water requirement for municipal, industry on private systems, and irrigated agriculture in the CRAG study area are presented in Table III-10.

TABLE III-5

PROJECTED MUNICIPAL WATER REQUIREMENTS BY WATER-USE AREA

		AVERAGE ANNUAL USE (MGD)				
WATER-USE AREA	CENSUS TRACTS	1960	1970	1980	1990	2000
CLACKAMAS COUNTY, OREGON						
108	29	0.29	0.33	0.37	0.60	0.95
111	27	0.23	0.56	0.99	1.13	1.52
115	28, 30	0.38	0.44	0.50	0.86	1.40
116	32-34	1.04	1.17	1.32	1.67	2.26
117	36-38	0.65	0.75	0.86	1.28	1.74
118	39	0.37	0.40	0.44	0.57	0.70
119	40-41	0.27	0.30	0.33	0.58	0.84
120	42	0.25	0.27	0.30	0.46	0.60
121	43	0.29	0.33	0.37	0.46	0.60
122	31,35	0.33	0.40	0.57	0.86	1.10
131	1-7	2.83	4.75	8.23	11.51	16.26
132	8-26	7.64	10.42	14.67	20.72	29.26
	County Total	14.57	20.12	28.95	40.70	57.23
CLARK COUNTY, WASHINGTON						
202	10-12	2.57	4.12	6.62	9.50	13.09
204	5B	0.30	0.37	0.61	0.72	0.91
205	7-9	1.21	1.80	2.48	3.14	4.00
206	6	0.48	0.58	0.71	1.14	1.44
208	3	0.23	0.36	0.43	0.48	0.62
209	2	0.26	0.30	0.33	0.38	0.49
210	1	0.19	0.25	0.33	0.38	0.49
211	5A	0.15	0.17	0.18	0.29	0.37
212	4	0.72	0.90	1.11	1.19	1.50
231	13-31	6.21	7.81	11.20	15.48	19.95
	County Total	13.47	18.01	25.58	34.99	46.14

		AVERAGE ANNUAL USE (MGD)				
WATER-USE AREA	CENSUS TRACTS	1960	1970	1980	1990	2000
MULTNOMAH COUNTY, OREGON						
308	71	0.21	0.28	0.39	0.59	0.65
314	105	0.24	0.32	0.43	0.48	0.59
331	1-42,44 72-78 86-88	47.65	51.10	54.89	59.15	60.13
332	43, 45-70	11.42	13.25	15.95	18.11	20.81
333	79-85, 89-104	12.86	16.85	23.41	29.25	38.46
	County Total	72.38	81.80	95.07	107.58	120.64
WASHINGTON COUNTY, OREGON						
410	21-22	0.47	0.59	0.82	0.99	1.49
411	23,30	0.47	0.56	0.68	0.96	1.32
412	24-26	1.70	2.01	2.37	3.60	4.65
413	27-28	0.36	0.50	0.62	0.82	1.63
414	29	0.28	0.35	0.44	0.60	0.91
415	31-33	1.14	1.31	1.49	1.77	2.48
416	34-35	0.26	0.30	0.35	0.47	0.61
417	36	0.15	0.17	0.20	0.26	0.34
431	1-6, 9-14	4.83	6.88	10.19	15.47	18.96
432	7-8, 19-20	0.94	1.82	3.55	4.68	7.33
433	15-18	1.47	2.72	5.07	9.70	15.41
	County Total	12.07	17.21	25.78	39.32	55.13
CRAG study area Total		112.49	137.14	175.38	222.59	279.14

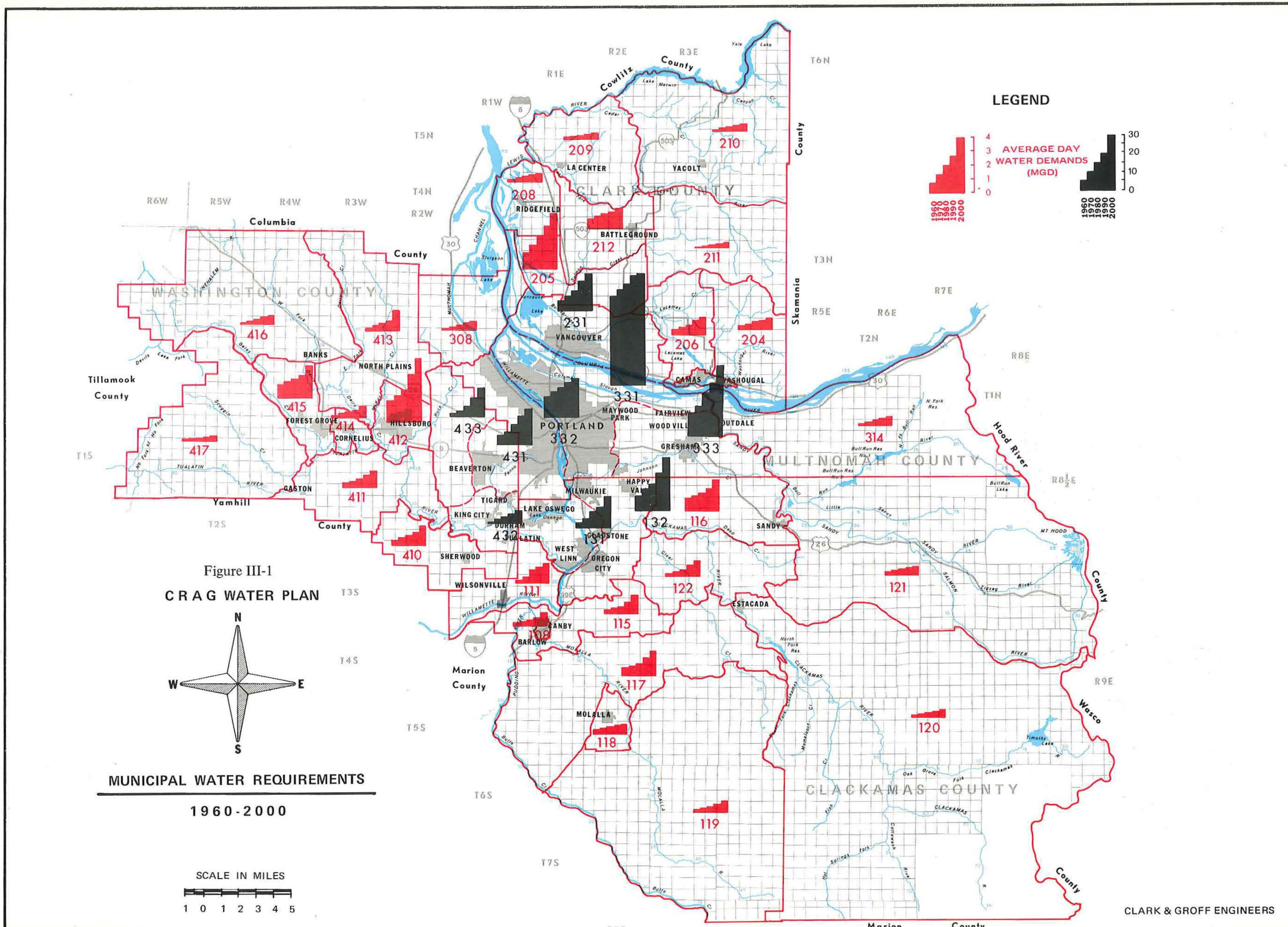


Figure III-1

CRAG WATER PLAN

MUNICIPAL WATER REQUIREMENTS

1960-2000

TABLE III-9

AGRICULTURAL WATER REQUIREMENTS

County	State	Agriculture Acreage (1964)	Water Requirements (acre-feet) 1970	1980	1990	2000
Clark	Wash.	180,000	270,000	256,500	243,675	231,490
Clackamas	Ore.	262,000	393,000	273,350	354,680	336,945
Multnomah	Ore.	67,000	100,500	95,475	90,700	86,165
Washington	Ore.	200,000	300,000	285,000	270,750	257,210
TOTAL		709,000	1,063,500	1,010,325	959,805	911,810

TABLE III-10

CRAG STUDY AREA PROJECTED WATER REQUIREMENTS

Average Annual Daily Requirements

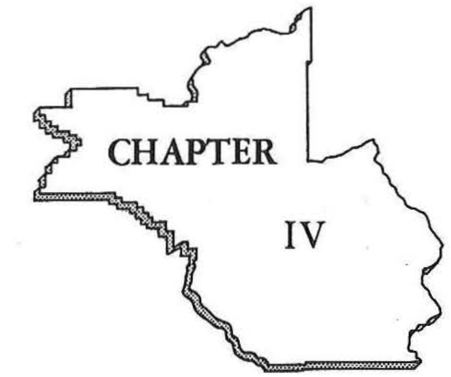
(MGD)

	1970	1980	1990	2000
Municipal	136	174	221	276
Industry Operating on Private Systems	230	265	344	423
Agriculture[1]	2,310	2,200	2,080	1,980

[1]Based upon an irrigating season of 150 days during the months of May through September.

WATER RESOURCES

SUMMARY



GENERAL

In the CRAG study area there is sufficient surface and groundwater to satisfy present and future water requirements to the year 2000 for municipal, industrial, agricultural and recreational purposes. In some areas, primarily in the Tualatin Valley, there are seasonal water shortages which occur during the summer months. The major problems in meeting the future water needs in the CRAG study area lie in the efficient use of the available water resources.

SURFACE WATER RESOURCES

Surface water resources of the CRAG study area are shown in Figure IV-1 and summarized in Table IV-24.

The major rivers in the area, and the primary potential sources of surface water, are the Columbia, Willamette, Lewis and Clackamas. The Columbia, Willamette and Lewis Rivers could each supply the projected municipal water requirements to the year 2000 of the entire CRAG study area on an average annual use basis. The characteristics of each of these streams and other significant streams in the area were examined in detail including such factors as streamflow characteristics, water quality, water rights and legal limitations on the use of water.

In general, the water quality in the area is good to excellent and with proper treatment the surface waters are satisfactory for municipal and industrial use. In a few cases, differences in water hardness were enough to be noticeable, though in no case was water hardness really objectionable. There are no basic chemical problems with any of the surface water in the area.

Several paper mills located on the Columbia and Willamette Rivers discharge wastes which cause the growth of a slime bacteria (spaerotilus). This growth forms "rafts" which tend to clog fish nets and create nuisance problems. Consideration should be given to this problem when locating intake structures on these rivers.

Water from the Columbia River below Bonneville Dam can be used as a supply of drinking water with no significant risk insofar as radioactive contamination is concerned. This subject is thoroughly explored in a special report appearing as Chapter IX of this report.

GROUND WATER

The availability of ground water varies widely throughout the CRAG study area. The high yield areas are along the Columbia River and lower Willamette River and in western Clark County. In other parts of the CRAG study area, ground water is available in limited quantities. Ground water resources of the CRAG study area are shown in Figure IV-12 and summarized in Table IV-27.

The City of Vancouver relies exclusively on the extensive, high quality ground water resource of western Clark County and intends to develop wells as future needs arise. The ground water supply in this area is estimated to have the capability of producing up to 500 MGD on a sustained basis.

The quality of ground water in the CRAG study area is generally quite good with the water being acceptable for municipal, industrial and agricultural purposes. There are some exceptions however where particularly hardness and iron have been a problem.

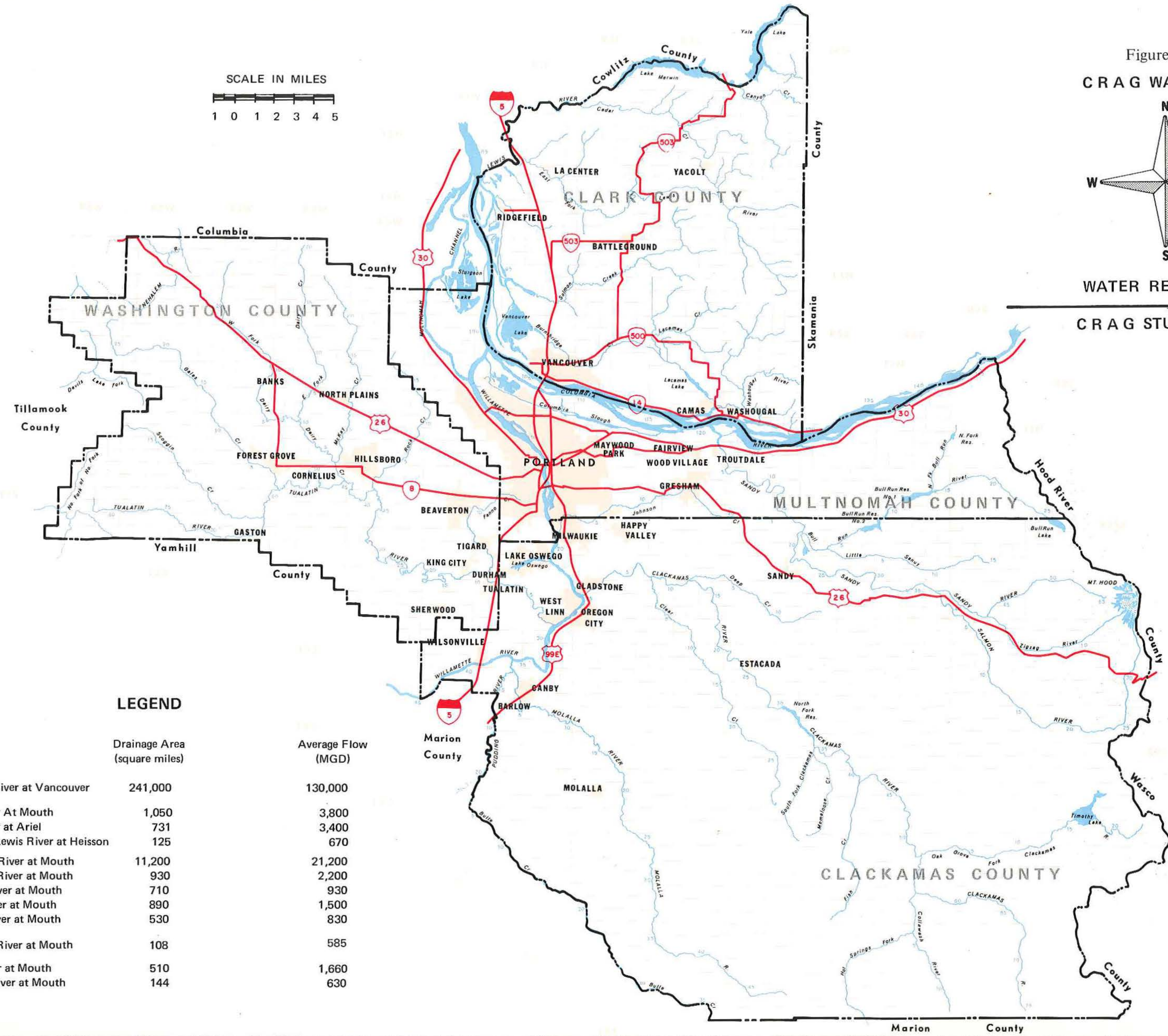
Industries are by far the largest users of ground water in the CRAG study area, using approximately 130 million gallons in an average day. The largest industrial ground water users are the paper mills and aluminum plants along the Columbia River.

Figure IV-1

CRAG WATER PLAN

WATER RESOURCES

CRAG STUDY AREA



LEGEND

Stream	Drainage Area (square miles)	Average Flow (MGD)
Columbia River at Vancouver	241,000	130,000
Lewis River At Mouth	1,050	3,800
Lewis River at Ariel	731	3,400
East Fork Lewis River at Heisson	125	670
Willamette River at Mouth	11,200	21,200
Clackamas River at Mouth	930	2,200
Tualatin River at Mouth	710	930
Molalla River at Mouth	890	1,500
Pudding River at Mouth	530	830
Washougal River at Mouth	108	585
Sandy River at Mouth	510	1,660
Bull Run River at Mouth	144	630

CLARK & GROFF ENGINEERS

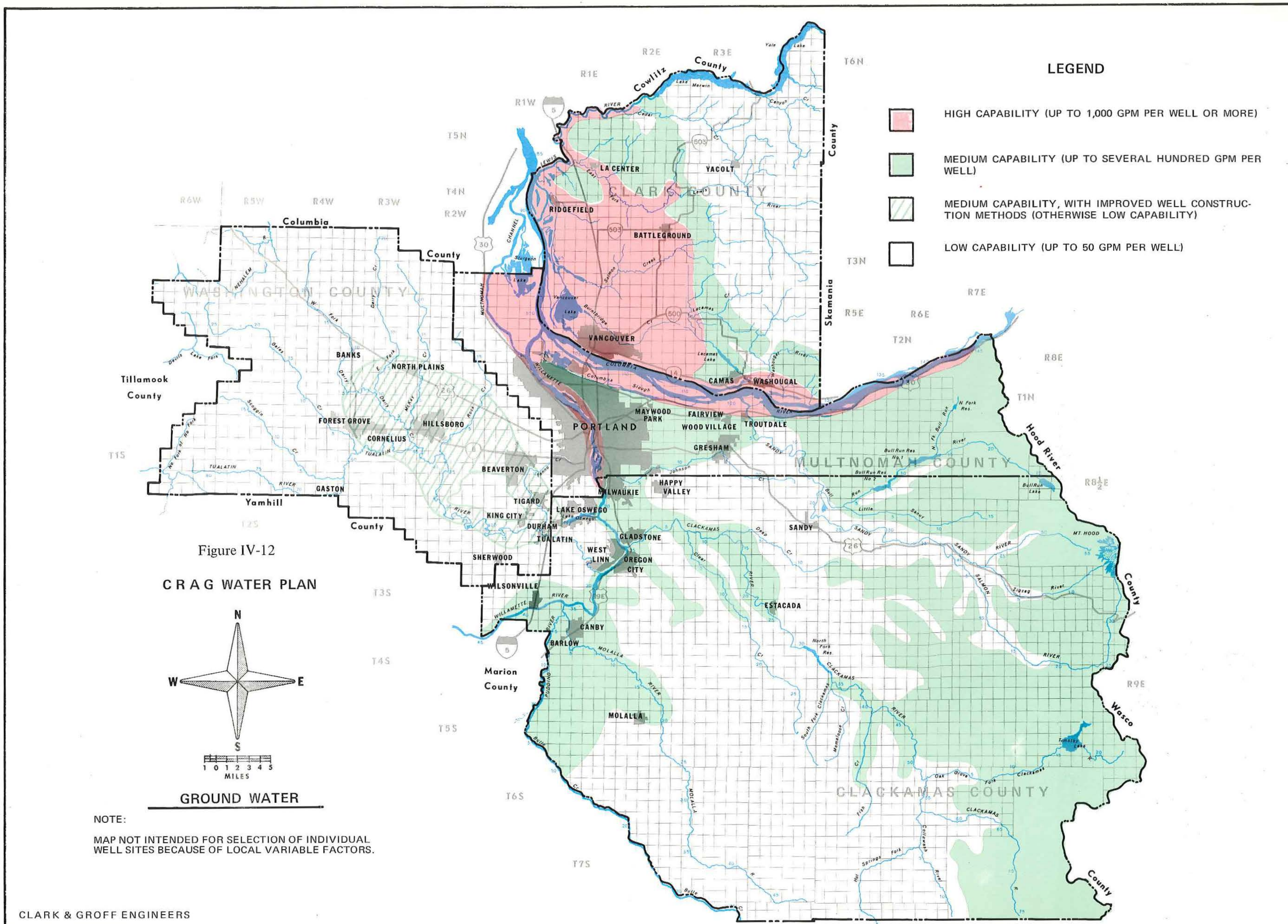


Figure IV-12

CRAG WATER PLAN

GROUND WATER

NOTE:

MAP NOT INTENDED FOR SELECTION OF INDIVIDUAL WELL SITES BECAUSE OF LOCAL VARIABLE FACTORS.

CLARK & GROFF ENGINEERS

TABLE IV-24

SURFACE WATER RESOURCES OF THE CRAG STUDY AREA

SOURCE	MINIMUM FLOW (Existing Conditions) MGD	WATER QUALITY	TREATMENT REQUIRED	WATER RIGHTS	COMMENTS
Columbia River at Vancouver, Washington	63,000 - Average Minimum Month (October).	Fairly high quality suitable for municipal, industrial and agricultural uses.	Coagulation, Filtration and Disinfection.	No interstate compact. Minimum flow in excess of water rights.	Sufficient quantity to meet CRAG Study Area needs to year 2000.
Sandy River Near Mouth	208 - Average Minimum Month (August).	Excellent quality suitable for municipal, industrial and agricultural uses. Seasonal turbidity.	Coagulation, Filtration and Disinfection.	Limitations on appropriation or diversion (ORS 538.251), domestic and municipal use excepted.	Diversion for regional needs would conflict with fish requirements.
Bull Run River Near Bull Run	41 - Average Minimum Month (August).	Excellent quality suitable for municipal, industrial and agricultural uses.	Disinfection.	Exclusive right granted to Portland (ORS 538.420).	Streamflow and existing storage is not adequate to supply total needs of CRAG Study Area to year 2000.
Lewis River At Ariel, Washington	450 - Averave Minimum Month (October). Streamflow is regulated by upstream reservoirs.	Excellent quality suitable for municipal, industrial and agricultural uses.	Coagulation, Filtration and Disinfection.	A few minor rights below Ariel. Major rights at three dams for power generating purposes.	Sufficient quantity between mouth and Ariel to supply Clark County municipal and industrial needs to year 2000. Diversion from reservoirs above Ariel would require compensation to power company.
East Fork of Lewis River Near Heisson	19 - Instantaneous Minimum.	Excellent quality suitable for municipal, industrial and agricultural uses.	Coagulation, Filtration and Disinfection	Stored water would be used—water rights not effected.	Storage will be required.
Willamette River at Wilsonville, Oregon	2,851 Average Minimum Month (September).	Fairly high quality suitable for municipal, industrial and agricultural uses. Possible taste and odor problems.	Coagulation, Filtration and Disinfection. Taste and odor control.	Water rights at Willamette Falls not adjudicated (19,500 MGD). Diversion above falls may conflict with present industrial use at the falls.	Purchase of storage space from Corps of Engineers in upstream reservoirs may provide firm water for diversion above Willamette Falls.
Willamette River below Willamette Falls	In excess of the 2,851 MGD as indicated above.	Suitable for municipal, industrial and agricultural uses. Possible taste and odor problems	Coagulation, Filtration and Disinfection. Taste and odor control.	A few minor water rights.	Sufficient quantity of water to meet CRAG study area needs to year 2000.

(CONTINUED)

TABLE IV-24 (Cont.)

SURFACE WATER RESOURCES OF THE CRAG STUDY AREA

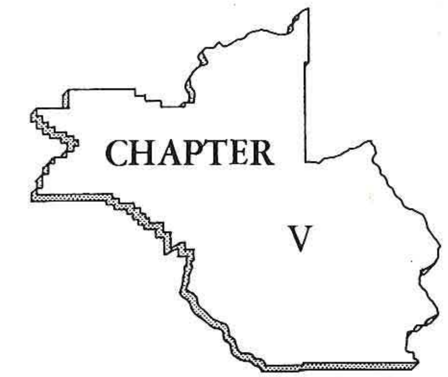
SOURCE	MINIMUM FLOW (Existing Conditions) MGD	WATER QUALITY	TREATMENT REQUIRED	WATER RIGHTS	COMMENTS
Clackamas River at Estacada, Oregon	432 Average Minimum Month (September). 149 Instantaneous Minimum (1967) Streamflow regulated by upstream reservoirs	Excellent quality suitable for municipal, industrial and agricultural uses. Seasonal turbidity.	Coagulation, Filtration and Disinfection.	Downstream water rights which are primarily non-consumptive exceed 3,500 MGD. Water rights have not been adjudicated.	Storage or purchase of stored water from power company would be required.
Clackamas River Near Barton,Oregon	538 Average Minimum Month (September). Streamflow regulated by upstream reservoirs.	Excellent quality suitable for municipal, industrial and agricultural uses. Seasonal turbidity.	Coagulation, Filtration and Disinfection.	Downstream water rights are about 90 MGD and are for consumptive uses. Water rights have not been adjudicated.	Sufficient quantity of water to serve the needs of a portion of CRAG study area to year 2000. Low flows could possibly be augmented by purchase of water from upstream storage. Water rights should be adjudicated.
Clackamas River Near Mouth	548 Average Minimum Month (September). 220 Instantaneous minimum (1967). Streamflow regulated by upstream reservoirs.	Excellent quality suitable for municipal, industrial and agricultural uses. Seasonal turbidity.	Coagulation, Filtration and Disinfection.	Water rights near the mouth are about 90 MGD and are for consumptive purposes. Water rights have not been adjudicated.	Sufficient quantity of water to serve the needs of a portion of CRAG study area to year 2000. Low flows could possibly be augmented by purchase of water from upstream storage. Water rights should be adjudicated.
Molalla River Near Canby, Oregon	27 - Average Minimum Month (August). 19 - instantaneous minimum (1967).	Excellent for municipal, industrial and agricultural uses. Seasonal turbidity.	Coagulation, Filtration and Disinfection.	Consumptive rights are about 5 MGD near Canby.	Adequate water available to serve needs of Canby area to year 2000. Insufficient water to serve a regional plan without storage.
Tualatin River at West Linn, Oregon	1 - Average Minimum Month (August)	Very poor quality during low flow periods.	Coagulation, Filtration and Disinfection	Entire stream heavily over-appropriated. One non-consumptive right upstream from West Linn for 37.2 MGD which allows diversion from Tualatin into Lake Oswego. Water rights have been adjudicated.	Insufficient water available to serve a regional plan without upstream storage.
Trask River, Middle Fork of North Fork (Diversion of stored water to headwaters of Tualatin River and Hillsboro's intake).	18-Ultimate development.	Excellent for municipal, industrial and agricultural uses.	Disinfection	Stored water to be used, downstream water rights on Trask River not effected.	Plans are now progressing for storage of 1,300 MG for use in 1970. Project can be expanded to ultimately store 6,500 MG.
Wilson River, Devils Lake Fork (Diversion of stored water to headwaters of Clear Creek and Forest Grove's Intake).	No available	Excellent for municipal, industrial and agricultural uses.	Disinfection	Stored water to be used, downstream water rights on Wilson River not effected.	Preliminary plans call for storage of 600 MG. Project can be expanded to ultimately store 3,300 MG.

TABLE IV-27

GROUND WATER RESOURCES OF THE CRAG STUDY AREA
(See Figure IV-12)

SOURCE	SPECIFIC CAPACITIES OF EXISTING WELLS GPM/FT. DRAWDOWN	WATER QUALITY	TREATMENT REQUIRED	WATER RIGHTS	COMMENTS
Vancouver, Washington Lowland Area	200-500 is common. Maximum may exceed 1,000.	Excellent for municipal, industrial and agricultural uses.	Disinfection	Application must be made to appropriate state agency for permit to obtain ground waters.	This area can possibly be developed for an additional 500 MGD.
Camas - Washougal, Washington Area	200-500 is common. Maximum may exceed 1,000.	Excellent for municipal, industrial and agricultural uses.	Disinfection	Application must be made to appropriate state agency for permit to obtain ground waters.	This area can possibly be developed for an additional 250 MGD.
Troutdale - Sauvies Island, Oregon Area	200-500 is common. Maximum may exceed 1,000.	Excellent for municipal, industrial and agricultural uses. Hardness possibly a problem.	Disinfection and possible softening.	Application must be made to appropriate state agency for permit to obtain ground waters	This area can possibly be developed for an additional 50 MGD.
Tualatin Valley, Oregon		Variable - Problems have been encountered regarding salinity, hardness, iron and hydrogen sulfide. Many wells producing high quality water suitable for municipal, industrial and agricultural uses.	Disinfection, possible softening and iron removal.	Application must be made to appropriate state agency for permit to obtain ground waters.	It is doubtful that ground-water resources in this area could be developed to adequately serve the municipal needs of the area to year 2000.
Milwaukie, Oregon Area		Satisfactory for municipal, industrial and agricultural uses. Iron content found to be as high as 0.7 ppm in some well water.	Disinfection and possible iron removal.	Application must be made to appropriate state agency for permit to obtain ground waters.	Ground water is an acceptable local alternate but doubtful that it could be developed to serve municipal needs of the area to year 2000.
Canby, Oregon Area		Satisfactory for municipal, industrial and agricultural uses.	Disinfection	Application must be made to appropriate state agency for permit to obtain ground waters.	Ground water is an acceptable local alternate but doubtful that it could be developed to serve municipal needs of the area to year 2000.

EXISTING MUNICIPAL WATER FACILITIES



SUMMARY

At the present time the five primary sources of water in the CRAG study area are the ground water of Clark County and the watersheds of the Bull Run, Clackamas, Molalla and Tualatin Rivers. Figure V-1 shows the location of municipal water distribution systems as distinguished by their source of water.

The region within the boundaries of Clark County, Washington contains the ten water service areas listed in Table V-1 and shown in Figures V-2 and V-3. All but one of the systems is entirely or partially dependent on ground water as their source of supply.

The largest water system in the CRAG study area is the Bull Run system. The source of supply, transmission facilities and distribution facilities within the City of Portland are owned and operated by the City of Portland. Portland sells about one-third of the total water distributed outside the corporate limits as shown in Table V-2. The transmission conduits are shown on Figure V-4 and the primary distribution facilities are shown on Figures V-5, V-6, and V-7.

The principal source of water for the majority of the people in the Clackamas region, which is Clackamas County exclusive of the Molalla River drainage, is the Clackamas River. Figures V-8 and V-9 show the location of intakes and transmission lines on the upper and lower Clackamas River. Figure V-10 and V-11 show the location of primary water distribution facilities and service areas and Tables V-3 and V-4 provide a listing of 47 water distribution systems in the Clackamas region.

The lower Molalla River watershed is the principal water source for the cities of Molalla and Canby which are the principal cities in this region. Table V-5 lists the water distribution systems in the region and Figure V-12 shows the Canby and Molalla water systems.

The Tualatin region embraces those water systems located in Washington County. The Tualatin River watershed is the major source of water for the western part of the region with Bull Run being the principal supply for the eastern part. Table V-6 lists the water distribution systems in this region and Figures V-13, V-14, and V-15 show the service areas, transmission facilities and primary distribution facilities of the Tualatin region.

Many communitites in the CRAG study area have recently made studies of their future water supply needs and means of fulfilling these needs. These plans were of invaluable assistance in making this regional plan and were given serious consideration when exploring the possible advantages of regional water systems. Table V-7 summarizes the significant features of these plans that are relevant in their relationship to regional water planning.

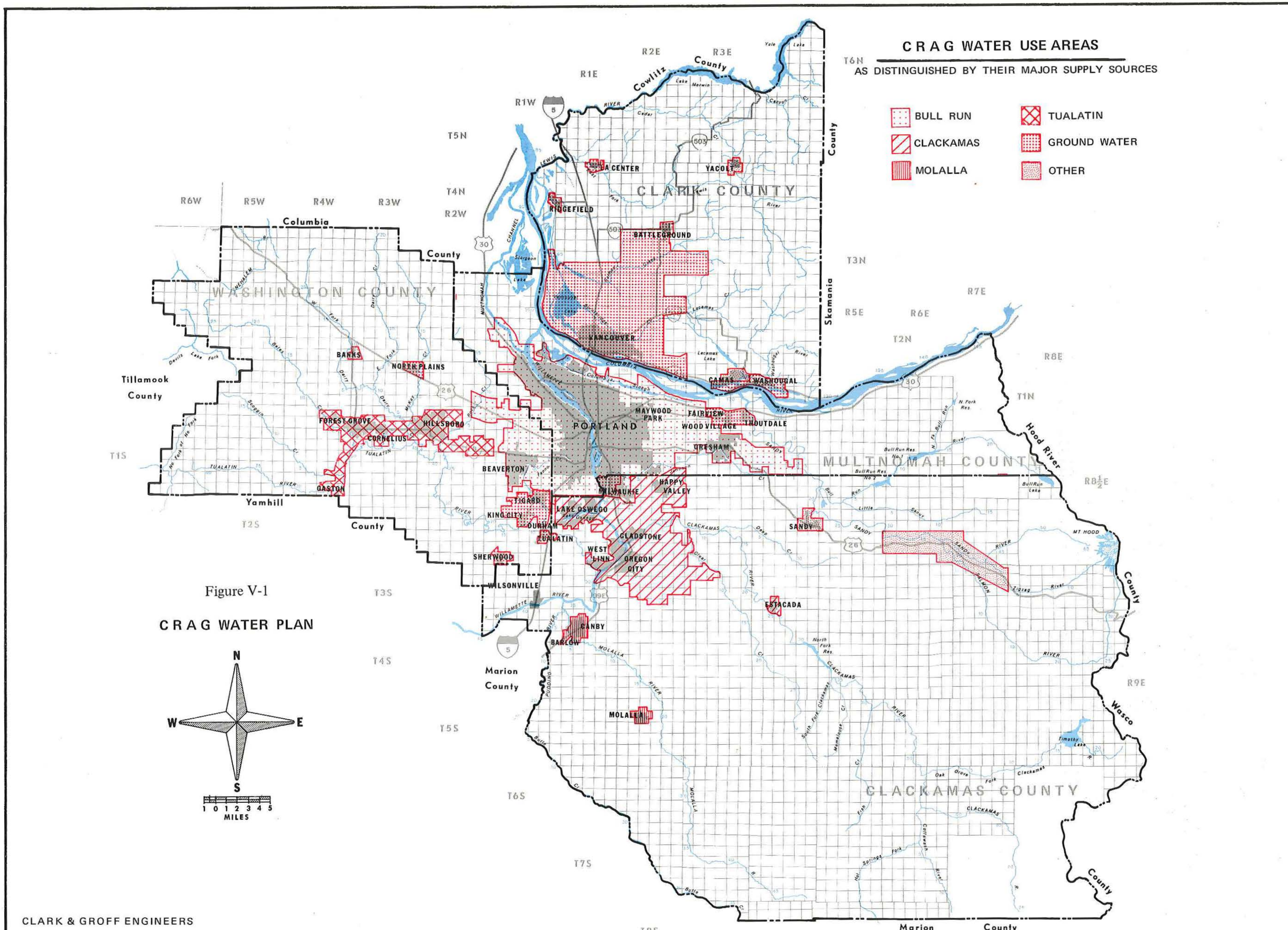


Figure V-1

CRAG WATER PLAN

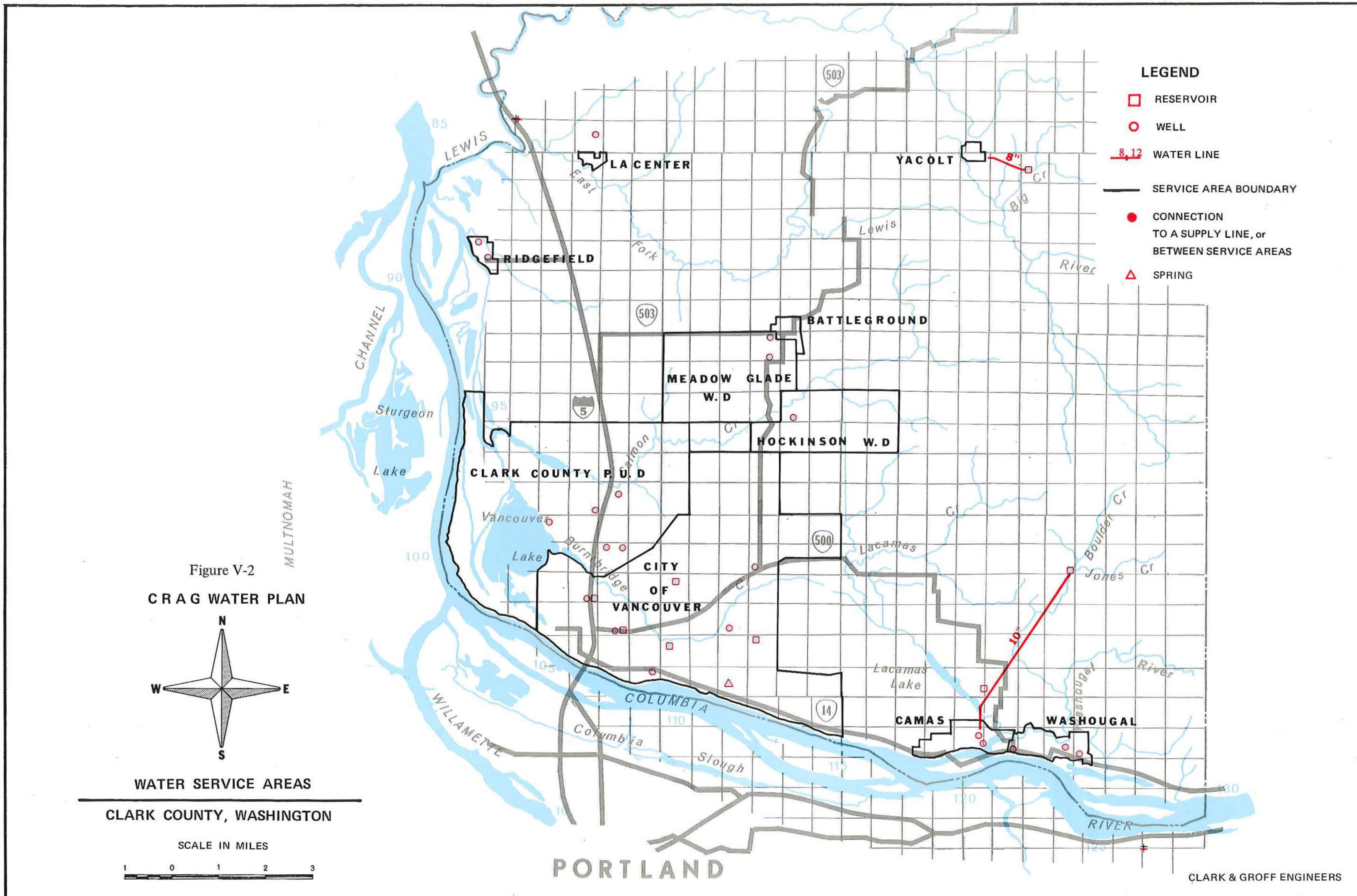


Figure V-2

CRAG WATER PLAN

WATER SERVICE AREAS

CLARK COUNTY, WASHINGTON

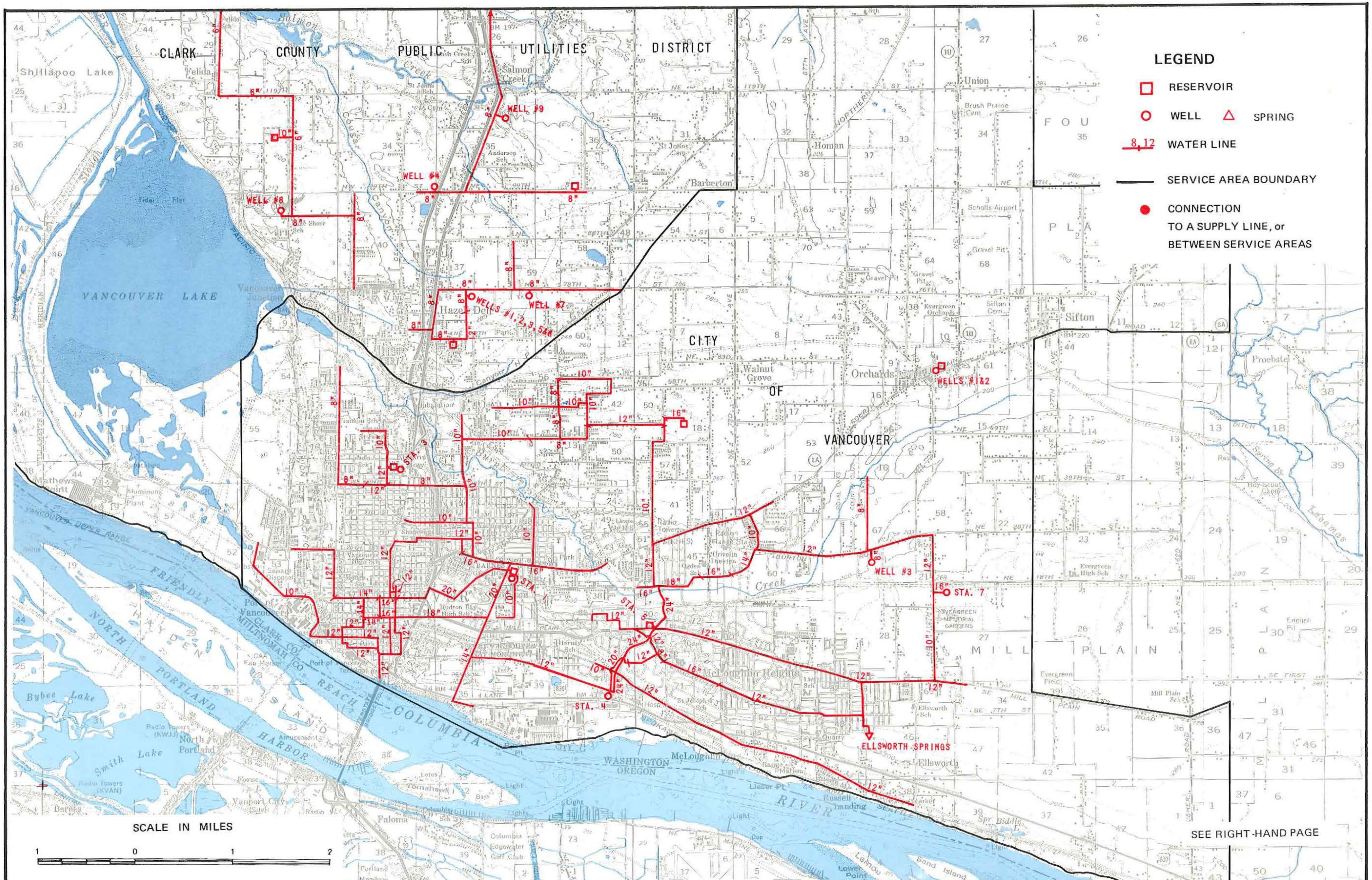
SCALE IN MILES

TABLE V-1

CLARK COUNTY, WASHINGTON

WATER DISTRIBUTION SYSTEMS

Name of System	No. of Services	Source	Major Storage (MG)
Battle Ground	415	Wells (2)	
Camas	2,000	Boulder & Jones Creeks, Wells (2)	1.2
Clark County PUD	3,660	Wells (9)	
Hockinson Water Association	80	Well	
La Center	115	Wells (2)	
Meadow Glade Water Association	150	Well	
Ridgefield	360	Wells (3)	
Vancouver	20,500	Ellsworth Springs, Wells (17)	18
Washougal	1,800	Wells (8)	
Yacolt	200	Big Creek	58



CLARK COUNTY PUBLIC UTILITIES DISTRICT
CITY OF VANCOUVER
FOURTH PLAIN
MILL PLAIN
LEGEND
RESERVOIR
WELL
SPRING
WATER LINE
SERVICE AREA BOUNDARY
CONNECTION TO A SUPPLY LINE, or BETWEEN SERVICE AREAS
WELL #9
WELL #4
WELL #8
WELL #7
WELLS #1, 2, 3, 5 & 6
WELLS #1 & 2
WELL #3
STA. 3
STA. 1
STA. 4
STA. 5
STA. 7
ELLSWORTH SPRINGS
VANCOUVER LAKE
COLUMBIA RIVER
SCALE IN MILES
1 0 1 2
SEE RIGHT-HAND PAGE

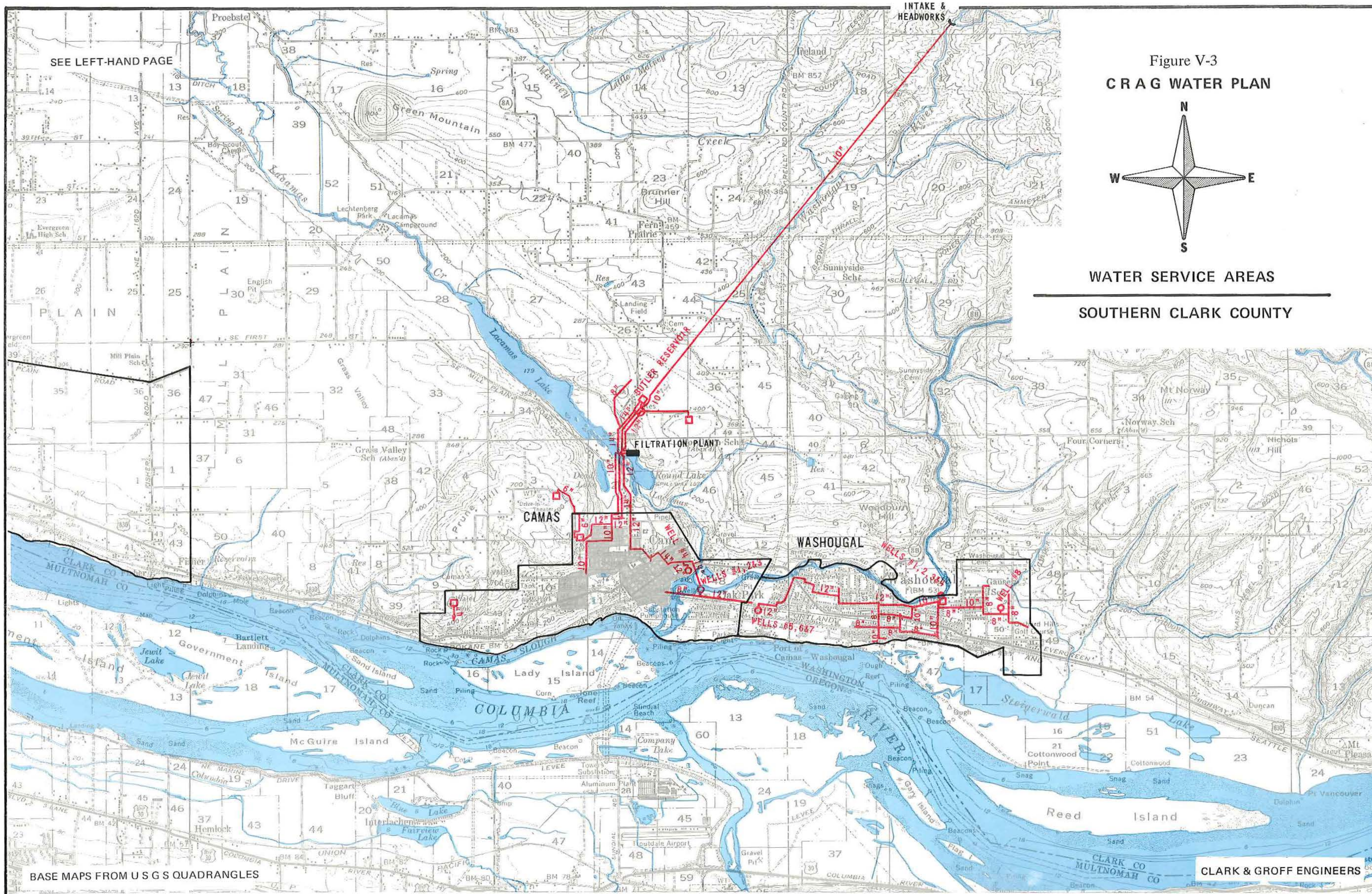


Figure V-3
CRAG WATER PLAN
N
S
E
W
WATER SERVICE AREAS
SOUTHERN CLARK COUNTY
SEE LEFT-HAND PAGE
INTAKE & HEADWORKS
FILTRATION PLANT
BUTLER RESERVOIR
CAMAS
WASHOUGAL
WELLS #1, 2 & 3
WELLS #5, 6 & 7
COLUMBIA
RIVER
Lady Island
McGuire Island
Reed Island
Government Island
Green Mountain
Lacamas Lake
Round Lake
Prune Hill
Woodburn Hill
Mt Norway
CLARK CO
MULTNOMAH CO
WASHINGTON
OREGON
BASE MAPS FROM U S G S QUADRANGLES
CLARK & GROFF ENGINEERS

TABLE V-2

WATER SYSTEMS IN THE

BULL RUN WATER USE AREA*

Name of System	No. Of Services	Source	Major Storage MG	County
Alto Park Water District	230	Well	–	Multnomah
Baseline Water District	1,350	Bull Run	–	
Beaverton	4,000	Bull Run	1.5	Washington
Bedford Pk. Mutual Water Co.	32	Bull Run	–	Multnomah
Burlington Water District	140	Bull Run	–	Multnomah
Capitol Hwy. Water District	1,740	Bull Run	–	Multnomah
Columbia Mutual Water Co.	150	Well	–	Multnomah
Columbia Water Co.	9	Bull Run	–	Multnomah
Community Water Co.	650	Bull Run	–	Multnomah
Corbett Water District.	400	Gordon Creek	–	Multnomah
Darlington Water District	230	Bull Run	–	Multnomah
East Seventy-Second St. Water Co.	13	Bull Run	–	Multnomah
Fairview	260	Wells (2)	–	Multnomah
Garden Home Water District	1,120	Bull Run	–	Washington
Gilbert Water District	1,650	Bull Run	2	Multnomah
Gresham Water District	2,210	Bull Run	3	Multnomah
Hazelwood Water District	3,040	Bull Run	–	Multnomah
Industrial Water Company	7	Bull Run	–	Multnomah
Lake Grove Water District	540	Bull Run-Via Palatine	–	Multnomah
		-Hill Water Dist.	1	Clackamas
Lorna Water Company	80	Bull Run	–	Multnomah
Lusted Water District	660	Bull Run	–	Multnomah
Menlo Park Water District	1,990	Bull Run	–	Multnomah
Metzger Water District	2,390	Bull Run	1.2	Washington
Mont Brae Mutual Water Co.	38	Bull Run	–	Multnomah
Naegeli Water Company	12	Bull Run	–	Multnomah
Palatine Hill Water District	1,260	Bull Run	–	Multnomah
Parkrose Water District	3,900	Bull Run & Wells (2)	1.5	Multnomah
Pleasant Home Water District	370	Bull Run	–	Multnomah
Portland	127,040	Bull Run	190.5 (Reservoirs)	Multnomah
			26.0 (Tanks) (within city)	Multnomah
Powell Valley Rd. Water District	7,700	Bull Run	6	Multnomah
Progress Water District	400	Bull Run-Via Metzger Water Dist.	–	Washington
Raleigh Water District	720	Bull Run	–	Washington
Richland Water District	670	Wells (3)	–	Multnomah
Riverton Water Company	220	Bull Run	–	Multnomah
Rockwood Water District	9,050	Bull Run	7.2	Multnomah
Rose City Water District	2,720	Bull Run	–	Multnomah
Russelville Water District	420 480	Wells (2)	–	Multnomah
Seventy-Fifth Avenue Water Dist.	23	Bull Run	–	Multnomah
Stanley Water District	570	Bull Run	–	Clackamas
Sylvan Water District	460	Bull Run	1	Multnomah
Troutdale	180	Springs	–	Multnomah
Tualatin Valley Water Co.	300	Bull Run	–	Washington
Valley View Water District.	220	Bull Run	–	Multnomah
Van Ness Water Company	340	Bull Run	–	Multnomah
West Slope Water District	2,810	Bull Run	4.5	Washington
Wichita Water District	1,070	Bull Run	–	Clackamas
Wolf Creek Highway Water Dist.	6,570	Bull Run	6	Washington
Wood Village	250	Well	–	Multnomah

* This table includes all systems using Bull Run water, some of which are also listed in Table V-3 or V-5

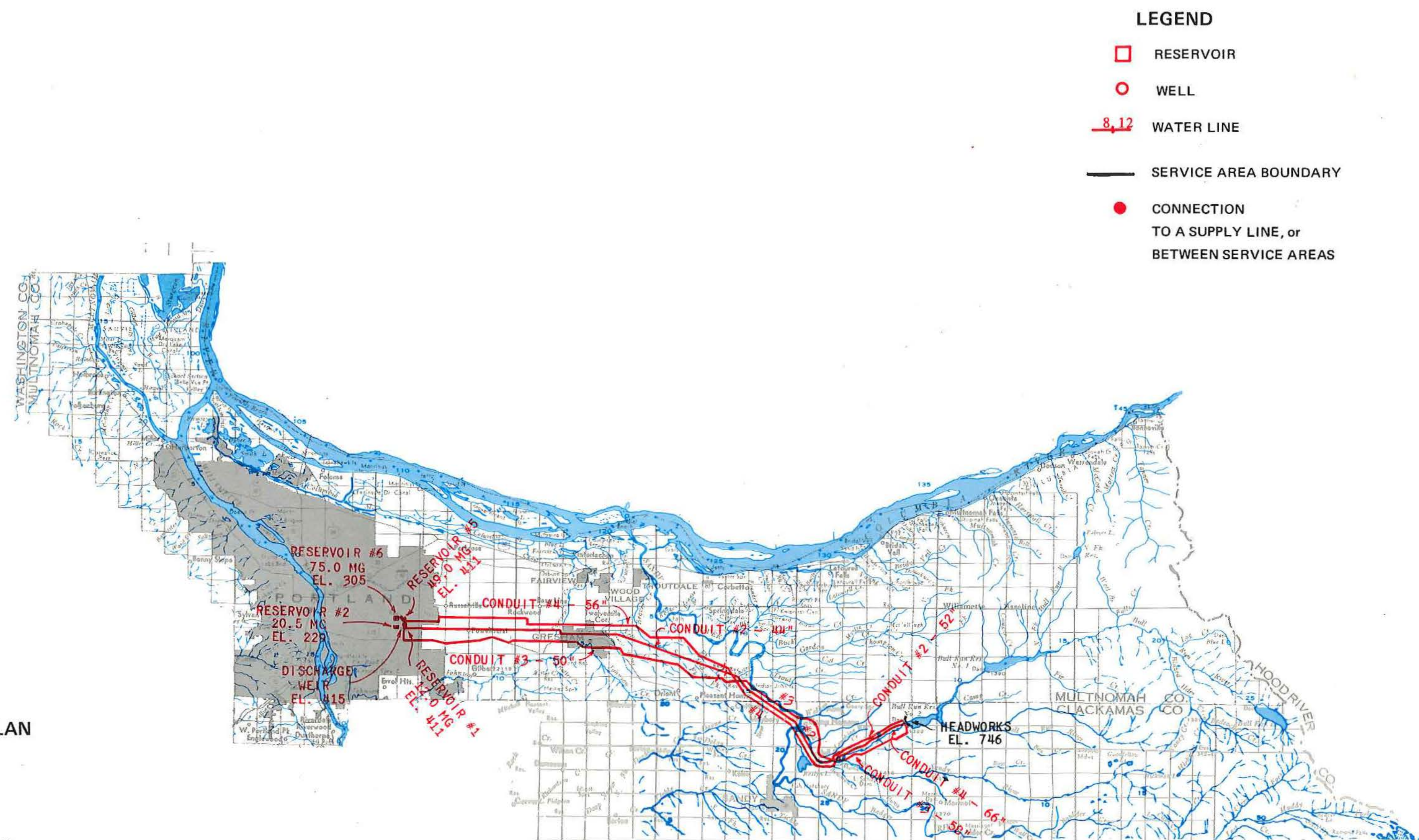


Figure V-4

C R A G WATER PLAN

N
W E
S

WATER TRANSMISSION

BULL RUN WATERSHED

SCALE IN MILES

1 0 1 2 3 4 5

BASE FROM OREGON WATER RESOURCE MAP

CLARK & GROFF ENGINEERS

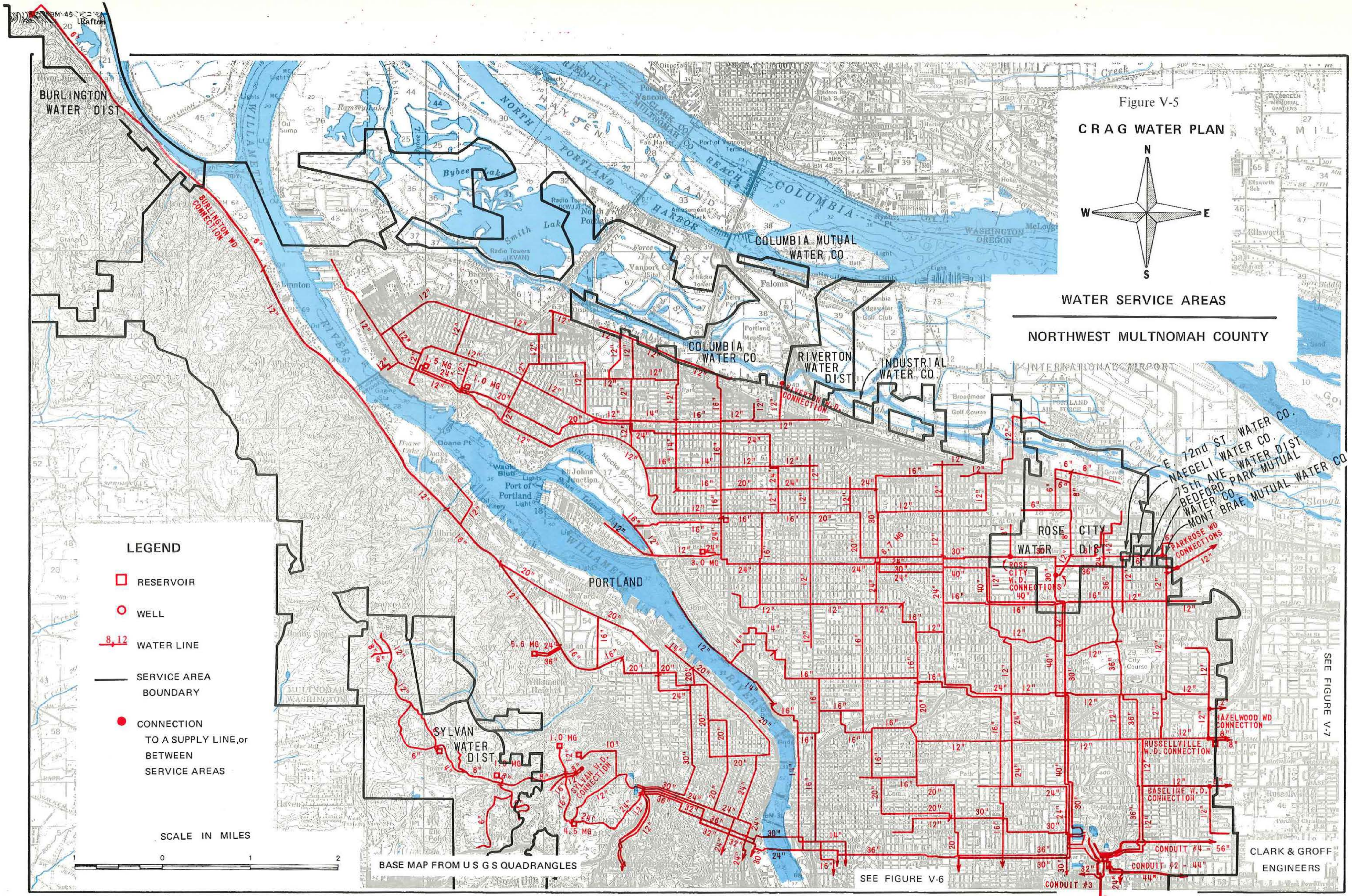


Figure V-5
CRAG WATER PLAN
N
W
E
S
WATER SERVICE AREAS
NORTHWEST MULTNOMAH COUNTY
BURLINGTON WATER DIST
BURLINGTON WD CONNECTION
COLUMBIA MUTUAL WATER CO.
COLUMBIA WATER CO
RIVERTON WATER DIST
INDUSTRIAL WATER CO.
RIVERTON W.D. CONNECTION
E. 72nd ST. WATER CO.
NAEGELI WATER CO.
75th AVE. WATER DIST
BEDFORD PARK MUTUAL WATER CO.
MONT BRAE MUTUAL WATER CO.
PARKROSE WD CONNECTIONS
ROSE CITY WATER DIST
ROSE CITY W.D. CONNECTIONS
PORTLAND
SYLVAN WATER DIST
SYLVAN W.D. CONNECTION
HAZELWOOD WD CONNECTION
RUSSELLVILLE W.D. CONNECTION
BASELINE W.D. CONNECTION
CONDUIT #4 - 56"
CONDUIT #2 - 44"
CONDUIT #3
SEE FIGURE V-7
SEE FIGURE V-6
COLUMBIA
WILLAMETTE RIVER
NORTH PORTLAND HARBOR
INTERNATIONAL AIRPORT
LEGEND
RESERVOIR
WELL
WATER LINE
SERVICE AREA BOUNDARY
CONNECTION TO A SUPPLY LINE, or BETWEEN SERVICE AREAS
SCALE IN MILES
1 0 1 2
BASE MAP FROM U S G S QUADRANGLES
CLARK & GROFF ENGINEERS

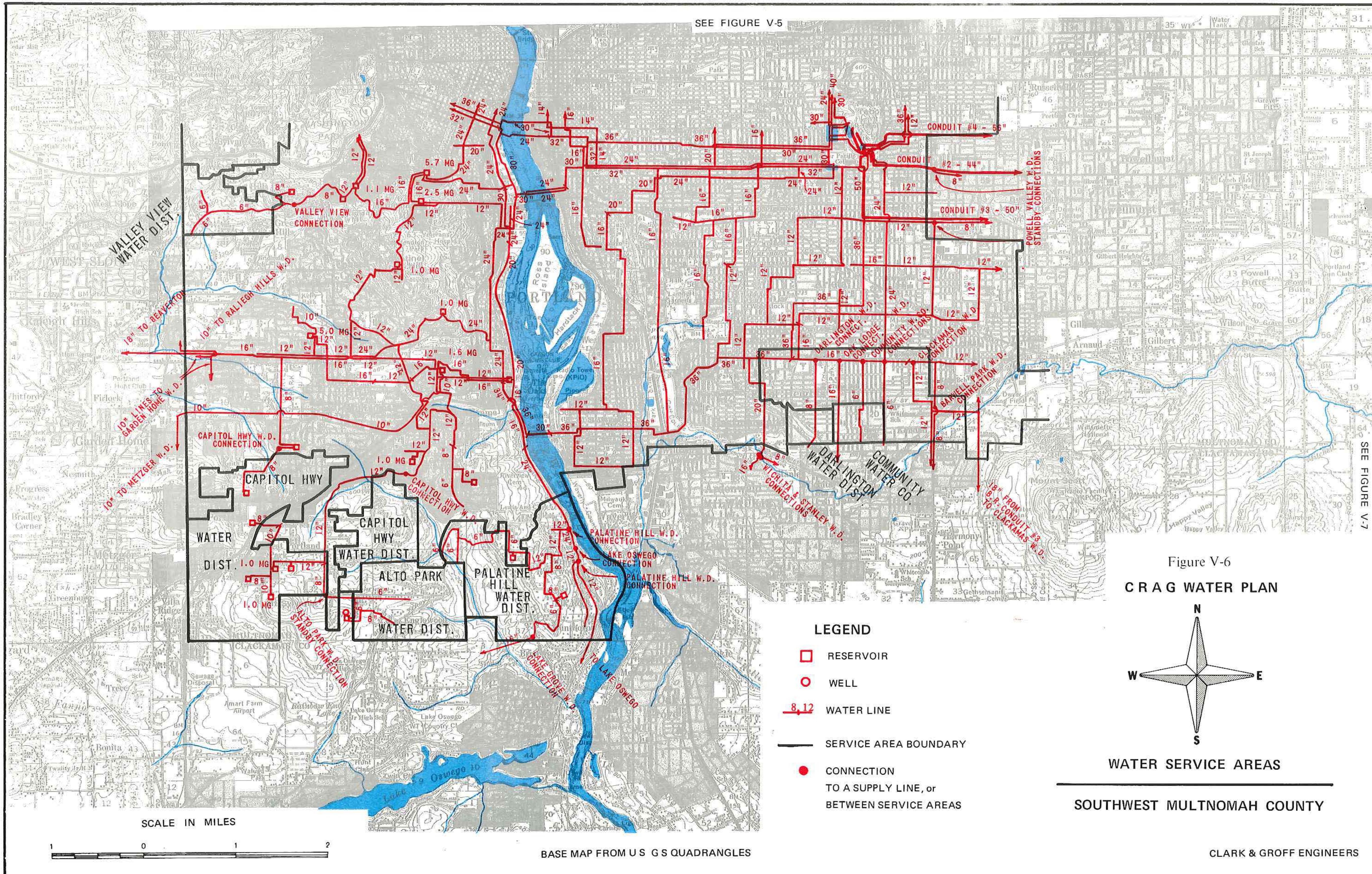


Figure V-6

CRAG WATER PLAN

WATER SERVICE AREAS

SOUTHWEST MULTNOMAH COUNTY

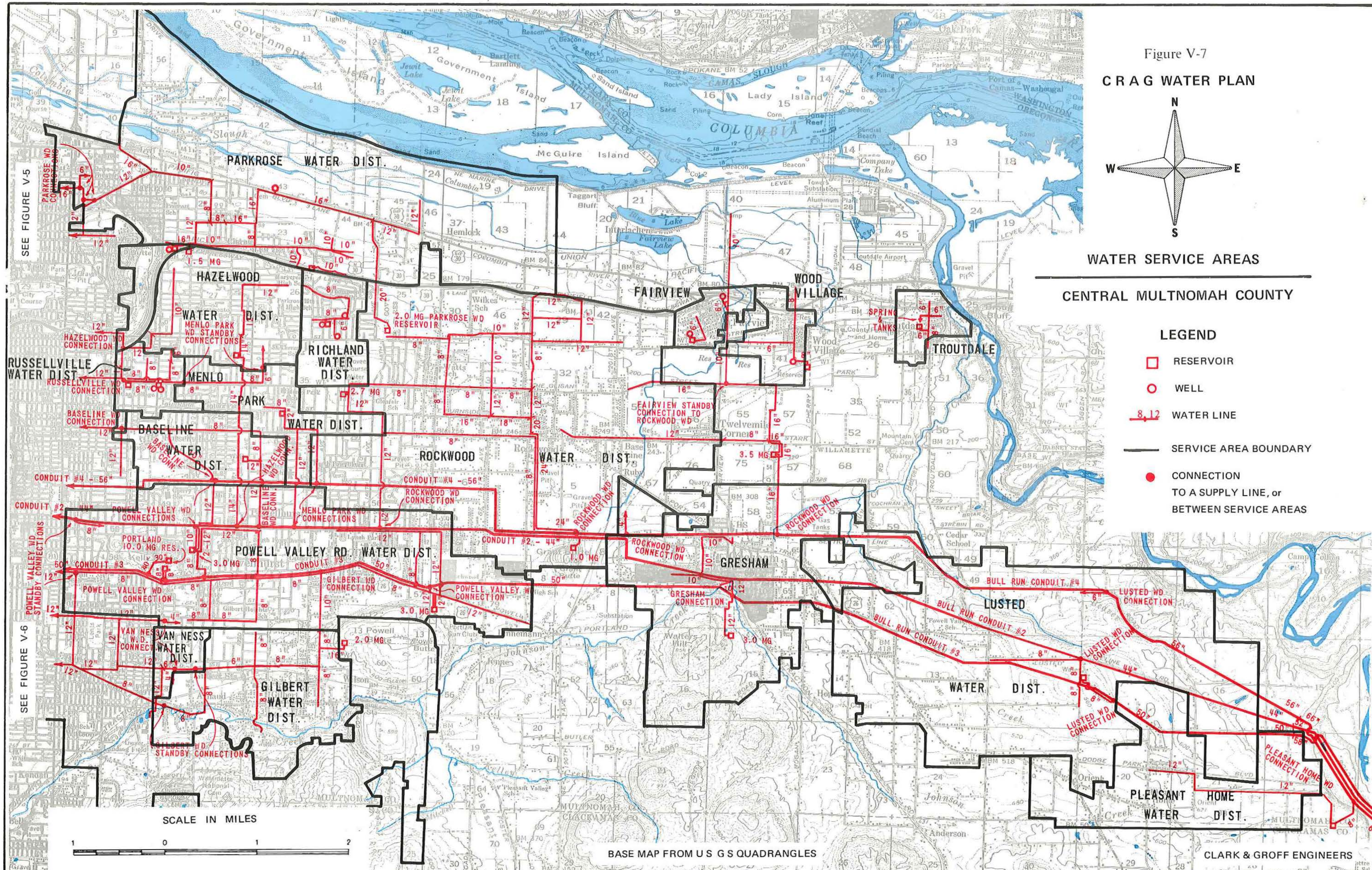


Figure V-7
C R A G WATER PLAN
N
S
E
W
WATER SERVICE AREAS
CENTRAL MULTNOMAH COUNTY
LEGEND
RESERVOIR
WELL
WATER LINE
SERVICE AREA BOUNDARY
CONNECTION TO A SUPPLY LINE, or BETWEEN SERVICE AREAS
PARKROSE WATER DIST.
HAZELWOOD WATER DIST.
RICHLAND WATER DIST.
RUSSELLVILLE WATER DIST.
MENLO PARK WATER DIST.
BASELINE WATER DIST.
ROCKWOOD WATER DIST.
FAIRVIEW
WOOD VILLAGE
TROUTDALE
POWELL VALLEY RD. WATER DIST.
VAN NESS WATER DIST.
GILBERT WATER DIST.
GRESHAM
LUSTED WATER DIST.
PLEASANT HOME WATER DIST.
BULL RUN CONDUIT #4
BULL RUN CONDUIT #2
BULL RUN CONDUIT #3
CONDUIT #4 - 56"
CONDUIT #2
CONDUIT #3
SEE FIGURE V-5
SEE FIGURE V-6
SCALE IN MILES
1 0 1 2
BASE MAP FROM U S G S QUADRANGLES
CLARK & GROFF ENGINEERS

LEGEND

- RESERVOIR
- WELL
- 8, 12 WATER LINE
- SERVICE AREA BOUNDARY
- CONNECTION TO A SUPPLY LINE, or BETWEEN SERVICE AREAS

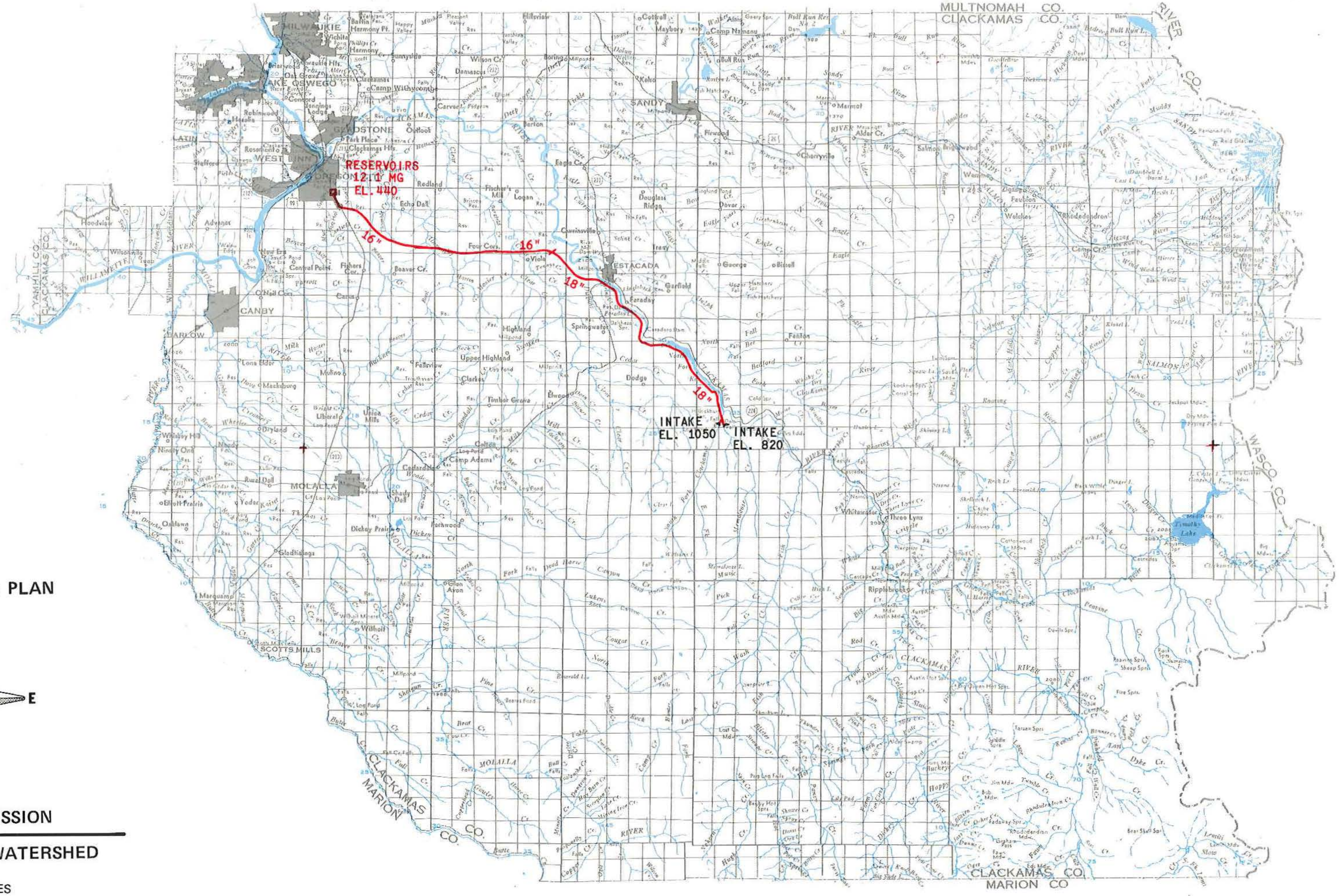


Figure V-8

CRAG WATER PLAN

N
W E
S

WATER TRANSMISSION

UPPER CLACKAMAS WATERSHED

SCALE IN MILES

1 0 1 2 3 4 5

BASE FROM OREGON WATER RESOURCE MAP

CLARK & GROFF ENGINEERS

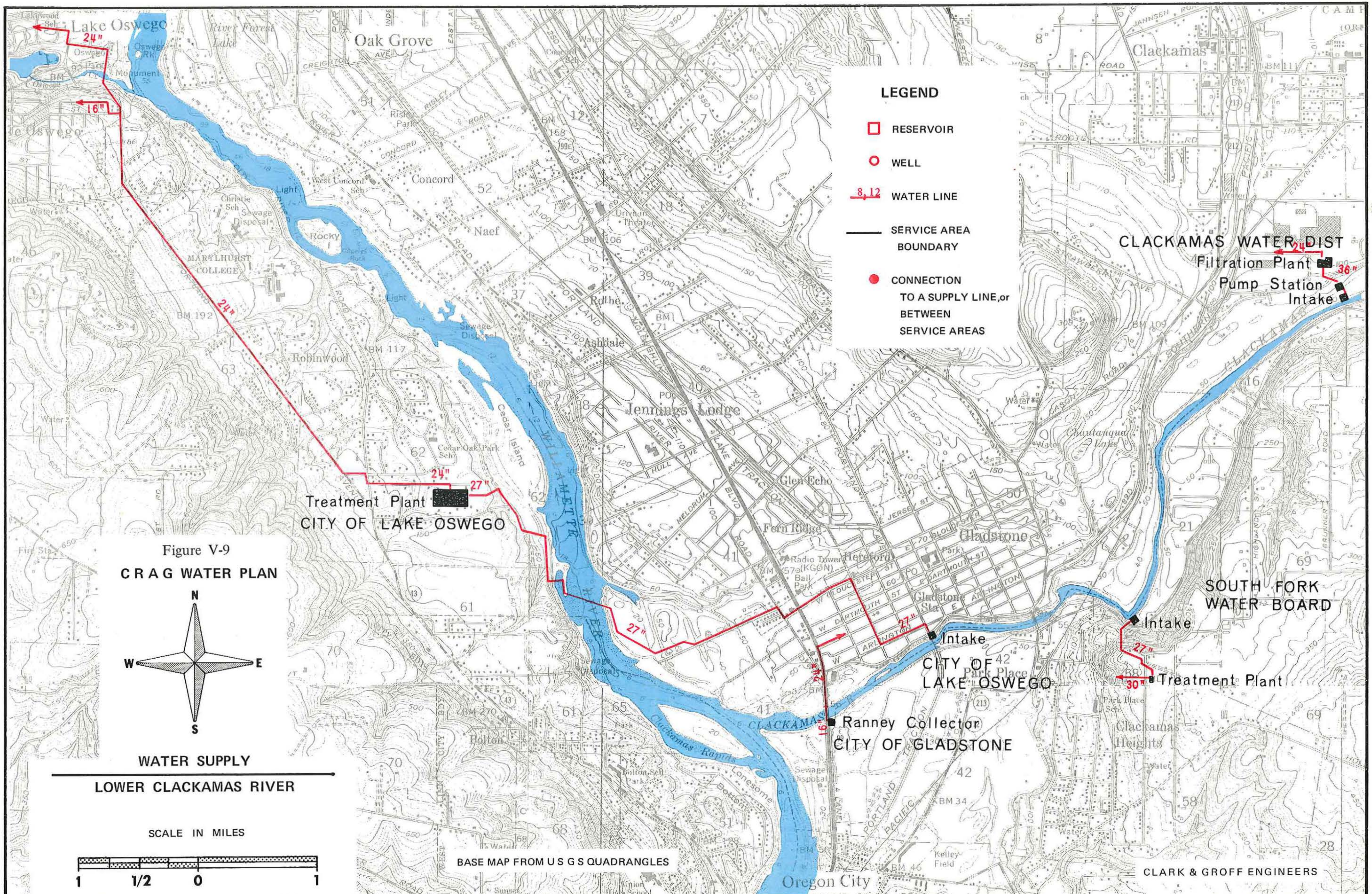

LEGEND
RESERVOIR
WELL
8, 12 WATER LINE
SERVICE AREA BOUNDARY
CONNECTION TO A SUPPLY LINE, or BETWEEN SERVICE AREAS
Figure V-9
CRAG WATER PLAN
N
S
E
W
WATER SUPPLY
LOWER CLACKAMAS RIVER
SCALE IN MILES
1
1/2
0
1
BASE MAP FROM U S G S QUADRANGLES
CLARK & GROFF ENGINEERS
Treatment Plant
CITY OF LAKE OSWEGO
CLACKAMAS WATER DIST
Filtration Plant
Pump Station
Intake
SOUTH FORK WATER BOARD
Intake
Treatment Plant
Intake
CITY OF LAKE OSWEGO
Ranney Collector
CITY OF GLADSTONE
24"
16"
24"
24"
27"
27"
27"
24"
16"
24"
36"
27"
30"
Lake Oswego
Oak Grove
Concord
Jennings Lodge
Gladstone
Clackamas
Oregon City
Glen Echo
Fern Ridge
Rocky
Cedar Island
WILLAMETTE RIVER
CLACKAMAS
Clackamas Rapids
Park Place
Clackamas Heights
MARYLHURST COLLEGE
Robinwood
Oswego

TABLE V-3

CLACKAMAS REGION LARGE WATER DISTRIBUTION SYSTEMS

Name of System	No. of Services	Source	Major Storage (MG)
Barwell Park Water District	760	Clackamas Water District	–
Clackamas Housing Authority	200	Wells (2)	–
Clackamas Water District	2,400	Clackamas River	2.6
Clairmont Water District	360	South Fork Water Board	–
Estacada	500	Clackamas River	–
Forest Highlands Water District - Operated by City of Lake Oswego –			
Gladstone	1,500	Clackamas River (Ranney Well)	2.2
Glenmorrie Water Coop.	110	Wells (3)	–
Government Camp	105	Camp Creek	–
Holcomb-Outlook Water District	180	South Fork Water Board	–
Lake Grove Water District	540	Bull Run Via Palatine Hill Water Dist.	1.0
Lake Oswego	4,200	Clackamas River - Wells (5) Standby	2.0
Milwaukie	3,430	Wells (5)	3.1
Mount Scott Water District	650	Clackamas Water District	–
Oak Lodge Water District	4,800	Clackamas Water District	7.8
Oregon City	2,600	2/3 Partner in So. Fork Water Board	12.1
Park Place Water District	300	Springs	–
Redland Water District	110	South Fork Water Board	–
Rhododendron	250	Henry Creek	–
River Grove Water District	570	Wells (2)	–
Robinwood Water District	550	South Fork Water Board	–
Sandy	500	Springs	–
South Fork Water Board (See Other Systems in this Table)		Clackamas River, So. Fork Clackamas and Memaloose	
Southwood Park Water District	220	Well	–
Stanley Water District	550	Bull Run	–
West Linn	1,660	1/3 Partner in So. Fork Water Board	2.5
Wichita Water District	1,250	Bull Run	–
Zigzag	380	Lady Creek	–

TABLE V-4

CLACKAMAS REGION

SMALL WATER DISTRIBUTION SYSTEMS

Name of System	No. of Services	Source
Alder Creek Water Company	40	Alder Creek
Arrah Wanna	23	Crystal Creek
Boskey Dell	40	Spring
Brightwood	23	Spring
Brightwood	16	Creek
Brightwood	37	Well
Carver	16	Well
Damascus Water District	80	Well
Eastmont Heights	80	Well
Marylhurst	–	Wells (2)
Mossy Brae Water District	33	Well
Mountain Air Water Association	45	Spring
Mt. Hood Country Club	35	Creek
Mt. Hood Terrace	42	Well
Shadowood Water Company	34	Well
Silver Leaf Water Company	–	Spring
Skylands Water Company	28	Well
Welches Water Company	80	Springs
Wilsonville Coop.	50	Well

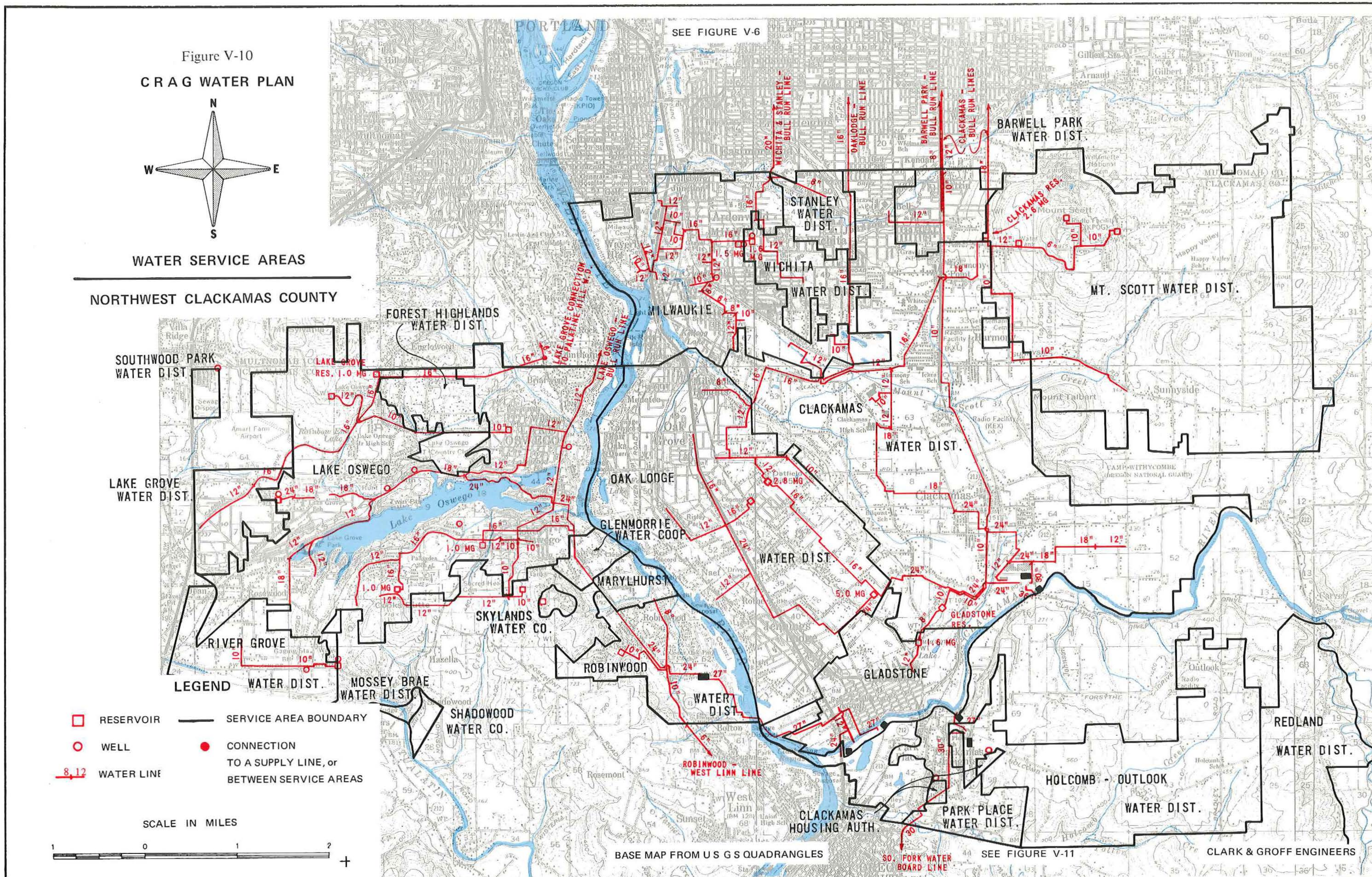
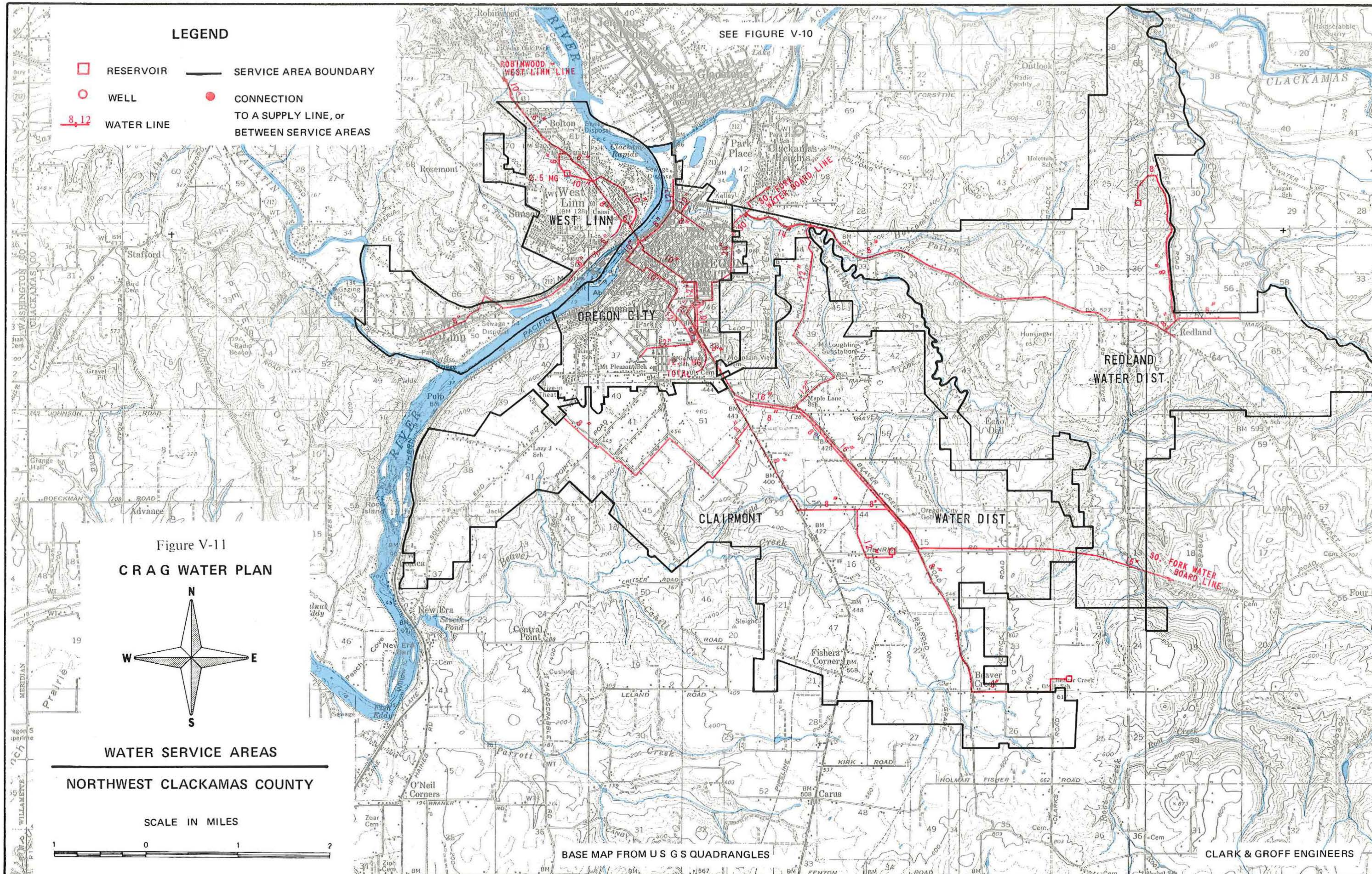


Figure V-10

CRAG WATER PLAN



LEGEND
RESERVOIR
SERVICE AREA BOUNDARY
WELL
CONNECTION
TO A SUPPLY LINE, or
BETWEEN SERVICE AREAS
WATER LINE
SEE FIGURE V-10
ROBINWOOD – WEST LINN LINE
2.5 MG
WEST LINN
OREGON CITY
12.5 MG TOTAL
SO. FORK WATER BOARD LINE
CLAIRMONT
WATER DIST.
REDLAND
WATER DIST.
Redland
Figure V-11
CRAG WATER PLAN
N
W
E
S
WATER SERVICE AREAS
NORTHWEST CLACKAMAS COUNTY
SCALE IN MILES
1
0
1
2
BASE MAP FROM U S G S QUADRANGLES
CLARK & GROFF ENGINEERS

TABLE V-5

MOLALLA REGION

WATER DISTRIBUTION SYSTEMS

Name of System	No. of Services	Source	Major Storage (MG)
City of Molalla	740	Infiltration Gallery	0.6
City of Canby	1,070	Infiltration Well Near Molalla River	0.6
Mulino	130	Well	
Colton Water District	130	Jackson Creek	
Barlow	40	Well	
Trout Creek	40	Trout Creek	

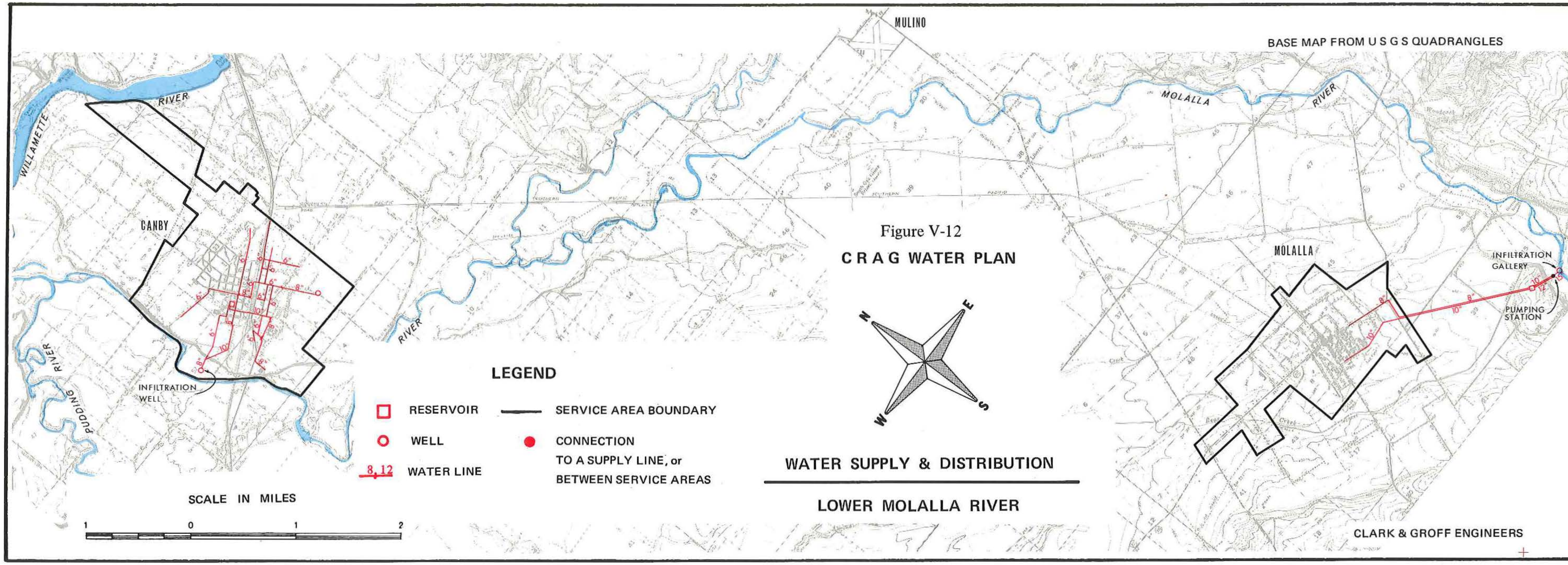
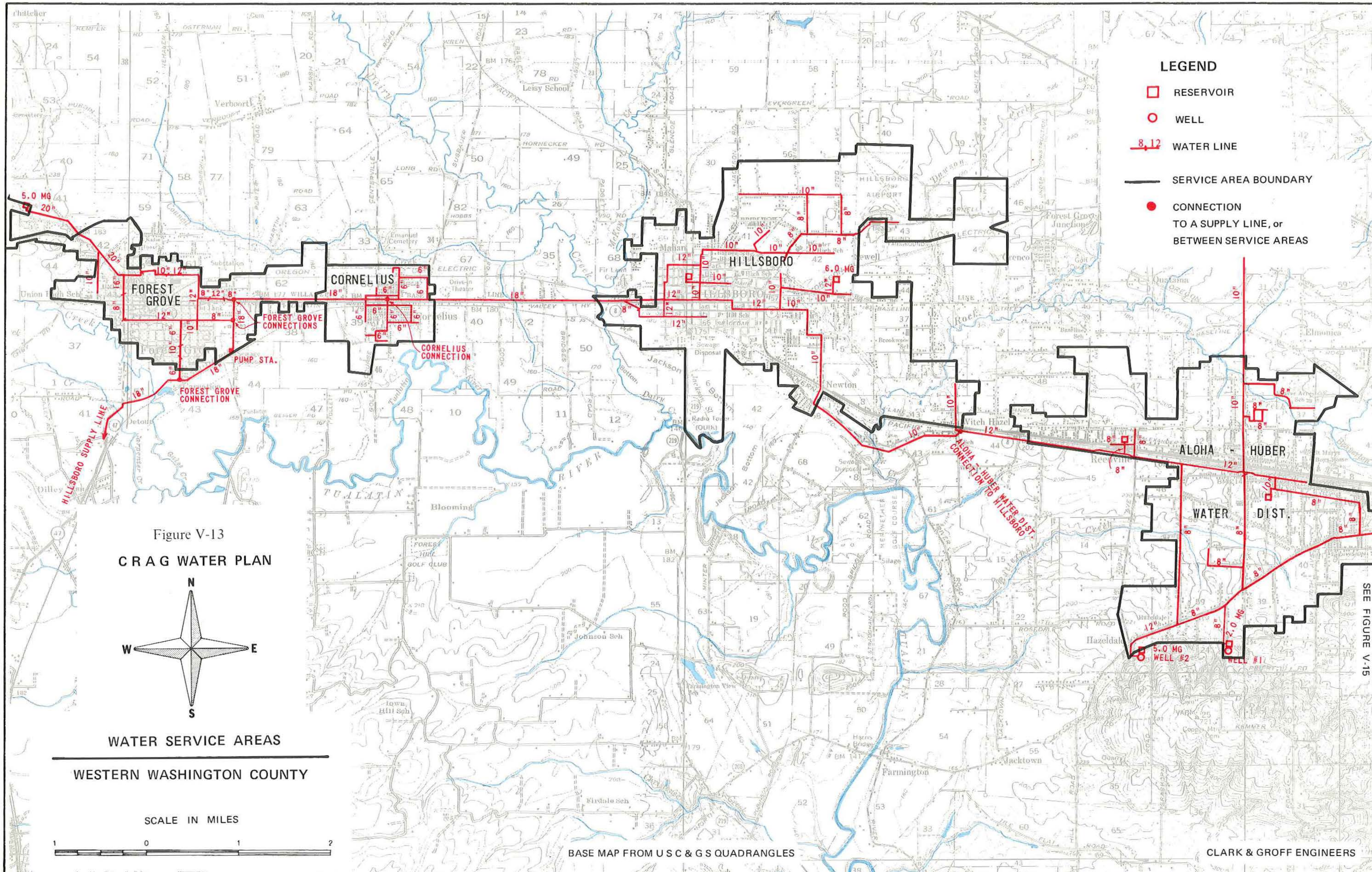

MULINO
BASE MAP FROM U S G S QUADRANGLES
WILLAMETTE
RIVER
MOLALLA
RIVER
CANBY
MOLALLA
INFILTRATION GALLERY
PUMPING STATION
INFILTRATION WELL
PUDDING RIVER
Figure V-12
C R A G WATER PLAN
N
E
W
S
LEGEND
RESERVOIR
SERVICE AREA BOUNDARY
WELL
CONNECTION
TO A SUPPLY LINE, or
BETWEEN SERVICE AREAS
8,12 WATER LINE
WATER SUPPLY & DISTRIBUTION
LOWER MOLALLA RIVER
SCALE IN MILES
1 0 1 2
CLARK & GROFF ENGINEERS

TABLE V-6

TUALATIN REGION WATER DISTRIBUTION SYSTEMS

Name of System	No. of Services	Source	Major Storage (MG)
Aloha-Huber Water District	2,400	Hillsboro, Wells (2)	7
Banks	200	Springs	–
Beaverton	4,000	Bull Run - Well	1.5
Cornelius	490	Hillsboro	–
Forest Grove	2,370	Clear Creek - Gales Creek	5
Garden Home Water District	1,080	Bull Run	1
Gaston	150	Hillsboro	–
Hillsboro (includes Cherry Grove & Dilley)	4,120	Tualatin River - Seine Creek	7
Laurelwood Water Users Coop.	30	Spring	–
Metzger Water District	1,800	Bull Run	1
North Plains	170	Wells (3)	–
Progress Water District	400	Bull Run Via Metzger W.D.	–
Raleigh Water District	710	Bull Run	–
Sherwood	200	Wells (3)	–
Tigard Water District	2,300	Wells (4) (Bull Run via Metzger Water District - Standby)	2
Tualatin	200	Well	–
Tualatin Valley Water Company	140	Bull Run	–
West Slope Water District	2,760	Bull Run	5
Wolf Creek Highway Water Dist.	6,510	Bull Run	6


LEGEND
RESERVOIR
WELL
WATER LINE
SERVICE AREA BOUNDARY
CONNECTION TO A SUPPLY LINE, or BETWEEN SERVICE AREAS
FOREST GROVE
CORNELIUS
HILLSBORO
ALOHA - HUBER WATER DIST.
5.0 MG
6.0 MG
2.0 MG
5.0 MG WELL #2
WELL #1
FOREST GROVE CONNECTIONS
PUMP STA.
FOREST GROVE CONNECTION
CORNELIUS CONNECTION
HILLSBORO SUPPLY LINE
ALOHA - HUBER WATER DIST. CONNECTION TO HILLSBORO
ALOHA - HUBER WATER DIST. CONNECTION TO BEAVERTON
SEE FIGURE V-15
Figure V-13
CRAG WATER PLAN
N
S
E
W
WATER SERVICE AREAS
WESTERN WASHINGTON COUNTY
SCALE IN MILES
1 0 1 2
BASE MAP FROM U S C & G S QUADRANGLES
CLARK & GROFF ENGINEERS

LEGEND

- RESERVOIR
- WELL
- 8, 12 WATER LINE
- SERVICE AREA BOUNDARY
- CONNECTION TO A SUPPLY LINE, or BETWEEN SERVICE AREAS

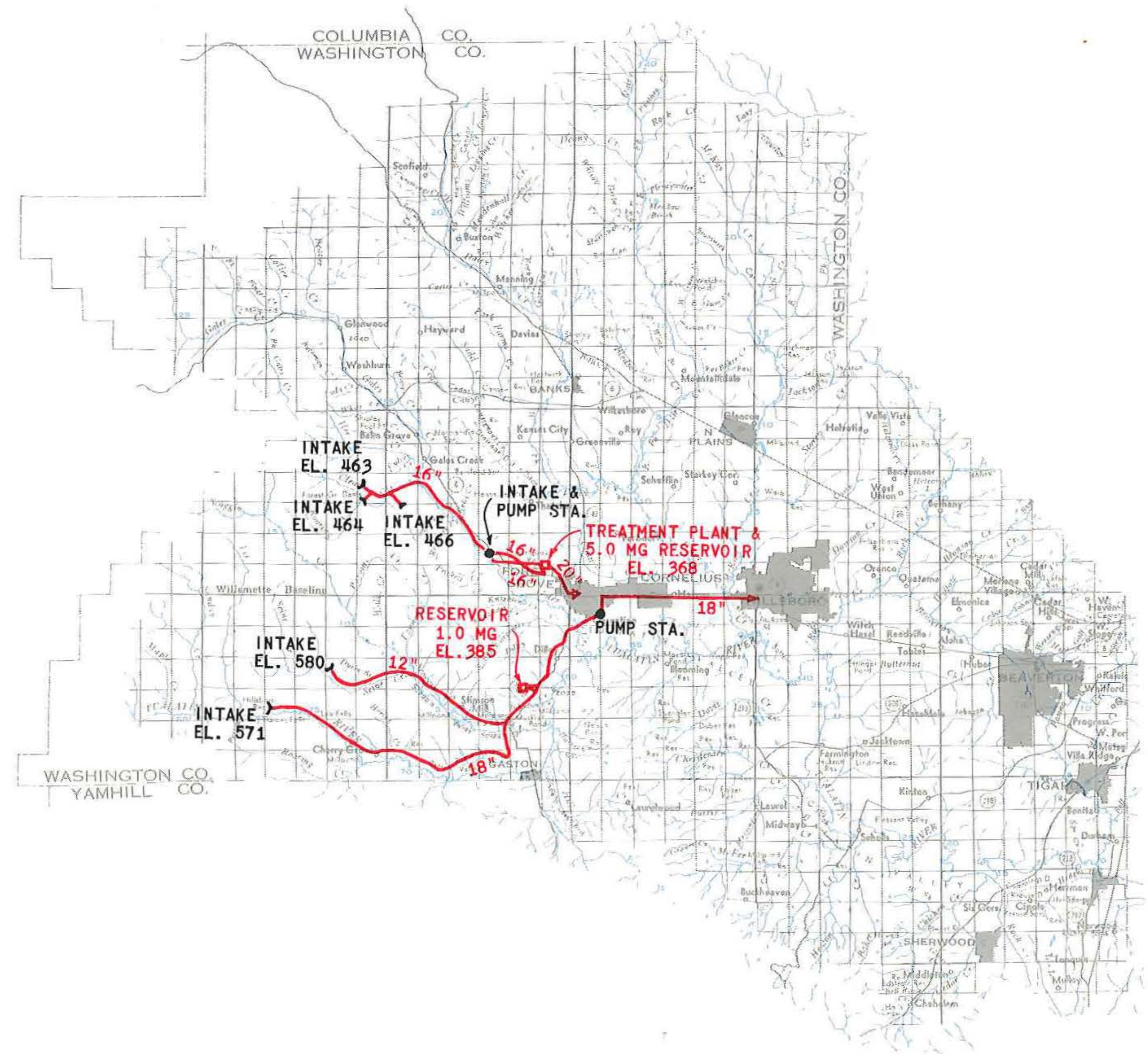
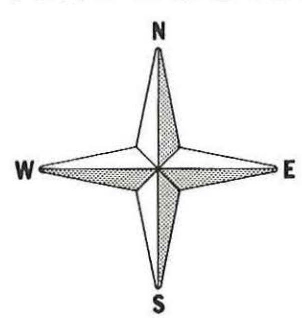


Figure V-14

C R A G WATER PLAN



WATER TRANSMISSION

TUALATIN WATERSHED

SCALE IN MILES

1 0 1 2 3 4 5

BASE FROM OREGON WATER RESOURCE MAP

CLARK & GROFF ENGINEERS

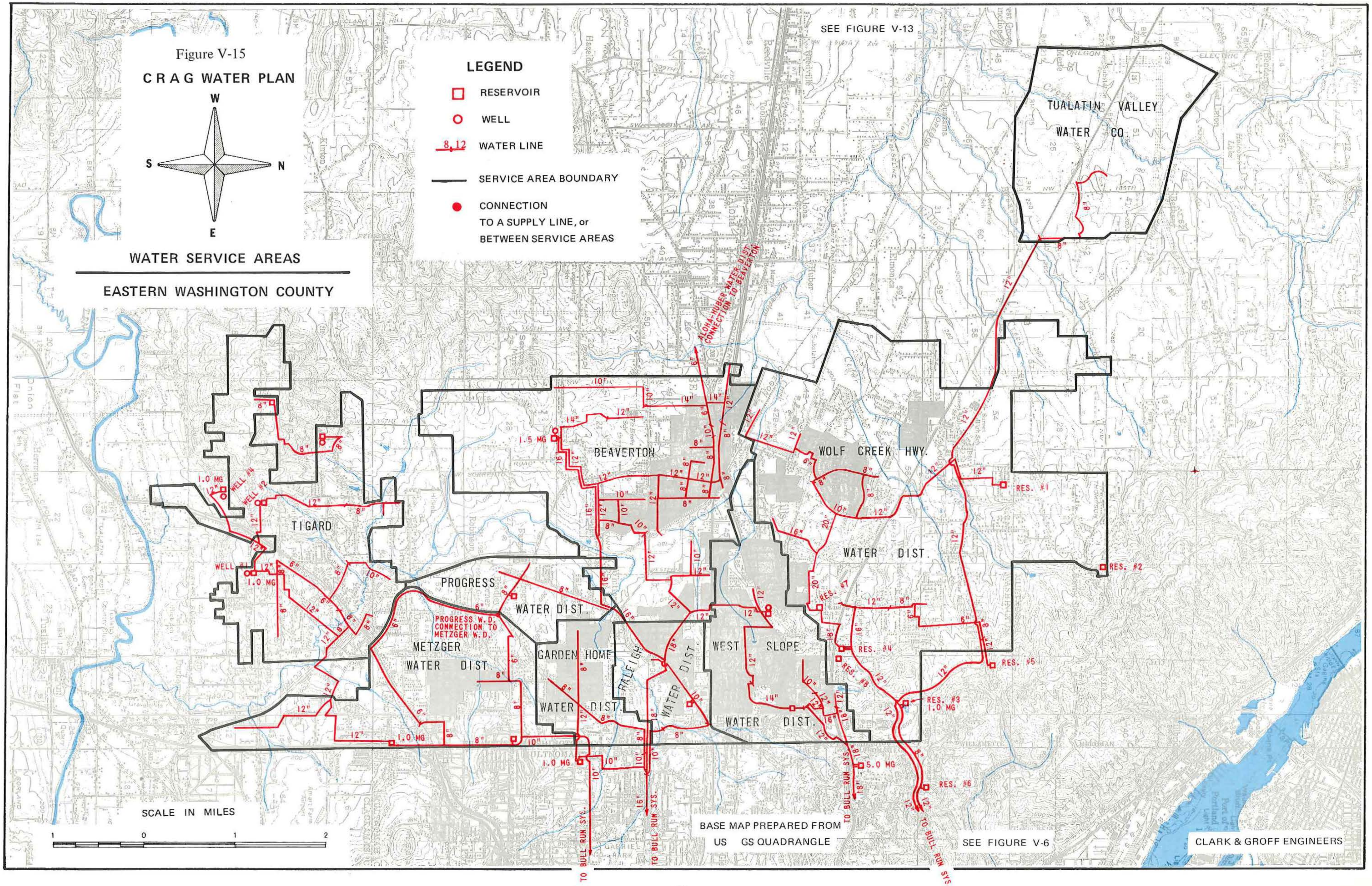


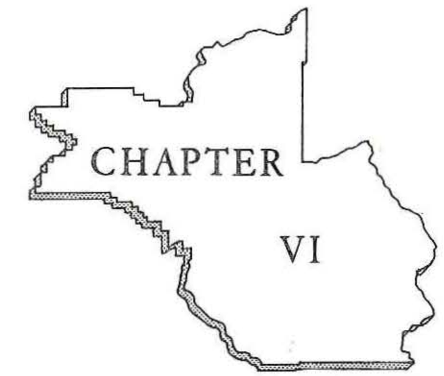
Figure V-15
C R A G WATER PLAN
W
S
N
E
WATER SERVICE AREAS
EASTERN WASHINGTON COUNTY
LEGEND
RESERVOIR
WELL
8, 12 WATER LINE
SERVICE AREA BOUNDARY
CONNECTION
TO A SUPPLY LINE, or
BETWEEN SERVICE AREAS
SEE FIGURE V-13
TUALATIN VALLEY
WATER CO.
ALOHA-HUBER WATER DIST.
CONNECTION TO BEAVERTON
BEAVERTON
1.5 MG
WOLF CREEK HWY.
WATER DIST.
RES. #1
RES. #2
RES. #3
1.0 MG
RES. #4
RES. #5
RES. #6
RES. #7
RES. #8
TIGARD
WELL #4
WELL #2
WELL #1
1.0 MG
PROGRESS
WATER DIST.
PROGRESS W.D.
CONNECTION TO
METZGER W.D.
METZGER
WATER DIST.
GARDEN HOME
WATER DIST.
RALEIGH
WATER
DIST.
WEST SLOPE
WATER DIST.
5.0 MG
TO BULL RUN SYS.
SCALE IN MILES
1 0 1 2
BASE MAP PREPARED FROM
US GS QUADRANGLE
SEE FIGURE V-6
CLARK & GROFF ENGINEERS

TABLE V-7

EXISTING LOCAL AND REGIONAL WATER PLANS

County	Plan Developed For	Date of Plan	Design Year	Water Design Flow MGD	Proposed Source	Plan Developed By	Remarks
Clackamas County	City of Canby	1968	1980	2.0	Molalla or Willamette River	Clark & Groff Engineers, Inc.	No conflict with CRAG Water Plan.
	City of Lake Oswego	1965	1995	32	Clackamas River	Cornell, Howland, Hayes & Merryfield	No conflict with CRAG Water Plan.
Clark County	City of Camas	1967	1990	13.6	5 Wells	Cornell, Howland, Hayes & Merryfield	No conflict with CRAG Water Plan.
	Clark County PUD No.1	1964	1980	5.7	1 Well	R. W. Beck	No conflict with CRAG Water Plan.
	Clark County PUD No. 1	1966		50-250	Lewis River	R. W. Beck	Costs too high in relation to available alternates.
	City of Vancouver	1968	1990	66	Wells	Stevens, Thompson & Runyan	No conflict with CRAG Water Plan.
	City of Washougal	1967	2000	12	Wells	Stevens Thompson, & Runyan	No conflict with CRAG Water Plan.
Multnomah County	City of Portland	1962	2000	575	Bull Run	Bureau of Water Works	Plan should be updated to reflect recent trend toward use of other water souces by water users outside the City of Portland.
Washington County	U. S. Department of Interior	1963		6.5 for M&I	Scoggins Creek (Tualatin Project)	U. S. Department of Interior Bureau of Reclamation	Not recommended for municipal supply at this time. Other features do not conflict with CRAG Water Plan.
	Washington County Court	1969		42	Trask and Clackamas River	Stevens Thompson, & Runyan	No general conflict with CRAG Water Plan. See comments on McKay Rock.
	Washington County Soil and Water Conservation Project	1969		20-24	McKay Creek	U. S. Department of Agriculture Soil Conservation Service	No conflict with CRAG Water Plan, allocations in dry years and cost to municipalities need further consideration.

AN ANALYSIS OF ALTERNATIVES LEADING TO DEVELOPMENT OF THE CRAG WATER PLAN



SUMMARY

The first step in evaluating the possible sources of municipal water in the CRAG area was to subdivide the area into five smaller subareas. The subareas selected, on the basis of possible independent supply systems, were: Clark County, Washington; Washington County and Clackamas County west of the Willamette River; Clackamas County east of the Willamette River; Portland (or west Multnomah County); and east Multnomah County. Figure VI-1 shows the potential alternative sources of water that might be used to provide water to the CRAG study area. It also shows the various alternatives for the transmission of this water to the water-user areas.

The potential municipal water sources in each of these areas were evaluated on the basis of relative "economic cost." These costs included: a) costs at the source, b) costs of a water transmission line, c) costs of a water treatment plant, d) costs of treatment plant operation, and e) costs of pumping water. This approach emphasized the significant cost factors which might differ from one source to another. Relatively fixed costs such as administration, billing, and general system supervision were excluded. Costs were allocated on the basis of percent of capacity used to the point of withdrawal from the system, hence local cost aspects of distribution and distribution storage were also excluded. Figure VI-2 shows the economic cost of providing water from potential sources to the following four areas: Vancouver, Washington; Gladstone-Oregon City, Beaverton, and east Multnomah County.

The costs of treating and transporting water vary with the capacity of the system. In nearly all cases, costs per gallon of water are either constant or decrease with increases in system size. The three major cost elements in this study which varied with system capacity are shown in the following table. The costs shown are only approximate averages based on regional experience. Note the large reductions in the cost of water transmission as the capacity of the transmission line increases.

ECONOMIC COSTS OF WATER TRANSMISSION AND TREATMENT

System Capacity (MGD)	Transmission Line (Dollars/MGD/Mile)	Treatment Plant Construction (Dollars/MGD)	Treatment Plant Operation (Dollars/MG)
1	$63,000	$316,000	$125
5	22,000	190,000	77
10	14,000	150,000	63
50	6,000	140,000	39

MG = Million Gallons
MGD = Million Gallons Per Day

EVALUATION OF ALTERNATIVES

CLARK COUNTY, WASHINGTON

Preliminary estimates were made of the cost of City of Portland water delivered to Vancouver, and of Lewis River water delivered to Portland. These analyses firmly established that for all possible scales of development, there would be no justification for transporting large volumes of water from one state to the other. Planning for Clark County water supply can, therefore, proceed without considering connection to the other service areas.

The Troutdale ground-water formation and four potential surface water sources in Clark County were all found adequate for a regional water supply system. The surface water resources considered were the Columbia River, the Lewis River at its mouth, the East Fork of the Lewis River above Heisson, and the Lewis River behind Swift Dam. The costs of diverting from Swift Dam were assumed to be roughly equal to the costs of diverting from behind Yale Dam.[1]

The mouth of the Lewis River had not been previously studied as a potential source of water. It is included in this study for several reasons. The mouth of the Lewis River is close to Vancouver and also close to some of the potential industrial sites along the Columbia River. The first costs of developing an intake at this point would be low when compared to the other diversion points on the Lewis. Pumping costs would be an added future expense, but at low capacities (25-50 MGD) this diversion would still be the most economical along the Lewis River.

For large volumes (over 100 million gallons per day) of high quality water, diversion from behind Swift Dam may be the most economical alternative. This source might provide water of slightly higher quality and would eliminate any need for pumping. Although the water in this reservoir probably could be used without treatment, it is now virtually a statewide requirement in Washington that all newly developed surface water sources be protected by chlorination and filtration facilities.

FUTURE WATER SUPPLIES FOR CLARK COUNTY

At present, there appears to be little justification for developing a surface water source for the Vancouver area. Existing ground water supplies in the Vancouver area are more than adequate for the rest of this century.

The Camas-Washougal area is not yet large enough to justify a connection with the water systems in the Vancouver area. This area, along with the smaller communities in Clark County, will have to develop local sources of their own. The most likely sources appear to be the Troutdale aquifer and the Columbia River.

WASHINGTON COUNTY

Six proposed water storage projects for the Tualatin Valley were evaluated initially. Three of these, the Devils Lake Fork of the Wilson River, a dam near Gaston on the Tualatin River, and the "Dickey Bridge" dam on the Molalla River were quickly eliminated as being uneconomical at this time. The three remaining projects considered were the Tualatin Project for a dam on Scoggins Creek, the McKay-Rock Creek Project including a dam on McKay Creek, and the Trask River development, the first phase of which is now under construction. The other sources that were evaluated were the Willamette River, the Clackamas River, the Columbia River via Cornelius Pass and Bull Run water.

It was assumed that if Willamette River water were used, it would be withdrawn above the Oregon City falls. Because of local dislike for Willamette River water, and the fact that a diversion from the mouth of the Clackamas River would be only slightly more expensive for a regional water supply system, economic analysis was limited to the Clackamas River. One should keep in mind that the Willamette River could be substituted for the Clackamas River at a slight saving in cost.

Two points of diversion from the Willamette River would have almost equal costs, but serve water to slightly different areas. Diversion from West Linn, above the Willamette Falls would be the most efficient method of serving the existing and projected future population. Diversion from the Willamette at Wilsonville would not serve as many people, but might be justified if the area along Interstate 5 and the Southern Pacific Railway were to be developed for medium or heavy industry.

The area around Beaverton was found to be the key link in the economic analysis of possible water supply systems for Washington County. Development of the Trask River, now in its initial phase of construction, was found to be the most economical source for Hillsboro, Cornelius, and Forest Grove.

With the needs of the Hillsboro, Cornelius and Forest Grove area satisfied, the nearest market for Tualatin Project (Scoggins Creek) municipal water would be east of Hillsboro. The long distance for the relatively small amount of water made the Tualatin Project uneconomical when compared with the Clackamas, the Willamette, the Columbia or Bull Run.

The McKay Water Control District has indicated a charge of 5 cents per 100 cubic feet (70 dollars per million gallons) for water from the McKay Creek Project. At this price, "source costs" were one-third of the economic cost of McKay Creek water, hence, McKay

Creek was found to have slightly higher economic cost than the other major sources, assuming they were developed on a large scale. The primary advantage of the McKay Creek project is its relatively small size and, hence, the relative ease with which the project might be organized and financially sponsored.

The yields of the Trask River and the McKay Creek will be insufficient to meet the needs of the Tualatin Valley in the year 2000. One of the other three major sources will have to be used, at least during periods of peak demand. As previously mentioned, the Clackamas River was chosen over the Willamette because of its higher quality, even though the Clackamas would be slightly more expensive to develop. The relative amounts of transmission line costs, treatment costs, and pumping costs were the same, so a change in cost of one should result in a similar change in cost of the other alternative.

A major item (33%) in the cost of Columbia River water, brought over the Cornelius Pass, was the cost of power for pumping. An analysis of the overall situation, however, revealed that the power requirements for pumping water from the Clackamas River are equal to those of the Columbia River because of the larger pipe. Furthermore, even though pumps on the Columbia would be relatively near the recently proposed nuclear power plant, the charges for electrical energy would be the same at the mouth of the Clackamas as at the foot of Cornelius Pass. Consequently, the relative economic merits of these two alternatives will not be affected by the final cost of electrical energy.

The economic cost of providing Bull Run water to east Washington County was found to be lower than any of the alternate sources. These economic costs, however, do not reflect the added cost of laying a transmission line through a city and over a river. It should also be noted that Portland does not deliver water to Beaverton through a single transmission line. Portland uses its distribution system to move water from the east part of Portland towards Beaverton. This makes it impossible to assign a cost to a pipe going to Beaverton.

EASTERN CLACKAMAS COUNTY

Most of the people in Clackamas County live along either the Willamette or Clackamas River. Their principal current source of water is either the Clackamas River, the City of Portland water system, or local wells. Other potential water sources are the Willamette River and the Molalla River. All present indications are that the Clackamas River is the logical source for much of the area and that it should be fully utilized before turning to other more expensive sources.

All of the major existing intakes on the Clackamas River are located near its mouth. The distribution systems are designed for flows originating from the mouth of the Clackamas River in the Gladstone-Oregon City area. It was assumed that this area was the center of need and that if the Clackamas River were used as a regional source, that the major transmission lines would either originate in or pass through this area.

The existing North Fork reservoir, located above Estacada was considered as an alternate diversion point. This reservoir is at an elevation of 700 feet, high enough to provide an all gravity supply to the Gladstone-Oregon City area. In order to make this practical, diversion would have to take place on a large scale (over 100 MGD).

The dependable yield of the Clackamas River, at least for municipal purposes, was found to be limited by several factors. The early water rights (prior to 1909) on this river have not been adjudicated. Until they are, the relative value of all other water rights on the river will be somewhat uncertain. The Clackamas is a valuable recreational resource, popular with fishermen, campers, and boaters. Some flow will have to be preserved for these recreational purposes.

Releases from the existing storage facilities on the Clackamas River, now operated for hydroelectric power purposes, could be coordinated with the projected municipal water needs of the area without seriously changing the amount of power generated. Re-regulation of these facilities could raise the low flows at the mouth of the Clackamas River by 25 to 30 percent.

Other sources initially considered were the City of Portland, ground water, and the Dickey Bridge Project. Ground water quality and quantity considerations made the source questionable. The Dickey Bridge Project, a preliminary proposal by the Bureau of Reclamation, would include a large dam on the Molalla River. This site was too low and too far away to be economically attractive.

The economic cost of providing Bull Run water to this area appears to make this a reasonable alternative. However, substantial investments have now been made by the various water supply agencies in this area for supply, transmission and treatment facilities which have the capability through future expansion to supply the water needs of the area to the year 2000.

EAST MULTNOMAH COUNTY

There appears to be three alternatives open to east Multnomah County, all approximately the same in cost. From an economic point of view, the least expensive course of action would be for east Multnomah County to share with the City of Portland in the expansion of the Bull Run water system. The next most economical source would be Columbia River water, treated in a single central treatment plant. At a slightly higher cost, Clackamas River water could be brought to east Multnomah County.

The City of Portland, through state legislation, has exclusive rights to the waters of the Bull Run. Portland has never offered to develop this watershed on a joint basis, but has always offered to sell Bull Run water, on short-term contracts, at established rates to outside users. The current rate for outside users, who can be supplied by gravity, is 50 percent over the charge to in-city users supplied by gravity plus a 50 cents per month demand charge on residential meters.

For roughly the same cost as they are now paying for Bull Run water, the water districts of east Multnomah County could obtain treated Columbia River water from a common treatment plant. In future years, a large number of people could be sharing in the use and, hence, the cost of these Columbia River facilities. As the population increases, the cost of water would decrease.

The Clackamas River would be a good source of water, but there may not be enough water left in this river after meeting the needs of the communities in Clackamas County and in the Tualatin Valley. The construction of a major reservoir on the Clackamas River could result in a greatly increased availability of water, but the costs of such a reservoir could not be justified on the basis of municipal supply needs alone.

Water facilities for east Multnomah County and the City of Portland could be combined in the future. Should this occur, a source separate from the Bull Run would be very valuable as an emergency source for the entire county. During periods of relatively low demand, the existing Bull Run system could serve the entire county. Hence there would be advantages to both the city and county in the event of a consolidation.

CITY OF PORTLAND

The most economical source of additional water for Portland is the Bull Run. Portland's Bull Run water conduit system can now provide a peak flow of 225 MGD of very high quality water. The watershed can eventually be developed to supply a peak-day demand of 575 million gallons according to a 1962 study conducted by the Portland Bureau of Water Works. The restricting factor at present is the capacity of Portland's three water transmission lines.

In addition to providing water to residents of Portland, the Portland Bureau of Water Works supplies water to communities and water districts outside Portland. The peak-day water demand in Portland and the remainder of Multnomah County is estimated to be 310 million gallons at year 2000. Thus, if Portland is to continue to serve the communities and districts outside Portland a capacity of between 300 and 350 MGD will be needed by year 2000. This means Portland's present system would have to be expanded.

By year 2000, peak-day water demand is expected to reach 210 million gallons in the City of Portland. If Portland decides to discontinue service to outside communities and districts or if these communities and districts turn to other sources of supply then Portland's existing supply systems will be adequate until the year 2000.

As an alternate source of supply Portland can turn to the Willamette or Columbia River. The water from each source would require complete treatment and pumping. Either of these sources would be more costly than the existing Bull Run supply system.

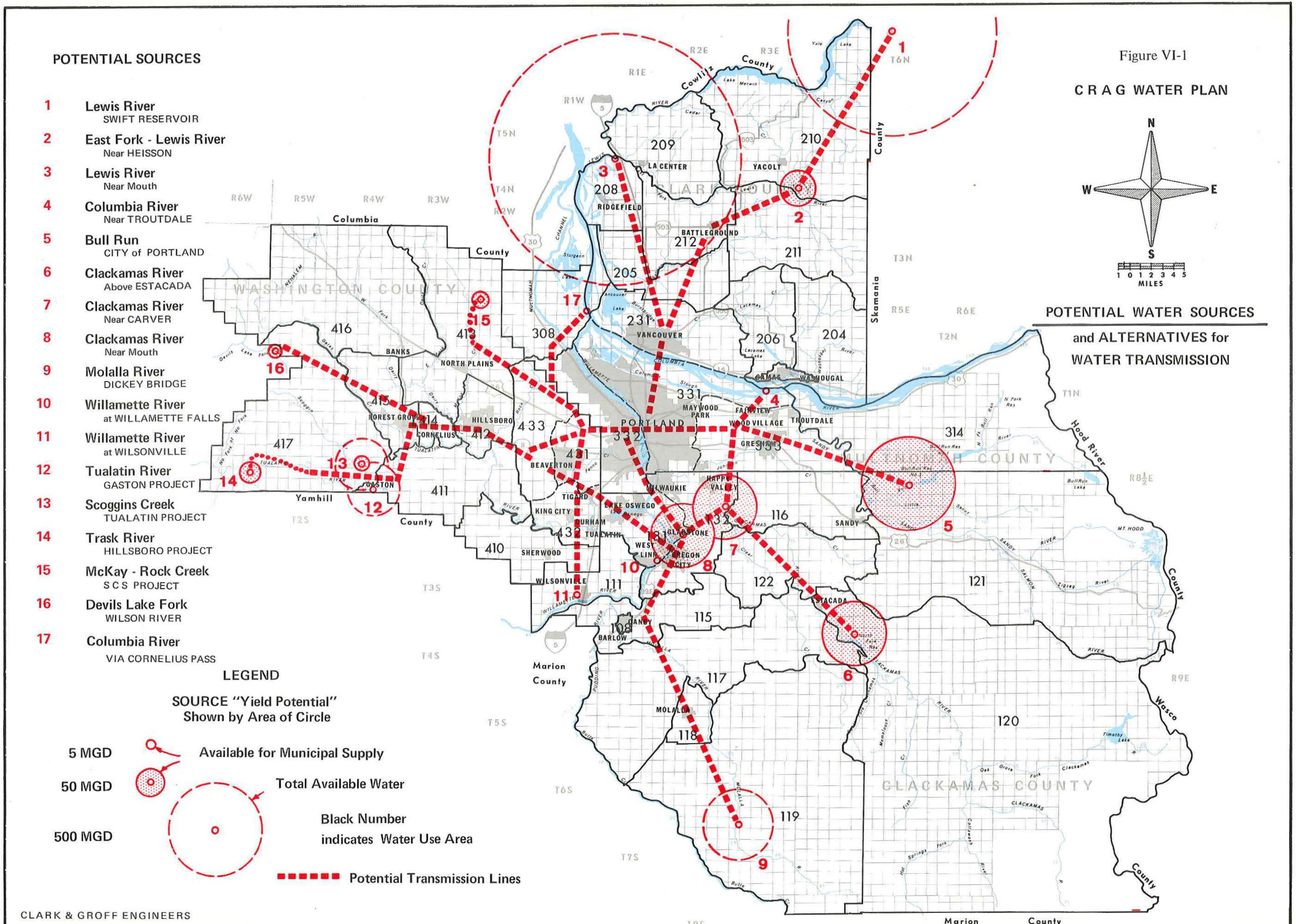
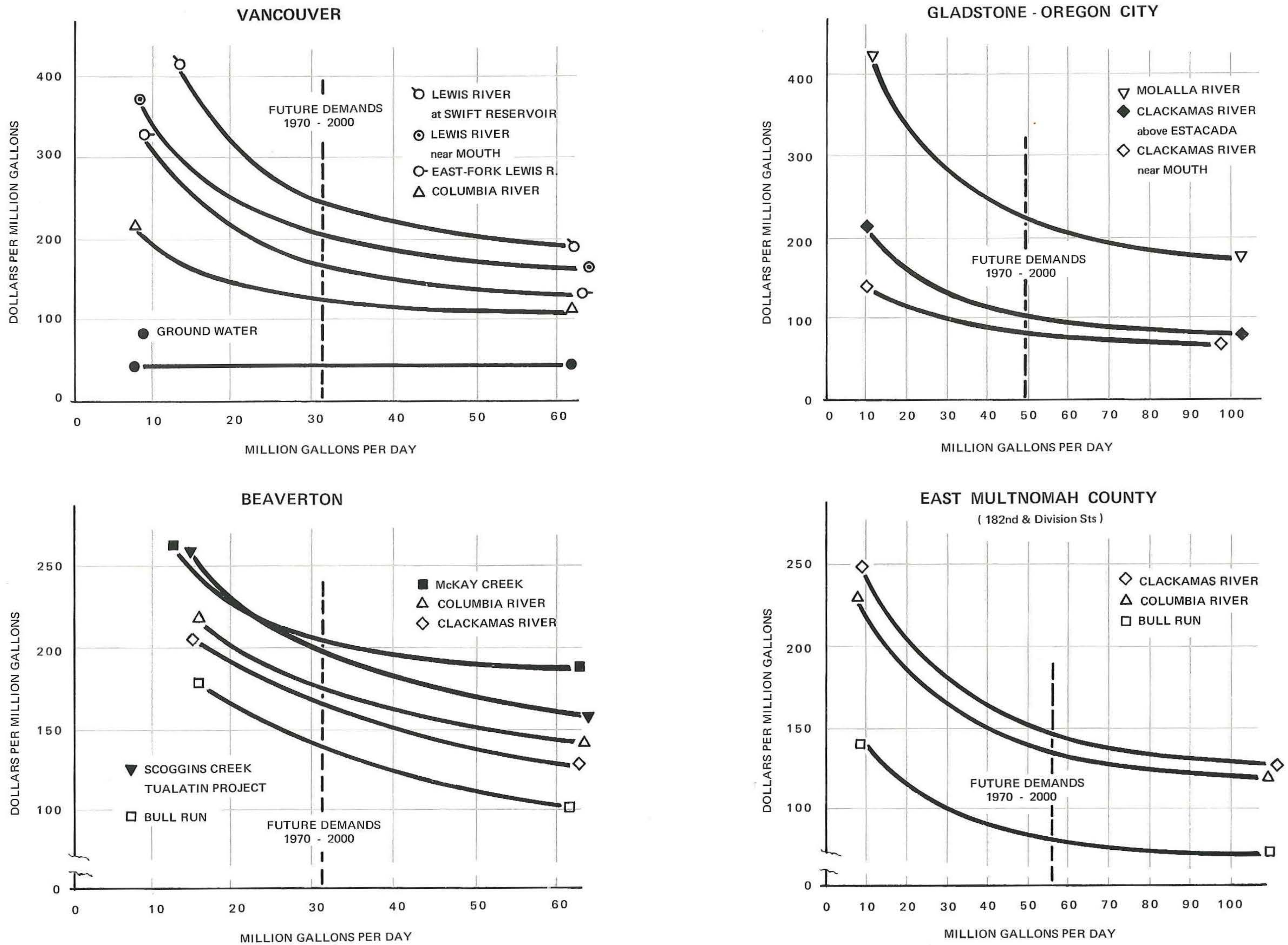
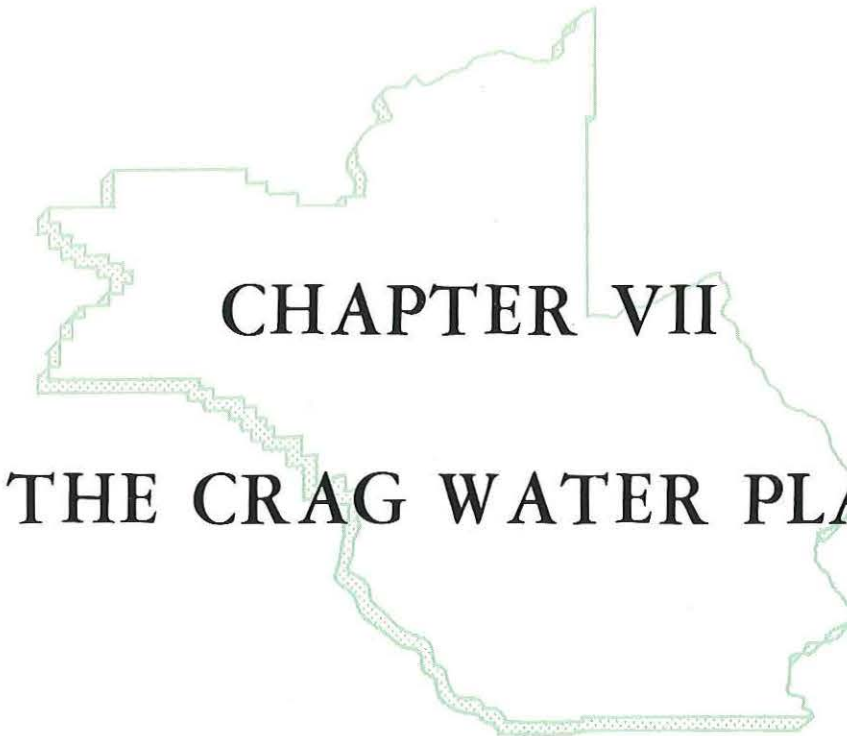


Figure VI-1
C R A G WATER PLAN
POTENTIAL WATER SOURCES
and ALTERNATIVES for
WATER TRANSMISSION
POTENTIAL SOURCES
1 Lewis River SWIFT RESERVOIR
2 East Fork - Lewis River Near HEISSON
3 Lewis River Near Mouth
4 Columbia River Near TROUTDALE
5 Bull Run CITY of PORTLAND
6 Clackamas River Above ESTACADA
7 Clackamas River Near CARVER
8 Clackamas River Near Mouth
9 Molalla River DICKEY BRIDGE
10 Willamette River at WILLAMETTE FALLS
11 Willamette River at WILSONVILLE
12 Tualatin River GASTON PROJECT
13 Scoggins Creek TUALATIN PROJECT
14 Trask River HILLSBORO PROJECT
15 McKay - Rock Creek S C S PROJECT
16 Devils Lake Fork WILSON RIVER
17 Columbia River VIA CORNELIUS PASS
LEGEND
SOURCE "Yield Potential" Shown by Area of Circle
5 MGD
50 MGD
500 MGD
Available for Municipal Supply
Total Available Water
Black Number indicates Water Use Area
Potential Transmission Lines
N
S
W
E
1 0 1 2 3 4 5 MILES
WASHINGTON COUNTY
MULTNOMAH COUNTY
CLACKAMAS COUNTY
PORTLAND
VANCOUVER
CLARK & GROFF ENGINEERS

TYPICAL RELATIVE ECONOMIC COSTS

Figure VI-2





CHAPTER VII

THE CRAG WATER PLAN

In Chapter VI, the alternative sources of water for the CRAG study area were examined and compared on the basis of economic costs. The five basic cost elements included were supply, transmission, treatment plants, treatment plant operation, and pumping costs. The analysis described in Chapter VI included alternative sources by subarea. These subareas are Clark County, Washington County, Clackamas County, east Multnomah County, and the City of Portland.

On the basis of least-cost considerations the following water plan has evolved as an efficient and effective water supply development on a regional basis.

The plan is illustrated in Figure VII-1.

In the following discussion, the CRAG study area has been divided into six subareas. These subareas are larger than the water-use areas and appear to be logical dividing points for future service areas. In keeping with the rest of the report, these areas are defined in terms of census tracts. The actual boundaries of the final service areas should be based on local conditions such as elevations, existing facilities, and housing density.

Under the plan:

Subarea No. 1 in Clark County includes Census Tracts 10 through 31. This area would obtain its water from ground-water sources.

Subarea 2a, that area within Washington County lying east of Hillsboro (Census Tracts 1 - 20), would obtain its water supply from the Bull Run system. Subarea 2b, the Hillsboro-Cornelius-Forest Grove area (Census Tracts 24 - 26, 29 and 31 - 33), would continue to obtain additional water from the Trask River.

Subarea No. 3 would include the area in Clackamas County presently taking water from the Clackamas River. Subarea 3 would encompass Census Tracts 1 through 26, which is the Milwaukie, Lake Oswego, West Linn, Oregon City and Gladstone area.

Subarea No. 4 is the area in Multnomah County lying east of the City of Portland and west of the Sandy River. It includes Census Tracts 80 - 82 and 90 - 104. The most economical source of water for this area is the Bull Run system.

Subarea No. 5 is the City of Portland and includes Census Tracts 1 - 70, 72 - 79 and 83 - 89. The most economical source of water for this area is also the Bull Run system.

A more detailed discussion of the plan by subareas follows:

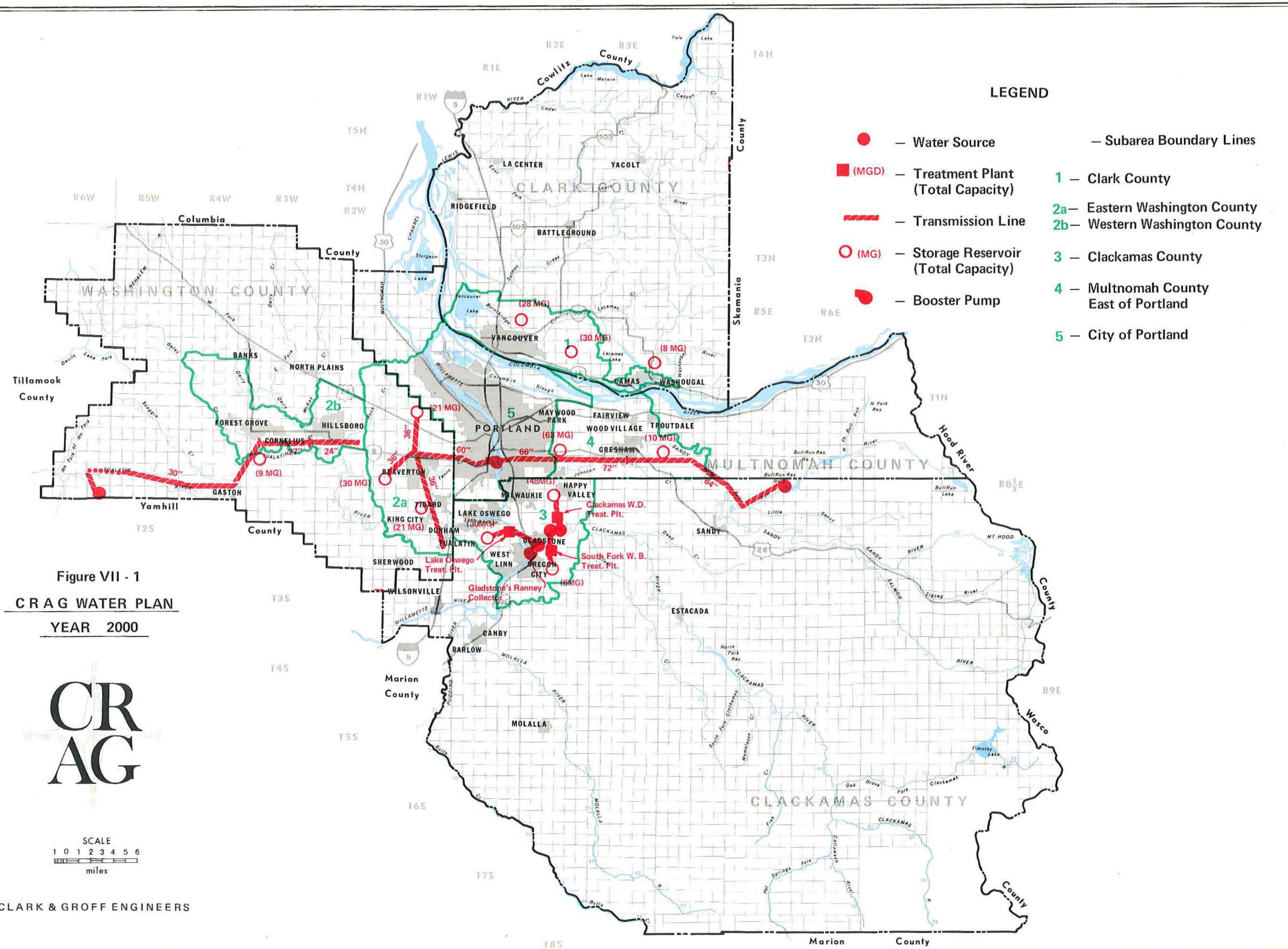


Figure VII - 1

CRAG WATER PLAN

YEAR 2000

CRAG

CLARK & GROFF ENGINEERS

CLARK COUNTY, WASHINGTON – Subarea No. 1

Clark County is fortunate in having an abundance of good quality ground water available throughout the urban area. The Troutdale formation has been estimated to be capable of supplying Clark County with up to 750 MGD on a sustained basis. This amount is many times the peak-day municipal demand projected for the year 2000. The current level of industrial ground-water usage in this area, approximately 60 MGD, is also far below the potential yield of this aquifer.

Because of its ready availability and the savings in cost over Columbia River and Lewis River water, large, deep wells are recommended as the future source of municipal water for the urban area of Clark County, Washington. These wells can be drilled as needed. Chlorination would be the only treatment required.

The City of Yacolt in the northern part of Clark County now obtains its supply from surface water sources. Yacolt and other communities in this area not able to obtain water from the Troutdale aquifer will doubtless continue to rely on surface water as their source of supply. The communities of Battleground, Ridgefield and La Center now obtain their water supply from wells and should continue to do so in the foreseeable future.

Preliminary estimates developed in Chapter VI indicate an immediate need for additional storage capacity in the urbanized area of Clark County. Storage requirements recommended are:

1970-1980	1980-1990	1990-2000
27 MG	Add 19 MG	Add 20 MG

These requirements are based on storage for one peak-use day. In Clark County, this guide is not always applicable as wells can be substituted for storage capacity. The precise system storage requirements depend on local conditions, especially distribution system layout, available sources, and available reservoir sites.

WASHINGTON COUNTY – Subarea No. 2

NO. 2a - WASHINGTON COUNTY EAST OF HILLSBORO. The comparative cost procedure developed for this study indicates that Bull Run water appears to be the most economical source of water for Beaverton and Washington County east of Hillsboro. This would require the construction of additional storage in the Bull Run Reserve and a major transmission line from the Portland Headworks through Multnomah County and the City of Portland all the way to the Beaverton area.

Clackamas River water delivered to the part of Washington County east of Hillsboro is the next most economical alternative to Bull Run water. The degree of difference in cost between the two sources is on the order of 5 to 20 percent. If the Clackamas River is selected as the source for this area, development should take place in accordance with the recommendations found in the "Tualatin Basin Water and Sewerage Master Plan."

For either of these sources to become available at the costs indicated, all users must share equally in the cost of developing a regional system. This will necessitate long-term agreements extending well beyond the current 5-year maximum now granted by the City of Portland for the supply of Bull Run water.

Eastern Washington County now has almost 23 million gallons of distribution storage. During the next three decades, approximately 28 million gallons of additional capacity will be needed in each decade to provide one peak-day demand of storage. Because of the variations in topography and the consequent need for separate pressure systems along the West Portland Hills, additional storage capacity over this suggested minimum may be desirable. If Bull Run continues to be the source of supply for this area, then system reliability should also be taken into consideration.

Some potential storage sites in eastern Washington County are indicated in the "Tualatin Basin Water and Sewerage Master Plan." There are also a number of potential sites in the west Portland Hills which could serve both western Multnomah County and eastern Washington County.

NO. 2b - HILLSBORO-CORNELIUS-FOREST GROVE. The most economical source of water for the Hillsboro-Cornelius-Forest Grove area is the Trask River. Continued development of this source is recommended to the year 2000. This development includes the construction of a storage reservoir on the headwaters of the Trask River and diversion of this water to the Tualatin River. The water may then be directed into a conduit near the present Hillsboro intake and transmitted to the Hillsboro-Cornelius-Forest Grove area.

There appears to be adequate distribution storage capacity in western Washington County for the next ten years, though it is quite possible that the existing capacity may not be located in the most advantageous places. In the following two decades, approximately 4 and 5 million gallons of additional distribution storage, respectively, will be needed (Table VI-6).

The outlying Washington County communities of Sherwood, Wilsonville, Banks, North Plains, and Laurelwood should continue to develop independent water supply systems.

CLACKAMAS COUNTY – Subarea No. 3

The communities and water districts of Clackamas County that are presently using the Clackamas River should continue to do so. Gladstone, Oregon City, West Linn, Lake Oswego and several water districts obtain water from the Clackamas River. Although Milwaukie now draws from local wells, it is planning to fill its additional needs from the Clackamas.

This recommendation is made because new or recently completed treatment plants are now in use and can be expanded to meet future needs. Were these plants not in existence, Bull Run water developed on a cooperative basis could well be competitive in cost.

The Clackamas Water District treatment plant may appropriately continue to serve those communities north of the Clackamas River, with the exception of Gladstone. The "Ranney Well" collector system developed in Gladstone appears to be adequate to the year 2000.

The Clackamas Water District and the Oak Lodge Water District have commissioned a system analysis of their distribution network. It is assumed that this study will take into account the need for service to that part of Clackamas County lying north of the Clackamas River and within their general boundaries.

The South Fork Water Board, made up of the cities of Oregon City and West Linn, should continue to serve these two communities and the surrounding areas south of the Clackamas River. The existing South Fork treatment plant may be expanded to meet the area's needs for the next 30 years.

Lake Oswego is currently engaged in a $4 million water system improvement program. Construction of an intake on the Clackamas River and a transmission line to a treatment plant site is expected to be completed in the summer of 1969. Also scheduled for completion at this time is the first phase of the water treatment plant and a transmission line from the treatment plant to the Lake Oswego distribution system.

Some additional distribution storage capacity for these three systems will be needed in the future. Using the one peak-day guide, approximately 30 million gallons of additional storage will be needed in each of the next three decades.

Storage locations for Lake Oswego are indicated in a recent Lake Oswego water plan. Storage location for the areas now served by the Clackamas Water District and the Oak Lodge Water District should be designated in local plans now in preparation. Gladstone now has storage capacity sufficient to at least the year 1990. Milwaukie may rely on its existing wells rather than local storage as a means of meeting peak and emergency demands. Oregon City can expand existing reservoir sites.

The more isolated cities of Canby and Molalla must of necessity develop independent water supply systems, presumably drawing from the Molalla River or possibly the Willamette River in the area of Canby. The outlying communities of Sandy, Estacada, and the Government Camp-Rhododendron-Zigzag area would continue to develop independent water supply systems from nearby local sources under the plan.

EAST MULTNOMAH COUNTY – Subarea No. 4

This study indicates that because of its low operating cost, Bull Run water is the most economical supply source for east Multnomah County. (See Figure VI-5). The primary operating costs are chlorination and watershed protection. There are no pumping expenses as this is an all-gravity system through Multnomah County and into the City of Portland.

As desirable as the Bull Run source may be for this subarea, reliance on this single source, with long transmission lines, carries with it a degree of risk. Catastrophic events may interrupt the flows and leave large populations without suitable water.

For this reason, there is something to be said for eventually developing an alternate supply from the Columbia River or the Clackamas River, which, in emergency, could furnish limited quantities to Portland and eastern Washington County.

Whether the degree of risk is high or low requires more detailed study and evaluation. Certainly, a large water department has exceptional capabilities for making repair and promptly restoring lines to service.

It appears that a realistic appraisal of this situation would find Subarea 4 turning first to the Bull Run source as a matter of economics for as much water as it can get. Thereafter, the most economical choice would be the Columbia River. The Clackamas River should also be considered because its water is softer than Columbia River water.

Some water districts in east Multnomah County appear to be relying on the City of Portland for local distribution storage. This is not always the most efficient procedure.

Storage needs in this area should be carefully investigated because at present there is only 20.7 MG of local storage. To supply a peak day of demand, 40 MG of additional storage capacity will have to be provided in the next decade. In the following two decades, 15 MG and 24 MG of additional capacity will be needed.

There are only a few good reservoir sites in this area. The most obvious possibilities are Powell Butte, Kelly Butte, and Grant Butte. Future storage reservoir sites in east Multnomah County should be carefully studied in the not too distant future.

CITY OF PORTLAND – Subarea No. 5

Bull Run water is clearly the most economical water source for the City of Portland. The City of Portland now has complete ownership of a 225 MGD water transmission system and complete control of the waters from the Bull Run watershed.

On June 18, 1969, 225 MGD were drawn from the intake works to meet the peak demands on that day. Thus, while Portland continues to serve outside users, the capacity of its transmission lines has already been reached.

As previously mentioned, outside users consume about 30 percent of the Portland supply. If this condition continues, further development of the Bull Run should be undertaken in the immediate future.

For the City of Portland alone, the present transmission capability appears to be adequate.

Distribution storage in Portland now amounts to 216 MG which is slightly greater than one peak-day demand projected within the city limits for the year 2000. This storage, however, serves outside users as well. This factor, together with the desirability of having excess storage to meet the exigencies previously cited, would indicate that, within reasonable financial limits, additional local reserve should be established.

UPDATING THE PLAN

The CRAG Water Plan was based on the best data available during the period of study. In some cases, excellent data was available and very reliable cost estimates possible. In other cases, only preliminary information was available.

The following is a discussion of some of the factors and assumptions which were of major significance in determining the most economical sources of water for the CRAG area.

POPULATION

Population changes are difficult to predict with accuracy. There will inevitably be some revisions in the estimates based on 1970 census data and on future developments in the area. A close examination of the cost curves (Figures VI-2, VI-3, VI-4, and VI-5) indicates that slight changes in demand do not significantly affect the relative economic costs of the various alternatives. If the population estimates for 1970 are within about 15 percent of true value, a revision for this purpose alone does not appear necessary. The population estimates for 1970 used in this report were interpolated between 1960 census data and 1980 estimates furnished by the former Metropolitan Planning Commission.

COSTS

SOURCE COSTS. Accurate estimates of the cost of water at its source were not always available. The assumed values of the more important sources are stated below along with the percent of total economic cost attributed to the source of supply at the anticipated scale of development. See Table VII-1.

TABLE VII-1
SOURCE COSTS AND THEIR RELATION TO TOTAL COSTS

Source	Assumed Cost	Source Cost as a Percent of Total Economic Cost
Bull Run	$4,300,000 for 5,000 MG Storage Capacity[1]	23% at Beaverton 49% at east Mult. Co.
Trask River	$3,679,000 for 10,000 acre-ft. Expansion[2]	22% at Hillsboro 27% at Forest Grove
Tualatin Project	$1,417,760 for 14,000 acre-ft.[3]	5% at Hillsboro 6% at Forest Grove
McKay-Rock Creek Project	5 Cents per 100 cubic feet[4]	32% at Beaverton

[1] The Cost of Blazed Alder Creek Dam,Adjusted to 1969 Levels, *Progressive Development of Bull Run,* p.47.

[2] *Tualatin Basin Water and Sewerage Master Plan,* p.69.

[3] *Tualatin Project, Oregon*, p. 4.

[4] Conferences with Soil Conservation Service, Portland.

The percent of total economic cost is stated to permit a rapid adjustment of total economic costs without resorting to a complete computer analysis. For example, if McKay Creek water were eventually sold at 3 cents per 100 cubic feet, this would be a 40-percent reduction in source costs. Total economic costs would therefore be reduced by 12.8 percent (0.40 x 0.32).

TREATMENT PLANT AND TREATMENT PLANT OPERATING COSTS. Only two conditions of water treatment were permitted in the economic model; no treatment, or complete treatment. For Bull Run and the Trask River, it was assumed that no treatment plant facilities or treatment plant operating expenses were involved. In reality, Bull Run water is treated with chlorine and is under constant surveillance by skilled water chemists. Chlorination will also be necessary for Trask River water, and there will be some expenses involved in periodic water analysis. The costs of water from these two sources are therefore understated only by the extent of the cost of chlorination and water analysis.

The costs of treating the other sources were based on fairly complete treatment which may not be necessary in all cases. These costs may be somewhat overstated in a limited number of cases.

No allowance was made for the cost of filtering Bull Run or Trask River water. If filtration is ever required for water from these two closed watersheds the plan should be carefully reviewed before any additional expansion takes place.

TRANSMISSION LINE COSTS. As stated previously, transmission line costs were based on the rule of $1 per inch per foot. This is known to be a reliable figure for pipe up to 36 inches in diameter; it is possibly a bit low for larger pipes. When larger pipes are involved, however, any errors should be somewhat self-compensating as large pipes would generally be involved, regardless of source. No allowance was made for special costs such as expensive rights-of-way, river crossing facilities, or unusual soil conditions. These were also assumed to be somewhat self-compensating.

POWER COSTS. Power costs were set at 2 cents per kilowatt hour (KWH), high enough to cover all pumping costs including demand charges, pump maintenance and depreciation, and general pump operation costs. Power costs were especially significant in the costs of Columbia and Clackamas River water. Special analyses for rates of only 1.0 cent per KWH indicated, however, that a lowering of the power costs would not drastically affect the relative economic merits of the various sources. Power costs are generally involved in the alternate systems.

At present, the same rates are charged for the same type of service anywhere in the populated parts of the CRAG area. If cooperative development of the Bull Run, including east Washington County, does not take place, then a special rate for pumping Columbia River water over Cornelius Pass should be investigated. The large, steady, off-peak load should be very attractive to Portland General Electric, especially since it will be near the proposed Trojan atomic power plant.

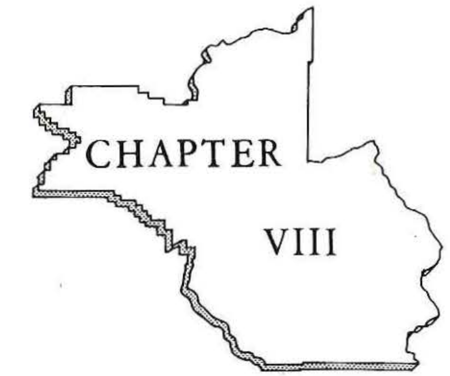
FUTURE CAPITAL EXPENDITURES. Some of the basic cost assumptions in the CRAG Water Plan were discussed in the previous section on updating the plan. The following capital expenditure cost estimates (Table VII-2) are based on these assumptions and the system configurations proposed in the CRAG Water Plan. In general, these costs probably slightly understate the actual costs that would be involved. These costs are based on 1969 prices and are given to provide an order-of-magnitude approximation only. They should not be used for detailed financial planning or as the basis for a bond issue.

TABLE VII-2
CRAG WATER PLAN
CONSTRUCTION COST SUMMARY
(1969 Prices)

		Subarea No. 1 Clark Co.	Subarea No. 2B Western Washington Co.	Subarea No.'s 2A, 4 & 5 E. Mult. Co., Portland, E. Wash. Co.	Subarea 3 Clackamas Co.	Total
1970-1980	Impoundment and Supply	$ 260,000[1]				
	Transmission Lines		3,340,000	16,160,000[3]		
	Treatment Plants				3,070,000[6]	
	Distribution Storage[9]	1,220,000		950,000	150,000	
	TOTAL	1,480,000	3,340,000	17,110,000	3,220,000	25,150,000
1980-1990	Impoundment and Supply	290,000[1]		4,300,000[4]	300,000	
	Transmission Lines				1,110,000	
	Treatment Plants				2,040,000[7]	
	Distribution Storage[9]	840,000	160,000	2,700,000	750,000	
	TOTAL	1,130,000	160,000	7,000,000	4,200,000	12,490,000
1990-2000	Impoundment and Supply	350,000	3,679,000[2]	9,100,000[5]		
	Transmission Lines					
	Treatment Plants				2,000,000[8]	
	Distribution Storage[9]	900,000	243,000	2,900,000	1,575,000	
	TOTAL	1,250,000	3,922,000	12,000,000	3,575,000	20,747,000
GRAND TOTAL		3,860,000	7,422,000	36,110,000	10,995,000	58,387,000

[1] Wells
[2] Phase II-Trask River Dam.
[3] Conduit No. 5 - Bull Run and Booster Pump
[4] Blazed Alder Dam - Bull Run.
[5] South Fork Dam - Bull Run
[6] Addition of 10 MGD capacity to Clackamas Water District Treatment Plant, 6 MGD Capacity to South Fork Water Board Plant.
[7] New 15 MGD Clackamas Water District Treatment Plant and 10 MGD to Lake Oswego Treatment Plant.
[8] Addition of 15 MGD to Clackamas Water Treatment Plant.
[9] Distribution Storage Priced at $45,000 per Million Gallons Capacity, Required Capacities from Table VI-6.

IMPLEMENTING THE CRAG WATER PLAN



SUMMARY

This chapter contains a discussion of the governmental organizations authorized to build water supply systems under Oregon or Washington law. Those organizations pertaining to Oregon include cities, domestic water supply corporations (water districts), county service districts and the Metropolitan Service District Act of 1969. The organization pertaining to Washington include water districts and metropolitan municipal corporations. The discussion of Oregon cities is generally applicable to Washington cities also.

There is also a discussion of the various means of financing water systems. The methods discussed in this chapter are assessments, connection charges, water service charges, ad valorem property taxes, revenue bonds, and general obligation bonds. The 1968 assessed value of property in the CRAG area was approximately $7 billion (true cash value). Bond issues amounting to 10 percent of this could therefore be for as much as $700 million.

Federal financial assistance may play a major role in the financing of a regional water supply system. Because of the regional problems associated with water supply and the need to coordinate planning, it would appear that CRAG would be the logical agency to initiate and coordinate efforts to establish regional water supply systems. CRAG will, in any event, play a major role in the application and allocation of federal financial assistance.

Three suggested alternatives for implementing the CRAG Water Plan were also discussed. These alternatives included a regional water authority, separate governmental organizations responsible for each subarea, the role of CRAG as a regional planning and coordinating agency, and local agreement contracts. Table VIII-2 summarizes the organizations and responsibilities of each of these alternatives.

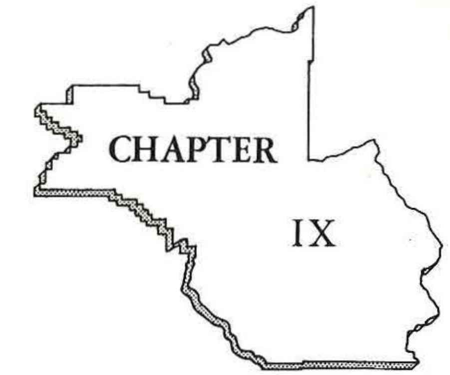
The CRAG Water Plan is believed to contain sound procedures for meeting future water needs as they appear today, based on information accumulated during the past 12 months. Like all plans, this plan should be continually reviewed and occasionally revised to meet changes in the local situation.

To facilitate updating the CRAG Water Plan, considerable data are compiled on computer punch cards. This data includes stream flows, precipitation, water rights and population. In addition, the five basic elements of cost, namely, source development, transmission, treatment, operation, and pumping were incorporated into a systems program. This program will also facilitate updating the plan.

TABLE VIII-2

POSSIBLE GOVERNMENTAL ORGANIZATIONS
FOR IMPLEMENTING THE CRAG WATER PLAN

Organization	Responsibility
ALTERNATIVE NO. 1	
1. Regional Water Authority	A. Regional Planning. B. Implementation of Plan. C. Coordinating Regional Plans With Local Plans. D. Supply and Distribute Water To Local Agencies on Wholesale Basis.
2. Local Water Supply Agencies	A. Supply Water to Residents Of CRAG Study Area.
ALTERNATIVE NO. 2	
1. CRAG	A. Regional Planning Agency. B. Coordinate Regional Plans With Local Plans. C. Maintain Close Relationship With Subareas.
2. Subarea Governing Bodies	A. Implement Area Plan. B. Service Districts Wholesale Water To Local Water Supply Agencies. C. Enter Into Cooperative Agreements. D. Coordinate Local Plans With Regional Plans.
3. Local Water Supply Agencies	A. Supply Water to Residents of CRAG Study Area.
ALTERNATIVE NO. 3	
1. Local Water Supply Agencies	A. Cities and Districts Enter Into Various Cooperative Agreements. B. Implement CRAG Water Plan. C. Supply Water to Residents of CRAG Study Area.



A REVIEW OF INFORMATION ON THE RADIOACTIVITY OF THE COLUMBIA RIVER IN THE HANFORD TO VANCOUVER REACH AND ITS BEARING ON WATER QUALITY

By

Dr. Arthur F. Scott, Professor of Chemistry and
Director of Nuclear Reactor Project, Reed College, Portland, Oregon

This report deals with the question of radioactive contamination of the Columbia River water, one of the factors to be considered in any judgment of the quality of this water. The plan of the report is given in the outline below:

Section 1. Introductory Note on Radioisotopes: Pertinent terms and units of radioactivity.
Section 2. Potentially Harmful Effects of Radiations Emitted by Radioisotopes.
Section 3. The Sources of Radioisotopes Found in the Columbia River.
Section 4. The Fate of Radioisotopes in the Columbia River.
Section 5. Columbia River Water as a Source of Drinking Water.
Section 6. Conclusions

To anticipate the conclusions drawn from this report it can be stated that water from the Columbia River between Bonneville Dam and Vancouver can be used as a supply of drinking water with no significant risk so far as radioactive contamination is concerned.

SECTION 6

CONCLUSIONS

Our study of the Columbia River system to determine its radioactive content in the reach between Bonneville Dam and Vancouver has shown clearly that this factor does not impair the quality of the river water from the standpoint of its use as a source of drinking water. The lines of evidence on which this conclusion is based can be summarized as follows:

1. Radioisotopes enter the Columbia River from three sources: the Hanford Operations at Richland, Washington; fallout of debris from atomic weapons tests; and radioisotopes naturally present in the soils. The Hanford operation overshadows the other two sources.
2. The Hanford operation is carefully monitored and from these observations, it is known that the radioactive contamination introduced into the river by the plant falls well below limits set by the Atomic Energy Commission.
3. Three communities, Richland, Pasco and Kennewick, located less than fifty miles downstream from the Hanford operation, have, for more than five years, derived water for their domestic water systems from the Columbia River. The river water is subjected to the usual purification treatment before being distributed to the users. The drinking water from each of these three systems is under constant surveillance for radioactive contamination and has been found to meet quite satisfactorily the standards established by the Federal Radiation Council and other responsible agencies.
4. Whatever the radioactive contamination of the drinking water in the water system of Richland, it can be viewed as maximum from the standpoint of any location downstream from Richland. Because one of the characteristics of radioisotopes is that it is always decaying away with time (i.e. disappearing), the rate of decay being a unique property of the radioisotope. What this means in the present instance is that the concentration of each radioisotope in the Columbia River at Richland will diminish with time as the radioisotope moves downstream, the degree of reduction depending on the half-life of the radioisotope and on the flow time between Richland and the specified downstream location.
5. From (1) the known facts regarding the drinking water at Richland, Pasco and Kennewick; and (2), the inevitable decay of radioactivity with time, it follows that drinking water derived from the Columbia River at some point below Bonneville Dam will, in all probability, never carry a greater contamination than that found in the Richland water. Since the quality of Richland water is acceptable, water in a system deriving its supply from the Columbia below Bonneville Dam must also be acceptable.
6. The data assembled and examined in the present Review are, for the most part, for a period when five or more production reactors were in operation at Hanford. The number of reactors now in operation has recently been reduced from three to two. It is reasonable to expect, therefore, a gradual reduction of the radioactive contamination levels in the Columbia River to approximately 50 percent of the values cited in this Review.

* *

The writer wishes to acknowledge with thanks the helpful suggestions he has received from a number of persons who were kind enough to read this Review while it was in preparation. He is especially indebted to Mr. George L. Toombs, Chief Radiochemist, Division of Sanitation and Engineering of the Oregon State Board of Health.