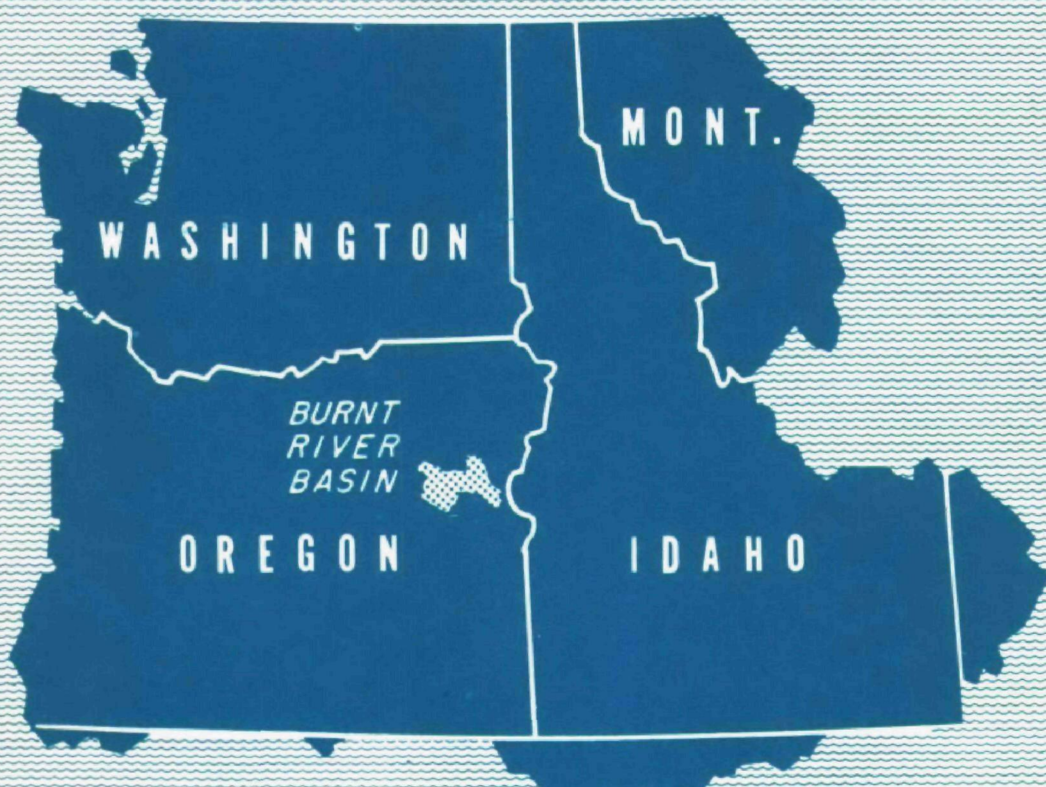
WATER QUALITY CONTROL STUDY

Burnt River Basin Project

Dark Canyon Division, Oregon



APRIL 1966

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

W A T E R Q U A L I T Y C O N T R O L S T U D Y

B U R N T R I V E R B A S I N P R O J E C T

D A R K C A N Y O N D I V I S I O N

O R E G O N

AN INVESTIGATION OF QUALITY CONDITIONS IN THE BURNT RIVER BASIN DISCLOSES NO FUTURE NEED FOR STORAGE FOR WATER QUALITY CONTROL AS EXISTING DEVELOPMENT WILL CONTINUE TO PROVIDE SUFFICIENT FLOW REGULATION. FUTURE WATER REQUIREMENTS AND QUALITY PROJECTIONS ARE BASED ON ECONOMIC, DEMOGRAPHIC, AND ENGINEERING STUDIES.

P r e p a r e d a t t h e R e q u e s t o f t h e

U. S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation, Region 1
Snake River Development Office
Boise, Idaho

B y t h e

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration, PNW
Portland, Oregon

April, 1966

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I. INTRODUCTION

A. Request and Authority

The request for this report was made by the U. S. Bureau of Reclamation, Region I, Snake River Development Office, Boise, Idaho, by letter dated October 23, 1964. Authority for the investigation and report is the Federal Water Pollution Control Act, as amended (33 U.S.C. 466d(b)).

B. Purpose and Scope

This investigation was conducted to advise the Bureau of Reclamation on the need for and value of storage for water quality control in the Burnt River Project, Dark Canyon Division. The Burnt River drainage basin lies in the southern portion of Baker County, Oregon.

Available data on water uses, waste sources, and water quality in the study area were examined, evaluated, and projected. Evaluations are based on projected conditions for periods to 1985 and 2010. The economic base study prepared for this purpose is summarized in the report.

C. Acknowledgments

Assistance in this investigation was provided by officials of the town of Huntington, the Oregon-Portland Cement Company, the Oregon State Sanitary Authority, and the U. S. Bureau of Reclamation. The cooperation of persons within these organizations is gratefully acknowledged.

II. SUMMARY of Findings and Conclusions

A. Summary of Findings

1. The Bureau of Reclamation is evaluating the availability of water for irrigation of new lands and as a supplement for lands presently inadequately irrigated. Municipal, industrial, and domestic water supply needs, flood control, and other multi-purpose uses are being studied to coordinate the use of new facilities with the existing Unity Reservoir. Development of multi-purpose storage at the Hardman site on the South Fork of Burnt River and at the Dark Canyon site on the main stem (see Location Map, back cover) is being considered as a source of additional water. The enlargement of existing Unity Dam and Reservoir is also being considered as an alternate to storage at the Dark Canyon site.

2. The study area covered in this report is the entire Burnt River drainage basin which is comprised roughly of the southern half of Baker County, Oregon. The principal community in the area is Huntington; other communities are Dixie, Durkee, Pleasant Valley, Bridgeport, Hereford, and Unity.

3. The 1960 population of the study area was 1,110, of which about 700 lived in the Huntington area. Economic studies show only limited potential for population growth. The economic base of the Burnt River valley is agriculture, and water resource development is oriented principally toward this base.

4. The drainage area of the Burnt River Basin is about 1,100 square miles. Existing water resource development in the basin consists of Unity Reservoir (total capacity of 25,820 acre-feet) and four small reservoirs (aggregate storage capacity of about 3,900 acre-feet).

5. The average annual runoff of the basin is 82,530 acre-feet, as measured at the lower-most gaging station on the river. The one-in-ten year low mean annual runoff of the Burnt River is 37,600 acre-feet. Before regulation by Unity Reservoir, the river was often dry during July and August.

6. Municipal and industrial (M&I) water use in the study area presently averages about 0.8 million gallons per day (mgd). About 80 percent of this use is for industrial purposes (Union Pacific Railroad and Oregon-Portland Cement Company).

7. In addition to being the major source for M&I supply, surface water is used for irrigation, fish and game propagation, stock watering, and recreation. Stream waters of the basin receive irrigation return flows and waste waters from M&I sources.

8. The mineral quality of waters in upper watershed areas of Burnt River is excellent; i.e., dissolved solids are about 100 parts per million (ppm). Waters in lower reaches of the river are higher in mineral content but are suitable for all uses, including M&I water supply. The organic matter discharged to the river from M&I waste sources and land drainage has been adequately assimilated under regulated flow conditions in recent years without detriment to the requirements of fish and other aquatic life. Discharge of untreated sewage to the river from the City of Huntington, however, has created conditions hazardous to public health.

9. The only sewage collection system in the basin is located at Huntington. Preliminary plans have been made to install a secondary waste treatment plant. When this plant is in operation, the loading to the river (including uncontrolled runoff wastes from urban and rural areas) is expected to average about 100 population equivalents (PE) per day.

B. Conclusions

1. The population of the study area will be 1,600 by 1985 and 1,900 by 2010.

2. Water quality should be provided in the Burnt River at a level to protect fish and wildlife, maintain recreational opportunities, safeguard public health, and preserve the attractiveness of stream waters. In addition to the need for adequate waste treatment--including effluent disinfection and controlled surface drainage--there is a need for assured quantities of streamflow in the lower reaches of the river to assimilate residual waste materials. Control of flow to maintain dissolved oxygen (DO) at and above a minimum of 5 milligrams per liter (mg/l) in the critical zone of the river during the summer and early fall months will provide protection of all stream uses, including passage of anadromous fish and propagation of resident fish species.

3. Even with adequate waste treatment providing 85 percent reduction of oxygen-demanding wastes, the remaining loads, together with uncontrolled loads from urban and rural runoff, pose a potential hazard to stream uses, particularly if further development of the basin's water resources for irrigation results in a reduction of streamflows. Daily residual loads to the river from all sources by the years 1985 and 2010 are expected to be relatively small, averaging about 120 and 150 PE, respectively. It is anticipated that additional irrigation return flows created by the proposed project will not significantly degrade Burnt River water quality. It is possible, however, that nutrients contained in these waters, together with other factors, may at times stimulate excessive biological growths.

4. Waters stored at the Dark Canyon site would consist partly of irrigation return flows originating from lands located upstream. Biological growths stimulated by nutrients in these waters would, upon decomposition in the reservoir, be expected to reduce DO concentrations at lower depths of the impoundment.

5. Without specific releases of water to the lower Burnt River from storage, the average monthly low flows at Huntington having a recurrence frequency of once-in-ten years would be less than one cubic foot per second (cfs) in July and zero in August. Under these conditions, flows below Huntington would consist mainly of waste effluent. Regulation provided by Unity Reservoir has resulted in average monthly flows at Huntington during July and August of 25 cfs or more each year since the beginning of its operation in 1938. With the proposed irrigation project, however, this flow could be expected to be considerably reduced.

6. A total minimum sustained flow of 5 cfs will adequately control water quality in the lower reaches of Burnt River (below the proposed Dark Canyon Dam) throughout the 50-year study period, provided that waters released from storage contain a DO concentration of at least 5 mg/1 and that all M&I wastes receive adequate treatment--at least 85 percent biochemical oxygen demand (BOD) removal. This minimum flow would complement waste control at the source and would not be a substitute for adequate waste treatment. An annual draft-on-storage[1/] of approximately 600 acre-feet would be required to maintain this control of water quality.

1/ Annual draft-on-storage is the sum of incremental excesses of needed releases over inflows during a climatic year (April through March).

7. Storage releases in excess of 5 cfs, as now provided by Unity Reservoir, will continue to control water quality in the river basin. These releases enhance the attractiveness of the stream and otherwise affect the well-being of the more than 1,000 residents in the area. The benefits derived from water quality maintenance in the Burnt River are both tangible and intangible and are widespread both in area and type of beneficiary.

8. The minimum value of water quality control storage is equal to the cost of providing regulation by the cheapest single-purpose alternative reservoir that could be built in the absence of the proposed project. The minimum value assignable to an annual draft-on-storage of 600 acre-feet in either Dark Canyon Reservoir or enlarged Unity Reservoir for water quality control is estimated to be $28,770 or $48.00 per acre-foot based on a 100-year project design life, an annual operation and maintenance expense of $4,200, and interest at 3.125 percent. However, inasmuch as continued flow regulation by Unity Reservoir is expected to meet all future requirements, no monetary benefit for quality control can be attributed to the proposed project. If the proposed development curtails streamflow to less than 5 cfs, then the project should be assessed a cost or damage of $28,770 per year.

9. Waters available from Burnt River are of adequate quality and quantity to meet projected M&I demands through the 50-year study period. Also, as long as the quality of ground water is protected, this source is expected to adequately supply the needs of the smaller communities in the basin.

III. PROJECT DESCRIPTION

A. Location

Storage requirements of the proposed Dark Canyon Division of the Burnt River Project would be met by development at two sites. The first is Hardman Dam and Reservoir on the South Fork Burnt River 8 miles upstream from the existing Unity Dam. The other is Dark Canyon Dam and Reservoir on the main stem Burnt River 37 miles downstream from Hardman Dam. The enlargement of existing Unity Dam and Reservoir is also being considered as an alternative to storage at the Dark Canyon site. Dark Canyon Dam is 18 air-miles south of Baker, Oregon, and 42 air-miles northwest of Weiser, Idaho (see Location Map, back cover).

The drainage area of the South Fork Burnt River at Hardman Dam is approximately 45 square miles. Runoff of the South Fork originates entirely from snowmelt on a heavily timbered watershed. Topography, climate, and cover on the watershed are conducive to a sustained year-around runoff. Flows increase moderately in the spring. During the latter part of the irrigation season, the South Fork very seldom drops below 25 cfs. The average, maximum, and minimum annual runoff at the Hardman Dam site are 25,400, 32,600, and 17,500 acre-feet, respectively, as determined from recorded and estimated flows for the period 1928 through 1955.

The Burnt River above Dark Canyon Dam drains an area of about 650 square miles. Runoff of Burnt River at the dam site comes from spills at Unity Reservoir in the spring, runoff between Unity Reservoir and the Dark Canyon site, irrigation return flows from the Bridgeport area, and waste flows from upstream diversions. The average, maximum, and minimum annual runoff of the river at this site with present upstream development are estimated to be 48,600, 104,700, and 15,800 acre-feet, respectively.

The drainage area above Unity Dam is about 308 square miles. The North, West, Middle, and South Forks of the Burnt River flow into Unity Reservoir. The average, maximum and minimum runoff into Unity Reservoir, as determined from recorded and estimated flows for the period 1928 through 1964, are 60,000, 108,000, and 22,500 acre-feet, respectively.

B. Proposed Project

The proposed Dark Canyon Division will be integrated with the existing Burnt River Project to supply water for irrigation on new lands, to provide a supplemental supply for lands now inadequately irrigated, and to serve other multi-purpose needs, including M&I water supply, water quality control, flood control, fish and wildlife, and recreation. Approximately 5,500 acres of irrigated land would be provided a supplemental irrigation water supply, and about 5,000 acres would be provided a full irrigation water supply. These lands are scattered along the Burnt River from near Unity on the South Fork down to Huntington near the mouth of the river.

With either Hardman and Dark Canyon Reservoirs or Hardman and enlarged Unity Reservoirs in the plan of development, storage in the Burnt River Basin will control about two-thirds of the average annual discharge of the river at Huntington. Principal features of the proposed reservoirs are given in TABLE III-1. A minimum sustained release would be provided from Dark Canyon Reservoir. Minimum releases from Hardman Reservoir and from existing or enlarged Unity Reservoir might not be maintained during part of the storage season of dry years. However, the increased return flow resulting from project irrigation will assure that a live stream is maintained a short distance below the Hardman and Unity dam sites.

The quality of water impounded in Dark Canyon Reservoir will be affected somewhat by irrigation return flows. Nutrients carried by drainage from irrigated lands will tend to accumulate in the reservoir and thereby stimulate algal growth. Unity Reservoir will be similarly affected but to a lesser degree. If lands above Hardman Reservoir remain undeveloped, nutrient build-up would be limited.

Flow requirements for water supply and water quality control are centered at Huntington, which is located near the confluence with the Snake River. Huntington, with a population of about 700 persons, is the only community of significant size in the basin.

TABLE III-1
PROPOSED RESERVOIRS
BURNT RIVER BASIN, OREGON

Reservoir	Storage Class	Storage (acre-feet)	Water Surface Elevation (feet)	Surface Area (acres)
HARDMAN	Total	14,000	4,370	257
	Inactive	1,850	4,296	80
	Usable	12,150	---	---
DARK CANYON	Total	12,000	3,323	210
	Inactive	2,000	3,255	95
	Usable	10,000	---	---
ENLARGED UNITY. . .	Total	52,000	3,842	1,450
(alternate to	Inactive	5,800	3,793	520
Dark Canyon)	Active	46,200	---	---

IV. STUDY AREA DESCRIPTION

A. Location and Boundaries

The Burnt River drainage basin in Baker County, Oregon, comprises the study area of this report (see Location Map, back cover). Huntington is the principal community. The basin also contains several smaller communities including Dixie, Durkee, Pleasant Valley, Bridgeport, Unity, and Hereford. Agriculture forms the primary economic activity in the study area.

B. Geography and Topography

The Burnt River is formed by the junction of its North, West, Middle, and South Forks, which drain part of the southeastern slopes of the Blue Mountains in East-Central Oregon. The river flows eastward 53 miles to join the Snake River near Huntington. U. S. Highway 30 and the main line of the Union Pacific Railroad follow the river from its mouth to Durkee. U. S. Highway 26 traverses the eastern part of the basin.

Draining approximately 1,100 square miles, the basin is about 25 to 30 miles wide at each end, 8 miles wide near the center, and 55 miles long. The western part of the basin lies almost wholly in the timbered Blue Mountains. The central part of the basin is characterized by high, steep, grassy, rolling hills which rise from narrow canyons to elevations of about 5,000 feet above sea level. In the eastern part of the basin, tributary streams have wider valleys which contain cultivated irrigation areas surrounded by rolling sage- and grass-covered hills at elevations up to 4,000 feet above sea level.

The Burnt River Valley, throughout most of its length, is narrow and canyon-like. In several areas, however, it broadens appreciably and is relatively flat bottomed. One such area is just north of Unity; a second, and the largest, lies between the mouth of North Fork Burnt River and Bridgeport; and a third is in the vicinity of Durkee.

C. Climate

The climate of the study area is typically semi-arid, although local areas of higher elevations are moderately wet. Normal annual precipitation varies from 10 inches near Unity to 40 inches in the extreme western portion. The average for the basin is approximately 15 inches. Precipitation is fairly evenly distributed, with some variation in the dry areas throughout the year; whereas, in wetter areas, increased amounts occur during the winter months. The proportion occurring as snow increases with elevation and is about 30 percent of the total at the 3,000-foot level.

Hot, dry summers are characteristic of the area. Although nights are cool, daytime termperatures above 90 degrees Fahrenheit (^{o}F) are common and occasionally exceed 100 ^{o}F. Winters are generally mild, but short periods of sub-zero temperatures occur occasionally. The growing season in agricultural areas ranges from 150 to 180 days.

Significant storms affecting this area are those consisting of widespread precipitation. Such storms occur chiefly during the winter months and have an average duration of three days. Convective-type storms of a more localized nature occur chiefly during the summer months and, because of the short duration and small areal coverage, are of little significance.

D. Principal Communities and Industries

The present population of the study area is approximately 1,100. Huntington, with a population of about 700, is the only notable community in the area. In addition to livestock raising, the cement mill at Lime is the only significant industry.

V. WATER RESOURCES of the Study Area

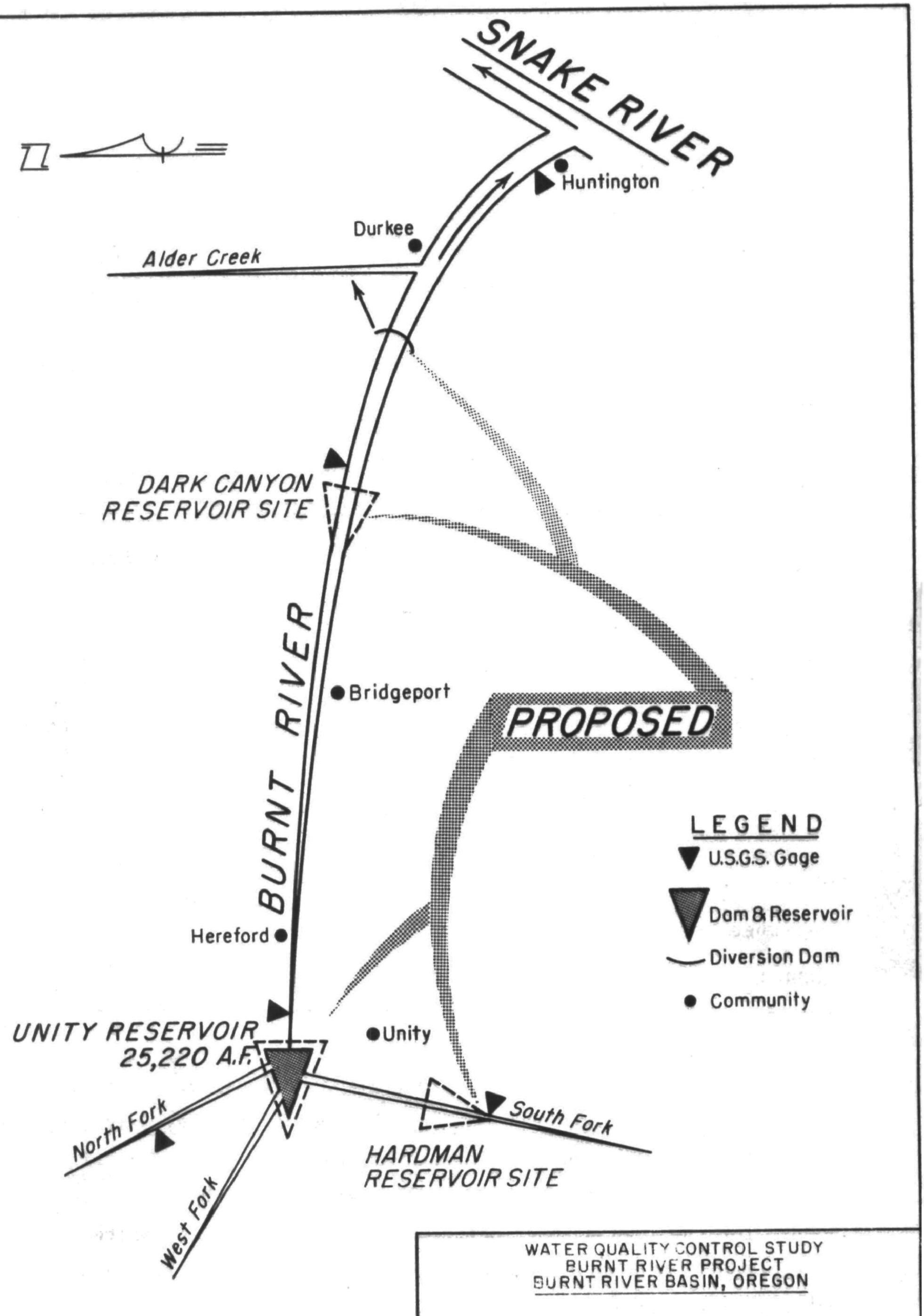
A. Surface Water

1. Quantity

In 1933, the Bureau of Reclamation, in cooperation with the State of Oregon, investigated the possibility of developing storage on Burnt River as a source of late-summer water supply. Unity Dam and Reservoir and the present Burnt River Irrigation Project were then built, following the plan developed from this investigation. The reservoir, completed in 1938, has a total capacity of 25,820 acre-feet, with 25,220 acre-feet as active storage. The surface area of the reservoir, when full, is 926 acres. Unity Dam is located about 70 miles upstream from the river's mouth and has a drainage area of 308 square miles (see FIGURE 2, Schematic Diagram).

Burnt River Basin waters are used to irrigate about 23,000 acres of land located in three non-contiguous valleys along the main stream. Water is supplied by gravity diversions of natural flow and supplemented by water stored in four small reservoirs, with an aggregate storage capacity of about 3,900 acre-feet, and by Unity Reservoir.

Highest streamflows, which result from melting of winter snows, usually occur in March or April. The duration of the high-water stage is short, and the rate of flow diminishes rapidly. At the beginning of the irrigation season, water supply is sufficient for lands now irrigated, but natural runoff must be augmented from storage reservoirs as the season advances.



WATER QUALITY CONTROL STUDY
BURNT RIVER PROJECT
BURNT RIVER BASIN, OREGON

SCHEMATIC DIAGRAM

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Federal Water Pollution Control Administration, P.N.W.
REGION IX (DATE: 3/66) PORTLAND, OREGON

FIGURE 2

A frequency analysis was calculated for the uncontrolled Burnt River runoff at Huntington and is presented in TABLE V-1. The annual mean flows (with recurrence intervals of five, ten, and twenty years) and the typical monthly distribution of annual mean flows are shown. Monthly mean flows were determined for purposes of calculating draft-on-storage needs.

TABLE V-1
EXPECTED MEAN MONTHLY LOW FLOWS UNDER UNREGULATED CONDITIONS
BURNT RIVER AT HUNTINGTON, OREGON

Month	Percent of Annual Mean	Recurrence Intervals - Years		
		Five (cfs)	Ten (cfs)	Twenty (cfs)
January	62.7	48	33	23
February.	93.4	72	49	34
March	178.4	137	93	64
April	455.6	351	237	164
May	165.3	127	86	60
June.	58.1	45	30	21
July.	1.1	0.8	0.6	0.3
August.	0.1	0.1	0.0	0.0
September	15.3	11.8	8.0	5.5
October	52.0	40	27	19
November.	55.7	43	29	20
December.	66.5	51	35	24
ANNUAL MEAN		77	52	36

Since 1938, streamflow regulation by reservoir storage has substantially increased flows during the months of June, July, August, and September. Although regulation has been primarily for irrigation purposes, other stream users have also benefited. These include water supply for the town of Huntington and the Union Pacific Railroad which, respectively, have rights to 0.5 cfs (360 acre-feet per year) and 450 acre-feet per year.

Summaries of recorded streamflows and flows that would exist without releases from existing storage are included in the Appendix. Historical data were derived from the U. S. Geological Survey gage located near Huntington. The drainage area at that point is 1,093 square miles. The average discharge for the period of record is 114 cfs (82,530 acre-feet per year). Maximum recorded daily discharge of 2,190 cfs occurred in February 1957. Before regulation by Unity Reservoir, the river was often dry during July and August. Streamflow regulation has improved this situation, although there are indications that flows are curtailed somewhat during periods of reservoir filling.

2. Quality

In general, water quality throughout the Burnt River Basin is suitable for all present and expected future uses. The analyses of Burnt River water samples show a variation in chemical quality in the river system with respect to high and low flow and a general increase in dissolved mineral concentrations in a downstream direction.

Samples for mineral analyses, collected in 1958-60 by the U. S. Geological Survey in the headwaters of the Burnt River, generally had dissolved solids contents of less than 100 ppm during high-flow periods and less than 200 ppm during low-flow periods (see Appendix). In the lower reaches of the Burnt River, the nature and magnitude of the dissolved solids has been changed somewhat by return flow from irrigation. Dissolved solids content increased from an average of about 100 ppm in the headwaters to about 350 ppm at Huntington. Water was generally of a calcium bicarbonate type, except in a few tributaries where water contained appreciable sodium concentrations during low-flow periods.

The Burnt River Basin has very little industrial activity. A large cement plant at Lime, Oregon, utilizes part of a sizeable deposit of limestone. Waste waters, high in solids content and having characteristic gray color, are occasionally discharged to the river from this plant but apparently have very little effect on the chemical quality of the river. Although complete data are not available, chemical and bacteriological quality of the river is adequate for the water uses of this sparsely settled basin.

B. Ground Water

1. Quantity

Quantities of ground water sufficient for farm and domestic use are generally available from the alluvium located along the main stem Burnt River and its tributaries. Although many parts of the remainder of the basin have not yet been drilled or tested, it is not believed that large supplies of good quality ground water exist. Yields of individual wells of moderate depth range from less than 1 to more than 50 gallons per minute (gpm), depending upon the hydrologic characteristics of the aquifer at each well location.

Maximum sustained yields of the existing wells in the area are about 75 gpm. Considering the low permeability of most of the rocks in the Burnt River Valley, it is concluded that most aquifers in the Valley would yield water too slowly to sustain the large continuous draft needed for irrigation.

2. Quality

Chemical quality data indicate that, except for a few localities, ground water in the Burnt River Valley is satisfactory for all existing uses. Samples of water from seven wells were collected in September 1963 and analyzed for mineral content. These data are included in the Appendix. Analyses of samples from four of these wells indicate that waters are of suitable chemical quality for irrigation and most other uses. Analyses of samples from two other wells indicate that the water from these wells may be undesirable for irrigation due to relatively high concentrations of boron and sodium. A sample from still another well contained 205 ppm nitrate, which is far in excess of the 45 mg/l recommended by the USPHS as the maximum allowable concentration of nitrate in drinking water.

Comparison of the analyses of ground and surface water shows that, as is usual, the ground water generally has greater concentrations of dissolved minerals than the surface water. For example, the specific conductance, which is an indication of concentration of dissolved minerals, ranged from 433 to 1,590 and averaged about 884 micromhos in the ground water samples. The specific conductance of the surface water samples ranged from 89 to 677 and averaged only about 536 micromhos.

VI. THE ECONOMY

A. General

The economic base area used in this study conforms to the Burnt River drainage basin. Fifty-year economic and demographic projections have been made to year 2010 from the base year of 1960, with an intermediate point at year 1985. These projections serve as a basis for estimating future M&I water use and for estimating waste loads that will be discharged to the Burnt River.

B. Present

Agriculture is the principal economic activity of the study area. Livestock raising has been the most important type of agriculture in the basin since the area was settled, and an increasing portion of the total available farm area is being used for hay and pasture land. Existing irrigated lands, comprising about 23,000 acres, are utilized primarily to support beef production with forage and winter feed crops. Irrigated land at lower elevations is suitable for growing potatoes, sweet corn, sugar beets, and onions. Processing markets for these and other commodities have developed rapidly at several nearby communities, including Ontario (a food processing center about 25 miles from Huntington), Weiser, Nyssa, Payette, and Fruitland. The regional service center, Boise, also provides well-developed service markets accessible to the study area.

The Oregon-Portland Cement Company plant at Lime, with its associated limestone quarry at Durkee, is the only manufacture-based industry in the study area. Present production of the plant is about 1.2 million barrels per year. Limestone is abundant, and major construction projects in the central and lower basin of the Snake River promise ample market support for the facility far into the future.

The direction of population change in the study area over the last three decades is shown in TABLE VI-1. The picture of declining rural population that the table presents is a typical one for an agricultural area. The rate of decline, however, is remarkably steep. There are few places in the Pacific Northwest that lost population during the 1940's, a period of explosive growth for the region. The rather less severe decline in population of the community of Huntington seems explainable in terms of habit, ability to provide the functions of a minor rural service depot, and employment opportunities in nearby communities.

TABLE VI-1
STUDY AREA POPULATION, 1930-60

Location	Number of Persons				Annual Rate of Change			
	1930	1940	1950	1960	1930-40	1940-50	1950-60	1930-60
Huntington	803	741	733	689	-0.8	-0.1	-0.6	-0.5
All Other	970	885	648	423	-0.9	-3.2	-4.3	-2.8
TOTAL . .	1773	1626	1381	1112	-0.9	-1.7	-2.2	-1.6

NOTE: For 1960, the study area is assumed to be coterminous with the census division "Huntington". For prior years, the precincts "Huntington", "Rye Valley", "Bridgeport", "Durkee", "Connor Creek", and "Weatherby" (an area slightly smaller than the 1960 census division) are assumed to represent the study area.

SOURCE: U. S. Census of Population, 1950 and 1960.

C. Factors Influencing Future Growth

Relying largely on agriculture for its economic livelihood, the Burnt River Basin's future development must be related to the evolution of agriculture in the Central Snake River area. The likely course is marked by existing trends. The predominant factors which will influence the economic future of the study area to the year 2010 seem to be (1) continuing decline in farm employment opportunities as a result of farm consolidation, (2) continuing erosion of the service base at Huntington as farm populations drop and residents of the area turn increasingly to markets in larger communities, (3) expanded agricultural outputs resulting from additional irrigation, and (4) steady operation of the one manufacturing industry.

Development of a substantial manufacturing industry appears most unlikely. The area is not favorably oriented to major markets for heavy manufacturing industries. The presently known mineral resources present little prospect of intensive exploitation. The absence of educational and cultural resources generally associated with industries employing advanced technology precludes likelihood of establishment of science-based industries.

D. Future

The irrigation projects under study are the principal modifying factors to be considered in gaging the future of the area. If the history of other irrigation developments may be used to interpret probable effects in the study area, additional irrigation can be expected to slow the downward course of population.

Although it is recognized that row crops could be grown on some land in the basin, it is anticipated that water supplies furnished by the Dark Canyon Division will be used primarily to produce additional feed and forage for livestock. Any agricultural outputs are more likely to result in expansion of food processing activities in the Ontario service area than in establishment of processing in the Burnt River Basin.

Under the Dark Canyon plan of development, approximately 5,500 acres of irrigated land would be provided a supplemental irrigation water supply and about 5,000 acres would be provided a full irrigation water supply. These lands are scattered along the Burnt River from near Unity on the South Fork down to Huntington near the mouth of the river.

In the past, logging and sawmilling have contributed to the economy of the basin. However, future development of the basin's timber resource will probably take place near Baker, Oregon, where moderate expansion of the forest products industry is expected to take place.

The cement-producing facility at Lime appears to be the principal force sustaining population in the area. As the only producer of cement in a large area marked by major construction projects, the plant may well experience sharp rise in output over the study period. Expansion of capacity to 5 million barrels per year (the median size of modern plants) between years 1985 and 2010 may be postulated for design purposes.

Neither the recent history of the area nor the prospects of economic development outlined above suggests vigorous population expansion during the study period. A projection based on past trends would suggest continuing decline. However, in the interest of consistency and to provide a margin for error, an allocation method has been used which consists of the application of growth rates to groups of communities of a certain size class. These rates were developed in the economic forecast for the Central Snake River Basin. This procedure suggests a population for Huntington of roughly 800 by year 1985 and 1,000 by year 2010 (see TABLE VI-2).

TABLE VI-2
ESTIMATED POPULATION
BURNT RIVER BASIN

Location	Number of Persons 1960	1985	2010
Huntington	689	800	1000
All Other	423	800	900
TOTAL	1112	1600	1900

It should be noted, however, that establishment of a moderately sized factory in the area would create conditions for expansion of greater magnitude. Conversely, failure of new irrigation opportunities might result in slower growth or even decline.

VII. WATER REQUIREMENTS
Municipal & Industrial

A. Past and Present Water Use

Irrigation has been the prevailing water use in the Burnt River Basin for more than 30 years. Other uses are minimal and include farm uses, such as stock watering, and domestic water supply. The cement plant at Lime has a modest requirement, as does the Union Pacific Railroad shop at Huntington.

The Burnt River Basin is presently developed to the extent that about 23,000 acres (mostly in narrow areas along the river) are being irrigated with natural flows, 25,220 acre-feet of storage in Unity Reservoir, and 3,900 acre-feet in four other reservoirs.

The Huntington municipal water facilities serve approximately 700 persons at the average rate of 150,000 gallons per day (gpd). Water is obtained from a well and an infiltration gallery on the Burnt River. The water plant has a rated capacity of 480,000 gpd (0.75 cfs). Other communities in the study area have less than 200 residents and are served by wells or other individual facilities.

The Oregon-Portland Cement plant, producing about 1.2 million barrels per day, uses approximately 540,000 gpd for cooling and 190,000 gpd is consumed in the slurry process. Thus, total demand from the river is approximately 730,000 gpd or 1.1 cfs. The Union Pacific Railroad has a water right of 450 acre-feet per year, which is an average of about 0.6 cfs.

B. Forecast of Future Water Needs

Projections developed in the Economy Section indicate that no substantial increase in population or economic activity, with the exception of the cement plant, will occur in the study area within the next 50 years. It is probable, therefore, that future demands for municipal and industrial water will not increase significantly. Installed capacity of the municipal plant at Huntington is considered adequate to meet future needs. Similarly, future rail activities in the area are not expected to create an additional need for water. Increased production at the cement plant (to 5 million barrels per year) will require an estimated 1.7 mgd (2.7 cfs) for cooling and process water in year 2010. This includes about 900,000 gpd for cooling and about 800,000 gpd for the slurry process.

VIII. WATER QUALITY CONTROL

A. Need for Control

Water quality control needs in the Burnt River Basin reflect requirements of several water uses. M&I demands, although limited, require a relatively constant supply of good quality water. Irrigation is the major water use in the study area and requires water free of chemical constituents which are harmful to crops and soils.

Recreational use of the reservoirs and streams in the basin for boating, fishing, camping, picnicking and swimming is another legitimate use of the water resource which necessitates quality control. Basic recreational facilities are included in the plan of development for the proposed reservoirs. A forest camp and several good sites for cabins exist near the proposed Hardman Reservoir site.

Unity Dam and associated irrigation development on Burnt River has virtually eliminated runs of anadromous fish, such as chinook salmon and steelhead trout. Through the years, unscreened diversion of the river to irrigated lands has contributed substantially to the destruction of fish in the course of their migration downstream. Moreover, passage upstream to spawning and rearing areas was completely blocked by construction of Unity Dam in 1937.

However, numerous species of resident fish are present in the basin and a variety of fishing opportunities are available to the sportsman. Unity Reservoir is managed as a trout fishery and receives intensive angling use. Warm water fishes (such as crappie, bass and perch) inhabit the lower portion of the Burnt River near its confluence with the Snake River.

Provision of a dead storage pool in each of the reservoirs, minimum sustained releases from Dark Canyon Reservoir of 25 cfs (April through July) and 10 cfs (August through March), free public access, and screens on the headworks of the project canal diverting from the Burnt River below the Dark Canyon site are all included in the plan of the proposed project to protect sport-fishery use of the river.

The existing and proposed reservoirs are anticipated to become increasingly important to the recreation-seeking public for fishing, boating, and other related activities.

B. Municipal, Industrial, & Agricultural Pollution

The City of Huntington contributes the only significant amount of municipal wastes discharged to the Burnt River. The present quantity of this waste is estimated to average 105 PE, including wastes from rural and urban land drainage. Secondary treatment (85 percent BOD removal) of domestic wastes from Huntington has been assumed. Based on projections developed in the economic study (Chapter VI), by year 1985 municipal wastes discharged to the river will amount to approximately 120 PE and by year 2010 will amount to about 150 PE.

Industrial wastes (specifically, from the cement plant at Lime), after adequate treatment or control, are not of a nature that would seriously affect quality of the Burnt River, although operational difficulties experienced at the plant occasionally permit discharge of wastes which cause considerable turbidity in the river. Although the plant is expected to expand, no pollutional load is projected for this or any other industrial source.

Irrigation return flows may degrade Burnt River water quality as minerals are leached from irrigated lands. Studies conducted in the Yakima River Basin, for instance, indicate that significant algal and other aquatic growth has been stimulated in the lower reaches of the river by nutrients contained in irrigation return flows (X-5). Storm water may also occasionally wash livestock wastes into the water courses. The nature and magnitude of waste constituents discharged to the river from these and other agricultural practices, even with increased irrigation, are not expected to change much in the future.

C. Water Quality Criteria

On the basis of this analysis of present and anticipated water use, DO has been selected as the governing criteria that determines the need for and value of storage for quality control purposes. Objectives for DO were set at a level adequate to support a desirable aquatic environment for the purpose of enhancing wildlife and recreational potentialities. In particular, the oxygen level below the proposed Dark Canyon Reservoir is designed to maintain resident species of fish. This requires a minimum of 5 mg/l of DO at all points in the Burnt River downstream from the proposed reservoir. Control at this level would also provide adequate quality for recreation and for protection of the river's natural attractiveness.

In selecting the above criteria, the probable effect of nutrients on water quality has been evaluated and indicates that nitrates and phosphates will not reach concentrations sufficient to cause objectionable algal blooms in the streams or reservoirs of the basin under present and projected conditions of development. Thus, increased irrigation will not adversely affect downstream water uses.

D. Flow Regulation

Regulation necessary to achieve the above stated quality objective is based on streamflows required to assimilate present and projected organic waste loads. Provision of adequate treatment of municipal wastes has been assumed in establishing the waste loads to be assimilated by the river. In this report, adequate treatment has been considered capable of reducing the organic waste loads by at least 85 percent at each source before discharge to the stream.

Streamflows required to maintain the objective under 1960, 1985, and 2010 conditions were computed by means of a technique for balancing the oxygen supply with oxygen consumed in the stream. The results show that, through the year 2010, a flow of 5 cfs during the summer would be sufficient to assimilate organic wastes.

In consideration of all stream uses, a minimum sustained flow of 5 cfs should be maintained in the lower reaches of the river to insure sufficient flow for proper waste assimilation. As indicated in TABLE VIII-1, there will continue to be a need through the 50-year study period for an annual draft-on-storage of nearly 600 acre-feet. This is the storage required to maintain streamflows for adequate quality control in the lower reaches of the river on a one-in-ten year low-flow recurrence basis.

A minimum sustained release is provided from Unity Reservoir under the operating schedule presently employed. If the proposed reservoir at the Dark Canyon site is constructed, provision should also be made to release sufficient water so that at least 5 cfs would continuously flow through the lower reaches to the mouth of Burnt River.

The comprehensive study presently under way by the Federal Water Pollution Control Administration will consider future water supply and quality control needs of the area in the context of basin-wide needs. Storage in this project will be considered as a part of the comprehensive study.

TABLE VIII-1
REQUIRED STREAMFLOW REGIMEN FOR QUALITY CONTROL PURPOSES[1/]
BURNT RIVER BASIN, OREGON

Month	Design Low Flow (cfs)	Required Streamflow (cfs)	Draft-on-Storage[2/] (acre-feet)
January	33	5	0
February. . . .	49	5	0
March	93	5	0
April	237	5	0
May	86	5	0
June.	30	5	0
July.	0.6	5	270
August.	0.0	5	310
September . . .	8.0	5	0
October	27	5	0
November. . . .	29	5	0
December. . . .	35	5	0
ANNUAL.			580

1/ Based on adequate treatment of organic wastes discharged to stream.

2/ This is the additional quantity needed downstream at Huntington and does not include storage and transmission losses.

IX. BENEFITS....Water Quality Control

Storage releases for control of water quality, in addition to adequate waste treatment, are needed in the Burnt River to protect fish and wildlife, maintain recreational opportunities, safefuard public health, and preserve the aesthetic attractiveness of stream waters. A population of more than 1,000 persons located in areas contiguous to about 30 miles of the lower river is affected by this control. The precise value of benefits assignable to releases necessary to serve these uses or to prevent damage to these uses, however, is not readily measurable. Many benefits--such as those resulting from reduced stream temperature, decreased concentrations of dissolved solids, maintenance of the aquatic habitat, increased land values along the stream, and general protection of aesthetic values--are particularly difficult to assess in monetary terms. Because multiple values are realized through control of water quality by flow regulation, the composite value of benefits assignable to storage for this purpose is considered at least equal to the cost of the most reasonable alternative means of providing the same level of water quality in the absence of the proposed project.

Since the results achieved by flow regulation relate primarily to control of waste effluents and urban and rural land runoff, the only reasonable or known equivalent alternative means of achieving similar results in the absence of the project is by release of water from a single-purpose storage facility. Alternatives such as underground disposal of waste, transportation of waste out of the basin, or other means of handling the collectible portion of wastes would be neither feasible nor produce similar results. Several sites exist on Burnt River tributaries where alternative storage could be impounded to furnish an annual draft of 600 acre-feet. The cost to construct this impoundment was estimated from average construction costs of similar-sized reservoirs in the Snake River Basin, and is estimated to be $28,770 or $48.00 per acre-foot, with operation and maintenance expenses of $4,200 annually and interest at 3.125 percent on a 100-year basis.

Monetary benefits for water quality control applicable to the proposed Burnt River Project are based upon existing conditions in the river basin. Because regulation of streamflow by Unity Reservoir now maintains a perennial release in excess of 5 cfs, no benefit for water quality control can be realized by development of the proposed project. On the other hand, if a flow of 5 cfs is not maintained, thus causing adverse water quality conditions at Huntington, the project would then be assessed a cost or damage of $28,770 per year.

Continued regulation of Burnt River streamflows in the future would maintain full protection of water quality in the Burnt River and, to a lesser degree, in downstream reaches of the Snake River. The adverse effect of all organic wastes entering the river, including those collectible wastes remaining after adequate treatment, would be reduced to acceptable levels, as measured in terms of dissolved oxygen (DO) requirements. In addition, soluble nutrients discharged to the river from irrigation, from the municipal treatment plant (constituents which are not significantly reduced by available treatment methods), and from other sources would be moderately reduced in concentration by flow regulation.

The benefits derived from water quality maintenance in the Burnt River Basin are both tangible and intangible and are widespread both in area and types of beneficiaries.

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APPENDIX

M.E.G.
12/23/65

TABLE 1
HISTORICAL (REGULATED) FLOWS AT HUNTINGTON
BURNT RIVER BASIN, OREGON
(cfs)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Average
1927-28	61.8	94.8	107.4	94.0	186.5	264.0	623.9	242.8	59.3	3.3	2.6	0.0	144.3
-29	13.0	43.7	52.0	52.0	69.6	231.0	206.7	99.2	52.1	6.5	1.6	3.4	69.2
1929-30	11.4	35.3	73.1	53.6	96.5	143.2	43.7	13.0	10.1	1.6	0.0	0.0	39.9
31	1.6	11.8	43.9	39.0	48.2	110.7	191.6	8.1	6.7	1.6	0.0	0.0	38.4
32	0.0	3.4	19.5	35.8	48.2	299.2	719.3	291.0	50.4	3.3	0.0	0.0	122.5
33	15.6	39.4	29.1	35.8	32.0	76.1	485.4	350.4	70.7	2.6	0.6	4.0	95.1
34	13.3	34.6	58.2	80.5	85.8	96.1	55.5	13.0	9.6	0.0	0.0	4.0	37.4
1934-35	13.3	16.1	33.5	47.0	49.1	127.5	342.0	74.1	9.6	0.0	0.0	1.7	59.3
-36	20.2	23.2	22.4	31.2	41.8	102.8	651.8	83.4	28.8	0.6	0.0	4.0	83.6
-37	9.0	23.2	26.8	20.2	34.3	98.5	268.0	100.2	30.6	0.0	0.0	8.7	51.5
* -38	50.3	68.2	193.8	120.3	106.5	174.3	1224.2	266.4	38.5	28.1	41.8	48.7	196.0
-39	46.6	36.1	35.0	23.4	21.4	166.6	528.2	142.6	82.0	44.1	48.6	48.7	102.0
1939-40	66.0	48.2	38.8	31.1	21.4	159.0	552.1	163.6	90.3	37.2	56.6	37.0	108.4
-41	35.0	40.2	38.8	38.9	123.4	414.0	424.2	200.5	131.1	56.6	58.8	39.3	133.5
-42	178.0	116.2	178.6	174.3	153.2	244.0	952.0	276.9	158.4	72.5	56.6	100.6	221.2
-43	73.6	48.2	93.0	151.0	293.4	461.0	1488.3	369.1	240.0	79.4	73.7	133.5	290.2
-44	83.4	144.3	162.6	35.0	25.7	23.4	56.1	142.6	41.2	57.7	56.6	88.8	77.1
1944-45	38.9	100.2	31.1	23.4	25.7	131.7	424.2	189.9	190.9	48.6	72.5	95.9	114.2
-46	110.6	42.0	35.8	45.5	146.4	432.5	1062.2	265.0	181.6	65.0	80.5	119.4	214.7
-47	120.3	77.3	113.9	191.9	121.4	47.8	463.9	214.6	166.5	59.4	61.8	119.4	146.2
-48	68.2	47.1	126.9	133.4	71.5	65.0	642.0	461.8	342.9	77.2	68.3	138.8	186.8
-49	214.5	87.4	87.9	133.4	164.4	426.0	843.7	292.7	168.1	58.5	75.2	131.5	223.3
1949-50	203.2	131.1	97.6	97.6	107.2	164.2	596.7	256.9	181.5	65.0	65.0	124.4	173.9
-51	152.9	114.3	133.4	87.9	114.4	365.9	966.4	224.4	146.3	52.8	68.3	95.8	209.7
-52	110.6	94.2	96.0	104.1	130.4	286.2	1347.9	190.2	198.3	87.0	73.1	119.4	235.2
-53	169.0	82.4	91.1	97.6	117.9	242.3	571.5	416.3	510.9	82.1	81.3	126.9	215.5
-54	242.3	174.8	130.2	96.0	71.5	61.8	215.1	185.4	105.9	50.4	71.5	124.4	127.6
1954-55	185.4	100.9	79.7	84.6	50.0	27.6	20.0	117.1	161.3	39.8	60.1	6.7	76.4
-56	29.3	30.3	29.3	178.9	228.5	614.6	1270.6	422.8	198.3	70.7	81.3	85.7	269.2
-57	76.4	67.2	65.1	50.4	232.0	315.5	539.5	382.1	163.0	84.5	58.5	55.5	173.5
-58	63.4	70.6	86.3	97.5	368.0	422.8	897.5	765.9	270.6	120.4	99.2	111.0	280.0
-59	82.9	79.0	110.6	92.7	80.4	78.0	225.2	91.0	53.8	55.3	42.3	87.4	89.8
1959-60	170.4	120.2	65.9	42.8	47.0	65.9	480.2	208.4	190.9	71.4	60.0	62.9	132.0
-61	62.2	36.1	38.8	42.8	34.1	38.8	120.2	226.8	128.2	60.0	56.6	34.6	73.6
-62	29.3	28.6	27.6	27.6	32.2	65.0	453.8	221.1	75.6	56.9	55.3	47.1	93.2
-63	71.5	55.5	53.6	34.1	232.1	71.5	215.1	177.3	94.1	66.6	63.4	72.3	99.6

SOURCE: U. S. Bureau of Reclamation
*Unity Reservoir in operation.

TABLE 2
NATURAL FLOW AT HUNTINGTON (ADJUSTED FOR REGULATION)
BURNT RIVER BASIN, OREGON
(cfs)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Average
1927-28	61.8	94.8	107.3	94.0	186.7	263.8	623.8	242.8	59.3	3.3	2.6	0.0	144.3
-29	13.0	43.7	52.0	52.0	69.6	230.8	206.8	99.2	52.1	6.5	1.6	3.3	69.2
1929-30	11.4	35.3	73.1	53.6	96.4	143.2	43.7	13.0	10.1	1.6	0.0	0.0	39.9
-31	1.6	11.8	43.9	39.0	48.2	110.6	191.7	8.1	6.7	1.6	0.0	0.0	38.4
-32	0.0	3.4	19.5	35.8	48.2	299.2	719.3	291.1	50.4	3.3	0.0	0.0	122.5
-33	15.6	39.3	29.1	35.8	32.0	76.1	485.4	350.4	70.7	2.6	0.6	3.9	95.1
-34	13.3	34.6	58.2	80.5	85.9	96.0	55.5	13.0	9.6	0.0	0.0	3.9	37.4
1934-35	13.3	16.1	33.5	47.0	49.1	127.5	342.0	74.1	9.6	0.0	0.0	1.6	59.3
-36	20.2	23.2	22.4	31.2	41.8	102.8	651.8	83.4	28.8	0.6	0.0	3.9	83.6
-37	9.0	23.2	26.8	20.2	34.3	98.4	268.1	100.2	30.6	0.0	0.0	8.4	51.5
* -38	50.4	68.2	193.7	120.2	106.4	174.3	1239.8	260.5	20.7	0.0	0.0	0.0	185.4
-39	59.2	76.0	67.8	46.8	52.2	316.0	603.0	82.9	18.6	0.0	0.0	9.3	110.8
1939-40	52.3	57.5	51.4	46.3	91.6	374.1	552.1	89.8	10.1	0.0	0.0	2.8	110.4
-41	72.7	66.9	66.2	63.3	127.2	541.5	504.7	193.0	108.4	0.0	0.0	35.6	148.3
-42	138.4	117.3	181.4	173.2	153.3	292.4	1117.3	291.8	104.1	0.0	0.0	36.4	216.5
-43	74.7	69.3	106.2	150.2	260.7	534.2	1709.1	367.6	184.6	0.0	0.0	42.4	289.8
-44	93.4	134.0	133.8	58.7	58.6	105.6	161.8	105.8	29.4	0.0	0.0	36.4	76.6
1944-45	57.7	146.0	75.0	54.3	48.2	158.0	543.7	257.4	109.8	0.0	0.0	22.6	122.5
-46	100.4	75.3	80.9	86.3	153.6	483.8	1188.4	288.2	95.8	0.0	0.0	58.8	216.7
-47	122.8	108.4	170.2	162.5	189.3	247.5	482.2	139.6	82.4	0.0	0.0	46.1	145.2
-48	80.2	79.5	131.9	149.5	123.4	138.6	761.3	551.2	327.7	0.0	0.0	73.1	200.9
-49	168.8	117.4	112.6	136.5	163.1	499.0	1019.3	298.6	74.1	0.0	0.0	56.8	220.0
1949-50	176.9	138.7	106.6	110.4	124.0	212.2	839.2	308.6	122.4	0.0	0.0	50.3	181.9
-51	144.3	126.8	154.0	117.1	178.0	402.1	1112.6	225.8	62.4	0.0	0.0	24.0	211.2
-52	102.8	108.0	116.3	118.3	139.0	303.2	1514.1	308.8	121.9	0.0	0.0	57.5	239.4
-53	141.7	92.6	107.4	141.9	170.0	341.8	746.9	413.2	486.7	0.0	0.0	38.8	222.7
-54	174.9	171.2	139.7	118.8	161.6	174.0	380.6	110.3	72.1	0.0	0.0	47.5	128.6
1954-55	144.4	112.8	87.7	84.6	60.7	47.0	146.6	155.2	66.6	0.0	0.0	0.0	75.6
-56	43.4	47.4	188.8	190.9	237.8	700.8	1376.5	427.5	119.8	0.0	0.0	16.8	278.4
-57	43.1	82.0	123.4	101.9	346.6	358.0	528.9	286.1	45.1	0.0	0.0	0.0	158.1
-58	52.0	90.6	96.5	109.2	470.7	420.5	1065.5	104.2	216.5	35.3	0.0	24.2	300.3
-59	68.4	103.9	159.2	136.8	135.2	184.5	326.2	48.6	0.0	0.0	0.0	34.1	99.4
1959-60	165.9	133.8	86.2	74.3	80.9	241.4	610.8	149.5	83.2	0.0	0.0	17.0	136.6
-61	64.0	82.8	69.9	70.3	101.8	156.6	234.4	118.0	41.4	0.0	0.0	7.7	78.6
-62	38.7	62.3	66.0	76.9	85.9	142.0	611.4	151.6	0.0	0.0	0.0	0.0	102.4
-63	92.7	107.1	116.8	67.8	380.2	155.3	234.0	151.3	6.9	0.0	0.0	0.0	107.6
												AVERAGE:	141.8

NOTE: The above flows are estimated for natural (unregulated) conditions and equal recorded and estimated historical flow, plus change of storage in Unity Reservoir.

SOURCE: U. S. Bureau of Reclamation.

*Unity Reservoir in operation.

TABLE 3
REPRESENTATIVE ANALYSES OF SURFACE WATERS
BURNT RIVER BASIN, OREGON

Analyses	Location and Date of Sample									
	NF Burnt River near Whitney		SF Burnt R. Near Unity	Burnt R. Below Unity Res. near Hereford		Burnt River at Durkee		Burnt R. near Huntington		
	9/17/59	4/6/60	4/6/60	9/17/59	9/2/60	4/6/60	9/29/60	7/25/58	9/17/59	4/6/60
High or Low Flow	Low	High	---	Low	Low	High	Low	-	Low	High
Discharge, cfs	---	---	---	41	82	173	43	100	80	---
Chloride (Cl), ppm	1.1	0.0	0.0	3.6	2.1	2.1	5.0	4.6	6.0	2.1
Fluoride (F), ppm	---	0.2	0.2	---	0.4	0.4	0.4	0.4	0.6	0.4
Nitrate (NO_3), ppm	---	0.0	0.0	---	1.2	1.2	0.0	1.2	0.6	1.9
Dissolved Solids[a/]	---	86	103	---	191	188	386	384	471	200
Specific Conductance[b/]	254	89	119	368	255	274	558	548	677	289
pH	8.5	7.4	7.5	7.6	7.5	7.6	8.4	8.0	8.5	7.6
Hardness as $CaCO_3$, ppm:										
Calcium-Magnesium	106	36	44	132	94	103	218	220	252	112
Non-Carbonate	0	0	0	15	2	0	0	14	0	0

DATA SOURCE: U. S. Geological Survey, Professional Paper 417-D

a/ Dissolved Solids--Residue on evaporation at 180 °C., ppm.
b/ Specific Conductance--Micromhos at 25 °C.

TABLE 4
REPRESENTATIVE ANALYSES OF GROUND WATERS
BURNT RIVER BASIN, OREGON
(Samples Collected 9/24/63 & 9/25/63)

Analyses	Durkee Area #18J1	Durkee Area #28D1	Unity Dam Site Area #28E1	Hereford Area #27A1	Bridgeport Area #25PL	Bridgeport Area #26PL	Bridgeport Area #29B1
Depth of Water-Bearing Zone (feet)	30+	931-983	220-232 280-282	74-81	-	-	-
Temperature (^{o}F)	60	68	58	54	54	54	53
Calcium (Ca), ppm	67	0.8	44	109	72	18	21
Magnesium (Mg), ppm	19	1.0	24	109	5.1	6.7	8.5
Sodium (Na), ppm	80	212	49	38	14	397	23
Potassium (K), ppm	18	1.6	21	7.8	5.5	15	4.7
Bicarbonate (HCO_3), ppm	410	372	225	626	212	11	95
Carbonate (CO), ppm	0	82	0	0	0	0	0
Sulfate (SO_4), ppm	88	12	135	91	59	1.4	50
Chloride (Cl), ppm	7.1	12	19	49	2.8	24	9.9
Nitrate (NO_3), ppm	6.2	0.0	4.3	205	0.0	0.0	0.0
Boron (B) , ppm	0.6	3.6	0.0	0.0	0.06	2.3	0.0
Sodium Absorption Ratio (SAR)	2.2	37	1.5	0.6	0.4	20	1.1
Residual Sodium Carbonate (Me/I.)	1.86	8.72	-.51	-4.14	-.52	17.38	-.18
Specific Conductance (micromhos at 25° C)	774	871	683	1,400	436	1,590	433
pH	7.3	9.4	7.0	7.6	7.5	7.8	7.2

DATA SOURCE: U. S. Bureau of Reclamation .

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DIGITALLY