REPORT
ON
SOURCES OF WATER SUPPLY
FOR THE
CITY OF BEND

JOHN DUBUIS
CIVIL AND HYDRAULIC ENGINEER
CONSULTING ENGINEER

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REGISTERED ENGINEERS
OREGON

No. 1.

JOHN DUBUIS
ASSOC. MEM AM. SOC. C. E.

C. M. REDFIELD
MEM. AM. SOC. C. E.

DUBUIS AND REDFIELD
ENGINEERS

BEND, OREGON

May 2, 1924.

To His Honor the Mayor,
The Water Committee of the Common Council
and The Common Council of the City of Bend,
Bend, Oregon.

Gentlemen:

In accordance with your instructions I submit herewith my report on the sources of water supply for the City of Bend.

The object of this report is to give you the data necessary upon which to base your judgment as to what supply of water will likely prove most economical and ample for Bend's future needs, as well as the best in quality.

The cost estimates given herein are preliminary, based on feasibility surveys and must be followed by estimates made on careful location surveys after the source of supply is decided upon.

HISTORICAL:

Prior to 1900 the present site of Bend was noted chiefly for the existance of a convenient camping place and a good place to ford Deschutes River. Here was the location of the Old Emigrant Ford where emigrant trains of the early pioneer days of the 40's and 60's crossed Deschutes River on their way to Western Oregon.

The bend in the river at this point made a picturesque spot, and to travelers east, was the last place to get good water before starting out across the desert plains. The inviting shade of the pine trees and the abundant clear water was a welcome sight to the desert traveler westward bound. About 1890 the timber resources began to attract attention, and Farewell Bend, as the place was then called, began to be known as a convenient and delightful camping place to the explorers of this little known Oregon interior.

In 1900 L. D. Wiest and A. M. Drake came to Bend and organized an irrigation company for the development of an Irrigation Project under the "Carey Act", which had been recently accepted by the Oregon legislature. The Swalleys had started their irrigation ditch just below Bend. Under the influence of this development the community of Bend became a town. The water supply for the community was taken directly from the Deschutes River.

This community gradually increased until in 1905 it was declared by the County Court of Crook County a duly and regularly incorporated city, which status it has ever since maintained. Up to about 1906 the water supply came either from ditches or directly from the river, but in this year the Bend Water, Light & Power Company and John Steidl built and extended a pipe system and furnished the residents of Bend with water for domestic, fire protection

and general municipal purposes. The present water system is the development of these earlier systems.

For many years the Deschutes River furnished a splendid wafer supply for domestic purposes. It was inevitable that the increasing population on the river above Bend, and the lumber operations on the water shed, would pollute the water, so that in due course of time the Water Company installed a chlorination plant.

In 1922 there were built at Crane Prairie and at Crescent Lake, dams for the impounding of water for irrigation. During the summer of 1923 these impounded waters flooded many thousands of acres of wooded and meadow land not heretofore flooded. Under the action of the hot summer sun the water of the river became filled with algea to such an extent that both the odor and taste became disagreeable, making the water decidedly unpalatable. After an investigation by the State Board of Health the Deschutes River water was condemned and the local water Company made an unsuccessful attempt to secure a supply of water from Tumalo Creek. Acting with the approval of the State Board of Health, the Company then undertook the construction of a filter plant which is expected to remove the organic matter in the water so as to render it palatable.

In the meantime the State Engineer had fixed a date for hearings in the matter of the adjudication of the water of Deschutes River and its tributaries. The City Council, impressed with the necessity of safeguarding the City water supply, both for the present and for the future, began an investigation of possible sources of water supply and the preparation of the necessary data to present to the State Engineer in order to protect the city's interests in the

adjudication proceedings.

After a personal visit of the City Council to Green Lake, a beautiful, clear lake at the foot of the South Sister near the summit, filings were made in the State Engineers office, under the direction of the Water Committee, on Green Lake, Soda Creek, Fall River and Spring River. Permission was asked to hold these applications on file until investigation should be made to determine the feasibility and cost of these various sources of water supply. A aurvey was made from Green Lakes to the Tumalo Divide, and also a line was surveyed from the Forest Reserve Boundary on Tumalo Creek to a point near the City's west boundary to determine the feasibility of bringing water on this route. Water samples were collected and sent away for bacteriological examination.

POPULATION:

To know the future population of Bend and its growth is a matter of vital importance in estimating its future water requirements.

Uncertain elements effect the growth of western cities so such an estimate cannot be made with a high degree of accuracy, but there are certain well established methods of making population estimates which are used all over the U. S. and will be employed here in estimating Bend's future population.

1. Census records show that Bend's population increased from 536 in 1910 to 5415 in 1920, a most unprecedented rate of growth. Should this rate of growth continue at the same rate per annum, Bend would reach a population of 40,000 in 1984 or 60 years fron now, 1924. For the year 1924, or four years after the last census, the population should be 7367. As a matter of fact, the recent census

undertaken by the Welfare League shows a population of 7779. There is a possibility that some people were overlooked within the City limits and on the outskirts which properly contribute to the City's population. This method, however, overlooks the fact that as cities get larger the rate of increase is faster.

2. Population is sometimes estimated on the basis of density. In Eastern cities of about 40,000 in population the density runs from 5 to 50 persons per acre. In Western cities as a rule the congestion is not so great. Using as a basis one family (5) to a 50x100 lot, the density would be 25.8 per acre for a city like Bend.

As some areas are taken up by parks, etc., this figure may be reduced to 20 souls per acre as applicable to Bend's area of 2380 acres, which makes a population estimate by this method of 47,600. The actual experience of industrial centers with territory far smaller than that tributary to Bend, shows that it is not impossible for this city to attain this size.

3. A superior method which is quite generally used is described in detail on page 188 of Engineering Economis by Fish. By this method U. S. census figures on population of cities are plotted, using decades and population as a basis, and a curve of growth is drawn which shows how a city has grown. A number of such curves are drawn using cities which have as near the same conditions as the one for which the estimate is to be made. The various curves are brought together and a one typical composite curve is drawn. On the basis of this composite curve, a curve representing the probable growth of Bend may be drawn. Bend is a lumber city and it may be expected to grow as other lumber cities in the Northwest have

grown. Accordingly a composite curve of 6 northwest cities was drawn.

The region tributary to Bend is one of rare beauty and exceptionally attractive to tourists, so the City's growth may have some characteristics of California cities whose growth has been largely influenced by tourist trade. Accordingly a composite of six California cities was drawn.

Bend's curve of growth was projected on the basis of these two curves, but leaning to a slower rate of growth in order to be conservative. This curve is shown herein as Diagram No. 1. On this basis Bend may attain a population of 40,000 in 1952. No claim for great accuracy is made for these figures. They serve as a basis for judgment, which experience has found to be better than a guess unsupported by such reasoning.

It is my judgment that plans for the future should allow for a population not less than 40,000, and that the present supply and equipment should be sufficient for not less than 20,000 people.

THE RATE OF USE:

The rate of use is based on the number of gallons per capita. Municipal water supplies are used for drinking, sanitary purposes, manufacturing, fire protection, flushing of sewers, irrigation of gardens and lawns, etc. This use is generally expressed as gallons per day and runs from 30 gallons per day to over 600 gallons per day, including leakage of mains. The average rate for the cities of the United States is 100 gallons per day. Figures much higher than this generally indicate an excessive loss through leakage. Cities in the arid and semi-arid parts of the United States require a larger rate of use because of the larger needs of lawn and garden irrigation and the need of a more liberal use of

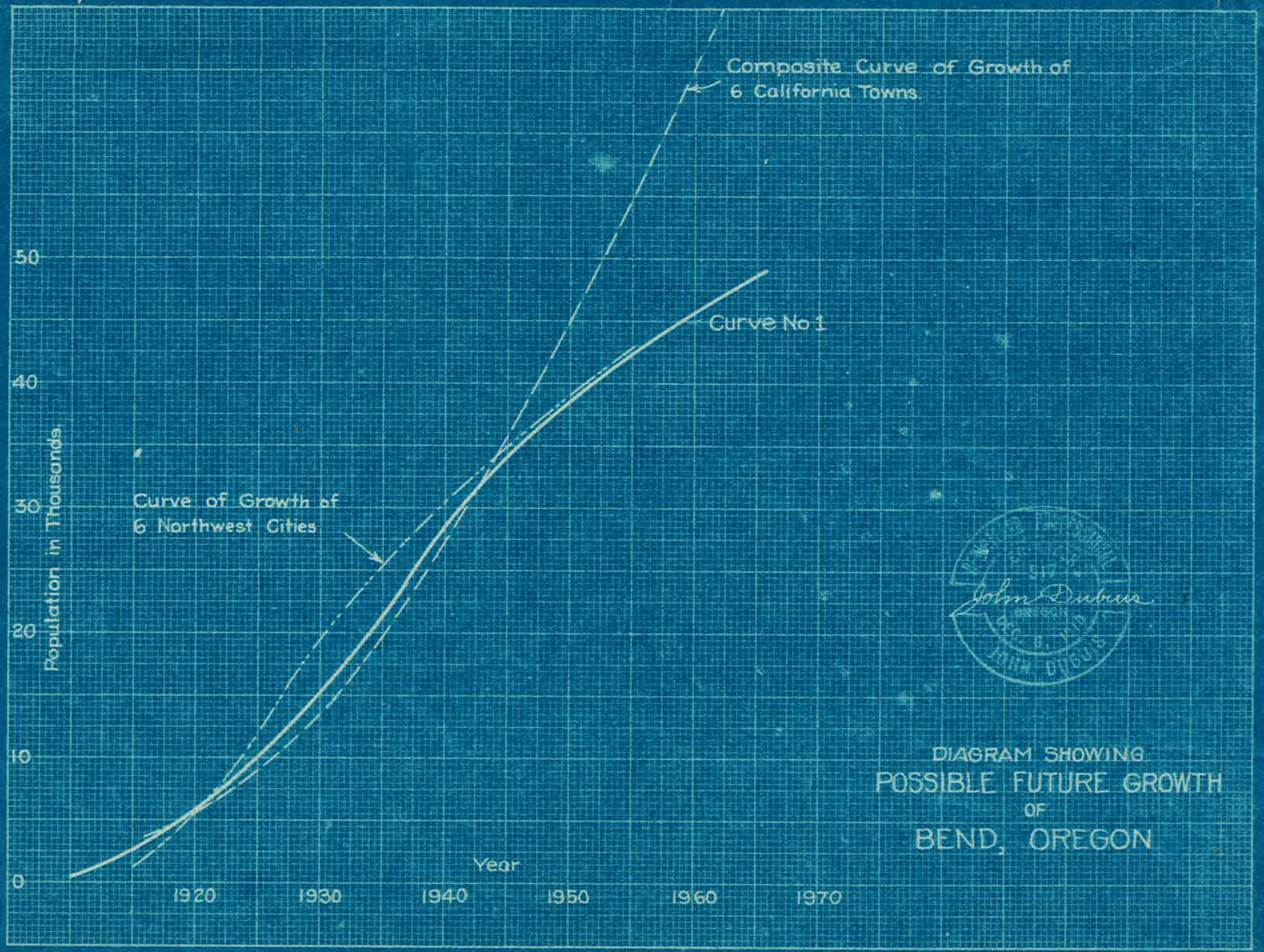

DIAGRAM SHOWING
POSSIBLE FUTURE GROWTH
OF
BEND, OREGON

water caused by the warm dry climate. The engineers for the Los Angeles aqueduct used a rate of 150 gallons per capita per day. Bend's climate is neither so hot nor so dry as that of Los Angeles, and 125 gallons per day may be used as a safe estimate where other conditions are properly provided for.

In all municipalities the use of water during certain parts of the year is at a greater rate than the average, and the usual percentage for the cities of the United States is about 175%. Bend's rate, which should be higher than this average, may be properly taken at 200%, applicable to such hot dry months as July, August and September. There is a further daily rate higher than this which varies from 150 to 200%, but in this study it is assumed that it will be provided for in storage.

FIRE PROTECTION--QUANTITY:

The use of water for fire protection is second only to domestic use. Negligence of this feature has resulted in the loss of untold millions in property as well as loss of life. The National Fire Underwriters Bureau makes recommendations for fire streams as follows, in cities from 10,000 to 100,000 population:

Table of Water Supply Requirements of National Board of Fire Underwriters.

Estimated Population	Required Fire Flow Gals. per minute	Flow for 10 hours
10,000	3,000	1,800,000
13,000	3,500	2,100,000
17,000	4,000	2,400,000
22,000	4,500	2,700,000
28,000	5,000	3,000,000
40,000	6,000	3,600,000
60,000	7,000	4,200,000
80,000	8,000	4,800,000
100,000	9,000	5,400,000

Referring to these requirements of the National Board of Fire Underwriters, Mr. Robt. E. Andrews, Asst. Chief Engineer, says: "If there is any error in the quantities we recommend, I believe it is not asking enough." It is well to remember that most of the great disasterous fires that have laid waste the cities of the U. S. were due more to the break down or inadequacy of the water supply than to lack of fire department equipment or fire alarm system. As Mr. Andrews says: "A water system is of some value for fire protection where there is no organized fire department, but a fire department without water is almost helpless." Turneaure and Russell in their book on Public Water Supplies, estimate the required quantity from the following formula: $F = \frac{1000}{\sqrt{X}}$. F is the allowance for fire protection in gallons per capita per day, and X is the population in thousands. This formula would give for a 40,000 population, an allowance of 6,350,000 gals., almost the Bureau allowance. Cities situated as Bend is, a mercantile center of a population much greater than that within its limits, and with the prevailing use of yellow pine as building material, require more than the average fire flow.

In view of the allowances made for the Domestic rate during the hot months which amounts to 250 gals. per capita per 24 hours, a fire allowance greater than that suggested by the Underwriters Bureau, but less than suggested by Turneaure and Russell, would be safe for Bend.

My recommendation is that the fire requirement be figured on the basis of $F = \frac{880}{\sqrt{X}}$. See table of Water Requirements, columns 4 and 6.

FIRE PROTECTION PRESSURE:

Water supply for fire protection must be sufficient not only in quantity but also in pressure. In business districts where buildings are set close together, good practice demands a pressure of 80 lbs. per square inch. In residence districts a pressure of 50 lbs. per square inch would be adequate if the distribution system is well designed, hydrants properly located, water mains a minimum of six inches in diameter, and few, if any, dead ends.

Pressure that comes from gravity is considered more reliable than that obtained by pumping. Where gravity pressure is impossible or impractical almost equal protection can be had by duplication of pumping equipment and the maintenance of a special high pressure pipe line in the thickly built up districts. Where either system may be used the question of cost governs.

Table of Water Requirements estimated for Bend, Oregon.

Col 1	Col 2	Col 3	Col 4	Col 5		Col 6.	
Population	Max. Rate Domestic & Irrigation	Amount for Fire Protection Fire Underwriters Bureau	Amount for Fire Protection $F = \frac{880}{\sqrt{V}} X$ Recommended.	Col 2 & 3 Total Domestic & Fire Requirement F. U. B. Allowance		Col 2 & 4 Total Domestic & Fire Requirements recommended in this report	
	Gallons per day	Gallons per day	Gallons per day	Gallons per day	Sec Ft.	Gallons per day	Sec. Ft.
10,000	2,500,000	1,800,000	2,785,000	4,300,000	6.65	5,285,000	8.18
20,000	5,000,000	2,580,000	3,940,000	7,580,000	11.7	8,940,000	13.80
30,000	7,500,000	3,100,000	4,825,000	10,600,000	16.4	12,325,000	19.10
40,000	10,000,000	3,600,000	5,600,000	13,600,000	21.1	15,600,000	24.1
50,000	12,500,000	3,900,000	6,225,000	16,400,000	25.4	18,725,000	29.0

The present capacity of the filters plant is 4,608,000 gals. daily.

SOURCES OF WATER SUPPLY:

Municipal water supplies come in the main from two sources, underground waters and surface waters. As far as Bend is concerned, underground waters as a source may be dismissed. The broken lava which underlies the City yields no water, and furthermore its cavernous and fissued nature has been utilized as a disposal plant for innumerable small sewer systems throughout the City. Any ground waters existing would, therefore, probably be polluted beyond purification, except at excessive expense. The sources of surface supply that have been investigated are as follows: Green Lake, Soda Spring Creek, Tumalo Creek, Fall River, Spring River and Deschutes River.

GREEN LAKES:

These lakes consist of three beautiful clear bodies of water lying at the foot of the South Sister. They are the source of Fall Creek, which empties into Sparks Lake. (See map). From surveys made in 1923 it was found that these lakes lie some 490 feet below the divide at Tumalo Creek, necessitating an expensive tunnel to make it available for a municipal supply for Bend. Few water flow records are available and the indications are that this source of supply cannot be depended on the whole year around. For these reasons this source is not considered feasible.

SODA CREEK:

This stream was found to be deficient in supply, and like Green Lakes, would require tunneling in order to be available. It is, therefore, considered infeasible.

FALL RIVER:

Fall River is a peculiar spring-fed stream seven miles in length which flows into Deschutes River twenty miles south of

Bend. Miscellaneous discharge measurement of the U. S. G. S. show that this stream has almost a constant flow varying only from 115 second feet to about 122 second feet. This would be adequate for a city five times the size of Bend is expected to become. The water shed of this stream is largely underground and cannot be definitely measured. The territory which is contiguous is characterized by numerous lava flows, cinder cone buttes and a porous pumaceous soil cover which supports a rather dense growth of yellow and lodge pole pine. Analysis of this water taken after a long dry spell, in which there was no opportunity for surfact contamination to pollute the stream, showed a very low bacterial count. In other words, the water has the characteristics of an underground supply. As far as the quality is concerned, it should prove "par excellence", as it is cool, clear, very palatable and free, for a part of the time at least, from an excessive amount of bacteria.

Its defects, however, are as follows:

(1) Long distance to Bend--29 miles of pipe required.

(2) Difficulty of controlling possible future contamination because of unknown source of supply.

(3) Excessive cost per mile of pipe line.

(4) The State has established a fish hatchery at the head of Fall River.

(5) Much of the supposed water shed may need to be logged in the near future.

For these reasons it is judged best to eliminate Fall River from present consideration.

SPRING RIVER:

Spring River is similar in character to Fall River, but

is somewhat larger, having a discharge of about 175 second feet. It is located only about fifteen miles in a straight line south-east of Bend. The quality of water at the source is equal to that at Fall River, but it soon becomes polluted from the large amount of camping on its banks. It rises at an elevation so nearly the same as the Deschutes River level that the fluctuations of that stream effect Spring River. In 1923 the releasing of Crane Prairie and Crescent Lake waters highly impregnated with organic substances, raised the Deschutes River and backed its waters up into Spring River. These springs might be tapped above any possible back water contamination, but its practicability is lessaned by the fact that the back water from Benham Falls Reservoir would cover the springs with about 40 feet of water.

Whether the springs could be tapped at all above this elevation is problematical, and the expense involved, uncertain, and possibly quite high. Until the construction of Benham Falls Reservoir is proved infeasible or otherwise definitely abandoned, the plan of utilizing Spring River might well be laid aside.

TUMALO CREEK:

This stream rises on the Eastern slopes of Ball Butte and Broken Top Mountain, about 20 miles West of Bend, and empties into the Deschutes River about 5 miles North of the City. A large portion of its water shed is in the Deschutes National Forest.

The distance from the Forest Boundary to the city limits is about 10 miles, and the elevation is about 1160 feet above the steps at the Pilot Butte Inn. Four canals have been constructed to divert water from the stream for irrigation purposes. It would be necessary to divert water for municipal purposes above these

canal diversion in order to avoid the pollutions resulting from their construction and operation.

The quality of water is better than that of Los Angeles. A bacteriological analysis of a sample taken below the mouth of the stream draining Tumalo Lake showed a bacterial content of 115 with bacillus coli present in 10 c.c., while the analysis of the Owen's River supply for the Los Angeles aqueduct shows 175 bacteria per c.c. and bacillus coli present. Additional analysis are being made of Tumalo Creek water.

Filtration would be unnecessary. Sterilization either by cholorination or violet ray process would be necessary, but not all the time.

The lowest flow of the stream is 46.5 second feet recorded in September 1915, the mean daily flow for the same year being 83.3 second feet.

Since records are available as far back as 1906 the adequateness of the supply is unquestionable.

The waters of the stream are owned jointly by the State of Oregon and the Deschutes County Municipal Improvement District. Negotiations between the Bend Water, Light & Power Co. and the District during 1923 failed to bring results. There are, however, no insurmountable obstacles to the securing of this Tumalo supply. Two municipalities such as the City of Bend and the District, with the common interest of the public welfare at heart, can arrange the transfer of water on terms advantageous to both parties.

The water shed reservation can be had from the Forest Reserve. (See letter from Forest Supervisor H. L. Plumb.)

DESCHUTES RIVER:

Bend's present water supply is pumped directly from the Deschutes River and filtered and chlorinated. The capacity of the filter plant is 3200 gallons per minute. Since the Fire Underwriters Bureau requirements for a city of about 8000 people would be about 2800 gallons per minute, only 400 gallons per minute is left for domestic supply, which is entirely too small; therefore, in the event of even a moderately large fire it will be necessary to use the auxilliary intakes at the old Pilot Butte Canal and at the mills which would flood the mains with raw, untreated water. The fire pressure is maintained by pumps. The headwaters of Deschutes River contain many lakes and reservoir sites, and the future development of the country will compel the construction of the reservoirs. This will greatly increase the troubles due to excess quantities of organic matter in the water, and also increase the cost of filtration. Whatever the cost or difficulties of using Deschutes River water for domestic purposes may be, it must be understood to be the logical result of the development of natural resources of the country and cannot be avoided. This River has been Bend's source of supply for many years, and a right to enough water for Bend's reasonable future needs has attached to the river itself, and will, doubtless, be recognized by the State Engineer. Should the Tumalo supply be obtained, Deschutes water would be exchanged for Tumalo water after reimbursing the Tumalo users for any expense involved. This should be done with the advice and support of the State Engineer's Office.

COMPARISON OF VARIOUS SOURCES:

Manifestly the proper way to compare the various sources

of supply would be to estimate the cost of developing each source to render the same service; then compare them on the basis of operating and fixed charges. In order to do this, cost figures were prepared for Fall River, Deschutes River, Spring River, and Tumalo Creek, each one to furnish approximately 7 million gallons daily at a pressure off 80 pounds per square inch in the business district. These figures were made to include interest depreciation and operating charges on the basis of the annual cost per million gallons daily capacity.

Source of Supply	Annual Operative Cost per Million Gallons Daily Capacity
Fall River	$10,200.00
Spring River	6,172.00
Deschutes River	7,940.00
Tumalo Creek	3,702.00

It is evident from these figures that Tumalo Creek has a very decided advantage on the basis of operating cost.

The Deschutes River supply has the advantage of low first cost to offset its high operating cost. It has the disadvantage of being less dependable, because of pumping, and being so grossly polluted that filtration is necessary for palatibility. It is my judgment that a supply but slightly contaminated which can be easily and cheaply guarded against, is superior to a supply heavily polluted and treated by the best of mechanical filters, even though the cost is the same. In this case, however, the cost is decidedly in favor of the Tumalo supply.

COST OF TUMALO SUPPLY

The basis of these figures given above are:

1. An all steel pipe line.
2. Fencing in completely the water shed of Tumalo Creek.
3. Telephone line from Headgate to City.
4. Diversion dam and house for gate tender.
5. Payment to Tumalo people for water rights.

Quantities are based on a preliminary feasibility survey and many uncertainties had to be estimated liberally. The cost, therefore, may be too high as additional careful survey may develop economies in location which is now shown by the information at hand.

Cost of a steel pipe line to deliver 7,000,000 gallons daily to the City of Bend would be $325,000.00 Should wood pipe be substituted where possible, and cheaper type of construction adopted elsewhere, this cost would be lower.

RESERVOIR:

It was found in studying the water supply situation that public interest would demand a reservoir. This expense would apply to all sources equally, and, therefore, was not considered in cost figures. The location of the reservoir governs the cost, and there is no careful study that has been made sufficient to definitely fix the location or size. Judging from experience in other localities, a reservoir could be built for from $25,000.00 up.

FIRE PROTECTION ADVANTAGES OF TUMALO SUPPLY:

The gravity pressure afforded by the Tumalo supply is a dedided advantage over the best pumping scheme now used in Bend. With the Tumalo supply built, the City would be in a position to demand better fire insurance rates than at present. It has been estimated that the fire insurance premiums in Bend amount to $100,000 per

year. According to a representative of the Oregon Rating Bureau, Bend's rate compares with Portland's rate as $2.05 is to $1.50, or 26.8% more. Thre is then a possible saving of $26,800 per year, one half of which, or $13,400, can be saved directly by an improved water supply with gravity pressure. Capitalizing the $13,400 at 8%, this saving represents a total of $167,500.00 to Bend.

RATE ADVANTAGE OF THE TUMALO SUPPLY:

Should the Tumalo supply be brough in, reduced water rates may result. Assuming a rate of $1.00 per month per family of 5 people, the income would be at a rate of $53.00 per million gallons. Out of this $53.00, $10.14 would be deducted for Tumalo supply source charges, leaving $42.86 to cover distribution charges and overhead expense.

In Allentown, Pa., the water rates are $3.75 per year per family, or about 30 cents per month. The cost there for water figures on maintenance plus interest, and amounted to $33.66 per million gallons in 1922. Although Bend's conditions are not directly comparable with Allentown, which has 85,000 population, it would seem that $30.00 additional to the water supply cost would be sufficient for maintenance and distribution expense, in view of the fact that that the Tumalo supply requires neither pumping nor filtration, while Allentown requires both. What the rate would be would depend largely on how quickly the city or company cared to retire the bond issue.

According to the statement filed with the Public Service Commission, a copy of which is enclosed herewith, the gross revenue from the water customers, which is anticipated for the year 1924,

is $54,484.83. This is supposed to include operation, maintenance, interest and depreciation on Bend's entire water system including pumping charges and filter operation for a supply which would furnish 4,600,000 gallons daily of potable water.

$25,910.00 would pay interest, depreciation, operation and maintenance charges on a 7,000,000 gallon supply from Tumalo, superior in every way to the present supply, and leave $28,574.83 for the charges of distribution from which all pumping charges, filtration charges and the depreciation charges against the supply have been eliminated.

This seems more than ample. As a matter of fact, should smaller pipe be used and in other ways the Tumalo gravity supply skinned down to the 4,600,000 gallon capacity now furnished by the filter plant, these charges could be reduced. Such a limit to the capacity is not in my opinion to the public interest.

It is not my intention to discuss at length in this report the question of rates, which is a problem all its own. Nor do I wish to criticize the present rates of the Bend Water, Light & Power Company which are doubtless the outcome of the old water system built in the pioneer days before the advent of the railroad, when first cost was the controlling factor, and operation and maintenance very secondary. I wish to emphasize, however, that the City has attained such a size and importance that cost of maintenance and operation is of vital importance, and that the present rates can be reduced if a gravity pressure system, such as the Tumalo Creek supply, is adopted.

To briefly summarize the situation, the following paragraphs are given:

1. Bend's future population upon which to base the

estimates of its water supply needs should not be less than 40,000.

2. Bend's domestic and municipal needs should be estimated at 125 gallons per capita per 24 hours as the mean average for a year, and for the month of maximum use, at 250 gallons per capita per day.

3. Bend's needs for fire protection are estimated at 140 gallons per capita per day in addition to the 250 gallons for other purposes.

4. The total maximum daily water requirements for Bend are 15,500,000 gallons per day, equal to 24 second feet for a population of 40,000.

5. Soda Creek and Green Lakes are infeasible as a source of supply for Bend, both as to quantity of water and cost.

6. Fall River, Spring River, Tumalo Creek and Deschutes River are possible sources of supply of which Tumalo Creek and Deschutes River are the least expensive and most practicable.

7. All supplies require sterilization of some kind; the Tumalo supply requiring the least.

8. The annual operating, interest and depreciation cost of the Tumalo Creek supply is $3702.00 per million gallons daily capacity as against $7940.00 for Deschutes River supply filtered and pumped.

9. The first cost of Tumalo Creek supply is about $46,400 per million gallons daily capacity, and that of the pumped and filtered Deschutes River water about $15,000.00.

10. Fire pressure furnished by the Tumalo supply will be by gravity , while that furnished by the Deschutes River must be pumped. The superior fire protection afforded by the Tumalo supply can be valued at approximately $~~14~~13,400.00 per year, which represents the saving in fire insurance rates under 1924 valuations.

11. The quality of Tumalo Creek is superior to that furnished by the famous Los Angeles Aqueduct, and while requiring sterilization, does not require and will not require filtration. During certain seasons of the year even sterilization will not be necessary. Deschutes River water not only requires filtration but due to proposed reservoir developments in the Upper Deschutes River, will continue to require filtration for all time to come.

12. The water shed of Tumalo Creek can be controlled and protected against pollution, it being in the Forest Reserve. The Forest Service offers full cooperation in this matter. The Deschutes River water shed cannot be so controlled and protected, and conditions will be worse instead of better.

13. The acquisition of water rights on Tumalo Creek must be undertaken, the cost of which is included in the estimates. There are other rights to be considered but a transfer arrangement can be made by which the Tumalo irrigation interests are fully protected at a reasonable cost to the City. The Deschutes River rights can be obtained without expense.

14. The increased operating cost of the Deschutes filtered supply over the Tumalo supply for 7 million gallons daily capacity would amount to $41,900.00 per annum. This amount will pay interest, depreciation and operating charges at the rate of 10% on an investment of $419,000.00. For a larger capacity the difference will be more than proportionately greater.

15. The estimated cost of the Tumalo water supply connected to the City mains is $325,000.00 for an all steel pipe line of 7,000,000 gallons daily capacity.

16. The annual operating, depreciation and interest

charge of this gravity supply is estimated at $25,910.00, while that for a filtered and pumped sypply of the same capacity is estimated at $55,576.00.

In order to protect the City's interest I recommend that the following steps be taken:

1. Appoint a committee to negotiate with the Deschutes County Municipal District and the State Engineer for the purchase of transfer of water rights.

2. Take the necessary steps to secure water shed reservation on Tumalo Creek for municipal purposes from the Department of Agriculture.

3. Continue taking of water samples and preparation of data to submit to State Board of Health.

4. Make location surveys for pipe line, prepare plans and cost estimates to serve as a basis of bond issue, and collect such other data as may be necessary to secure the best water at the lowest cost.

Respectfully submitted,

John Dubuis

John Dubuis
of
Dubuis & Redfield,
Consulting Engineers.

REGISTERED PROFESSIONAL ENGINEER 517 OREGON DEC. 8, 1919 JOHN DUBUIS

John Dubuis

C O P Y

Bend, Oregon,
March 10, 1924.

John Du Buis,
Bend, Oregon.

Dear Sir:

Reference is made to my conversation with you on March 10th.

The regulations of the Forest Service provide for the reservation of watersheds for municipal water supplies. Regulation L-11 is quoted for your information:

> "When necessary for the protection of water supplies of towns, cities, or irrigation districts, the Secretary of Agriculture will enter into formal agreements with the properly authorized officials of the town, city, or irrigation district, to restrict certain prescribed forms of use upon the National Forest Lands from which the water supplies are derived. The forms of use to be restricted, the nature and extent of the restrictions, the special protective measures which may be necessary or desirable, the assistance to be given the Forest Service in the enforcement thereof by the town, city or District, and the payments, if any, which shall be made to compensate the United States for losses of revenue resulting from the restrictions proposed, shall all be clearly and specifically defined in the agreement."

To insure the efficiency and purity of a water supply for municipality use, the use of watersheds for grazing, timber, special uses or settlement will be especially restricted by the Secretary of Agriculture when such restriction is necessary. Applications for such restrictions should be made to the Forest Supervisor by the City authorities. Where there are special protective measures, such as the construction of fences, fire brakes or other works, or the appointment of additional patrolmen, a stipulation is inserted in the agreement, defining definitely the assistance to be given by the parties benefitting from the restriction of use. Loss of revenue by closing to certain forms of use will be considered and provision made for reimbursement.

C O P Y

The Tumalo watershed at present brings in a yearly revenue of approximately $300.00. The Tumalo watershed has, in my mind, an advantage over other possible sources of supply for several reasons. In the first place, it is close to Bend. Second, it would have a good head of water. Third, very little of the timber within the watershed is commercial. The use of the area by tourists at present is not extensive. The area can be easily fenced. The fire hazard is not particularly dangerous, the water is cold and pure.

If there are any questions which you have, I would be glad to go into the proposition in more detail.

Very truly yours,

H. L. Plumb,

Forest Supervisor.

ANNUAL REVENUE--WATER UTILITY.

Total number of customers affected----------Flat water 1680
Irrigation 1015

FLAT WATER	Present Schedule	Proposed Schedule with Filter Plant installed
Total Annual Revenue	$38319.40	$ 45216.90
IRRIGATION		
Total Annual Revenue	3282.80	5547.93
FIRE HYDRANTS		
Total Annual Revenue	1575.00	3720.00
Total Water Revenue . . .	$43177.20	$54484.83

EXPENSES IN 1923		Estimated Expense 1924 with Filter Plant Installed.
Water supply Expense	2414.28	6200.00
Water distribution expense .	2775.29	3686.00
Commercial Expense	2936.97	3480.00
General & Misc. Expense	4509.77)	3912.00
Undistributed Expense	)	
Depreciation.....	4066.64	8400.00
Total for 10 months 17302.95		
Estimated Expense Nov. & Dec	4000.00	
Total Expense 1923	$21302.95	
Total Estimated Expense 1924		$27358.00
Net Operating Revenue	21874.25	27126.83
DEDUCTIONS:		
Taxes	8383.00	8500.00
Uncollectible Revenue.....	252.00	320.00
Total Deductions.....	8635.00	8820.00
OPERATING INCOME	13239.25	18306.83

Fixed Capital November 1st, 1923..... $180,031.03
Approximate Fixed Capital Jan. 1st, 1924....
with Filter Plant installed 250,000.00

C O P Y

October 31, 1923.

Mr. John Dubuis,
500 Journal Building,
Portland, Oregon.

My dear Sir:

Mr. Simmons of this department has completed the bacterial test of the samples of water, which he took with you in Bend, about a week ago, with the following results:

	Total Bact. Count	Presence of B. Coli
Sample No.1	112 per cubic centimeter	Positive in 10 c.c.
Sample No.2	115 per cubic centimeter	Positive in 10 c.c.
Sample No.3	120 per cubic centimeter	Positive in 10 c.c.

From a public health standpoint these samples are practically identical. The slight difference in the total bacterial count 112 to 120 is negligible. The presence of a Bacillus coli in 10 c.c. portions indicate definite pollution. From a public health standpoint it is useless to test in smaller quantities than 10 c.c. portions.

Confirmative tests were made to identify the colon bacillus beyond any question and was found there in every case. Such water as this is slightly but definitely contaminated. The standard methods allow about 100 bacteria of all kinds per cubic centimeter, provided that none of these bacteria are the colon bacilli. The results show that the colon bacillus is present in every 10 c.c. portion, at least, and that will condemn it for drinking purposes without first being treated with chlorine. Such water as this, however, can be very easily made potable where the contamination is very slight. If the organic matter is low then a very small amount of available chlorine would be sufficient to render the water perfectly safe, and it would also be free from objectionable flavor from the chlorine. Less than one part of available chlorine per two million parts of water is sufficient to render the water safe provided the organic is negligible. Filtration in this case would not be necessary.

If these samples are representative samples of your water supply and you have a sufficient quantity of such water, I should consider it as being the logical source of supply for your purpose. The slight amount of contamination and the low bacterial count we report are very typical of most mountain water supply. We scarcely ever find any mountain supply which drains any area of ground absolutely free from the colon bacillus of either the human or animal origin. While this is objectionable it can be very

readily disposed of by a slight amount of chlorine. There can be no possible objection to the chlorine treatment unless it is not properly mixed with the water. Too little chlorine will not destroy the intestinal bacteria and too large amount will give a slight flavor to the water, but even a large amount would not be absolutely injurious. It would be well for you, I think, to submit further samples from time to time in order that you may be sure that the samples you have already sent are representative of the average supply so that we can have an accurate idea of the comparative purity of the water.

I am

Very truly yours,

OREGON EXPERIMENT STATION

By G. V. Copson,

Bacteriologist.

GVC HMW

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EXTRACT FROM A PUBLICATION OF THE DELAVAL STEAM TURBINE CO
Referring to the Annual Report of the City of Allentown, Pennsylvania Water Department.

The annual report of the Allentown Water Department for the year 1922 shows that with No. 1. buckwheat coal costing $4.38 per ton, the total cost of pumping was $20.07 per million gallons, or 9.7 cents per million gallons raised 1 foot. Ordinarily the reciprocating pumps receiving water from Schantz's Spring work against a net head of 150 feet, whereas the centrifugal pump taking water from Crystal Spring works against a head of 245 feet. The total pumpage for the year against the higher head was 1,728,258,917 gallons, and against the lower head 2,009,596,443 gallons. In addition two deep well pumps supplying the Sixteenth Ward delivered 37,721,230 gallons at a cost for current alone of $59.60 per million gallons pumped, considerably raising the average cost of pumpage for the whole city. The overall cost of supplying water figured on total maintenance is $32.14 per million gallons, and figured on total maintenance is $33.66. The Water Department's net debt amounts to $123,500.00.

Allentown's water supply has been under municipal control since 1869, and evidence of this ownership is shown most conclusively in the low water rates continuously prevailing since 1877, the single family rate being $3.75 net per year with but 1½% of the 19,000 connections metered. Pressures vary through the city from 40 to 100 lbs., which is sufficient for fire purposes.

C O P Y

EXTENSION SERVICE

Oregon Agricultural College

Corvallis, Oregon

April 29, 1924

Mr. John Dubuis,
Bend, Oregon.

My dear Mr. Dubuis:

I have received the sample of water which you sent for bacterial test and have given it an especially sever examination, with the result that we find absolutely no indi cation whatsoever of any sewage contamination of any sort. The bacterial count is 95 per c.c. which is normal, although perhaps you might call it a high normal, but as far as the special tests are concerned for the definite types of sewage bacteria, there is no indication whatever of their presence. The water is above all suspicion and perfectly pure.

I am

Very truly yours,

OREGON EXPERIMENT STATION

By G. V. Copson,

Bacteriologist.

GVC EH

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DUBUIS AND REDFIELD

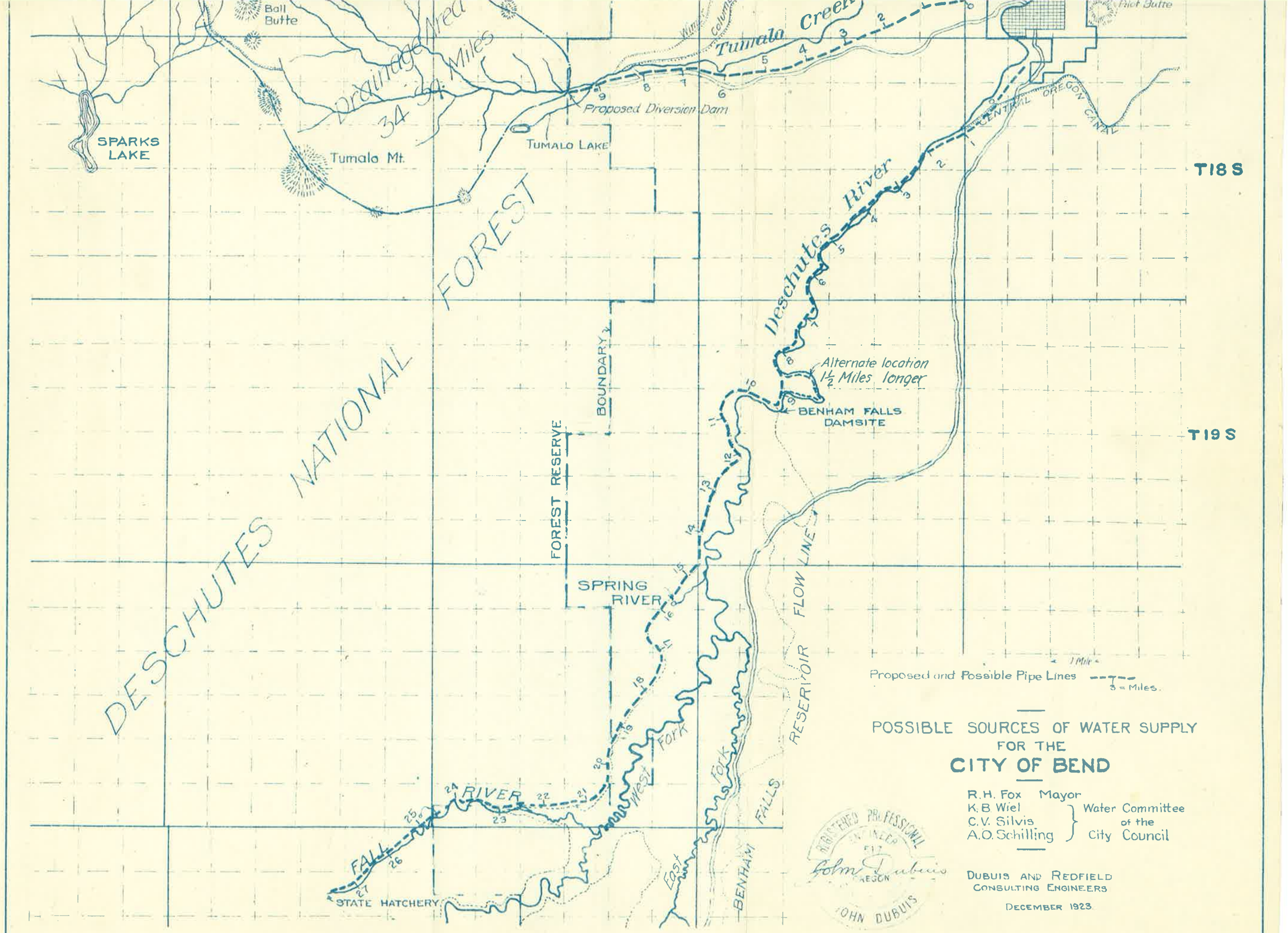
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
T 17 S
T 18 S
T 19 S

GREEN LAKES
SPARKS LAKE
Broken Top Mt.
Ball Butte
Tumalo Mt.
Water shed Line
Drainage Area 34 3/4 Miles
Proposed Diversion Dam
TUMALO LAKE
Tumalo Creek
Wilson Lindsley Columbia Southern Canal
CITY OF BEND
Pilot Butte
CENTRAL OREGON CANAL
Deschutes River
Alternate location 1½ Miles longer
BENHAM FALLS DAMSITE
DESCHUTES NATIONAL FOREST
BOUNDARY
FOREST RESERVE
SPRING RIVER
FORK
RESERVOIR
FLOW LINE

1 Mile

Proposed and Possible Pipe Lines ---1--- 3 = Miles.

POSSIBLE SOURCES OF WATER SUPPLY FOR THE CITY OF BEND



POSSIBLE SOURCES OF WATER SUPPLY FOR THE CITY OF BEND

R. H. Fox Mayor
K. B. Wiel
C. V. Silvis
A. O. Schilling
} Water Committee of the City Council

REGISTERED PROFESSIONAL ENGINEER
John Dubuis
OREGON
JOHN DUBUIS

DUBUIS AND REDFIELD
CONSULTING ENGINEERS

DECEMBER 1923