985. The price of fuel varies with market conditions. At the present time, May 1931, the price of fuel oil delivered in large quantities at Puget Sound points is $0.85 to $1.10 per barrel. This is $0.25 per barrel higher than the price of the same oil at Long Beach or San Pedro, Calif.

986. Plate no. 123 [2] has been prepared to show the cost per kilowatt-hour with different costs of fuel oil. In its preparation it is assumed that the annual peak load is equal to the plant capacity. In other words, the load factor and plant capacity factor are both assumed to be equal to $\frac{100K}{8{,}760}$.

987. The above determination of the cost of competitive steam power fixes a limit to the value of hydroelectric energy when delivered at load centers. The principal centers will be at tidewater. It next becomes necessary to know the cost of transmitting power from the proposed power sites to the load center.

988. E. A. Loew, professor of electrical engineering, University of Washington, has prepared a solution of the transmission problem, which is set out in appendix II of part 1, the division engineer's report. In the estimates for the transmission lines are included the cost of transformers and substation equipment at each end of a transmission line as well as the lines themselves.

989. The distances involved and the amount of energy to be transmitted make it appear certain that the transmission lines will operate at 220,000 volts. The number of lines will be such that under peak condition each will be loaded approximately to its capacity. Cost per kilowatt-hour varies with the length of line and with the load factor. Computations have been made for two cases. One considers that the lines will be financed by utility corporations borrowing money at 6 percent. The other assumes public financing with 4 percent money. The conclusions regarding cost per kilowatt-hour are shown in the following tables nos. 180 and 181 and in the plate no. 124.[2]

990. Subtraction of the cost of transmission from the cost of steam power gives the limiting price for hydroelectric energy at the bus bars of the generating station.

TABLE NO. 180.—*Cost of transmission per kilowatt-hour for 220,000-volt lines of different lengths (mills)*

[6 percent money]

Load factor (percent)	Length of line (miles)			
	100	150	200	250
50	0.525	0.675	0.921	1.350
55	.477	.615	.838	1.225
65	.403	.518	.709	1.037
75	.350	.449	.615	.898
85	.309	.396	.542	.797
100	.262	.337	.461	.675

[2] Not printed.

TABLE No. 181.—*Cost of transmission per kilowatt-hour for 220,000-volt lines of different lengths (mills)*

[4 percent money]

Load factor (percent)	Length of lines (miles)			
	100	150	200	250
50	0.409	0.527	0.724	1.060
55	.372	.479	.657	.965
65	.314	.405	.556	.817
75	.272	.351	.483	.707
85	.241	.310	.426	.625
100	.204	.264	.362	.530

(D) GROWTH OF MARKET

1. INVESTMENT AND REVENUE

991. The figures of investment in the electrical industry compiled by the Bureau of the Census, as given in table no. 182, purport to show the value of the plant and equipment of central station electric utilities. The table has been extended by using figures for invested capital as published by Electrical World. Figures of value and investment are difficult to obtain on a sound and comparative basis. An enormous amount of data is available in the records of taxing and regulatory bodies and in financial reports of the corporations. Compilations for the country as a whole and for various subdivisions would yield interesting results. Totals obtained from one source would probably vary widely from those of another. The difference made by the point of view has been clearly illustrated in many cases that have been before commissions and courts.

TABLE No. 182.—*Value of plant and equipment in light and power industry*

[Millions of dollars]

Year	United States	Pacific States	Washington	Oregon	Idaho	Montana
1902	505	45	3.5	5.2	0.8	4.7
1907	1,096	147	20.8	14.4	3.3	18.0
1912	2,175	391	22.5	23.8	32.5	64.6
1917	3,060	447	40.0	26.0	28.0	86.0
1922	4,465	600	86.0	37.0	36.0	86.0
1927	9,297					
1928	[1] 10,300					
1929	[1] 11,100					
1930	[1] 11,800					

[1] Data from Electrical World, Jan. 3, 1931, page 26.

992. Gross revenue is less dependent on personal opinion and prejudice, but still involves difficulties to the compiler, due to the many activities upon which some utilities have entered and the extent to which published figures are influenced by the showing which it is desired to make. The accompanying figures of the Bureau of the Census and Electrical World (see table no. 183) have been carefully prepared and are probably as nearly comparable as any that are available.

TABLE No. 183.—*Annual revenue from electric service*

[Millions of dollars]

[Source: Bureau of the Census]

Year	United States	Pacific States	Washington	Oregon	Idaho	Montana
1902	84.19	6.199	0.59	0.67	0.19	1.01
1907	169.61	18.98	3.22	1.84	.692	2.38
1912	287.14	30.80	2.98	1.38	1.58	3.29
1917	502.06	45.40	4.20	2.45	2.20	7.95
1922	1,020.44	99.30	17.42	4.85	4.22	9.18
1927	1,802.66	172.80	25.50	13.90	5.41	20.43
1928	[1] 1,941.95	[1] 186.70				
1929	[1] 2,105.90	[1] 203.00				
1930	[1] 2,155.00	[1] 209.00				

[1] From Electrical World, Jan. 3, 1931, page 30.

2. INSTALLED CAPACITY

993. Beginning in 1902 inventories of the capacity of generating equipment have been taken at frequent intervals; first by the Bureau of the Census, and, in later years, by the United States Geological Survey. From time to time, particularly in the earlier years, modifications were made in the basis for classification. While these influence detailed comparisons drawn from the figures, it is believed that for the purpose of illustrating the general trend the figures given will be useful. In tables nos. 184 and 185 the installed capacity is shown in kilowatts of generator rating. It varies somewhat from the rating of the prime movers, water wheels, steam engines, steam turbines, and gas engines.

TABLE No. 184.—*Generator rating installed in central power stations*

[Sources: 1902-17, Bureau of the Census, central electric light and power stations; 1920-30, U.S. Geologica Survey]

[Thousands of kilowatts]

Year	United States	Pacific States	Washington	Oregon	Idaho	Montana
1902	1,212	107	13	11	3	21
1907	4,432	411	95	35	7	40
1912	7,671	894	210	71	36	75
1917	11,919	1,233	273	113	37	182
1920	13,094	1,266	275	119	115	242
1921	14,399	1,387	328	125	137	219
1922	15,483	1,537	331	141	148	215
1923	15,971	1,695	362	150	157	215
1924	17,369	1,873	362	166	158	221
1925	19,519	2,116	447	200	171	221
1926	23,619	2,536	525	213	177	243
1927	25,398	2,738	556	233	189	243
1928	27,691	2,929	563	238	223	219
1929	29,630	3,382	606	268	224	226
1930	31,952	3,672	693	284	226	310

TABLE No. 185.—*Rated generator capacity installed in central stations in the Seattle district, which includes Washington, northern Idaho, and western Montana*

Year	Western Washington group [1]	Eastern Washington group [2]	Total	Year	Western Washington group [1]	Eastern Washington group [2]	Total
	Kilowatts	*Kilowatts*	*Kilowatts*		*Kilowatts*	*Kilowatts*	*Kilowatts*
1906	37,060	10,068	47,128	1919	171,940	112,100	284,040
1907	50,060	16,533	66,593	1920	173,440	139,600	313,040
1908	50,060	23,659	73,719	1921	173,440	139,600	313,040
1909	58,060	34,822	92,882	1922	205,940	139,600	345,540
1910	58,060	34,600	92,660	1923	218,240	149,400	367,640
1911	66,940	49,350	116,290	1924	218,240	151,000	369,240
1912	66,940	54,850	121,790	1925	268,740	174,750	443,490
1913	118,440	69,850	188,290	1926	316,247	187,300	503,547
1914	118,440	69,850	188,290	1927	348,247	186,700	534,947
1915	125,940	70,000	195,940	1928	370,247	221,260	591,507
1916	125,940	96,250	222,190	1929	405,947	247,010	652,957
1917	125,940	126,250	252,190	1930	443,447	247,010	690,457
1918	125,940	112,100	238,040				

[1] Figures in column headed "Western Washington group" are compiled from reports of Puget Sound Power & Light Co., city of Seattle, city of Tacoma, Washington Pulp & Paper Corporation, Grays Harbor Ry. & Light Co., and associated companies and their predecessor companies, insofar as information is available.

[2] Figures in column headed "Eastern Washington group" are compiled from reports of the Washington Water Power Co., Pacific Power & Light Co., and the Thompson Falls plant of the Montana Power Co. and their predecessors, insofar as information is available.

3 OUTPUT IN KILOWATT-HOURS

994. Production of electric power is measured directly in kilowatt-hours. The industry has been fortunate in having at its command since early days a simple mechanical device of great accuracy for metering its product. As a result the figures available are very satisfactory. They are, in a large measure, free from the assumptions and approximations which frequently introduce uncertainties into compiled statistical data.

995. Records of production by the Bureau of the Census and United States Geological Survey are accepted as authoritative and thoroughly reliable. Taken with the reports of installed generator capacity they show the strides that have been taken by the industry in the United States and its subdivisions. In table no. 186 are given the figures for the United States, the Pacific States, and for the States of the Northwest, which lie within the North Pacific power zone. In table no. 187 are given the corresponding data for eastern and western Washington.

TABLE NO. 186.—*Production of central electric power stations*

Sources: 1902–17, Bureau of the Census. Central Electric Light and Power stations; 1920–30, United States Geological Survey.

[Millions of kilowatt-hours]

Year	United States	Pacific States	Washington	Oregon	Idaho	Montana	Market area for C.R. power [1]
1902	4,768	3,880	0.9	0.6	0.2	0.7	1.5
1907	10,621	1,149	283.0	93.0	10.0	137.0	375.0
1912	17,572	2,398	511.0	228.0	116.0	381.0	737.0
1917	32,679	3,954	869.0	325.0	145.0	965.0	1,347.0
1920	43,555	5,408	1,197.0	476.0	591.0	1,126.0	1,842.0
1921	40,976	5,628	1,177.0	469.0	550.0	597.0	1,748.0
1922	47,653	6,178	1,286.0	513.0	616.0	985.0	1,927.0
1923	55,665	7,109	1,447.0	594.0	695.0	1,139.0	2,243.0
1924	59,014	7,748	1,504.0	678.0	793.0	1,145.0	3,130.0
1925	65,870	8,569	1,623.0	730.0	754.0	1,263.0	3,400.0
1926	73,791	9,537	1,807.0	831.0	811.0	1,408.0	3,759.0
1927	80,205	10,322	2,122.0	845.0	806.0	1,395.0	4,148.0
1928	87,850	11,382	2,361.0	1,041.0	948.0	1,619.0	4,795.0
1929	97,352	12,563	2,552.0	1,161.0	894.0	1,614.0	5,180.0
1930	95,936	12,723	2,555.0	1,219.0	912.0	1,320.0	5,260.0

[1] Includes U.S. Geological Survey reports for Washington and Oregon, plus companies' reports for Thompson Falls plant in western Montana, and Lewiston and Grangeville plants in northern Idaho.

TABLE No. 187.—*Production of central electric power stations in the Seattle district which includes Washington, northern Idaho, and western Montana*

Year	Western Washington group [1]	Eastern Washington group [2]	Total	Year	Western Washington group [1]	Eastern Washington group [2]	Total
	1,000,000 kw.-hrs.	*1,000,000 kw.-hrs.*	*1,000,000 kw.-hrs.*		*1,000,000 kw.-hrs.*	*1,000,000 kw.-hrs.*	*1,000,000 kw.-hrs.*
1909	32	106	138	1920	688	621	1,309
1910	34	123	157	1921	604	571	1,175
1911	29	135	164	1922	677	617	1,294
1912	30	177	207	1923	821	727	1,548
1913	67	195	262	1924	883	750	1,633
1914	69	204	273	1925	906	795	1,701
1915	[3] 370	234	[3] 604	1926	1,178	842	2,020
1916	439	323	762	1927	1,369	909	2,278
1917	522	442	964	1928	1,482	1,087	2,569
1918	614	432	1,046	1929	1,550	1,155	2,705
1919	648	510	1,158	1930	1,693	1,118	2,811

[1] Figures in column headed "Western Washington Group" are compiled from reports of the Puget Sound Power & Light Co., city of Seattle, city of Tacoma, Washington Pulp & Paper Corporation, the Grays Harbor Ry. & Light Co., and associated companies and their predecessor companies insofar as information is available.

[2] Figures in column headed "Eastern Washington Group" are compiled from reports of the Washington Water Power Co., Pacific Power & Light Co., and the Thompson Falls plant of the Montana Power Co., and their predecessor companies insofar as information is available.

[3] Production for years prior to 1915 does not include data for the Puget Sound Power & Light Co.

996. While the consumption of electricity in the United States has reached enormous totals, and, in fact, is probably greater than in all the rest of the world combined, yet it is interesting to note that in spite of this supremacy, the United States is by no means the leader in the per-capita use of electricity. Three countries exceed it in this respect as follows (see Electrical World, Jan. 3, 1931, p. 48):

Country:	*Kilowatt-hours per capita*
Norway	3,560
Canada	2,124
Switzerland	1,043
United States	1,025

997. The relative positions shown above have been maintained by these countries for many years. The figures make an interesting exhibit in considering the future that may be ahead of the electrical industry in the United States.

II. PROBABLE FUTURE EXPANSION

(A) BASED ON PAST RECORDS

998. In the 10-year interval ending December 31, 1930, the production of electricity in the United States increased by 119.5 percent over that of 1920. This is equivalent to 8.2 percent per year if compounded annually. During this period there were two great industrial depressions, one in 1921 and the other in 1930. In both these years the production fell below that of the year immediately preceding. Output of electricity recovered rapidly after 1921, and by 1923 had nearly regained the place which would have been indicated by the trend curve prior to the depression. Whether recovery from the conditions of 1930 and 1931 will be as prompt and complete will be determined by the future.

999. If the production of 1929 is compared with that of 1920, the increase is found to be 123 percent, which is equivalent to 9.5 percent

per year when compounded annually. If 1930 is compared with 1921, both being years of depression, the increase is found to be 134 percent, equivalent to 9.9 percent per year when compounded annually.

1000. A similar comparison has been made for the Pacific States, and for several other subdivisions, as shown in table no. 188.

TABLE NO. 188.—*Percent increase in kilowatt-hour production*

	Comparison 1930 with 1920		Comparison 1929 with 1920		Comparison 1930 with 1921	
	10-year period	Annual [1]	9-year period	Annual [1]	9-year period	Annual [1]
United States [2]	120.5	8.2	124.0	9.4	134.2	9.9
Pacific States [2]	136.0	8.9	133.2	9.8	126.0	9.6
Washington and Oregon [2]	127.0	8.6	122.2	9.3	130.2	9.7
Washington [2]	115.8	7.8	114.0	8.8	118.3	9.2
Oregon [2]	156.8	9.9	144.6	10.7	159.3	11.3
California [2]	142.6	9.3	137.0	10.1	127.9	9.5
Washington [3]	114.0	7.7	107.0	8.5	138.0	10.1
Western Washington [4]	147.3	9.5	125.3	9.5	181.0	12.2
Eastern Washington [5]	80.0	6.0	86.0	7.2	95.5	7.9
Oregon [6]	128.0	8.6	132.0	10.1	123.0	9.3
Washington and Oregon [7]	117.2	8.1	112.8	8.8	134.0	9.9

[1] Percent increase per year if compounded annually.
[2] U.S. Geological Survey reports.
[3] Companies included in Washington are the Pacific Power & Light Co., the Washington Water Power Co., Puget Sound Power & Light Co., city of Seattle, city of Tacoma, Washington Pulp & Paper Corporation, Grays Harbor Railway & Light Co., and the Thompson Falls plant of the Montana Power Co.
[4] Companies included in western Washington are Puget Sound Power & Light Co., city of Seattle, city of Tacoma, Washington Pulp & Paper Corporation, Grays Harbor Railway & Light Co., and associated companies.
[5] Companies included in eastern Washington are the Washington Water Power Co., Pacific Power & Light Co., and the Thompson Falls plant of the Montana Power Co.
[6] Companies included in Oregon are the Eastern Oregon Light & Power Co., the Mountain States Power Co., Portland General Electric Co., Northwestern Electric Co., and Pacific Power & Light Co.
[7] Includes companies in ([3]) and ([6]) above.

1001. In view of the past performance of the electrical industry, it appears unreasonable to compare the figures of 1930, a depression year, with those of 1920, a prosperous year. The normal trend should be found to conform more nearly to the figures for the 9-year period ending with 1929 or 1930 than to those for the full decade. Accompanying charts which show the depressions and periods of prosperity of the electrical business make this clear. Consideration of the periodicity of the business cycle in the United States confirms this conclusion.

1002. Should the production of electric energy continue to increase in Oregon and Washington at a rate of approximately 10 percent per annum, the totals in 1940 will be 160 percent greater than in 1930. An inspection of year-to-year results shows this to be by no means impossible.

(B) SPECIAL CONDITIONS WHICH MAY AFFECT FUTURE GROWTH

1. FAVORABLE

1003. There is nothing definitely discernible in the history of the electrical industry to indicate that the rate of growth which has been maintained in the past will decrease in the immediate future. Lighting, the earliest commercial use made of electricity, is growing at a rapid rate. Domestic applications are expanding remarkably, following the trend toward a higher standard of comfort, convenience, and efficiency in the home, and fostered by extensive advertising programs. Rural distribution is only beginning. With the multiplicity of uses for electricity that can be found on the farm, this appears to be a promising field. Office and store appliances and equipment operated electrically are being generally installed. New industrial applications are constantly being found. Chemistry and metallurgy are fertile fields in which much work is being done at this time. Heating applications have enormous possibilities for consumption of electricity. Additional electrification of steam railroads is a future possibility. Locally, the lumber and paper industries have been using waste material for fuel in production of steam power. As wood waste becomes more valuable for other byproducts, much of the power thus produced will be replaced with purchased electricity.

2. UNFAVORABLE

1004. The location of the saturation point has been studied by many investigators. While the studies have not led to a definite conclusion, we know that at some time a point will be reached where the rate of growth in the use of electricity will begin to decline. It is difficult to believe that production, having reached the quantities of the present day, can continue to double every 6 or 7 or 8 years. The fact that the business is not static but is changing rapidly in its details, opens the way for a sudden climax followed by possible retrogression.

1005. It is conceivable that some competitive industry will arise which will retard the expansion of electric central stations, and perhaps will gradually supersede them. Notable examples exist in the competition which steam and electric railways are meeting from the automobile and truck.

1006. A part of the increase of the sales of electricity has been due to the extension of distributing systems into new areas, and to the wiring of old buildings in areas already covered. There has been a substitution of electricity generated in central stations for other types of power, and for electricity generated in factory plants. It is estimated that 86,500,000 people, or 70.5 percent of the 1930 population in the continental United States live in electric-lighted homes.[61] Of those to whom electric lights are not now available, a large part live on farms. Many factories do not use central station power. United States census figures for 1929 show that one half the factory power is produced in the factories themselves. Factory-generated power amounts to 15,000,000 kilowatts of rated capacity. This figure has shown no tendency to decrease.

(C) POSSIBLE NEW INDUSTRIES—ESPECIALLY THOSE WHICH MAY CONSUME LARGE QUANTITIES OF POWER

1007. The rate of growth of a community or of a region frequently is affected by the energy and promotional ability of a few individuals. New industries may be secured and old business may be expanded to utilize latent resources and possibilities, which might otherwise remain dormant for a long period.

[61] Electrical World, Jan. 3, 1931, p. 26.

1008. There may be no incentive to an industry established elsewhere, with heavy investment in property and equipment and satisfactorily supplying the market, to make use of greater natural advantages in another locality, when these will, to an extent, depreciate and make idle the investment already made. Yet competition, or its threat, set in motion in the new community, may force a move to secure economies of production. Thus, the human element is to be reckoned with, but the extent to which it will affect the future of a particular community cannot be predetermined. Many physical factors also influence the choice of a location for the establishment of new plants. The relative importance of each will vary with each industry. The complexity of the problem makes it futile to attempt to predict what industries may or may not locate within transmission distance of Columbia River power.

1009. The technical advancement which is taking place in many industries is leading to the adoption of new processes for old products, to the manufacture of new materials for old uses, and to new products which must create their own markets. With such changes come the establishment of new plants for both new and old industries, as well as the reequipment of old plants. When new plants are being considered the time is favorable for securing recognition of the advantages of particular new locations.

1010. In a period such as the present when manufacturing capacity in major industries exceeds market demands, markets stand forth as one of the most important factors in determining location of new or branch plants. The advantages to be obtained through easy contact with customer industries, the lessened risk involved when companies are not entirely dependent on conditions in one locality, and the wisdom of distributing investments, are tending more and more to the establishment of branch factories in consuming areas.

1011. Although such increases in population as have occurred in Oregon and Washington in the last 10 years, 21.6 and 15.1 percent, respectively, will gradually lead to increasing markets of all service industries, a greater demand for power will probably result from the establishment of industries on the Pacific coast which are related to industries already having a firm footing there, because of existing raw materials or existing markets. Thus the timber industry may find an outlet for its products and by-products through the establishment of cellulose solution industries such as rayon, photographic films, lacquers, safety glass, as well as paper. These industries in turn call for chlorine, caustic soda, and other chemicals which require large quantities of electrical energy in their manufacture. With a market established for their major products, these chemical industries will naturally turn their own by-products to account in other fields, such as the petroleum and metallurgical industries. A movement in this direction is already shown by the chemical works now operating in Tacoma.

1012. A wider development of basic industries will lead to a demand for service industries such as hydrogen and oxygen, graphite, or abrasives which are heavy consumers of power. Then, too, there is a noticeable trend toward the use of electricity in the final fabrication industries such as in the making of foundry castings of copper alloys and steel.

1013. An industrial market for hydrogen and oxygen, nitric acid, and synthetic ammonia, may in turn make it possible to establish a fertilizer industry with sufficient by-products to bear part of the costs, so that fertilizers can carry transportation expense to Middle Western markets. Local agricultural development will also make a nearby market for fertilizers.

1014. Industries whose products are rendered commercially possible only by electrochemical and electrothermal processes have as their first consideration a cheap and abundant power supply. Such products are aluminum, carborundum, calcium carbide, ferro-alloys, and others.

1015. Industries whose products may be manufactured by electrolytic or electrothermal processes, or by chemical or furnace processes, such as caustic soda, chlorine, phosphoric acid, and nitrogen will give consideration to the availability of raw materials and to markets, before determining which process or which location is of greatest advantage.

1016. Washington has extensive deposits of kaolins and clays, limestone, silica, both as quartz and as diatomaceous earth, coal and other nonmetallic minerals. Phosphates are important in Montana and southeastern Idaho. Eastern Washington and northern Idaho contain deposits of lead, zinc, copper, iron, tungsten, gold, and silver ores, many of which are developed.

1017. Consumption of electric power is important both in mining and refining operations. Metal mining in the United States has been overdeveloped, and it is not probable that the rate of production will be increased. Curtailment is affecting the least economical properties. The power requirement becomes greater as it becomes necessary to hoist ore and pump water from lower and lower levels. The adoption of more modern and efficient methods of milling and refining brings greater use of electric energy. Therefore, even though production does not increase, the demand for electricity may be expected to rise steadily.

1018. In appendix no. 1 will be found a discussion by Dean Henry Landes, geologist, and Frank H. Dickey, assistant geologist, Seattle, Wash., of the mineral resources of the Columbia River Basin in eastern Washington, northern Idaho, and Montana. Appendix I by Miss Bertha Nienberg, consulting economist, Washington, D. C., attached to part I (p. 85, vol. I of this document) of the report on Columbia River, contains careful studies of the electrochemical and metallurgical industries, an analysis of the raw material and power requirements, and the location and size of market for each.

1019. It is, of course, obvious that the ports of the Puget Sound area have easy access by water to the raw material from all ports of the world. Present establishments draw heavily on distant sources of supply. The same facilities provide transportation of finished products to world markets. Under these conditions it is quite possible that the enormous hydroelectric resources of the Pacific Northwest may become a controlling factor in securing the location of many industries in which electricity is an important requirement.

(D) COMMERCE AND DEVELOPMENT OF SEABOARD COMMUNITIES

1020. Elsewhere in this report will be found studies of the population growth and economic development which may be expected in the

Pacific Northwest during the next 30 or 40 years. It is shown that the development of the region west of the Cascade Mountains tends to be similar to that of New England and New York, while the area east of the Cascades is more like that of the agricultural States of Iowa and Missouri. There appears to be a reasonable basis for the prediction that in 1960 the population in the States of Washington, Oregon, and Idaho will total 4,395,000, and that 3,021,000 will reside west of the Cascades and 1,374,000 east of those mountains.

1021. Vessel traffic entering and leaving Pacific coast and Puget Sound ports of the State of Washington increased in value by 25 percent from 1920 to 1929. In tonnage it increased by 115 percent. Omitting the years 1921 and 1930, in which Nation-wide and world-wide business depressions caused sharp slumps in commerce, both tonnage and value of commodities handled have increased in a consistent manner. They may be expected to continue to so increase in future years.

1022. Manufacturing has had a gradual growth. Diversification is increasing, although lumber occupies a dominating position. A careful review of the status of the lumber industry indicates that it has passed the peak of its production and may be expected slowly to decline, although the reproductivity of the northwestern forests is such that it will always retain great importance. There is a probability that the decline in lumber production will be accompanied by an expansion of the pulp and paper industries, and by a more efficient use of the the timber that is cut. (See appendix no. 4.)

1023. Manufacturing of products in which wood is the raw material is already well established and appears to contain important possibilities for the future. It will mean much more in the economic development of the region than does the shipment of rough lumber. The use of electricity is certain to be a feature of woodworking establishments and of the processing of byproducts.

1024. Manufacturing industries will probably continue to congregate in the area west of the Cascades, where there is access to salt water and where a favorable climate increases the efficiency of labor.

1025. Much has been said and written of the great possibilities of the ports of the Pacific coast, as commerce increases between the peoples living on the shores of the Pacific Ocean. It is not necessary here to enlarge upon these possibilities. It will suffice to remark that, as frequently happens, development is steadily taking place, and, if continued in a way that can be regarded as truly normal, will ultimately reach a goal that would satisfy any enthusiast of the present day.

(E) FORECAST OF PROBABLE FUTURE EXPANSION

1026. The great strength of the electrical industry is that the use of electricity has become part and parcel of almost every department in the life and activity of the American people. The rapid growth of the industry has been outlined in the preceding pages. The years 1930 and 1931 are witnessing a slowing down in the rate of that growth. A similar condition occurred in 1921. The years 1922 and 1923 put the business back onto its former curve.

1027. Table no. 189 has been prepared to summarize the percentage increase which has occurred from year to year in the United States, the Pacific States, the entire State of Washington, and in that part of

Washington which lies west of the Cascades. On plate no. 125 [2] there is plotted to a semilogarithmic scale the average kilowatts generated for public use in each of several areas.

TABLE NO. 189.—*Increase in generation. Percent increase over preceding year*

Year	United States [1]		Pacific States [1]		Market area for Columbia River power [2]		Washington [1]		Western Washington [3]		Eastern Washington [4]	
	Average generation	Increase per year	Average generation	Increase per year	Average generation	Increase per year	Average generation	Increase per year	Average generation	Increase per year	Average generation	Increase per year
	Kilowatts	*Percent*	*Kilowatts*	*Percent*	*Kilowatts*	*Percent*	*Kilowatts*	*Percent*	*Kilowatts*	*Percent*	*Kilowatts*	*Percent*
1921		−5.9		4.3		−5.3		−1.6		−12.0		−7.9
1922		16.3		9.8		10.6		9.3		12.0		8.0
1923		16.8		15.1		16.3		12.5		21.3		17.8
1924		6.0		8.7		7.1		3.7		7.4		2.9
1925		11.6		10.9		8.6		8.2		2.8		6.3
1926		12.0		11.3		10.5		11.4		30.0		5.8
1927		8.7		8.2		10.3		17.4		16.2		8.0
1928		9.5		9.9		15.7		11.0		8.0		19.4
1929		10.8		10.8		7.9		8.4		4.8		6.5
1930		−1.5		1.2		1.7		.7		9.2		3.4
1920	4,958,432	[5] 8.2	615,653	[5] 8.9	210,192		136,379	[5] 7.8	78,279	[5] 9.5	70,751	[5] 6.0
1930	10,947,736		1,450,806		461,333		293,177		193,182		127,357	
1920	4,958,432	[5] 9.4	615,653	[5] 9.8	210,192		136,379	[5] 8.8	78,279	[5] 9.5	70,751	[5] 7.2
1929	11,109,367		1,433,745		453,803		291,259		176,858		131,838	
1921	4,675,933	[5] 9.9	642,254	[5] 9.6	199,103		134,275	[5] 9.2	68,916	[5] 12.2	65,196	[5] 7.9
1930	10,947,736		1,450,806		461,333		293,177		193,182		127,357	

[1] United States Geological Survey reports.
[2] United States Geological Survey reports for Washington and Oregon plus companies' reports for Thompson Falls plant in western Montana and the Lewiston and Grangeville plants in northern Idaho.
[3] Companies included in western Washington are Puget Sound Power & Light Co., city of Seattle, city of Tacoma, Washington Pulp & Paper Corporation, Grays Harbor Railway & Light Co., and associated companies.
[4] Companies included in eastern Washington are the Washington Water Power Co., Pacific Power & Light Co., and the Thompson Falls plant of the Montana Power Co.
[5] Compounded annually.

1028. Examination of these and other statistics of the Northwest, and their comparison with the statistics of other sections of the country, indicates that during the past 20 years there has been little of the sensational or abnormal in its growth. Certainly there has been no "boom." Indeed, the long-continued depression in the lumber business tended to retard business progress long before the beginning of the national depression of 1930 and 1931. Therefore, the use of the statistics of recent years as a basis from which to predict the future is not likely to lead to excessive optimism.

1029. In the preparation of studies for power plants on the Columbia River it is essential to have some reasonable basis for estimating the time that may elapse before the output can be absorbed by the probable market.

1030. Available data point to the conclusion that the normal growth in the northwestern market for electric energy is approximately 9.5 percent per year with the output of 1930 close to the trend curve. Events taking place within the industry do not point to any sudden and permanent change in the general trend. It is altogether probable that the present depression will be followed and offset by an accelerated expansion.

[2] Not printed.

1031. Ten years ago such a rate of growth appeared uncertain. Now it is an accomplished fact. Yet it is difficult to believe that the production of electrical energy can continue indefinitely to increase at the rate of 9.5 percent per year. In 7.6 years it would make production twice what it is at the present. In 15.2 years it would be 4 times and in 22.8 years, 8 times the present. It is considered expedient to provide in the estimates for the gradual reduction of this 9.5 percent rate without making any abrupt change in the trend.

1032. Furthermore, when it is considered that the electrical industry has sprung up within less than 50 years and during that time has profoundly modified many older industries, it is not difficult to imagine that in time some new discovery may render obsolete our use of electricity as we know it today. In such an event the vast investment in plant and equipment will conceivably prevent the early supersession of generating plants though it stop their expansion. Therefore, it is deemed conservative to assume that the rate of increase of production may ultimately reach zero and the industry become stationary.

1033. A study of trend curves of various forms has been made, including the much-discussed biological population curves, in the attempt to find one which will give reasonable results and will yield readily to mathematical computation. There has been selected for the rate of increase, a portion of a sine curve, such that the rate of increase of the production is 9.5 percent in 1930, decreases to 4.75 percent in 1960 and finally reaches zero in 1990.

1034. By integrating the equation it is possible to obtain a formula from which can be computed directly the estimated output of kilowatt-hours or average kilowatts for any year.

1035. To plate no. 125 [2] there has been added a graphical presentation of the estimated production in average kilowatts computed for market area for Columbia River power in accordance with the above formula. For comparison there is also shown production for a uniform rate of increase of 9.5 percent per year. The graphs for the Pacific States and for the United States have also been extended in accordance with their indicated trends.

1036. It is not asserted that there is mathematical accuracy in the estimates obtained by this method and shown on plate no. 125 [2] nor is it believed that it is possible to secure such accuracy. Should growth continue as in the past the estimate will be far exceeded. Should the industry fail to expand into new markets, or should it be seriously affected by some new discovery, it may fall short of the estimate.

1037. Even if we have been successful in determining the future trend, we do not expect that the output for any particular year will fall upon the curve. The irregularities of the past will certainly continue in the future and the best that can be expected is that some years will be above and some below the curve. At this writing it appears probable that 1931 will be in the latter class. Only the future can tell what will occur in later years.

1038. The curve of plate no. 125 [2] is presented only as a reasonable forecast of the growth of the market for electricity for use in connection with the study of a comprehensive plan for the development of the Columbia River.

[2] Not printed.

D. Flood Control

I. FLOODS

1039. The valley of the Columbia within the United States above the Snake is not subject to inundation, the banks being sufficiently high to confine flood waters except during extreme conditions, which will probably obtain only once in 400 years or longer. Even under these conditions only small isolated areas would be flooded. If a high water be considered a flood only when it overtops the river bank, then there has been only one flood of record on the Columbia above the Snake—the high water of 1894.

1040. The tributaries are likewise free from flood damage except for marginal lands on lakes.

1041. The Columbia and its tributaries, Clark Fork and Spokane River, are quite regular in behavior, being regulated by the natural storage of water in the many lakes on the tributaries and by snow and ice storage in the mountains. These rivers have only one high-water and one low-water stage each year. High water occurs in summer and is due to the melting of snow in the high altitudes. Low water is in winter when the precipitation is in the form of snow. High water is not directly dependent to any large extent upon the rainfall on the drainage basins.

1042. The lands marginal to Flathead, Pend Oreille, and Coeur d'Alene Lakes are the only areas subject to inundation that in any way affect the matters considered in this report and are therefore the only areas discussed.

1043. An unpublished report on flood control of Pend Oreille River, Idaho, was made by L. T. Jessup to the United States Department of Agriculture in 1918. This report considered the improvement possible in the river below Pend Oreille Lake in the interest of flood-stage reduction on the lake.

(A) MAGNITUDE

1044. The greatest flood on record occurred in June 1894. This was not only the greatest known flood at The Dalles, Oreg., but also on all of the tributaries. No flood of the last half century has closely approached this one, but that of 1849 may have equalled it at The Dalles, although the record is not clear. Maximum estimated discharges during the 1894 flood were as follows: Kettle Falls, 700,000 second-feet; Grand Coulee, 725,000; and Wenatchee, 740,000.

1045. The elevations of high water on Flathead, Pend Oreille, and Coeur d'Alene Lakes are given in table no. 190, arranged in order of magnitude. United States Geological Survey datum is used for Flathead Lake, and United States Coast and Geodetic Survey datum for Pend Oreille and Coeur d'Alene Lakes.

TABLE No. 190.—*High-water elevations on Flathead, Pend Oreille, and Coeur d'Alene Lakes*

Order	Flathead		Pend Oreille		Coeur d'Alene	
	Year	Crest elevation (United States Geological Survey datum)	Year	Crest elevation (United States Coast and Geodetic Survey datum)	Year	Crest elevation (United States Coast and Geodetic Survey datum)
		Feet		*Feet*		*Feet*
1	1894	[1] 2,900.0	1894	2,076.1	1894	2,134.7
2	1928	2,896.0	1913	2,069.1	1918	2,133.0
3	1916	2,895.7	1928	2,068.7	1917	2,133.0
4	1913	2,895.5	1916	2,068.4	1893	2,132.2
5	1927	2,895.2	1927	2,068.2	1913	2,131.6
6	1925	2,894.3	1908	2,067.4	1897	2,131.4
7	1921	2,893.7	1917	2,066.7	1925	2,130.5
8	1917	2,893.5	1903	2,065.7	1910	2,130.3
9	1918	2,893.3	1925	2,065.4	1899	2,130.0
10	1909	2,893.2	1921	2,065.3	1904	2,129.9
11	1922	2,892.6	1922	2,064.7	1916	2,129.9
12	1923	2,892.3	1909	2,064.5	1927	2,129.6
13	1919	2,891.8	1918	2,063.6	1898	2,129.6
14	1911	2,891.4	1907	2,063.2	1928	2,129.1
15	1924	2,891.3	1923	2,062.5	1921	2,129.0
16	1920	2,891.3	1912	2,062.2	1922	2,129.0
17	1910	2,891.0	1904	2,062.1	1919	2,129.0
18	1929	2,890.6	1920	2,060.7	1902	2,128.8
19	1912	2,889.9	1924	2,060.7	1903	2,128.2
20	1914	2,889.8	1919	2,060.6	1907	2,128.0
21	1926	2,888.6	1911	2,060.5	1908	2,128.0
22	1915	2,887.0	1910	2,060.2	1912	2,128.0
23			1914	2,059.9	1901	2,127.9
24			1929	2,059.4	1923	2,127.7
25			1905	2,056.0	1892	2,127.7
26			1926	2,056.0	1896	2,127.6
27			1906	2,054.7	1914	2,127.0
28			1915	2,054.4	1920	2,126.7
29					1924	2,126.5
30					1909	2,126.3
31					1911	2,126.3
32					1906	2,126.0
33					1895	2,125.8
34					1900	2,125.8
35					1926	2,125.6
36					1929	2,125.2
37					1915	2,124.2
38					1905	2,122.3

[1] Estimated.

(B) DURATION

1046. The Rocky Mountain Power Co. has been granted a license by the Federal Power Commission for power development on Flathead River at the outlet of Flathead Lake. This license authorizes regulating the lake below elevation 2,893 feet, United States Geological Survey datum. Considering high waters which exceed this elevation (2,893) as floods, the durations were as follows:

Year	Number of days water was above elevation 2893, United States Geological Survey datum	Year	Number of days water was above elevation 2893, United States Geological Survey datum
1894	No record.	1925	14
1928	19	1921	12
1916	28	1917	10
1913	23	1918	8
1927	23	1909	6

1047. Regulation of storage in Pend Oreille Lake has been studied below various elevations from 2,061.8 to 2,066.8 feet, United States Coast and Geodetic Survey datum. The durations of high waters above 2,064.3 and 2,066.8 are given in the following table:

Year	Number of days water was above elevation—	
	2064.3	2066.8
1894	No record	No record.
1913	do	Do.
1928	23	12.
1916	30	16.
1927	27	15.
1908	No record	No record.
1917	36	Did not reach elevation 2066.8.
1903	Record incomplete	Do.
1925	13	Do.
1921	Record incomplete	Do.
1922	8	Do.
1909	Record incomplete	Do.

1048. The Washington Water Power Co. has flowage rights on Coeur d'Alene Lake up to elevation 2125.1 feet, United States Coast and Geodetic Survey datum, although at present it is exercising those rights only up to elevation 2123.6. Storage below elevation 2129.1 in connection with irrigation has been considered. The durations of high waters above elevation 2129.1 are given in the following table.

Year	Number of days water was above elevation 2129.1 [1]	Year	Number of days water was above elevation 2129.1 [1]
1894	No record.	1910	22.
1918	14.	1899	No record.
1917	36.	1904	9.
1893	No record.	1916	6.
1913	44.	1927	10.
1897	No record.	1898	No record.
1925	12.	1928	3.

[1] U.S. Coast and Geodetic Survey datum=2132.5 U.S. Geological Survey datum.

(C) FREQUENCY

1049. The period of record of flood stages on the lakes on the tributaries to the Columbia is much too short upon which to base a study of the probable frequency and magnitude of future floods. The 1894 flood was by far the greatest flood of record on the Columbia and its tributaries. Studies of flood-discharge records at The Dalles, Oreg., which are available for a period of 73 years, from 1858 to date, indicate that a flood like that of 1894 (1,160,000 second-feet) may be expected once in about 400 years, and it is assumed that the frequency of floods on the upper river and tributaries is of like order; that is, that a high water like the 1894 flood may be expected about once in 400 years.

(D) AREAS AFFECTED

1050. The areas affected by floods are the delta of the Flathead River at the northern end of Flathead Lake; the lands marginal to

Pend Oreille Lake, and the city of Sandpoint, and the lands bordering Coeur d'Alene Lake and the delta of St. Joe River. Except at Sandpoint, the land subject to flood damage is devoted to agriculture. There are a few mills and other industries on Coeur d'Alene which are subject to flood damage during extreme high water.

(E) LOSSES AND DAMAGES

1051. The detrimental effect of high waters on Flathead, Pend Oreille, and Coeur d'Alene Lakes is more in the nature of losses than damages. Marginal lands are not protected by dikes, and some flooding during high-water periods is expected, which reduces the value of the lands, especially as high waters occur in the early summer during the growing season. The losses have been in crops, interruption to traffic, etc. A flood like that of 1894, however, would do considerable damage to towns, bridges, roads, farms, wharves, and railways. No reliable records are available of losses or damages on any of the above-mentioned lakes.

1052. On Flathead Lake the lands subject to inundation are located in the delta of the Flathead River at the north end of the lake. The highest high water of record occurred in 1928 and is exceeded in height only by the 1894 flood. During this 1928 high water the district engineer made an inspection and reported as follows:

> The valley of the Flathead River is most beautiful at this season of the year, with the wheat, alfalfa, and similar crops well advanced. It was estimated by local authorities that 4,000 acres of low-lying land was flooded, but I cannot verify this estimate at this time. It was also estimated that about one tenth of the cultivated land in the valley was flooded. This seems to be a generous estimate, as the flooded area is quite small in comparison to the total amount of cultivated land. The loss is limited to only a percentage of the value of the prospective crops in the flooded area. Most of the land can be replanted in grass or other crops and therefore the actual loss should not be great. The people in the flooded area were somewhat inconvenienced on account of the roads being flooded.

1053. No records of losses are available for Pend Oreille Lake. The highest flood recorded was that of 1894, the next highest being in 1913, which was 6.9 feet lower. A part of Sandpoint would be submerged by a flood like that of 1894, whereas the 1913 high water did but little damage.

1054. On Coeur d'Alene Lake the 1894 flood had a crest elevation of 2,134.7 feet, United States Coast and Geodetic Survey datum. The high waters of 1918 and 1917, the next highest, each reached elevation 2,133. Regulation of this lake below elevation 2,129.1 will not increase the flood stage. If enlarged outlets be provided, it may be possible even to reduce the flood heights.

1055. No control of floods on Coeur d'Alene Lake is contemplated in this study. The flood control proposed for Flathead and Pend Oreille Lakes is to be accomplished by storage in the Hungry Horse Reservoir, about as indicated in the following outline.

1056. The normal operation of the proposed Hungry Horse Reservoir in the interest of power would be to fill it during the spring and early summer rise of the South Fork of the Flathead River and draw on the storage during the fall and winter months. This river is very regular in its cycle of operations. High water is generally in June and low water occurs in the winter. The normal operation in the interest of power would therefore tend to reduce the high-water discharge and consequently the elevation of high water on the lakes below. By increasing the height of the dam and reserving the upper portion of the reservoir for flood control, this effect could be greatly increased. Furthermore, by snow surveys it is believed possible to determine in advance the years when an extreme high water may be expected and, with reasonable accuracy, the approximate time and magnitude. During other years by careful regulation, a portion, at least, of the upper part of the reservoir could be filled before the end of the spring rise and used for the benefit of power. The unusual conditions obtaining at this site, therefore, permit of a very satisfactory coordination of storage in the interest of power and flood control.

1057. Studies of the 1928 flood show that if 135,000 acre-feet of storage had been available in the Hungry Horse Reservoir for flood-control, in addition to the storage for power, the maximum elevation of Flathead Lake during 1928 would have been reduced from elevation 2,896 to 2,893 feet, United States Geological Survey datum, or 3 feet, and that the corresponding reductions in elevations on Pend Oreille would have been from 2,068.7 to 2,065.8, United States Coast and Geodetic Survey datum, or 2.90 feet. In those studies no account was taken of the channel storage in the river between Flathead and Pend Oreille Lakes, which would have further reduced the computed flood height on Pend Oreille.

1058. A similar study of the flood of 1894, with 279,000 acre-feet storage available in the Hungry Horse Reservoir for flood control, indicates that the elevation in 1894 on Flathead Lake would have been reduced by 3.28 feet and on Pend Oreille by 2.32 feet.

1059. The south fork of the Flathead is not a glacial stream and carries but little silt. It is believed that silting of the reservoir will be so minor that its effect may be neglected.

1060. It has been shown that normal operation of this reservoir in the interest of power at the site would reduce the flood heights on both Flathead and Pend Oreille Lakes. The crest heights could be further reduced by increasing the height of the dam and reserving a part of the storage for flood control. Any license issued by the Federal Power Commission for power development at the Hungry Horse site should require consideration of flood control.

II. EXISTING PROTECTIVE WORKS

1061. The only protective works on Flathead Lake are small dikes along the river in its delta section. There are no protective works on Pend Oreille Lake. Five areas have been diked on the St. Joe River near and below the mouth of the St. Maries River to protect the land from backwater from Coeur d'Alene Lake. Four of these were formed under State laws. The fifth is a private district of the Milwaukee Lumber Co. These five districts comprise nearly 2,500 acres. The cost of protection varied from $30 to $100 per acre. Each district is also provided with a pumping plant to care for the local drainage during high river stages. The lands in these districts are very rich.

E. Irrigation

(1) GENERAL CONSIDERATIONS—(A) PRESENT STATUS

1062. Irrigation in the arid regions of the Columbia River Basin, as in other parts of the world where it is being successfully practiced, is dependent for its success upon several factors, among which are:

First. Soil that is fertile and productive.
Second. Climate that is favorable.
Third. Water supply that is adequate.
Fourth. Project works that are reasonable in construction and operation costs.
Fifth. Market for products, which includes the question of transportation.
Sixth. Settlers capable of proper development of the land.
Seventh. Capital and credit facilities needed for settlement and development.

1063. The soil of the irrigable areas within the basin of the Columbia is mainly a fine, silty, volcanic ash, containing iron, potash, and nitrates, with some disintegrated granite and lava. It is generally of good depth, easily tilled, fertile, and well adapted to almost all crops indigenous to the temperate zone, especially vegetables, apples, and soft fruits.

1064. The climate is generally mild, with occasional cold periods in winter, and hot days, but comfortable nights, in summer. The annual precipitation within the basin below the boundary, ranges between a minimum of 6.6 inches and a maximum of about 30 inches, with a mean of about 20 inches over most of the area. According to R. P. Teele, in Economics of Land Reclamation, 1927, page 22:

> For many years a 20-inch annual precipitation was supposed to mark approximately the dividing line between the sections in which irrigation was necessary to the maturing of crops, and those in which it was not necessary.
>
> While so-called dry farming is carried on in many sections in which the precipitation is considerably below 20 inches, crops often fail in sections where it exceeds 20 inches.

1065. Elevations of the irrigable areas in Washington range from 2,000 feet above sea level down to about 400 feet; in Montana they average about 3,000 feet.

1066. The water supply, obtained from the natural flow of the streams supplemented by storage, is usually adequate, but is limited by the capacities of the regulating reservoirs. In several of the smaller developments, during the recent years of subnormal precipitation, the available supply of water has not been sufficient to irrigate fully the lands of some projects, so that marginal lands have suffered.

1067. Construction costs of the earlier projects were low. Individual farmers, or groups of them, diverted small streams upon the adjacent lands, using the cheapest class of construction, and seldom counting their own time in computing costs. Thus, small enterprises were successively developed as needed. As land values increased, and all the easier projects were completed, more and more difficult ones were undertaken, and construction costs of irrigation works are found to range all the way from a nominal $3 to $5 an acre up to many times those amounts. The higher costs naturally have been in connection with the more difficult projects, and have been incurred to assure permanent construction, an adequate water supply, and continuity of service.

1068. Market, or demand, for products is an economic factor. In the early days the demand arose from the primitive need of the pioneers for a food supply that was assuredly more stable than the nomadic Indian tribes had possessed; this was the first incentive for irrigation of the arid lands of the Columbia River Basin. Next, the discovery of gold, as well as other valuable metals, and the consequent springing up of populous mining camps, gave irrigation additional impetus, because of the demand for foodstuffs. Then came the bona fide farmer-settler, attracted by the advantages which the basin offered. And lastly, the building of the railroads—the Northern Pacific in 1886, and the Great Northern in the early nineties—which afforded transportation to the rapidly growing market centers of Puget Sound. In addition, the Chicago, Milwaukee, St. Paul & Pacific Railroad, constructed in 1908, and the Union Pacific system now serve the territory.

There is no important crop grown under irrigation for which there is a sufficient local market; consequently, the farmers on irrigated lands must compete with the farmers growing the same crops on nonirrigated lands, and must do so usually under the handicap of a heavy differential in transportation.—R. P. Teele, Economics of Land Reclamation (p. 38).

1069. Obtaining qualified settlers for development of the land is a problem, fully as essential to success as the construction work of the project, and one that involves human and social relations as well as financial and economic questions. For many years it has been regarded as a good policy to select the proper kind of men, but to carry this policy into full effect has been found exceedingly difficult. Intensive cultivation of irrigated lands is a highly specialized industry which requires of the individual settlers adequate financial resources and experience, together with an aptitude for agricultural pursuits, home making, industry, and thrift. Unfortunately for the early development of reclamation projects, there was seldom a sufficient number of settlers having these qualifications, although there were many prospective settlers of the speculative type.

1070. As time passes, and the standards of living rise, more and more is desired and has to be created in the way of roads, schools, churches, amusement and educational facilities, and many other things that the earlier pioneer settlers of the country did not expect. To create these things takes time and money. The settler of today may be possessed of an abundance of ambition and hope, but he cannot be expected to succeed if placed on a previously untilled irrigated farm with only scanty equipment, limited financial resources, and little agricultural experience. The settler on irrigated land, like the individual embarking upon any other enterprise, is interested in the financial returns or profit that he may expect to realize from the investment of his capital, time, and effort. Unless he has reasonable assurance of profit he will not be a contented and successful farmer, and consequently, will probably not remain on the land permanently.

1071. When a new project is launched, the progress of settlement is gradual, and oftentimes disappointingly slow. If a given number of units be thrown open for settlement, it is probable that not more than 25 percent will be occupied the first year, and not more than 50 percent by the tenth year. United States Department of Agriculture Bulletin No. 1257, page 33, R. P. Teele, states:

The real problem in reclamation work is bringing the land into use promptly enough to prevent financial failure caused by heavy carrying costs chargeable to land that is not producing.

Figure 1 of the same bulletin, reproduced herein as plate no. 126,[2] shows graphically by means of curves the rate in the past at which land in irrigated enterprises has been put under cultivation. These curves show plainly one of the immediate causes of the financial failure of irrigation enterprises to be the very low rate at which the land included is brought into production. While these curves may not be applicable to future irrigation projects, yet, from the experience gained from past developments and the mistakes made, it is believed that they indicate the possibilities of a serious lag in bringing the land into early production.

(B) SOURCES OF WATER

1072. The natural flows of most of the tributary streams of Columbia River in Washington do not lend themselves readily to the needs of irrigation. During the fall and winter months there is an abundant precipitation, mostly, at least at the higher elevations, in the form of snow. During the spring and early summer months, while this snow is melting, there is ample natural flow in the streams. By the end of June the snow has nearly all disappeared, and, as there is but little rainfall in the irrigable districts during the summer, the natural flow of the streams is greatly diminished, and in some instances it ceases entirely several weeks before the end of the irrigating season. The obvious remedy is to provide storage reservoirs, which has been done in numerous instances on the more successful irrigation enterprises. In the Yakima, Wenatchee, and Okanogan districts, in the State of Washington, and in numerous smaller areas as well, probably 85 to 90 percent of the present irrigated lands are dependent upon storage reservoirs for their supply of irrigating water. In fact, in most districts, the development of additional excellent irrigable areas is halted, largely by the lack of suitable sites for storage reservoirs.

1073. The utilization of subsurface supplies of water is relatively very small, it being estimated that such source serves about 1 to 2 percent of the irrigated lands of the basin, the chief areas being in the vicinities of Ephrata, Moses Lake, Quincy, and Hanford, and in the Spokane Valley. The water is mainly obtained by pumping from wells, although in the vicinity of Hanford there are good artesian supplies. It is reported that the supply of subsurface water in those places is sufficient for the irrigation of quite extensive additional areas.

1074. There are numerous small enterprises that are supplied with water by pumping direct from rivers or lakes to low-lying contiguous lands. This is notably the case at various locations along the Columbia River, and to a lesser extent along the Okanogan and Spokane Rivers and other smaller streams, and also on the shores of Moses, Chelan, and Flathead Lakes. The acreage of lands thus irrigated is not definitely known, but is estimated to be about 4 percent of the whole.

(2) IRRIGABLE AREAS—(A) LOCATION

1075. The total drainage area of the Columbia River above the mouth of Snake River is 103,000 square miles, of which approximately two thirds lies within the United States and the remainder in Canada. Of the lands in the United States, above the mouth of the Snake, the

[2] Not printed.

area now (1931) irrigated is about 1,143 square miles (731,000 acres), located by States as follows: Washington, 703 square miles; Idaho, 13 square miles; Montana, 427 square miles. The location and extent of these lands is shown approximately on plate no. 3, page 591. The Columbia Basin lands in Washington above the mouth of Snake River, both irrigated and irrigable, total about 4,375 square miles, or 2,800,000 acres. The acreage of such lands in the States of Idaho and Montana has not been accurately determined. In the water-supply studies and estimates for this report, conservative allowances have been made for future irrigation requirements in both Idaho and Montana, although specific tracts may not be mentioned, and possibly in some instances not even known. These estimates were arrived at from data submitted by the State engineer of Montana, the Commissioner of Reclamation of Idaho, and the district chief engineer of the Dominion of Canada Water Power and Reclamation Service.

1076. Data relating to irrigated and irrigable areas in the States of Washington, Idaho, and Montana are given in table no. 191. Columns 2, 3, and 4 are copied from United States Bureau of the Census, Preliminary Announcement; 1930 Census of Irrigation. Column 5 is from data compiled in the office of the supervisor of hydraulics of the State of Washington. Column 6 is the result of a survey made in 1930 by the United States Engineer Department. Column 4 does not purport to be the entire irrigable acreage within the divisions named, but only the irrigable acreage within projects on which development has already been initiated. The irrigable lands of the State of Washington are considered in greater detail than those of Idaho and Montana because they comprise by far the major part, and interest, of the unirrigated lands of the Columbia River basin, and are the only unirrigated lands which affect the problems on the main stream.

TABLE No. 191.—*Data pertaining to irrigated and irrigable lands in Washington, Idaho, and Montana, in the Columbia River drainage basin above the mouth of Snake River*

WASHINGTON

County (1)	Acreage irrigated 1929 (2)	Acreage enterprises were capable of irrigating, 1930 (3)	Irrigable acreage in enterprises, including irrigated, 1930 (4)	Acreage of irrigable lands not irrigated, 1926 [1] (5)	Acreage of irrigable lands Columbia Basin irrigation project. Gravity plan with supplemental pumping to 100 feet, estimated to nearest 1,000 acres (6)
Benton	30,406	44,037	54,829	295,000	---
Chelan	36,096	38,518	43,177	42,000	---
Douglas	10,166	10,649	11,113		---
Ferry	1,246	2,028	5,835	15,000	---
Kittitas	45,960	66,869	126,343	89,000	---
Okanogan	36,322	50,209	60,877	58,000	---
Pend Oreille	896	2,705	3,334	4,000	---
Spokane	18,239	30,245	37,983	35,000	---
Stevens	3,077	3,602	5,182	13,000	---
Yakima	256,174	302,389	478,162	173,000	---
Adams	1,183	1,281	---	---	478,000
Franklin	2,616	4,521	---	---	383,000
Grant	7,619	8,253	---	---	659,000
Total	450,000	565,306	826,835	724,000	1,520,000

[1] Exclusive of Columbia Basin irrigation project.

TABLE No. 191.—*Data pertaining to irrigated and irrigable lands in Washington, Idaho, and Montana, in the Columbia River drainage basin above the mouth of Snake River*—Continued.

IDAHO

County	Acreage irrigated 1929	Acreage enterprises were capable of irrigating, 1930	Irrigable acreage in enterprises, including irrigated, 1930	Acreage of irrigable lands not irrigated, 1926	Acreage of irrigable lands Columbia Basin irrigation project. Gravity plan with supplemental pumping to 100 feet, estimated to nearest 1,000 acres
(1)	(2)	(3)	(5)	(5)	(6)
Bonner	922	1, 163	2, 098		
Boundary	628	628	702		
Kootenai	6, 404	10, 279	10, 681		
Total	7, 954	12, 070	13, 481		

MONTANA

County	Acreage irrigated 1929	Acreage enterprises were capable of irrigating, 1930	Irrigable acreage in enterprises, including irrigated, 1930	Acreage of irrigable lands not irrigated, 1926	Acreage of irrigable lands Columbia Basin irrigation project
Deer Lodge	19, 048	26, 562	27, 351		
Flathead	3, 703	7, 177	7, 792		
Granite	24, 503	26, 004	27, 976		
Lake	41, 237	108, 452	121, 502		
Lincoln	6, 960	8, 356	9, 200		
Mineral	1, 039	1, 184	1, 214		
Missoula	19, 640	28, 664	31, 358		
Powell	60, 550	73, 681	74, 614		
Ravalli	87, 183	105, 545	110, 275		
Sanders	9, 243	17, 466	20, 123		
Total	273, 106	403, 091	431, 405		
Grand total	731, 060	980, 467	1, 271, 721	724, 000	1, 520, 000

1077. Except for the areas embraced within the Columbia Basin irrigation project, the sources of water for most of these lands are the tributaries of the Columbia River. The source of water for that project would be either the Columbia River or its large tributary, Clark Fork, depending upon what plan of development is adopted. Two methods of irrigating the Columbia Basin irrigation project are being considered: diversion of water from Clark Fork near Albany Falls; and pumping water to the land from the Columbia in the vicinity of the north end of Grand Coulee. These plans are referred to respectively as the "gravity plan" and the "pumping plan." The gravity plan contemplates the irrigation of the Columbia Basin irrigation project with water diverted from the Clark Fork at Albany Falls into a canal some 130 miles long. This canal would include 30 miles of tunnel, 40 miles of natural and artificial lakes, and would have three inverted siphons. It would pass close to Spokane and end at Hillcrest, where the distribution of the water would begin. This plan would require regulation of Pend Oreille Lake in the interest of irrigation. The amount of storage to be regulated depends on the area irrigated and the duty of water. Under the gravity plan the ultimate irrigable area is 1,257,000 acres directly, and 263,000 acres additional by supplemental pumping to a height not exceeding 100 feet; total 1,520,000 acres.

1078. The pumping plan contemplates pumping the water from the Columbia at a point near the northern end of Grand Coulee. To obtain the necessary power, a dam about 220 feet high would be required, which would also reduce the pumping head to about 380 feet. This plan also contemplates using part of the Coulee as an equalizing reservoir. This reservoir would be about 23 miles long, and the main distribution canal system, not including the reservoir, about 12 miles long. A large amount of power could be generated at this Coulee dam site for commercial use, in addition to that required for irrigation pumping, if and when there is a market for its disposal. Under the pumping plan the ultimate irrigable area is 980,340 acres directly, and 219,090 acres additional by repumping to a height not exceeding 100 feet; total, about 1,200,000 acres.

Comparison of gravity and pumping plans, Columbia Basin Irrigation Project (acres)

	Gravity plan	Pumping plan
Irrigable lands lying below main canals	1,256,940	980,340
Irrigable by supplemental pumping 100 feet above main canals	262,950	219,090
Total irrigable	1,519,890	1,199,430
Nonirrigable within project limits, approximately	870,000	741,000
Total area within project limits, approximately	2,390,000	1,940,000

(B) CHARACTER

1079. According to some geologists, all of central Washington in prehistoric times was covered by a great lake on the floor of which was deposited an abundant blanket of sediment that has now become a fine fertile soil. It is consequently classed largely as alluvial, or of water-borne origin, although there exist important areas that are of wind-laid or wind-borne origin. This soil contains iron, potash, and nitrates, with some disintegrated granite and lava, and may be roughly divided into three classes: (1) A smooth-surfaced, close-textured silt loam; (2) a rougher-surfaced silt loam; and (3) a smooth-surfaced, light, sandy loam, gradually merging into the sand of the nonirrigable areas. The shallower portions of this last class may be found underlain at from 8 to 20 inches with gravel, sometimes quite coarse and porous, or with consolidated beds of sands and gravels. In the State of Montana the soil is light sandy to heavy clay, very retentive of moisture except for one area (Jocko Valley) which is shallow and underlain with gravel.

(C) OWNERSHIP

1080. When the transcontinental line of the Northern Pacific Railway was built through this part of the State of Washington in the early eighties, it was granted, by an act of Congress, every alternate section of land lying within 40 miles of its right of way, to assist in financing its construction. Most of that has since passed into private ownership, in tracts ranging in size from a quarter section to several sections. Also, two sections, nos. 16 and 36, in each township were granted to the State for school purposes. The remainder of the lands were held by the Government subject to homestead entry in quarter-section tracts or less. At the present time about 5 percent of the irrigable lands of the basin are thus held by the Government, and are mostly of a rough and undesirable character from an agricultural point of view, which accounts for their not having been taken up previously by homestead entry.

1081. During the cycle years of abnormally high rainfall, 1900 to 1906, much of the land in the basin was dry farmed with a small degree of success; but with the subsequent cycle of dry years—that is, years of normal or subnormal precipitation—dry farming almost invariably was a failure. As a result of this condition much of the land was abandoned by the original settlers, and title to large areas of it gradually passed into the control of banks and mortgage and loan companies.

1082. Table no. 192, showing the ownership of irrigable lands within the Columbia Basin Irrigation Project, is compiled from two similar tables published in a "Report by the Columbia Basin Survey Commission, State of Washington, 1920." This table indicates that in 1920 about half of the land was owned in small units of less than 640 acres. It is probable that the figures have undergone no material change since that date, except for some consolidation of the smaller private holdings for the reason stated above.

TABLE NO. 192.—*Ownership of lands under the Columbia Basin Irrigation Project*

County	Private		U.S. Government	State	Northern Pacific Ry.	Total irrigable
	Less than 1 section	More than 1 section				
Adams ....acres	205,230	224,980	3,660	20,790		454,660
Percent	45	49	1	5		
Grant ....acres	332,397	248,315	59,490	26,808	52,870	719,880
Percent	46	35	8	4	7	
Franklin ....acres	176,970	207,080	28,140	19,240	34,330	465,760
Percent	38	45	6	4	7	
Total ....acres	714,597	680,375	91,290	66,838	87,200	1,640,300
Percent	43.6	41.6	5.5	4.0	5.3	

(3) EXISTING IRRIGATION DEVELOPMENT

1083. The beginning of irrigation in the arid areas of Columbia River drainage basin above the Snake was probably about the year 1846 or 1847, at St. Mary's Mission in Montana. This mission had been founded in 1841 for the Flathead Indians by Father John De Smet, a Jesuit missionary, at what is now Stevensville, about 27 miles south of Missoula. It was abandoned in 1850 because of the pillaging and predatory activities of the hostile Blackfeet Indians, who continually persecuted the more peacable Flathead Tribe. On September 6, 1846, Father De Smet wrote: [62]

> Two large rivulets, now almost useless, can, with a little labor, be made to irrigate the fields and orchards of the village (St. Mary's).

1084. In 1846 (or 1847) St. Mary's Mission produced 7,000 bushels of wheat, 4,000 to 5,000 bushels of potatoes and other vegetables on the farm, which was irrigated by two small streams running through it.[63]

[62] Father De Smet's Life and Travels Among the Indians, ii, p. 271.
[63] Bancroft's History of Washington, Idaho, and Montana, p. 604.

1085. In 1854, four years after the abandonment of St. Mary's, Father De Smet founded St. Ignatius' Mission at a point about 32 miles north of present-day Missoula. Irrigation was soon begun, probably in 1855, and has been continued ever since.

1086. In the Yakima Valley there is an unauthenticated record of irrigation development antedating the year 1855, reported as follows: [64]

> When, in 1884, the Northern Pacific Railroad was built through Union Gap, an old ditch was destroyed, which was, according to Jay Lynch (S. Ex. Doc., 63d Cong., 2d sess., vol. 5, p. 112), the property of the Indians, for he testified: "There were old canals and fruit trees down in Union Gap that, according to the Indians, were planted and irrigated from the Yakima River before the treaty of 1855."

1087. In the Yakima Valley the first irrigation development of note was in the year 1867, at which time the Nelson Ditch was constructed. Washington had been organized as a Territory in 1853 (State in 1889). Previously, and continuing until 1855, when the first treaty was made with the Indians, the Yakima River Basin, as well as almost all of eastern Washington, had been in the possession of the natives, unfrequented by white men except for itinerant trappers and occasional bands of emigrants en route to the lower Columbia River or to Puget Sound. In 1861, 6 years after the making of the treaty, Yakima Valley was entered by the first white settler, and in 1865 Yakima County was created. The Nelson Ditch, which is still in existence, was the forerunner of the present extensive irrigation development in the Yakima Valley. It was quite small, having a capacity of only about 7 second-feet, but even this small beginning demonstrated the advantages of applying irrigation to the fertile volcanic ash soil of the valley.

1088. The existing irrigation projects in the Columbia River Basin have been initiated and developed under the supervision and regulation of one or more of five agencies, private, corporate, district, Federal or State, the earliest of which was, naturally, the private.

1089. During the early days of irrigation history, farmers, either individually or in groups, confined their efforts mainly to diverting water from small streams upon the adjoining bottom lands, where the slope and topography of the country were such as to make the work easy and of low cost. With the values of land and agricultural products then obtaining, no expensive enterprises were justifiable. Such developments, proceeding for a third of a century, although limited to comparatively small tracts widely scattered over the basin, proved the feasibility of the general policy of irrigation and provided the background upon which the irrigation of larger tracts has been based. The total area of these small tracts thus irrigated was not inconsiderable, amounting, as early as 1899, 3 years before the organization of the United States Reclamation Service, to approximately 135,000 acres, located largely in Yakima and Kittitas Counties.

1090. The earliest important corporate undertaking was that of the Northern Pacific Railway Co. in the Yakima Valley in 1884. During that year the railroad was completed as far west as Yakima, which remained its western terminus for 2 years, when it was continued on through to the coast. In 1890 the same company began construction of what was later known as the "Sunnyside project", comprising a main canal of about 650 second-feet capacity, 60 miles in

[64] History of Irrigation in the State of Washington, Rose M. Boening, in Washington Historical Quarterly, October 1918, p. 260.

length, with laterals and branches aggregating 550 miles, irrigating 40,000 acres. This was the first irrigation project of any magnitude in the United States. Purchase of the rights of the Northern Pacific Railway Co. in the Sunnyside Canal was decided upon in 1905 by the recently organized United States Reclamation Service. Since that time the project has been further developed, so that in 1930 it had an irrigated area of about 95,000 acres, out of a possible ultimate irrigable area of 107,600 acres.

1091. During the nineties there were numerous ambitious enterprises undertaken by stock companies, financed by eastern capital, attracted by a paper showing of tremendous profits on investments in irrigation works. The inherent difficulties were numerous and unforeseen; and the projects did not admit of much profit to the investors; in fact, in a majority of cases, financial ruin attended these exploitations. The investors lost a large part of their initial capital, to say nothing of interest and profits, and, although the general benefits for the development of the country were valuable and lasting, such universal losses made it more difficult, if not practically impossible, to enlist private capital in further irrigation enterprises.

1092. By the year 1900 most of the small, easily developed projects in the Columbia River Basin, as well as in other parts of the United States, had been taken up. The larger projects, which involved very considerable outlays of capital, had largely met with financial disaster. Various laws had been passed from time to time by the Federal Government to encourage the irrigation of arid lands, the most conspicuous examples being the Desert Land Act of 1877 and Amendatory Act of 1891. Also there had been passed the famous Carey Act [65] of August 18, 1894, "an act to aid the public land States in the reclamation of desert lands," and the Warren Act, with their amendments of June 11, 1896, March 3, 1901, and March 15, 1910, depending upon the investment of private or corporate capital. None of these measures ever accomplished outstanding benefits for the northwestern States. Under such conditions the passage of the Reclamation Act, June 17, 1902, and the immediate organization of the United States Reclamation Service, made possible the comprehensive development of several projects on a scale larger than anything previously undertaken. This was effected by employing a revolving fund derived by the Federal Government from the sale and disposal of public lands. From the outset it was understood that "the object of the Federal reclamation is not to supplant private projects, but to undertake projects involving the construction of extensive works beyond the financial and organizing capacity of private enterprise." [66]

1093. Under Federal supervision and regulation three projects have thus far been undertaken in the Columbia River drainage basin above the Snake—namely, Yakima, with which in this discussion is included Wapato project of the Bureau of Indian Affairs, and Okanogan in Washington, and Flathead (Indian Affairs) in Montana.

1094. Some of the laws of the State of Washington relating to irrigation and reclamation are noted under paragraph 1146 following.

[65] The Carey Act is sec. 4 of an act of Congress approved Aug. 18, 1894, entitled "An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1895, and for other purposes." The act granted to each State named in it such desert land within the State, not to exceed 1,000,000 acres, as the State would cause to be irrigated and cultivated, to the extent of not less than 20 acres out of each 160 acres, within 10 years of the passage of the act. The Carey Act was accepted in Washington in 1895.

[66] New Reclamation Era, July 1930, p. 132.

(A) YAKIMA PROJECT

1095. The Yakima project is located in south central Washington, in the valleys of the Yakima and Naches Rivers, on the eastern slope of the Cascade Mountains. This project was one of the first to be undertaken by the United States Bureau of Reclamation after the passage of the Reclamation Act in 1902. It, together with the Wapato project of the United States Bureau of Indian Affairs, now embodies nearly all of the reclamation development within the length of the Yakima Valley, a distance of 160 miles, and covers an ultimate irrigable area of 670,000 acres. As the conditions of soil, climate, probable crops and markets in the Yakima Basin district are similar to those in the Columbia Basin irrigation project, it is discussed here in considerable detail.

1096. The elevations of the irrigable area range from 2,000 feet above sea level near Cle Elum and 1,600 feet at Ellensburg down to 400 feet at Kennewick. The annual precipitation ranges from 11 inches to 6 inches between the same points. Precipitation at Lake Keechelus (elevation, 2,500) at the uppermost end of the valley is about 60 inches a year, nearly one half of which is in the form of snow. The climate is mild, with occasional cold periods.

1097. The character of the topography is generally rolling, and partly for that reason irrigation is carried on mainly by the furrow system. The soil, in general, is a fine,textured silt loam, locally known as volcanic ash. It is deep, fertile, easily tilled, and well adapted to almost all crops indigenuous to the temperate zone.

1098. Transportation is provided by three railways. The main transcontinental line of the Northern Pacific traverses the entire valley; a branch line of the Oregon-Washington Railroad & Navigation Co. connects Yakima with Kennewick, and the main transcontinental line of the Chicago, Milwaukee, St. Paul & Pacific Railroad crosses the upper end of the project. A paved State highway extends 45 miles down the valley from Yakima, through the Sunnyside division, and thence an excellent gravel road extends to Kennewick at the lower end of the project. An excellent gravel highway extends up the valley to Ellensburg and Cle Elum, and thence to Seattle. Yakima, with a population of 22,100 in 1930, is the principal city in the valley. A score of smaller cities and towns, including Cle Elum, Ellensburg, Toppenish, Sunnyside, Prosser, and Kennewick, with their tributary areas, bring the aggregate population living within the three counties Kittitas, Yakima, and Benton, in which the project is located, up to 106,508, according to the 1930 census.

1099. Under the Bureau of Reclamation the first new construction was commenced in 1906, on the unit designated Tieton division, and in the same year the Northern Pacific Railway Co.'s rights in the Sunnyside division were purchased. The first water furnished by the Bureau for irrigation was on the Sunnyside division for the irrigation season of 1907. Since that time the project has been progressively extended until there was, in 1929, a total area of 226,065 acres in crops.

1100. At the time that the Bureau of Reclamation took over the development of the Yakima project, the low-water flow of the Yakima and Naches Rivers was vastly overappropriated, there being over 50 appropriations with conflicting and overlapping claims. The settlement of these various conflicting interests was accomplished in 1905 and 1906 by mutual agreement. The Legislature of the State of Washington in 1905 (Mar. 4) granted to the United States certain water rights and rights of way that enabled the Government to carry on its operations without hindrance, with the view of ultimately developing the complete water resources of the Yakima Valley.

1101. The flow of water in the Yakima and Naches Rivers does not lend itself readily to the needs of irrigation without storage. During the fall and winter months there is an abundant precipitation, largely snow, in the Cascade Mountains, in which these rivers have their sources. During the months of February to June, when this snow is melting, the period of maximum flow occurs. By the end of June the snow has practically disappeared from all but the highest peaks, and, there being little or no rainfall in this region during the summer, the amount of water which flows in the streams is decreased to the point where even the largest ones are greatly reduced and many of the smaller watercourses are entirely dry.

1102. It early became apparent that if the irrigated acreage were to be increased materially the spring flood waters would have to be stored for use during the summer low-water periods. Fortunately several excellent reservoir sites were available, and plans were formulated by the Bureau of Reclamation at the start for their development as rapidly as the demands for additional irrigating water required it. These reservoirs and their capacities are given in table no. 193.

TABLE NO. 193.—*Storage reservoirs in the Yakima district*

Reservoirs	Surface elevation	Capacity	Kind of dam	Maximum height	Crest length	Volume
		Acre-feet				*Cubic yards*
Keechelus	2515–2425	152,000	Earth and gravel fill	70	6,500	639,000
Kachess	2258–2193	221,000	do	63	1,400	193,300
Cle Elum [1]	2252–2105	501,000	do	125	700	462,000
Bumping Lake	3426–3389	34,000	Earth fill	45	3,425	247,700
Tieton	2926–2766	198,000	Earth fill, rock fill, concrete core wall.	222	905	1,995,000
Clear Creek	3050–2990±	5,830	Single arch concrete	84	404	4,100

[1] Not yet completed, figures approximate.

1103. The Yakima project, as now planned, is made up of seven natural units or divisions, including the Wapato project of the United States Bureau of Indian Affairs. Named in the order of their location from the upper end of the Yakima Valley, they are: Kittitas, Tieton, Moxee, Wapato (Indian project), Sunnyside, Roza, and Kennewick.

1. GENERAL DESCRIPTION

1104. *a. Kittitas division.*—This division contains about 72,000 acres of irrigable land, as yet only partially developed, located in the higher reaches of the Kittitas Valley. It surrounds a body of bottom land, centered at Ellensburg, that for many years has been successfully irrigated and farmed by a system of privately owned canals and ditches, of which the three largest ones, irrigating about 26,000 acres, are the Cascade Canal, the Town Ditch on the east side of Yakima River, and the West Side Ditch on the west side. In addition, about