would be adequate for only the Hanford tract, of the three to which water could be pumped from unregulated river levels. This tract is favorably situated for irrigation from a construction point of view, but not favorably from others. Neither of the other two tracts irrigable by pumping from present river levels, the Pasco and the Priest Rapids, are considered feasible for irrigation with power from existing plants.

Even with such cheap power none of the projects is economically justified under present conditions.

246. Table I, in paragraph 230 above, includes all tracts along the Columbia believed worthy of consideration for irrigation with water from the main river. These are discussed in detail in the district reports. There are other tracts, on the tributaries of the Columbia, that present opportunity for irrigation. Consideration should be given to these before decision is reached to irrigate any of the tracts listed. Except as to the Rathdrum Prairie tract they are not discussed in detail, as not falling within the scope of this report. Attention is invited to reports under House Document 308, Sixty-ninth Congress, first session, on Snake, John Day, Willamette, Cowlitz, and Lewis Rivers, and to various reports listed in the district sections of this report.

III. Conclusions

247. Below are given the conclusions of the division engineer based on the matter presented in brief above and in detail in the reports of the Seattle and Portland district engineers, herewith as parts 2 and 3 of this combined report on Columbia River. (Printed in vol. II of this document.)

AS TO THE TIDAL SECTION OF THE RIVER

(*a*) Columbia River below Vancouver, Wash., and Portland, Oreg., is primarily of value as an avenue of commerce and in that respect ranks high among the waterways of the United States; it will continue to merit favorable consideration by the Federal Government in the matter of maintenance and improvement of the navigation channel.

(*b*) No power development is feasible in the tidal section of the river.

(*c*) There are areas of fertile low lands along the tidal section of the Columbia that are worthy of protection against the flood effects of the river. These areas have in part been protected to some degree; in some cases they have been fully protected. The most suitable method of securing protection is the one already adopted—by levees (or dikes as locally called). The present levee system is inadequate in places through deficient levee heights and improper levee location, and in extent. Raising of low levees, reconstruction of levees when too close to the river bank, and some extension of levee lines, while desirable, cannot be absolutely declared justified at this time. Works on the upper river specifically for flood protection of these areas or works for flood control in combination with navigation, power, or irrigation are not feasible, but some decrease of flood effects will be produced by any power or irrigation development that may be installed in the upper river. Finally, flood protection of the low lands in the tidal section of the Columbia is of local and State concern and not a matter for Federal control or the expenditure of Federal funds.

(*d*) No irrigation use of the water of the tidal section of the river is needed.

AS TO THE NONTIDAL SECTION OF THE RIVER UP TO THE INTERNATIONAL BOUNDARY

(*e*) While navigation of the river between the head of the tidal section and the mouth of the Snake is at the present time practically nonexistent, any dam erected across that section of the river for power development purposes should be provided with locks for the passage of water craft appropriate to that part of the river. Such locks, although made necessary by the bar to navigation created by the dam, should be paid for by the United States as compensation for the benefits to navigation conferred by the power reservoirs through creation of slack water and increase of depths over shoals. Commerce on the river between the head of tidewater and the mouth of the Snake is not assured to an amount sufficient to justify the expenditure of more than $5,000,000 of Federal funds as a navigation contribution on a power development (other than for locks) if such power development is at expense other than Federal, nor to justify charging more than $5,000,000 of the cost of a power development to navigation (other than for locks) if such power development is made with Federal funds contributed or loaned.

(*f*) Future navigation in the section of the Columbia between the mouth of the Snake and the international boundary is even less assured than in the nontidal section below the mouth of the Snake. There is a rather remote promise of through navigation as far up as Wenatchee, Wash., and above that point future navigation, except local, may be said to be exceedingly unlikely. In the section of the Columbia above the mouth of the Snake no steps should be taken in the interest of navigation in connection with power development except to reserve to the United States the right to install locks or similar works or require them to be installed when navigation requires them, leaving to the future the question of the time such works should be installed and the allocation of costs.

(*g*) The Columbia in its nontidal section is primarily a power stream and other uses should, in general, be subordinated to power development, provided always that development above the head of tidewater shall not adversely affect the rights of navigation in the tidal section.

This conclusion is reached with full acceptance of the principle that irrigation is a preferred use of the water, and is not incompatible with that principle. The conclusion is believed sound as irrigation development would need the economic support of power developed for the general power market of which irrigation is only a part.

The conclusion that power development is paramount in the nontidal section is reached with full appreciation of the just claims of navigation, and is not inconsistent with due regard therefor. Dams for navigation alone would not be justified. No works for navigation alone, other than dams, would on this steep river, adversely affect power development. Power development through creation of reservoirs by means of dams can be made to serve navigation. Power considerations should, in the main, control the location and height of the dams. At the appropriate time due provision should be made for passing navigation through or past the power dams, as stated in (*e*) and (*f*) above, and power pool levels and regulation of flow should always be so controlled that navigation will not be unduly and adversely affected.

(*h*) The great power potentialities of the Columbia can be increased by the use of reservoirs on the main stream and its tributaries by which the minimum natural low flow can be doubled at The Dalles and tripled at Grand Coulee with corresponding increase in the potential prime power. With such regulation the Columbia can be made to produce prime power amounting to 41 billion kilowatt-hours per year.

(*i*) This potential output is sufficient to meet the normal increase of power demand in the Pacific Northwest for about 30 years unless the growth of market be accelerated by the exceptional introduction of new industries requiring cheap power. On the other hand, the programs of the utilities, including power developments existing or under construction on the Columbia (at Rock Island) and on the tributaries (notably on Flathead River, Lewis River and on Willamette River and its tributaries) will provide for a considerable part of the prospective market until about 1940.

(*j*) There are numerous sites for power development on the Columbia. Three of these are of especial interest for the reasons given below:

1. The Dalles site about 3 miles above the city of The Dalles. This site has good foundations and a power dam would serve both navigation and irrigation.

2. At the head of Grand Coulee in the State of Washington. A dam at this point might be constructed for power alone, or for power and irrigation of the large area of land in Washington known as the Columbia Basin irrigation project. A dam at this isolated point would serve only a local river traffic, which may not occur.

3. At or below the foot of the rapids through the gorge. This location is of importance mainly because of the benefits it, in conjunction with a dam at The Dalles, might confer on through navigation from tidewater to the mouth of the Snake. It has the advantage of proximity to power market (Portland and vicinity) and to tidewater; and the disadvantage of uncertain foundations and higher unit costs than the other two dams.

Dams at the two sites, 1 and 3, may be built to heights affording canalization of the river from tidewater to the mouth of the Snake. Slack water, however, would not obtain during freshets. Such system of two dams would give pronounced benefit to navigation if it is revived and might bring about resumption of navigation.

Plans for dams at various sites along the Columbia are given in detail in the district reports, in part 2 as to the river above the mouth of the Snake and in part 3 as to the Columbia below that point. Statistics relating to the dams at the three sites, 1, 2, and 3 above, are given in tables Q and S, following paragraphs 157 and 180 of this report.

(*k*) Full power development at any one of the three points listed in (*j*) above should properly defer power development at the others until the growth of the power market justifies the inception of a second project. Benefits to navigation would not justify the construction of a second dam before it is needed for power development. Choice of the dam that should be built first may be based on considerations foreign to this report and no recommendation is made.

(*l*) Prime power from either The Dalles or Grand Coulee sites can be delivered in large quantities at the load centers in the Pacific Northwest at one half or two thirds the cost at which steam power

can be produced in large modern generating stations when the price of fuel oil is $1 per barrel.

(*m*) Works for flood control alone or for flood control in combination with navigation, power development or irrigation are neither needed nor feasible.

(*n*) The results of studies made by both the Seattle and the Portland districts of irrigable areas along the Columbia, not now irrigated, listed in table I in paragraph 230 above, definitely demonstrate that none of those areas can be considered as economically feasible of irrigation at this time with repayment of costs plus interest chargeable against the returns to the farmer from the sale of crops. The smaller tracts of land have an advantage in the economy represented by possible stage developments.

(*o*) Revenue from the sale of power could be applied as a subsidy for irrigation development. Such use of power revenue might perhaps be the best to which it can be applied, but the most beneficial use could be determined only by analyses and appraisals of the benefits that would flow from all possible uses.

(*p*) The so-called "pumping plan" for irrigating the Columbia Basin irrigation project would make possible the production of 400,000 kilowatts of prime power that would be lost should the "gravity plan" of development be adopted. Irrigation by the "pumping plan" would be served wholly by secondary power.

(*q*) As the development of the potential power of the river, the control of floods, the diversion for water for irrigation all depend largely on the quantity of water flowing in the stream and its tributaries, it is highly important that adequate records of stream flow should continue to be obtained.

IV. Recommendations

248. From the studies made it is concluded that the most feasible plan for ultimate utilization of the resources of Columbia River is as follows:

(1) A system of 8 dams along the main stream located at:

Head of Grand Coulee, Wash.
Foster Creek, Wash.
Chelan, Wash.
Rocky Reach, Wash.
Rock Island Rapids, Wash. (now under construction).
Priest Rapids, Wash.
The Dalles, Oregon-Washington.
At the foot of Cascade Rapids, Oregon-Washington.

Such system would develop for power purposes 92.3 percent of the total head between the international boundary and tidewater and all of the head economically developable. It would receive full benefit of storage and regulation in the tributaries, as may be created in the future. It would benefit navigation by furnishing, except at high water, slack-water conditions. It would permit irrigation of large tracts of land on both sides of the river in Oregon and Washington. It would confer incidental benefits upon lowlands along the tidal section of the river through reduction of flood heights.

Provision should be made for locks through the dams below the mouth of Snake River to be installed simultaneously with the con-