plates 11 and 13.[1] The intake channel lying south of, and confined by, this structure, will be excavated in solid rock to floor elevation 850 with a width sufficient to serve an ultimate installation much greater than now proposed. The extra canal capacity will be provided initially because later enlargement would involve hazardous underwater excavation or the installation of gates at the upper end, either of which would cost more than providing full capacity in the first instance.

92. The intake wall and powerhouse will extend downstream parallel with each other, but diverging slightly from the river. Penstocks, one for each generating unit, will lead from the intake wall to the powerhouse, at right angles to both. Each penstock will be equipped with a wheel gate and separate hoist at its entrance. Trash racks will be mounted on the face of the intake wall, and a crane for raking the racks and for servicing penstock gates and hoists will travel along the top.

93. The downstream end of the intake canal requires a terminal structure between the intake wall on the right and the rock abutment on the left. The structure will be removable to permit extension of the intake canal westward into Foster Creek Canyon, which will then become the forebay for a second powerhouse contemplated in ultimate development. The removable intake closure will include a gate and chute for disposing of floating trash. Ultimately these will be of use also in flooding the future forebay beyond, so that the closure structure may be floated out by the means described in appendix III.[1]

94. *Channel improvement.*—For about a mile below the proposed dam site, the channel is obstructed by reefs and bars that become quite prominent at low stages. With a flow of 45,000 cubic feet per second the surface fall in this mile is about 9 feet as compared with an average of 2.1 feet per mile in the reach below. Excavation for the powerhouse tailrace, and a small amount of channel improvement adjacent, will cut through the bank, reef, and bar at the mouth of Foster Creek. The resultant water-surface elevation at the draft-tube outlets for 45,000 cubic feet per second discharge will be more than 2 feet lower than the corresponding elevation at the dam site. The possible merits of more extensive channel improvement downstream cannot be weighed until more detailed studies of the Chelan site, the next downstream, are made. Preliminary estimates indicate that the advantage to be gained is slight. It may be found that head may be gained more economically by adopting a pool level at the Chelan site so high as to nullify the benefit of any major channel improvement below Foster Creek. This subject is treated in more detail in appendix IV.[1]

95. *Hydroelectric power—Definitions.*—Power terms used herein accord with American Standard Definitions of Electrical Terms, approved by the American Standards Association, August 12, 1941. Definitions of terms not defined therein are as follows:

(a) Capability: The capability of a machine, apparatus, device, generating unit, generating station, power site, or combination of generating stations or power sites is the maximum load or power output that can be maintained, under stated conditions such as head and flow, but disregarding the energy available and the characteristics of the load to be served other than the power factor assumed or nor-

[1] Not printed.

mally to be expected, without exceeding the operating limits of any of the component parts.

Unit: Kilowatt, megawatt, or horsepower.

(*b*) Firm capability: The firm capability of a generating unit, generating station, power site or combination of generating stations or power sites, or of a power system, is that capability which is intended to be always available even under emergency conditions, to the extent necessary to meet the peak requirements of a load of known or assumed characteristics.

Unit: Kilowatt, megawatt, or horsepower.

(*c*) Rated capacity: The rated capacity of a machine, apparatus, or device is a designated load limit based on definite conditions.

Unit: Kilowatt, megawatt, horsepower, kilovolt-ampere, megavolt-ampere.

(*d*) Installed capacity: The installed capacity is the total of the rated capacities of a designated class of equipment with which a plant or system is provided.

Unit: Kilowatt, megawatt, or horsepower.

(*e*) Prime energy: Prime energy is potential energy available or becoming available at a uniform time rate for transformation into prime power.

Unit: Kilowatt-hour, megawatt-hour, kilowatt-year, megawatt-year.

(*f*) Firm energy: Firm energy is the energy necessary to make possible the delivery of firm power or development of firm capability.

Unit: Kilowatt-hour, kilowatt-year, megawatt-hour, and megawatt-year.

(*g*) Secondary energy: Secondary energy during a stated period of time is the difference between the available total of potential energy and the firm energy during that period.

Unit: Kilowatt-hour, megawatt-hour, kilowatt-year, megawatt-year.

(*h*) Critical period: (1) A critical period is that historical interval of time within the longer period being considered during which the largest volume of stored water would have been needed, when most efficiently used in conbination with the historical or recomputed natural stream flow, to maintain a stipulated continuous or average release of water, or a stipulated output of prime power, at a specified power site or combination of power sites. (2) The critical period for a run-of-river station or site is that time interval, within which the longer period being considered, in which the stream flow was the smallest.

(*i*) Continuous flow, Q100: Continuous flow, for which Q100 is used as a symbol, is the uniform or average flow that might have been maintained at a power site during the critical period, by the most effective scheduling of the quantity of stored water assumed to be available, in combination with the historical or recomputed natural flow.

Unit: Cubic feet per second (c. f. s.).

(*j*) Stored water: Stored water is water which has been withdrawn from the flow of a stream and is held in a reservoir for release at some later time.

Unit: Acre-foot and second-foot day.

(*k*) Storage capacity—Reservoir capacity: Reservoir capacity or storage capacity is the total volume of a reservoir available for storing water.

Unit: Acre-foot and second-foot day.

(*l*) Usable reservoir capacity: Usable reservoir capacity is the volume of a reservoir available for storing water withdrawn from the flow of a stream and held for release at some later time.

Unit: Acre-foot and second-foot day.

96. *Power characteristics and installation.*—Graphs of flow, headwater, tail water, head, and power for each month of the 15-year period, October 1, 1927, to September 30, 1942, based both on observed flow and on regulated flow from existing storage reservoirs, each operated to obtain maximum prime power at its own plants, are shown on plate 14.[1] Duration curves of flow with corresponding headwater, tailwater, head, and power are shown on plate 15.[1]

97. Potential prime power and firm capability for different streamflow conditions are shown in table 6. Minimum head will occur at high tailwater, and the number of units required to supply the firm capability at 60 percent and 70 percent load factors, under the tailwater conditions corresponding to 500,000 cubic feet per second discharge, is shown. This discharge is taken as the practical limit in considering firm capability, as it was not exceeded in the period 1913–42, and is estimated to have been exceeded only 0.4 percent of the time in the period 1879–1942. Prime power and firm capability at Foster Creek as shown in table 6 are the differences between those items for Grand Coulee alone and the corresponding totals of both projects, operated under the conditions stated in each case. The duration curves and power graphs, plates 14 and 15,[1] however, show total power at Foster Creek without any adjustment for effects at Grand Coulee. Capability of generating units and over-all efficiencies of 88 percent at best gate, and 81 percent at full gate and rated head, are based on manufacturers' estimated performance curves for 16-foot diameter turbine runners. Net head of 162 feet for turbine rating, and capacity of 64,000 kilowatts for generator rating, have been selected tentatively. The capability of 15 such units at tail water corresponding to 500,000 cubic feet per second will be 794,000 kilowatts, which will be adequate to develop the firm capability of the site at the assumed load factor of 67 percent, as outlined in following paragraphs.

98. Water requirements for future irrigation have been deducted from flows in computing power and capabilities under all conditions involving regulated flow. Irrigation depletion was adopted directly from estimates published in the report under review. Recent unofficial estimates are slightly lower, but the more conservative result, reflecting the higher depletion, has been used.

99. The net prime power of the Foster Creek site, with the proposed pool elevation and each existing upstream storage reservoir operated to obtain maximum prime power at its own plant, would be 479,000 kilowatts, as shown in study 3*b*. With Foster Creek coordinated in operation with Grand Coulee, other conditions remaining the same, the net prime power will be 526,000 kilowatts. The construction of a reservoir on the Clark Fork, with 3,200,000 acre-feet of usable storage capacity operated in coordination with Grand Coulee and Foster Creek, would increase the net prime power available at Foster Creek by 87,000 kilowatts.

[1] Not printed.

TABLE 6.—*Potential prime power and firm capability at Foster Creek Dam site*

| Power study No. | Conditions | Prime power, megawatts | Firm capability, megawatts | | Number units required [1] | |
|---|---|---|---|---|---|---|
| | | | 60 percent load factor | 70 percent load factor | 60 percent load factor | 70 percent load factor |
| 1 | Observed flow: No regulation at Flathead Lake, Kootenay Lake, or Grand Coulee. | 243 | 405 | 347 | | |
| 3b | Regulated flow: Foster Creek using regulated flow from present upstream reservoirs; Grand Coulee, Flathead, and Kootenay Lakes each operated to obtain maximum prime power at its own plant; 5,200,000 acre-feet usable storage capacity at Grand Coulee operated to obtain the maximum prime power at Grand Coulee Dam; uniform flows from Flathead and Kootenay Lakes during critical period; deduction made for future irrigation. | 479 | 798 | 684 | 15.1 | 12.9 |
| 6 | Regulated flow: Foster Creek when coordinated with Grand Coulee for maximum combined prime power; Flathead and Kootenay Lakes operated as in 3b, and deduction made for future irrigation. | 526 | 877 | 751 | 16.6 | 14.2 |
| 9 | Regulated flow: Foster Creek when coordinated for maximum combined prime power with Grand Coulee and an assumed future project with 3,200,000 acre-feet usable storage capacity on Clark Fork; Flathead and Kootenay Lakes operated as in 3b, and deduction made for future irrigation. | 613 | 1,022 | 876 | 19.3 | 16.5 |

[1] Number of units is that required to maintain firm capability under minimum head conditions corresponding with tailwater elevation at 500,000 cubic feet per second flow.

NOTE.—Over-all best efficiency, 88 percent. Normal pool elevation 937.5. Foster Creek prime power is the difference between prime power at Grand Coulee alone and the total prime power of both projects operated as indicated, except in study 1, which is a condition prior to the existence of Grand Coulee Dam.

100. The number of generating units required at 500,000 cubic feet per second discharge, the condition of minimum head, to maintain the firm capability of the site at load factors of 60 and 70 percent, are shown in table 6 for the three conditions of operation mentioned above. Under the normal operating conditions, i. e., Grand Coulee operation coordinated with Foster Creek for maximum combined prime power (study 6), the number of units required to maintain the firm capability would range from 16.6 to 14.2 for load factors from 60 to 70 percent. An annual system load factor of 67 percent is assumed in the market area by the time the project is completely installed, which assumption would require 15 units. Therefore the installation of 15 units is proposed, with space for 1 additional unit to provide flexibility to meet load conditions as they develop. If a reservoir having 3,200,000 acre-feet of usable storage capacity were built on Clark Fork in the future, and its operation coordinated with Grand Coulee and Foster Creek, as indicated in study 9 of table 6, the installation of the sixteenth unit would maintain the corresponding firm capability at 72 percent load factor.

101. To provide for utilization of greater regulated flow from future storage reservoirs, the project is laid out so the intake works can be extended across Foster Creek to serve another powerhouse downstream. The closure at the downstream end of the intake canal is designed for removal, if and when such extension is required.

102. *Power facilities.*—The powerhouse will be of reinforced concrete, having the general arrangement and proportions shown on plate 13.[1] The massive substructure will contain the draft tubes and turbines. Provision will be made for stop logs and a handling crane to permit unwatering the draft tubes. Overhead cranes will serve the turbines and generators from tracks mounted in the building walls. A railroad track will enter the service bay through the main entrance at the downstream (west) end of the powerhouse. Water will reach the turbines through plate-steel penstocks, 23 feet in diameter and approximately 240 feet long. The upper ends will have individual gates and hoists. Provision will be made for placing bulkheads outside the trash-rack structure to permit unwatering the intake of any unit.

103. Turbines will be of the Francis reaction type, rated at 87,000 horsepower at full gate and 162 feet net head. The dimensions of the turbine runners will be so limited that shipment can be made in one piece. The generators will be 3-phase, 60-cycle, 13,800-volt, rated at 64,000 kilowatts. They will be fully enclosed and ventilated with water-cooled air. The generators necessarily will be so large that they must be built in the powerhouse. The rotors, when assembled, will be the heaviest pieces the cranes must be designed to handle. One bank of three transformers will be provided for each pair of main generators and the fifteenth unit. Each transformer bank will have a rated capacity of 150,000 kilovolt-amperes. The transformers will be located outdoors on a deck along the intake side of the powerhouse. A branch rail line beside the deck will facilitate placing and removal of the transformers.

104. The main switchboard and motor equipment will be installed in a control house located between the powerhouse and the intake wall. This building will contain accommodations for the load dispatchers and switchboard operators, offices for the engineering and supervisory organization, and reception rooms for the public. An electrical switchyard will be located south of the intake canal and adjoining its full length. High-voltage connections from the main powerhouse transformers to the switchyard will be supported on steel towers erected atop the intake wall and in the switchyard. Circuit breakers and disconnecting switches in the switchyard will be operated from the main switchboard in the control house through relay circuits carried in tunnels and conduits. A vehicular bridge across the intake canal in conjunction with elevator service from the powerhouse will provide convenient access to the switchyard. The bridge will serve also to carry control cable tunnels across the intake canal. For station service and local power, three units will be provided, each consisting of a hydraulic turbine, having a capacity of 4,150 horsepower at full gate, driving a generator rated at 2,500 kilowatts. Water will reach each unit through a separate steel penstock, 6 feet in diameter. Normally the station service will be supplied by one unit, outside local service by another, and the third unit will be stand-by.

105. *Access and operating facilities.*—As a prerequisite to estimating costs and construction schedules, it is necessary to plan some logical arrangement of the many facilities required for handling personnel and materials on the job. The nature and location of such

[1] Not printed.

facilities in some cases are determined rather clearly by physical conditions, but frequently there will be wide latitude for choice by the contractor and construction supervisor. A bench west of Foster Creek and south of the Bridgeport Highway between elevations 900 and 1,000 appears to be the most favorable location for the permanent operators' colony. This area will be occupied during the construction period by the engineering supervisory staff. Adjoining the permanent colony on the west is space for the construction crews. Water supply for domestic use and fire protection in the housing area will be obtained from wells in the glacial gravel beds. A permanent sewage collection and disposal system is required by State law.

106. Railroad and highway connections to Brewster are proposed on adjoining locations along the right bank of Columbia River, a distance of approximately 14 miles, as shown on plate 4.[1] Three permanent, steel, combination railroad and highway bridges will be required, crossing the Okanogan River near Brewster, the Columbia just below the dam site, and Foster Creek at its mouth. A railroad yard and wye will serve the main material-storage dumps and fabricating shops located on the right bank. At the south end of the Columbia Bridge, the railroad will turn east across Foster Creek to the powerhouse, with sidings as necessary to serve the working space. Power for construction purposes will be supplied from Grand Coulee Dam, 30 miles distant. The probable load will require a 115,000-volt transmission line. It may be that connection also can be made to the line that the Bonneville Power Administration is planning to build from Coulee City to Brewster.

107. The proposed access railroad and the highway from Brewster will pass the aggregate bed on the right bank below the dam site. Aggregate grading and washing, therefore, can be accomplished advantageously at a plant adjoining both the pits and the access route. Water supply for the purpose will be available conveniently from the river. The bench areas just north of the proposed Columbia Bridge are large enough to accommodate the general construction activities. The left bank benches between Foster Creek and Bridgeport are not so extensive. Their use as housing and administrative sites will leave comparatively little area close to the job for storage or shops. Side tracks and material yards between the Columbia and Foster Creek Bridges will be limited to the necessities of the powerhouse area. East of Foster Creek and close to, or within, the left bank construction area are several plots, including the eventual switchyard and intake canal sites, that may be used for temporary parking and storage.

108. *Land and relocations.*—The flow line of the reservoir will include an area of about 8,500 acres. Nearly 6,700 acres, or four-fifths of the flood pool, will lie below the meander lines. However, flowage rights will be required for a considerable margin of land above the periphery of the pool because of the possibility that slides may occur when the steep slopes are saturated and attacked by waves. For the purpose of this report, the boundary within which flowage rights will be acquired is established along lines of legal subdivision enveloping the reservoir outline. An exception is made through the settlement of Elmerton, where the only concentrated improvement values are encountered. There a State highway right-of-way forms a convenient boundary. The entire reservoir area thus delineated contains about

[1] Not printed.

22,000 acres, of which about 15,000 acres lie above the meander lines. Most of it is wasteland.

109. Elmerton, consisting of about a hundred small dwellings, lies within the reservoir area on the right bank below Grand Coulee Dam. It grew out of the construction activities there and is shrinking as the work approaches completion. The acquisition of flowage rights affecting these buildings represents the bulk of the improvement values involved. The cost should not exceed $100,000 and may be less in the course of a few years. Other than these, improvements that will be affected are a few miles of secondary State highway, unimproved county road and rural telephone line, and a few subsistence-type farms. There is practically no brush and only an occasional tree standing along the present river margin that will require clearing. Indicative of the undeveloped character of the lands are assessed values that average about $1 per acre, excluding improvements, over the reservoir and construction-site lands to be acquired.

110. The Colville Indian Reservation borders the Okanogan County side of the Columbia and about 4,000 acres of it are within the reservoir area. Interests of the Indians will be affected by the proposed project in the acquisition of necessary lands. Approximately half of the project lands within the Colville Reservation are alienated; that is, deeded out of Indian ownership. The Indian titles consist of both allotments and tribal lands. Unappropriated public lands, constituting about one-eighth of the area required for the project, have been withdrawn from entry by the General Land Office as power-site reservations. No Federal park or mineral reservations nor surviving mining claims will be involved in the project. National and private forest lands lie north of the river, but above and well beyond the reservoir flow line.

111. The area required for construction at the dam site, including a surrounding zone within which it will be possible to confine such operations as the aggregate excavation and spoil disposal, is about 6,000 acres. Like the reservoir area, most of it is wasteland of little value. Plans for a State park at Bridgeport will be coordinated with the land requirements of the project. Rights-of-way for access railroad and highway, for a power transmission line from Grand Coulee Dam, and for sections of roads and utilities to be relocated, will involve 550 acres additional.

112. The entire area that will be involved in outright purchase or easements for all project purposes, excluding public domain and stream bed, is about 19,000 acres. The estimated cost of acquisition, including an over-all allowance of about two-thirds the land value for legal and other indirect expense, will amount to less than 0.4 percent of the estimated project cost. When the cost of relocating roads, wire lines, and private ferries is included the total amounts to about 0.6 percent of the project cost. Details of land areas, classifications, ownerships, and values are contained in appendix VII.[1] A summary of these data is shown in table 7.

113. *Construction plan.*—Arrangements for handling materials and equipment customarily are made by the contractor. Those described here merely indicate one practicable plan and are not necessarily final. The topography and the relationship of the various units of the job suggest the use of two material distribution systems. Although the

[1] Not printed.

double arrangement would result in a higher initial outlay for equipment, it would be advantageous because the intake works and powerhouse could be worked either independently from, or in conjunction with, the dam. The primary material handling system would consist of movable cableways generally parallel to the axis. The other system, directly serving the powerhouse area, would consist of tracks with traveling cranes for loading and unloading.

TABLE 7.—*Estimated costs of land and relocations*

| Purpose | Ownership | Acres | Value | | Total (nearest 1,000) |
|---|---|---|---|---|---|
| | | | Land | Improvements | |
| Reservoir | Private | 8,662 | $53,293 | $104,305 | $158,000 |
| Do | Indian | 4,174 | 39,705 | 6,727 | 46,000 |
| Do | State | 207 | [1] (2,072) | | |
| Do | Government | 2,115 | [1] (2,644) | | |
| Subtotal | | 15,158 | 92,998 | 111,032 | 204,000 |
| Construction zone | Private | 4,355 | 23,765 | 7,178 | 31,000 |
| Do | Indian | 1,191 | 4,092 | 50 | 4,000 |
| Do | State | | | | |
| Do | Government | 400 | [1] (500) | | |
| Subtotal | | 5,946 | 27,857 | 7,228 | 35,000 |
| Access railroad | All | 79 | 1,610 | | |
| Access highway | do | 79 | 1,600 | | |
| Power line | do | 388 | 9,600 | | |
| Relocations | do | 15 | 2,300 | | 15,000 |
| Total direct cost | | 21,666 | 135,965 | 118,260 | 254,000 |
| Incidental cost: Severance, legal, engineering, overhead, and contingencies | | | | | 161,000 |
| Estimated total land acquisition | | | | | 415,000 |
| Construction cost of relocations (including engineering, overhead, and contingencies) | | | | | 249,000 |
| Grand total, land and relocations | | | | | 664,000 |

[1] The value of Government and State lands is not included in estimated costs.

114. *Available materials.*—Exploration and tests of the aggregate are described in appendix VIII.[1] Ample material of good quality which requires only moderate grading has been found on the right bank within 2 miles downstream from the dam site. Lumber in ordinary commercial sizes can be obtained from mills at Okanogan and other towns in the vicinity. Structural timbers and special lumber, such as millwork and plywood, probably will come from mills west of the Cascades, either by rail or truck. Gravel for grading roads is available in quantity at numerous places near the site. Basalt chips for surfacing and crushed basalt for finished grading can be produced at points nearby.

115. *River diversion.*—The conditions that will control river diversion are the underlying pervious gravels in the north bank, the narrow channel, the swift current, and the seasonal floods. Cofferdams about 60 feet high will be required to exclude floods that may be expected at least once in 2 years. Timber crib cofferdams will be used because there is insufficient bedrock cover in which to drive sheet piling. The plan contemplates two stages of river diversion; the first being from the right bank to facilitate early commencement

[1] Not printed.

of the right abutment cut-off wall. Operations within the first-stage cofferdam will include foundation excavation and preparation for the right half of the dam, the stilling basin floor and sill, and the right retaining wall, together with placing of the lower parts of these structures and setting of the central section of cribs for the second-stage, or south, cofferdam. Construction of the cut-off wall during this stage will be facilitated by the lowering of the water table in the gravel body. Alternate blocks in the dam will be left low so that flow may pass over them during the second stage of diversion. The intervening blocks to be placed above anticipated water levels will be those containing permanent and temporary sluice conduits. These, together with the low blocks, will accommodate the flow during second-stage diversion.

116. The right cofferdam will be removed following completion of operations there, allowing the river to pass through the low blocks and sluices. Cribs forming the end segments of the second cofferdam then will be sunk to connect the central section, which was built dry inside the first enclosure, with the left bank. The powerhouse area will be included so that foundation and tailrace excavation and placing of draft tubes may be commenced during the dam and stilling basin work on the left bank. The left half of the spillway will be built in the same general way as the right, with alternate low blocks and temporary sluices. Final control of the river will consist of raising the low blocks and stopping the temporary sluices.

117. *Spoil disposal.*—Left-bank excavations for the intake canal, powerhouse, and tailrace will involve some 2⅓ million cubic yards, mostly rock, measured in place. Some of this can be used to fill and grade the switchyard and visitors' parking areas south of the intake canal. Areas west of Foster Creek and upstream on the upper left bank will accommodate the remainder. A disposal area is available for spoil from the channel foundation and right-bank operations on the higher bench north and west of the dam.

118. *Construction schedule.*—Preliminary work, including final foundation exploration, surveys and land acquisition, preparation of plans and specifications, construction of access railroad, highway, and bridges, will require approximately 2 years. It is estimated that contracts for construction of the access railroad and highway can be awarded approximately 6 months after appropriation of funds. The estimated construction time for the general contract on the dam and power plant, including the first three units, is 5 years. This construction period will be controlled by river diversion and treatment of the right bank to secure a satisfactory seal. The rate at which the remaining 12 generating units are installed will depend upon several factors, including orderly organization of the work, the growth of the power load, and concurrent installations at other plants in the region.

119. *Costs—investment costs.*—The Federal investment required to complete the 15-unit Foster Creek project according to the construction plan and schedule outlined in this report, is estimated to be $110,430,000. This figure includes construction cost of $104,050,000, summarized in table 8, and interest charges during the construction period amounting to $6,380,000. The construction costs were estimated on the basis of 1940 prices for materials and labor. Interest charges were computed at 3 percent per annum, applied to one-half

of the construction period. In the first-stage development with its 3-unit installation, a construction period of 3 years was allowed for the generating station and switchyard, and 5 years for all other construction. In each of the successive stages, a construction period of 3 years was allowed for all items. The construction schedule is shown in appendix V,[1] figure 2. Table 9 herein gives the costs for the items included in the 3- and 5-year construction periods, together with the interest during the respective construction periods, and the total investment costs for the five stages of construction. Items in this table are segregated also as to anticipated life of 35 or 50 years, for later use in discussion of annual carrying charges.

TABLE 8.—*Summary of estimated construction costs—plant lay-out for 16 units*

| | |
|---|---|
| 3-unit initial installation: | |
| 1. Preliminary work | $1,013,000 |
| 2. Reservoir and flowage | 478,000 |
| 3. Access, highway, railway, power-line, construction area land | 3,704,000 |
| 4. Cut-off wall, north bank | 3,183,000 |
| 5. Cofferdam, river diversion and closure | 6,949,000 |
| 6. Dam; spillway and nonoverflow sections | 21,538,000 |
| 7. Buildings and grounds | 1,875,000 |
| 7a. Subtotal | 38,740,000 |
| 8. Intake works | 15,578,000 |
| 9. Powerhouse | 14,921,000 |
| 10. Switchyard | 1,835,000 |
| Total for 3-unit initial installation | 71,074,000 |
| 6-unit installation: | |
| Subtotal, item 7a | 38,740,000 |
| 11. Intake works | 16,106,000 |
| 12. Powerhouse | 21,271,000 |
| 13. Switchyard | 2,731,000 |
| Total | 78,848,000 |
| 9-unit installation: | |
| Subtotal, item 7a | 38,740,000 |
| 14. Intake works | 16,635,000 |
| 15. Powerhouse | 28,019,000 |
| 16. Switchyard | 3,626,000 |
| Total | 87,020,000 |
| 12-unit installation: | |
| Subtotal, item 7a | 38,740,000 |
| 17. Intake works | 17,163,000 |
| 18. Powerhouse | 34,375,000 |
| 19. Switchyard | 4,520,000 |
| Total | 94,798,000 |
| 15-unit installation: | |
| Subtotal, item 7a | 38,740,000 |
| 20. Intake works | 17,812,000 |
| 21. Powerhouse | 41,784,000 |
| 22. Switchyard | 5,714,000 |
| Total | 104,050,000 |

[1] Not printed.

TABLE 9.—*Foster Creek report—Investment costs*

[In thousands of dollars]

| Item | Increments | | | | |
|---|---|---|---|---|---|
| | First stage (3 units) | Second stage (3 units) | Third stage (3 units) | Fourth stage (3 units) | Fifth stage (3 units) |
| 35-year life items: | | | | | |
| 1. Construction cost, generating station and switchyard, 3-year construction period | 8,417 | 5,674 | 6,062 | 5,674 | 6,541 |
| 2. Interest during construction, 3 percent for one-half construction period | 379 | 255 | 273 | 255 | 294 |
| 3. Subtotal, investment in generating station and switchyard | 8,796 | 5,929 | 6,335 | 5,929 | 6,835 |
| 4. Construction cost, all except (1) above, 5-year construction period | 6,449 | 361 | 361 | 361 | 424 |
| 5. Interest during construction, 3 percent for one-half construction period | 484 | 27 | 27 | 27 | 32 |
| 6. Subtotal, investment in items other than generating station and switchyard | 6,933 | 388 | 388 | 388 | 456 |
| 7. Total investment in 35-year life items | 15,729 | 6,317 | 6,723 | 6,317 | 7,291 |
| 50-year life items: | | | | | |
| 8. Construction cost, generating station and switchyard, 3-year construction period | 8,339 | 1,572 | 1,581 | 1,576 | 2,062 |
| 9. Interest during construction, 3 percent for one-half construction period | 375 | 71 | 71 | 71 | 93 |
| 10. Subtotal, investment in generating station and switchyard | 8,714 | 1,643 | 1,652 | 1,647 | 2,155 |
| 11. Construction cost, all except (8) above, 5-year construction period | 47,869 | 167 | 168 | 167 | 225 |
| 12. Interest during construction, 3 percent for one-half construction period | 3,590 | 13 | 13 | 13 | 17 |
| 13. Subtotal, investment in items other than generating station and switchyard | 51,459 | 180 | 181 | 180 | 242 |
| 14. Total investment on 50-year life items | 60,173 | 1,823 | 1,833 | 1,827 | 2,397 |
| Combined total | 75,902 | 8,140 | 8,556 | 8,144 | 9,688 |
| Project investment: | | | | | |
| First stage (3 units) | 75,902 | | | | |
| Second stage (6 units) | | 84,042 | | | |
| Third stage (9 units) | | | 92,598 | | |
| Fourth stage (12 units) | | | | 100,742 | |
| Fifth stage (15 units) | | | | | 110,430 |

120. The investment per kilowatt of prime power, of firm capability, and of installed capacity for the entire project with 15 units is shown below. Upstream regulation by existing reservoirs and operation coordinated with Grand Coulee to obtain maximum combined prime power, are assumed as described in paragraph 100, and in power study 6 of table 6:

| | | |
|---|---|---|
| Available prime power | kilowatts | 526,000 |
| Firm capability, 15 units, 67 percent load factor | do | 785,000 |
| Installed capacity, 15 units | do | 960,000 |
| Investment cost: | | |
| Per kilowatt prime power | | $210 |
| Per kilowatt firm capability | | $141 |
| Per kilowatt installed capacity | | $115 |

121. *Annual carrying charges.*—The costs chargeable to the project each year following the respective periods of construction will consist primarily of interest on the investment, of amortization and interim replacement charges, and of the pay roll and material costs necessary

to operate and maintain the project. To these three chief items of annual cost have been added two minor ones: A contingency reserve of 0.10 percent of the investment cost, and payments in lieu of those which local taxing units would lose by reason of private property acquisition by the Government for the project. Table 10 contains a summary of the estimated annual carrying charges. For the purpose of this estimate, the successive 3-year construction periods mentioned in paragraph 119 have been overlapped 1 year and the installation of a corresponding group of three generating units is assumed to be completed each 2 years. The completion of 15 units as proposed, therefore, will extend over the assumed power absorption period of 10 years. Annual charges will be uniform at $5,950,000 per year following completion of the fifth stage of construction and the 15-unit installation.

TABLE 10.—*Foster Creek project—Annual costs summary*

[In thousands of dollars]

| Item | Investment | Annual costs | | | | |
|---|---|---|---|---|---|---|
| | | First and second years (first stage) | Third and fourth years (second stage) | Fifth and sixth years (third stage) | Seventh and eighth years (fourth stage) | After eighth year (fifth stage) |
| Interest at 3 percent: | | | | | | |
| First stage—3-unit installation | 75, 902 | 2, 277 | | | | |
| Second stage—6-unit installation | 84, 042 | | 2, 521 | | | |
| Third stage—9-unit installation | 92, 598 | | | 2, 778 | | |
| Fourth stage—12-unit installation | 100, 742 | | | | 3, 022 | |
| Fifth stage—15-unit installation | 110, 430 | | | | | 3, 313 |
| AMORTIZATION AND REPLACEMENTS[1] | | | | | | |
| 50-year life items: | | | | | | |
| First stage—3-unit installation, 0.89 percent | 60, 173 | 536 | 536 | 536 | 536 | 536 |
| Second stage—6-unit installation, 0.96 percent | 1, 823 | | 18 | 18 | 18 | 18 |
| Third stage—9-unit installation, 1.04 percent | 1, 833 | | | 19 | 19 | 19 |
| Fourth stage—12-unit installation, 1.12 percent | 1, 827 | | | | 21 | 21 |
| Fifth stage—15-unit installation, 1.22 percent | 2, 397 | | | | | 30 |
| 35-year life items, 1.65 percent: | | | | | | |
| First stage—3-unit installation | 15, 729 | 260 | 260 | 260 | 260 | 260 |
| Second stage—6-unit installation | 6, 317 | | 104 | 104 | 104 | 104 |
| Third stage—9-unit installation | 6, 723 | | | 111 | 111 | 111 |
| Fourth stage—12-unit installation | 6, 317 | | | | 104 | 104 |
| Fifth stage—15-unit installation | 7, 291 | | | | | 120 |
| Payments in lieu of taxes[2] | | 2 | 2 | 2 | 2 | 2 |
| Contingency reserve, 0.10 percent: | | | | | | |
| First stage—3-unit installation | 75, 902 | 75 | | | | |
| Second stage—6-unit installation | 84, 042 | | 84 | | | |
| Third stage—9-unit installation | 92, 598 | | | 93 | | |
| Fourth stage—12-unit installation | 100, 742 | | | | 101 | |
| Fifth stage—15-unit installation | 110, 430 | | | | | 110 |
| Operation and maintenance (table 4a, appendix IX)[3] | | 650 | 788 | 926 | 1, 064 | 1, 202 |
| Total annual charges | | 3, 800 | 4, 313 | 4, 847 | 5, 362 | 5, 950 |

[1] 50-year-life items initially installed (first stage) are to be amortized in 50 years. 50-year-life items installed in second stage are to be amortized in 48 years. 50-year-life items installed in third stage are to be amortized in 46 years. 50-year-life items installed in fourth stage are to be amortized in 44 years. 50-year-life items installed in fifth stage are to be amortized in 42 years.

[2] Estimated from current tax records.

[3] not printed

122. Interest on the Federal investment was computed at 3 percent. Provision was made for interim replacement of the equipment in the powerhouse and switchyard, the gates and operating mechanisms, other machinery, and underwater metal on the basis of an average useful life of 35 years. All other components of the project are assumed to have useful lives of 50 years. Among the latter are certain items that will be completed during the second to fifth stages of construction. These were assigned amortization rates corresponding to the respective parts of the 50-year period that will remain after their completion. Operation and maintenance costs are based upon experience at other Federal projects of comparable type and magnitude.

123. *Firm energy costs.*—The firm capability and firm energy of the plant operating at 67 percent load factor were assumed to be absorbed in 10 years after initial operation. This is conservative because the power market study discussed in succeeding pages indicates a growth that would absorb the output in less time. After the power absorption period, 90 percent of firm capability and firm energy were assumed to be revenue-producing. Rates for firm capability and firm energy were determined by trial at values sufficient to repay all charges within the 50-year amortization period and leave a small surplus. The rate was divided between capability and energy so that the revenues from each would be about equal. Below is shown the rate required under the conditions of coordinated operation and existing upstream regulation described in power study 6:

| | |
|---|---|
| Available prime power ---------- kilowatts-- | 526, 000 |
| Firm capability, 15 units, 67 percent load factor ---------- do---- | 785, 000 |
| 90 percent revenue-producing ---------- do---- | 707, 000 |
| Annual firm energy ---------- million kilowatt-hours-- | 4, 607 |
| 90 percent revenue-producing ---------- do---- | 4, 146 |
| Rates required to repay all charges within 50-year period: | |
| Capability (demand) charge ---------- kilowatt per year-- | $4. 30 |
| Energy charge ---------- mill per kilowatt-hour-- | $0. 90 |
| Equivalent total cost of energy ---------- do---- | $1. 63 |

124. *Power market.*—Since 1940, production of electric energy in the Pacific Northwest has increased rapidly with war activities, and there is now general expectation that a temporary load reduction will occur at the end of the war. However, an examination of statistical trends and power-market conditions indicates that the expansion in energy production has been accomplished largely by the abnormally high load factor of wartime loads, by demanding increased service from both old and new hydroelectric equipment, and by using steam-plant reserves that are essential to sustained output during periods of drought when water is scarce, reservoirs are drawn down, and hydroelectric generating units must operate at decreased capacity under low heads. Should there be a recurrence of dry years such as those of the 1930's, existing generating capacity would be unable to maintain the present output; indeed, a large reduction in load would have to occur before a normal relationship between generating capacity and output would be restored.

125. The Federal Power Commission reports a total of 3,535,843 kilowatts in rated capacity of electric generating equipment, both

steam and hydroelectric, available at the end of 1944 in the five-State area including Washington, Oregon, Idaho, Montana, and Utah, served by existing interconnected transmission systems. Experience indicates that this capacity is adequate to serve and meet the peak demands of a normal average load of not more than 1,750,000 kilowatts consuming 15.3 billion kilowatt-hours annually. The actual output in 1944 was about 19.2 billion kilowatt-hours, distributed among the States as follows:

| State | Energy generated, kilowatt-hours | Average output, kilowatts |
|---|---|---|
| Washington | 10, 286, 136, 000 | 1, 172, 000 |
| Oregon | 4, 784, 180, 000 | 546, 000 |
| Idaho | 1, 233, 820, 000 | 141, 200 |
| Montana | 2, 460, 064, 000 | 280, 500 |
| Utah | 436, 788, 000 | 49, 800 |
| Regional total | 19, 200, 988, 000 | 2, 189, 500 |

This is 3.9 billion kilowatt-hours, or 25 percent, in excess of the output that should be expected from present installations when operating under normal conditions.

126. It now appears unlikely that any material increase in generating capacity can occur before the end of 1947. No large installations have been authorized for completion before that date. Following authorization, about 2 years must elapse before large hydroelectric units can be purchased, manufactured, installed, and made ready for service. A longer time is needed where a dam must be built.

127. At several existing developments there is provision for expansion. The most important is at Grand Coulee, where the Bureau of Reclamation has space for nine new units, plus three more of the same size to replace two Shasta units now installed. Large new Federal developments are now authorized at several points on the Columbia and its tributaries. Additions are possible at Skagit River sites as planned by the city of Seattle; at Nisqually by the city of Tacoma; at Rock Island on Columbia River by Puget Sound Power & Light Co.; at Ariel on Lewis River by Inland Power & Light Co.; at Lake Chelan by Washington Water Power Co.; at Kerr Dam on Flathead River by Montana Power Co., and possibly others. Much of the additional capacity at existing plants would be useful principally to increase system capability. Their value depends largely upon coordination with development of such projects as Umatilla and Foster Creek, where large blocks of new prime power can be produced.

128. It is the record of the electrical industry in the Pacific Northwest and in the United States as a whole, that the load never has failed to double within 14 years, equivalent to compounding at the rate of 5 percent per annum. Frequently the load has doubled within a 7-year period or less, equivalent to average growth at the rate of 10 percent per annum. Installation of generating capacity has paralleled the load growth.

129. Discounting the present abnormal power production, and allowing for postwar readjustment, the average load may drop, say in 1947, to about 1,550,000 kilowatts for the five-State area. If from

that starting point the load should grow at the rate of 10 percent per annum, the firm capability of authorized Federal projects, and of strongly prospective installations by other organizations, would be fully utilized by 1954, and additional developments would be required then. Historical records indicate that such growth is well within the range of possibility and that, unless it is anticipated, the industrial development of the region may be seriously handicapped.

130. Should such rapid growth not materialize, and the load growth should be approximately 5 percent per annum, following past trends, all authorized and prospective installations would be absorbed by 1960. In recognition of the time required to develop any major site, it is desirable to supply not only these demands as they arise, but also to have a reasonable margin of generating capacity available in advance.

## Chapter IV—Discussion

131. *Place in the comprehensive plan.*—Foster Creek project will be an integral part of the comprehensive plan for the development of Columbia River, as set forth in the report under review. It will develop energy now unused, without encroaching upon other present or prospective uses of the river. It lies conveniently close to the existing regional power transmission system and Grand Coulee Dam, with both of which its operation can be advantageously coordinated, and comparatively close also to the main load centers of the Puget Sound area. Its generating capacity can be expanded conveniently to receive full benefit from whatever future regulation may be accomplished upstream. The existing project provides for rock removal to obtain a depth of 7 feet between Bridgeport and Kettle Falls. Construction of Foster Creek Dam would bar through navigation but would provide slack-water navigation in the 51-mile stretch upstream to Grand Coulee.

132. *Purpose.*—Foster Creek is primarily a power project. Pondage in the reservoir will be insignificant as a benefit to downstream navigation or flood control, although its effect in reregulating fluctuating releases from Columbia River Reservoir will benefit navigation and irrigation operators downstream, particularly during the power absorption period. Irrigation of about 15,000 acres may be accomplished either from the pool or independently by direct pumping from the river at points downstream. In either case, further investigations are necessary to determine what may be economically justified. The necessary facilities for irrigation may be provided without material effect on the proposed construction or the power capability of the project. The construction costs for irrigation from the pool, as tentatively estimated by the Bureau of Reclamation, would constitute less than 2 percent of the investment in the project proposed herein.

133. *Site selection.*—The basic project plan would be generally similar at the several alternate axes investigated. The axis selected, No. 3–C, is located approximately 1 mile downstream from axis No. 1, discussed in the report under review. All other axes studied are between these two. The selection of axis No. 3–C is based on over-all economics and definite physical advantages.

134. The downstream location permits development of nearly 3 feet more head than axis No. 1, worth at least $2,000,000 based on the investment per foot of head. It also places the construction closer to