Basalt, or trap rock, is also widespread in the Pacific Northwest, so that practically every county within the area is bountifully supplied with this useful stone. West of the Cascade Mountains it occurs as dikes, sills, or flows in the midst of Tertiary tuffaceous sandstones and shales, and east of these mountains as extensive flows which constitute the surface rock over wide areas. On account of this wide distribution and ready availability, production is more or less local and temporary, according to fluctuating needs for construction purposes. In the vicinity of the larger centers of population, however, production is relatively continuous and of large volume. Ninety-two plants in the State of Oregon in the year 1928 produced 1,530,430 tons of crushed basalt, valued at $1,670,627.

Multnomah County, containing nearly one third of the State's population and including Portland, is the main center of crushed rock consumption. On account of the general prevalence of this type of lava, shipments of crushed stone generally are for but short distances. It is noteworthy that certain deposits of basalt are accessible to barges on Columbia River, such as those at Mount Coffin below Longview, Wash., and at Brookfield. Crushed stone, which is ideally adapted to barge transportation, is thus directly available for shipment by water to points along the river. With continued growth of population, moderate increases in barge loadings of crushed basalt may be expected. Competing stones are virtually absent and the supply of basalt is prodigious.

There is a similar generally widespread distribution of gravels and sands, and of stone suitable for crushing, in all parts of the Snake River drainage in eastern Oregon and in Idaho. Practically all of the larger tributaries reach into regions of igneous or ancient metamorphic rocks which have furnished an abundance of hard resistant gravels that are now available in terraces, and especially in the bars and beds of the present-day stream channels.

## APPENDIX C

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WAR DEPARTMENT,
OFFICE OF THE DISTRICT ENGINEER,
*Portland, Oreg., January 26, 1932.*

Subject: Discussion of flood control benefits on Columbia River resulting from diversion of 16,000 second-feet at Grand Coulee during May, June, and July.

To: The Chief of Engineers, United States Army.

1. Pursuant to instructions contained in radiogram from the Chief of Engineers, dated January 20, 1932, the following discussion of flood control benefits which would result from continuous diversion of 16,000 cubic feet per second at Grand Coulee during May, June, and July, is submitted:

2. Below the mouth of the Snake flood damage occurs during the Columbia River annual freshets and is caused mainly by the overflow of lowlands adjacent to the stream along the lower 120 miles of its course—that is, below the mouth of Sandy River, which enters the Columbia on the Oregon side about 14 miles above Vancouver, Wash. Above the mouth of Sandy River little arable land is subject to overflow except during freshets of unusual heights.

3. The valley of the Columbia below the Sandy contains about 266 square miles of arable lands below the crest elevation of the flood of 1894. About 226 square miles of this are below the crest elevation of ordinary floods. These arable lands are scattered in small parcels. A total of about 119 square miles of the area subject to overflow is now protected against ordinary floods by about 233 miles of levees.

4. Flooding of the lowlands begins when the Columbia is discharging approximately 600,000 second-feet at The Dalles, Oreg. This stage is reached about once every 2 years. Small damage results

from floods of 600,000 to 700,000 second-feet. A flood of over 700,000 second-feet may be expected to occur once in 3 years. The flood of 1894, the highest of record, had a discharge of 1,160,000 second-feet at The Dalles. It caused a large amount of damage. Subsequent moving of the railroads and construction of some levees to an elevation about equal to the crest elevation of this flood has eliminated much of the source of damage from future floods of this height. A flood equivalent to that of 1894 may be expected to occur once in 400 years.

5. The flood discharge of Columbia River occurs once a year during the 3 months' period of May to July. The duration of the floods has varied from 10 to 60 days. The rise is gradual, seldom exceeding 1 foot a day; hence there is ample time to remove livestock and equipment to higher levels. Comparatively little property loss occurs. While little accurate information is available as to the actual losses, it is estimated that over a period of years the average damage from all sources will not exceed $150,000 per year.

6. The base gaging station for the lower Columbia is located at The Dalles, Oreg., 190 miles from the mouth and 50 miles above the head of tidal reach. This station has been maintained continuously from 1878 to date. Tables of discharge, prepared by the United States Geological Survey for this 74-year period, show that the peak of annual flood has varied from a minimum of 269,000 second-feet on May 8 and 9, 1926, to a maximum of 1,160,000 second-feet on June 6, 1894.

7. Discharges of 600,000 second-feet at The Dalles, Oreg., stage 34.7 feet, do not cause any flood damage. Any decrease in the discharges below this amount will not be of any benefit insofar as flood protection is concerned.

8. In the following table only freshets (floods) with discharge in excess of 600,000 second-feet have been tabulated. The observed discharges and stages at The Dalles, Oreg., and the effect of reducing these discharges and the corresponding stages are shown. The percent of decrease in discharge is also given.

*Columbia River at The Dalles, Oreg.—Yearly maximum discharges in excess of 600,000 second-feet (floods) and corresponding stages, and same discharges reduced 16,000 second-feet and resulting stages*

| Day | Year | Observed | | Corrected by minus 16,000 second-feet | | Percent decrease in discharge |
|---|---|---|---|---|---|---|
| | | Discharge | Stage | Discharge | Stage | |
| | | *Second-feet* | *Feet* | *Second-feet* | *Feet* | |
| Observations by Oregon Steam Navigation Co. | 1859 | 874,000 | 46.8 | 858,000 | 46.1 | 1.8 |
| | 1860 | 688,000 | 37.8 | 672,000 | 37.1 | 2.3 |
| | 1861 | 618,000 | 35.5 | 602,000 | 34.8 | 2.6 |
| | 1862 | 948,000 | 50.0 | 932,000 | 49.3 | 1.7 |
| | 1863 | 777,000 | 42.6 | 761,000 | 41.9 | 2.1 |
| | 1864 | 654,000 | 37.2 | 638,000 | 36.5 | 2.4 |
| | 1865 | 714,000 | 39.8 | 698,000 | 39.1 | 2.2 |
| | 1866 | 839,000 | 45.3 | 823,000 | 44.6 | 1.9 |
| | 1867 | 671,000 | 37.9 | 655,000 | 37.2 | 2.4 |
| | 1870 | 777,000 | 42.6 | 761,000 | 41.9 | 2.1 |
| | 1871 | 856,000 | 46.0 | 840,000 | 45.3 | 1.9 |
| | 1872 | 737,000 | 40.8 | 721,000 | 40.1 | 2.2 |
| | 1873 | 638,000 | 36.4 | 622,000 | 35.7 | 2.5 |
| | 1875 | 684,000 | 38.5 | 668,000 | 37.8 | 2.3 |
| | 1876 | 958,000 | 50.4 | 942,000 | 49.7 | 1.7 |
| June 18 | 1879 | 643,000 | 36.7 | 627,000 | 36.0 | 2.5 |
| June 30–July 2, inclusive | 1880 | 914,000 | 48.5 | 898,000 | 47.8 | 1.8 |
| June 13 and 14 | 1882 | 883,000 | 47.2 | 867,000 | 46.5 | 1.8 |
| June 13 | 1884 | 698,000 | 39.2 | 682,000 | 38.5 | 2.3 |
| June 9 | 1886 | 673,000 | 38.0 | 657,000 | 37.3 | 2.4 |

*Columbia River at The Dalles, Oreg.—Yearly maximum discharges in excess of 600,000 second-feet (floods) and corresponding stages, and same discharges reduced 16,000 second-feet and resulting stages*—Continued

| Day | Year | Observed | | Corrected by minus 16,000 second-feet | | Percent decrease in discharge |
|---|---|---|---|---|---|---|
| | | Discharge | Stage | Discharge | Stage | |
| | | *Second-feet* | *Feet* | *Second-feet* | *Feet* | |
| June 19 | 1887 | 896,000 | 47.7 | 880,000 | 47.0 | 1.8 |
| May 20 | 1890 | 633,000 | 36.2 | 617,000 | 35.5 | 2.5 |
| June 22 and 23 | 1892 | 607,000 | 35.0 | 591,000 | 34.3 | 2.6 |
| June 14 | 1893 | 679,000 | 38.3 | 663,000 | 37.6 | 2.4 |
| June 6 | 1894 | 1,160,000 | 59.4 | 1,144,000 | 58.7 | 1.4 |
| June 22 | 1896 | 785,000 | 42.9 | 769,000 | 42.2 | 2.0 |
| May 24 | 1897 | 780,000 | 42.7 | 764,000 | 42.0 | 2.0 |
| June 20 and 21 | 1898 | 649,000 | 36.9 | 633,000 | 36.2 | 2.5 |
| June 22 | 1899 | 787,000 | 43.0 | 771,000 | 42.3 | 2.0 |
| June 1 | 1901 | 662,000 | 37.5 | 646,000 | 36.8 | 2.4 |
| Do | 1902 | 644,000 | 36.7 | 628,000 | 36.0 | 2.5 |
| June 18 and 19 | 1903 | 787,000 | 43.0 | 771,000 | 42.3 | 2.0 |
| May 26 | 1904 | 629,000 | 36.0 | 613,000 | 35.3 | 2.5 |
| June 18 | 1908 | 653,000 | 37.1 | 637,000 | 36.4 | 2.4 |
| June 19 | 1909 | 675,000 | 38.1 | 659,000 | 37.4 | 2.4 |
| June 12 | 1913 | 759,000 | 41.8 | 743,000 | 41.1 | 2.1 |
| July 1 | 1916 | 727,000 | 40.4 | 711,000 | 39.7 | 2.2 |
| June 20 | 1917 | 727,000 | 40.4 | 711,000 | 39.7 | 2.2 |
| June 11 | 1921 | 773,000 | 42.4 | 757,000 | 41.7 | 2.1 |
| June 9 | 1922 | 677,000 | 38.2 | 661,000 | 37.5 | 2.4 |
| May 24 and 25 | 1925 | 642,000 | 36.6 | 626,000 | 35.9 | 2.5 |
| June 18 | 1927 | 690,000 | 38.8 | 674,000 | 38.1 | 2.3 |
| May 29 | 1928 | 766,000 | 42.1 | 750,000 | 41.4 | 2.1 |

This table has been prepared from published records of the U.S. Geological Survey and from unpublished records of the Portland (Oreg.) office of the U.S. Geological Survey.

9. It will be noted that the maximum discharge of 1894 would be reduced only 1.4 percent and the maximum discharge in 1892, which was only 607,000 second-feet, would be reduced 2.6 percent. The stage of the river at The Dalles would be decreased 0.7 foot in each instance. Although decreasing flood discharges by 16,000 second-feet would result in a decrease in stage of 0.7 foot at The Dalles, Oreg., the stage at Vancouver, about 102 miles from the mouth, would only be decreased 0.4 of a foot, the stage at Longview, 62 miles from the mouth, not to exceed 0.2 of a foot, and at Astoria there would be no noticeable decrease.

10. It would appear that the diversion of 16,000 second-feet would have but small effect on the maximum discharges that have occurred in the past. Insofar as the lessening of flood damage is concerned the benefit of this decrease in gage height is too slight to evaluate. However, a measure of the value might be obtained by assuming the reduction in gage heights equivalent to an increase in levee heights. The average reduction of flood heights along the leveed areas would be about 0.3 foot. On the basis of the cost of existing 233 miles of levees it is estimated that an additional 0.3 foot of levee height would cost about $300,000.

11. Conclusion: It is the opinion of this office that $300,000 is the maximum amount which could be considered as the capitalized value of the benefit to flood control on Columbia River below the mouth of Snake River, resulting from the continuous diversion of 16,000 cubic feet per second at Grand Coulee during May, June, and July.

OSCAR O. KUENTZ,
*Major, Corps of Engineers,*
*District Engineer.*

WAR DEPARTMENT,
OFFICE OF THE DISTRICT ENGINEER,
*Portland, Oreg., January 29, 1932.*

Subject: Discussion of flood-control benefits on Columbia River resulting from diversion of 16,000 second-feet at Grand Coulee during May, June, and July.

To the Chief of Engineers, United States Army.

1. Reference is made to air-mail letter from this office on above subject dated January 26, 1932 (Dist. Office file #838-Col (R)-1/115.1). Pursuant to the instructions of the division engineer, the following additional discussion is submitted.

2. In the discussion previously submitted it was estimated that the diversion of 16,000 second-feet at Grand Coulee would have the effect of lowering gage height of floods in the vicinity of the areas protected by levees along the lower 120 miles of Columbia River by not more than 0.3 of a foot and that if this lower gage height be considered equivalent to an additional 0.3 foot of levee height the capitalized value would amount to $300,000. No estimate was made as to the capitalized value which this lowering of flood height would have if new levees were constructed on the areas subject to inundation and not now protected by levees.

3. About 147 square miles of lowlands, without levees, along the lower 120 miles of the Columbia lie below the elevation of the 1894 flood crest and are subject to inundation. In the House Document 308 report on Columbia River, part III, dated July 31, 1931, paragraph 1109, it is estimated that about 23 square miles of these unprotected areas are so situated that they may be protected profitably sometime in the future. These areas would require about 38 miles of new levees. The reduction of the average height of these new levees by 0.3 of a foot would decrease the estimated cost by about $82,000.

4. This amount added to the $300,000 estimated capitalized value of increasing the existing levee protection by 0.3 of a foot, would bring the total capitalized value of the benefit to flood control from the diversion of 16,000 second-feet at Grand Coulee during May, June, and July to $382,000.

5. In this connection, however, attention is invited to the opinion of this office as expressed in paragraph 1445 of the above-mentioned House Document 308 report, which is, in part, as follows:

1445. * * * There is little demand at present for the extension of the existing diking districts. Private interests will undoubtedly undertake the diking of the additional areas whenever there appears to be economic justification. The problems of flood control are local and are not of the nature to warrant the United States undertaking levee construction. Neither private owners of land, organized districts, nor municipalities, having for their purpose flood-protective measures along lower Columbia River, have called upon the United States to assume part of the costs.

OSCAR O. KUENTZ,
*Major, Corps of Engineers,*
*District Engineer.*

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