

MAINE STATE LEGISLATURE

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SECOND REPORT

of the

MAINE

WATER POWER COMMISSION

Augusta, Maine

1921-1922

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MAINE WATER POWER COMMISSION

Commission

Edward F. Ricker, Poland, Chairman
 Arthur Chapin, Bangor.
 Alfred K. Ames, Machias.
 Charles F. Flagg, Portland.
 J. Frank Partridge, Waterville.
 William H. Looney, Portland.
 Leslie E. McIntire, East Waterford.
 Alton C. Wheeler, South Paris.
 Harry B. Brawn, Augusta.

George C. Danforth, Chief Engineer.
 Member American Society Civil Engineers.
 Miner R. Stackpole, Assistant Engineer.
 In charge of hydrographic work.
 Howard J. Williams, Assistant Engineer.
 Alice L. Barentzen, Clerk.

Cooperating Agency.
 U. S. Geological Survey.
 Dr. George Otis Smith, Director.

REPORT OF COMMISSION

To the Honorable the Governor and Council of Maine:

Pursuant to the provisions and requirements of Chapter 203 of the Public Laws of the State of Maine for the year 1921, the Maine Water Power Commission herewith respectfully submits its report as follows:

In accordance with the provisions of said chapter, the Commission was constituted by appointment by the Governor of the following members:

- | | |
|--------------------|--|
| EDWARD P. RICKER) | Appointed with the advice and consent of the Council. |
| ARTHUR CHAPIN) | |
| HARRY B. BRAVE) | |
| ALFRED K. AMES | Appointed from the Senate. |
| WILLIAM H. LOONEY) | Appointed from the House of Representatives. |
| ALTON C. WHEELER) | |
| CHARLES F. FLAGG | Member Maine State Board of Trade, appointed on recommendation of said Board. |
| LESLIE E. MCINTIRE | Member State Grange, appointed on recommendation of said Grange. |
| J. FRANK PARTRIDGE | Member Maine State Federation of Labor, appointed on recommendation of said Federation. |
| (No appointment) | Member Savings Bank Association of Maine, appointed on recommendation of said Association. |

The above members of the Commission duly qualified and have continued to serve since their appointment and qualification. Mr. Edward P. Ricker was designated by the Governor as Chairman.

Pursuant to the provisions of Section 2 of Chapter 132 of the Public Laws of 1919, at a meeting of said Commission held on August 14, 1919, it selected and employed Mr. George C. Danforth of Augusta, Maine, to act as Chief Engineer of the Commission, in which capacity he has since continued to act. As such Chief Engineer, Mr. Danforth has been in charge under the Commission of its operations and investigations and in the accumulation and tabulation of its data, employing such subordinates as in the opinion of the Commission were necessary.

In the clerical department there have been employed on the average by the Commission one clerk, and in the engineering force in addition to the Chief Engineer two assistant engineers, one of whom has been employed entirely in connection with the river gaging stations.

The Commission wishes to state its belief that the present disinclination to develop Maine power is due largely to the lack of a definite State policy toward such development. We believe that little development can be expected beyond the demands of actually existing markets until the State formulates a definite policy which the business world believes to be relatively stable and permanent. Unless this is done the tendency will be toward development by outside capital under a Federal license which we have believed to be unadvisable for this State in that the control of such developments passes into the hands of the Federal Government.

On page 16 of its report for 1920 the Commission stated that they deemed it unwise to make recommendations in the nature of a definite plan for the development of storage and water powers which in the present state of the constitution and laws as judicially construed could not be put into practical operation. In stating this opinion the Commission believed that such a detailed plan should be drawn only after the constitutional amendment should have been passed.

No such amendment having been passed the Commission deems it a part of its duty to state its conclusions in regard to such an amendment as will provide eminent domain for the purpose of storage construction and ability to recover the costs of such construction from the persons or corporations benefiting by the increased power.

After mature consideration and with the assistance of eminent legal counsel the Commission unanimously recommends the passage of the following amendment to the constitution of Maine for the purpose of bringing our definition of "public use" more into accord with that of other states and with the opinions of the Supreme Judicial Court of the United States.

"Sec. 20. Conservation, storage and control of the waters within the State. The conservation, storage and control by the State, or by a duly authorized public district or districts thereof, of the waters within the state are paramount public uses and for the benefit of the people of the state; and the Legislature may provide for the same and the apportionment to and assessment upon the lands and property which shall or may be benefited thereby, the whole or any part of the cost including maintenance and operation of said conservation, storage and control of said waters."

There appears in the report of the Chief Engineer, which is attached to and made a part of this report, a suggestion in regard to legislation which might be passed at the option of the legislature under such an amendment and which meets with the approval of the Commission, such approval being based on a study of the operation of

existing laws in New York, Wisconsin, and other states, and in the province of Quebec.

In the opinion of the Commission the item of greatest value in its work is its ability to place in the hands of engineers and others interested in power development accurate information in regard to river flow and the location and amounts of available power. These data should be in permanent form for reference and their importance is coincident with the importance of Maine's water powers as one of its natural resources and the desire of the State to encourage their development.

In the 1920 report previously obtained data in connection with river flow was revised in accordance with modern methods, data of insufficient accuracy being discarded and the complete records republished. From the point of view of economy it was decided to publish additional data every two years instead of annually. Arrangements were made to fill individual requests for information received by the Commission during the interim.

Material prepared for publication for the years 1921 and 1922 includes a bringing up to date of figures on river discharge, precipitation and evaporation, material of fundamental importance in connection with power development; and tables of maximum and minimum discharge, which are important in connection with the design of dams and computation of storage. There have also been prepared water power tables which represent an important part of the Commission's work of the past two years in gathering data of amounts and location of undeveloped and developed power. The Commission believes this data to be of very great value in enabling those contemplating power development to choose a suitable site, for use in connection with studies of comprehensive plans for development and in connection with the benefits to be received from storage.

In regard to the continuance of the work now carried on under this Commission, we wish to state our belief that this work should be permanent and that an interruption of the work, of no matter how brief duration, would be a loss to the State which could not be recovered.

In a report to the Commission in 1920 by the eminent engineers composing Engineering Council it is stated: "The Commission should properly supervise the making and recording of stream measurements, the investigation, and, when undertaken, the detailed survey of storage possibilities - in fact, continue to study the water power resources of the State. These are matters which cannot be completed in a year or two.....The publication of the results of the various water power investigations should likewise be a duty of such agency.... Despite perhaps a natural reluctance, in our opinion the Commission should advocate its own permanence. Water Power development is too important to risk neglect or failure because of the lack of a suitable fostering agency to deal with its problems."

The appropriations for the Commission have been small and any saving made by transferring the work to a subordinate position in another department would be small while there is every probability that the work would suffer as a result of such transfer. As a matter of record this experiment was made by the legislature of 1913 and as this transfer did not appear to be a successful one, the separate Commission was reestablished by the legislature of 1919.

The Commission desires to express to your Honorable Body its readiness to present for its consideration and for the consideration of the incoming legislature any details of information which it possesses as a result of its labors and investigations.

Respectfully submitted,

December 29, 1922.

Acting Chairman.

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REPORT OF CHIEF ENGINEER

Hon. E. P. Ricker, Chairman,
Maine Water Power Commission,
Augusta, Maine.

Dear Sir:

I herewith submit for your consideration a report of the work of this Commission on the topographic, geologic, and hydrographic work in this State during the years 1921 and 1922.

Respectfully submitted,

GEORGE C. DANFORTH,

December 29, 1922.

Chief Engineer.

STATEMENT OF EXPENDITURES

Under the classification of "Special Surveys" appears the entire cost of drafting on a Map of Maine prepared under the direction of the Chief Engineer of this Commission with the understanding that three other departments, the State Highway Commission, the Land Agent and Forest Commissioner, and the Public Utilities Commission, should share equally in the cost. The total cost of this work was \$1,594.96. The three above mentioned departments later refunded \$348.74 each, a total amount of \$1,046.22.

The cost of printing 2,575 copies and of binding 2,275 copies of the First Annual Report of the Commission amounted to a total of \$2,042.60. This number appears to be barely sufficient for supplying the demand in this and other states for copies of the report of the Commission.

The appropriation of \$5,000 a year for Hydrographic and Geological Surveys was neither appropriated for nor expended by this Commission. An agreement was made with the Director of the U. S. Geological Survey whereby the arrangement of past years was continued and this amount was expended by the Geological Survey on the topographic map work in Maine, together with an equal amount appropriated by the federal government. The expenditure from the State appropriation is as follows:

	Jan. 1-June 30, 1921	Jul. 1-June 30, 1922
Appropriation	2,500.00	5,000.00
Expended		5,076.45
Balance	2,500.00	1,923.55

Inasmuch as complete figures for 1920 were not available at the time of publication of the last report of the Commission, a statement of expenditures from the date of organization of the Commission in August 1919 to include June 30, 1922 is given in the following table:

	1919		1920	
	Income	Expend.	Income	Expend.
Appropriation	15,000.00		15,000.00	
Income (Bal. approp. previous yr. & Miscel.)			8,775.94	
<u>Salaries</u>				
Commissioners		295.00		552.50
Engineers		1,795.41		5,976.86
River Observers		504.06		1,177.50
Geologist		85.04		96.84
Special Surveys		530.00	697.48	3,176.69
Clerks		285.00		1,209.74
<u>Miscel. Expenditures</u>				
Foot. Tel. & Tel.		56.53		509.49
Print. & Bind.		523.15		2,037.95
Trov. Expenses		666.40		*6,549.18
Equipment		1,675.00		2,482.86
Supplies		257.47		623.33
Total Expenditures		6,224.06		24,472.93
Bal. carried forward		8,775.94		
Bal. lapse to conting. fund				.49
Totals	15,000.00	15,000.00	24,473.42	24,473.42

* Includes field expenses of Dead River & Brassua & Moccasin Lake Surveys.

1921
Jan. 1 - June 30

1921-1922

	Income	Expend.	Income	Expend.
Appropriation	7,500.00		15,000.00	
Income (Bal. approp. previous yr. & Miscel.)	884.67		4.98	
<u>Salaries</u>				
Commissioners		120.00		100.00
Engineers		4,249.94		6,861.34
River Observers		612.00		1,182.30
Geologist				
Special Surveys	545.74	70.00		
Clerks		520.00		1,049.15
<u>Miscel. Expenditures</u>				
Post. Tel. & Tel.		62.16		35.41
Print. & Bind.		143.18		105.65
Trav. Expenses		1,784.75	15.83	2,225.40
Equipment		670.67	209.91	234.56
Supplies		490.73	.50	535.90
Total Expenditures		6,728.43		14,577.49
Bal. carried forward		4.98		852.23
Totals	8,384.67	6,733.41	15,004.98	15,429.72

The work which should be done by this State in connection with water power is perhaps best summarized by the report of the eminent engineers of the Engineering Council to this Commission published in full on page 30 of the Commission's report for 1920. The complete report is worthy of careful study. Much, however, is contained in the one sentence, "We must first know what these resources are." This Commission in its study of dependable river flow, storage basin sites, evaporation and precipitation, amount and location of developed and undeveloped power is attempting to "find out what these resources are" and make them a matter of permanent record. The work demanding attention is, however, greater than the funds available can accomplish and it is suggested that the Commission request an increase of the appropriation to \$20,000 a year. It is believed that these expenditures will be returned to the State many times over in the development of its resources.

Present tendencies in hydro electric development tend toward the substitution of electric for mechanical power in existing plants, for greatly increased storage, for increased interconnection to permit interchange of power between stations of different characteristics and over large areas, for a reasonable overdevelopment to meet the existing load factor and a decrease in the number of units. Developments should be based on the community interest rather than the local considerations of an immediate market. The increase of interconnection is an important element of such development and it is believed that the proposed legislation permitting the development of storage on a comprehensive plan is an important step toward the desired result.

The State should use every means in its power to increase its developed water power in projects large enough to obtain a low unit cost, to bring about the substitution of water power for coal on our railways and the elimination of the small, isolated, low efficiency plant, whether using water power or coal.

In spite of a lessening coal supply, greatly increased costs and the continued threat of its interruption by mine or transportation strikes, comparatively little is being done toward the full use of our water power. Many small rivers exist where the fall is not large but where stations could be developed in groups, one station of a group to be used as a central station, the others to be provided with automatic equipment. It is believed that many such groups could be economically connected into the larger systems and in certain cases could be made to solve the difficulty of supplying power and light to sections where the number of customers is too small to justify the expense of transmission from the larger system.

An efficient development of Maine's water power may well prove the means by which the State can compete industrially on more nearly equal terms with states more favorably situated in regard to distances of raw materials and markets. In this connection, however, it may be well to call attention to the need of storage to obviate large use of auxiliary power during low water periods, a need which is greatly felt in southwestern Maine at the present time. Development in large, interconnected systems equipped with modern wheels is necessary for successful competition with other states from the point of view of continuity and costs. Although previous development has been, with one or two exceptions, largely from the point of view of local power markets, the present high efficiency of long distance transmission should tend more toward coastal industries with water transportation and shipment of power from any section of the state where it can be developed in comparatively large blocks.

1922 CENSUS OF WATER POWER

Summaries of power data for the different river basins are given below and show an increase of 22% in developed power during the past ten years. As our 1922 census shows a less amount of power in certain basins than was shown by the previous census, it seems reasonable to assume that the figures for that year were overestimated and the actual increase during the ten years somewhat greater than 22%.

Basin	Developed Power (Installed H. P.)	Undeveloped (Power 60% of time)	Total Without Addi- tional Storage
Coastal #1	1,542	815	2,357
" #2	955	975	1,930
" #3	4,050	970	5,020
" #4	6,512	1,923	10,435
Royal	493	68	563
St. John*	2,027	47,342	49,369
St. Croix*	23,735	27,775	51,510
Machias	1,243	5,455	7,298
Union	6,440	5,806	12,246
Kennebec	116,164	251,349	377,513
Kennebec	104,544	215,586	319,930
Androscoggin*	144,122	67,277	211,399
Freshwater	26,600	2,542	29,142
Saco*	30,521	22,237	52,758
Totals	475,640	659,920	1,135,560

Power in New Hampshire and Canada

St. John, N. H.	5,050	679,440	684,490
St. Croix, N. H.	5,020	12,211	17,231
Andros., N. H.	55,050	29,000**	84,050
Saco, N. H.	680	7,600	8,280
Coastal #4, N. H.	12,185	no data	12,185
Totals	77,985	128,251	206,236
Grand Totals	551,625	788,171	1,339,806

* Maine only

** Main river only

(a) Includes W. Branch and undeveloped part of $\frac{1}{2}$ total power on main river (dev. & undeveloped.)

(b) Grand Falls 70,600

Coastal #1	Cathance, Donny, Little, Orange & Pennequin Rivers
" #2	Bagaduce, Indian, Harraguagus, Chandler & Pleasant Rivers
" #3	Patton & Tunk Streams
" #4	Demaricotta, Mademac, Pennequin, St. George & Sheepscot Rivers
" #4	Little, Kennebec, Mousam, Ogunquit, Piscataqua, Salmon Falls, Stroudwater & York Rivers.

Developed Water Power Sites

Basin	1,000 to 10,000 H. P. capacity	Over 20,000 H. P.
Coastal #4	5	
St. Croix	1	1
Union	1	
Penobscot	11	2
Kennebec	14	2
Androscoggin	11	5
Presumpscot	9	
Saco	8	
Totals	58	11

Undeveloped Water Power Sites

Basin	1,000 to 10,000 H. P.	Over 10,000 H. P.
St. John	15	
St. Croix	4	
Machias	2	
Penobscot	36	5
Kennebec	25	6
Androscoggin	10	1
Saco	3	1
Totals	95	13

Available data show that Maine stands third in amount of developed power. Figures furnished by the U. S. Geological Survey for plants over 100 H. P. show that New York has 1,500,000 H. P. and California 1,111,000 developed H. P. Maine (counting only plants over 100 H. P. in capacity) has 460,493 H. P. Washington follows with 453,856 H.P.

Nearly all the developed power sites have been visited by an engineer of this Commission and all available material has been used in determining the amount and location of undeveloped power, concerning which little accurate information has previously been available. A method of filing on 5 x 8 cards has been adopted which will permit keeping this information continually up to date and readily available for the use of persons interested. Previous estimates have been tabulated in such form that neither expansion nor correction were possible. This material has been tabulated so as to show location and amounts of undeveloped and developed power on the different river basins. Copies of sections of these tables covering any special basin can be supplied to interested persons on request.

INFLUENCE OF FORESTS ON WATER POWER

In October 1928 we were informed by a firm of engineers in Philadelphia of the desire of a large manufacturing enterprise to obtain a power site - possibly in Maine. Several suitable sites were brought to their attention but we understand that their decision was in favor of the middle west, the reason being that "the continued cutting of Maine forests will ultimately affect seriously the water power resources of Maine."

There has been considerable discussion at various times concerning the effect of forests on stream flow. While no valid claim can be made that total rainfall is increased by the presence of forested areas, it appears to be true that its distribution is affected to a considerable extent and that forests during the spring act as reservoirs tending to reduce spring floods and increase the later flows. This is particularly true of mountain areas which, when completely cut or burned, become eroded to such an extent that renewal of the vegetal cover is impossible.

While it is doubtful if during the past fifty years there has been an appreciable loss in forest area, the present policy of complete cutting and the greater accessibility of mountain areas which have previously been left untouched will bring about a condition in which the fears expressed above may be realized.

WATER POWER ON THE PUBLIC LANDS

The following order was passed by the Senate of the 80th Legislature on February 23, 1931 and passed by the House in concurrence on February 24, 1931:

Ordered, the House concurring, that the Maine Water Power Commission be and hereby is directed to investigate and report to the Legislature, at as early a date as possible, upon the water powers located on the public lots, so called, in the wild lands of the State; and upon the possibilities of the development of said water powers; the expense of this investigation and report to be paid out of the regular appropriation for the Maine Water Power Commission.

Full compliance with this order would call for an engineer's visit to all public lots known to be in proximity to a water power and to many which were doubtful. The number falling in the latter class are numerous as accurate maps showing the public lots are not available. In many cases old lines have been obliterated and considerable research is necessary in order to locate the lot on the ground. Where water power does exist rough surveys are necessary in order to form any reasonable conclusion in regard to its amount and the possibility of its development.

This work properly carried out would require a considerable amount of the funds appropriated for other work of the Commission. Certain sites have, however, been visited and the data obtained which is included in the table following. Further work in connection with the public lands is planned for the summer of 1932 when rough surveys can be made where the existing power justifies the expenditure.

Surveys have been made in connection with a proposed development of Long Falls on Dead River. A report on this site appears on page 72 of the First Report of the Commission and some further comments may be found under "Kennebec River Storage" in this report.

ESTIMATED POWER ON THE PUBLIC LANDS

	Head in feet	D.A.	Power 60% of time	Storage Million cu. ft.	Remarks
<u>Kennebec Basin</u>					
Long Falls T S R 4	70'	500	2,800	10,000	Both banks, Dead River. If developed as power plant should be intercon- nected with Kennebec sites. 10 b.c.f. storage would flow out Flagstaff.
Taunton & Rayham	8'	1240			Moosehead Lake, S. outlet. Storage only. East bank.
Attean Falls, T 4 R 7	15'	236	175		East bank, Moose River.
Steepside, The Forks	155'	1670	26,000		East bank.
Hoxie Gore					East bank. Continuous with "Steepside."
Flagstaff & Bigelow	15'	270	230		One bank, Dead River. Development of Long Falls for storage would flow out this site.
Indian Pond	12'	1350	1,740	530	East bank at outlet. Logical site at Bowhog Rddy 2 1/2 miles downstream.
<u>Penobscot Basin</u>					
T 1 R 7	15'	1100	1,100		East Branch, both banks. Not logical site.
Bald Mt. Township	8'	13		750	Outlet Bald Mt. Pond.
Sebocook	17'	570	1,000		Sebocook Falls Both banks.
T 5 R 8	20'	500	500		Fenob., E. Br. at Bowlin Brook. Both banks.
T 6 R 7		200			Sebosis R. grand pitch. Both banks. No data on fall.
Leavitt		150			Mattawankeag, E. Br. Both banks. No data on fall.

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	Head in feet	D.A.	Power 60% of time	Storage Million cu. ft.	Remarks
<u>St. John Basin</u>					
T 18 R 11					Both banks Little Black River. No data on fall.
<u>St. Croix Basin</u>					
T 1 R 3	30	490	1760		West bank of St. Croix at Albee Rips. Logical site probably at Steep- bank 2 miles below.
<u>Machias Basin</u>					
T 18 E. D.		190			Machias, E. Br. Both banks. No data on fall.

KENNEBEC RIVER STORAGE

Some further study has been made of proposed storage on the Kennebec Headwaters (see 1930 report of the Commission). The only development recommended at the present time is that at Brassua Lake. The estimated cost of raising Moosehead Lake two feet is \$508,000 or \$78 per million cubic feet for an additional storage of 6.5 billion cubic feet and the amount of storage obtained would be considerably less than that required. It may be of interest to note what has already been stated by the Commission, that the low elevations of Moosehead Lake are controlled by a bar above the East Outlet Dam. During the unusually low year of 1921-1922 the lake was drawn down to a level of 10.7 leaving about 2.3 billion cubic feet above gage height 10.0. Although accurate information is not available in regard to the present height of the controlling bar, it is believed that the bar should be kept below elevation 10.0 and that some increased storage might be cheaply obtained by reducing this elevation to the elevation of the lower gate sills, 8.0 feet, with a provision for drawing below 10.0 only after November 30 of each year.

A discussion of new storage dams at Moosehead Lake appears in the Commission's report for 1920 on the basis of an increase in elevation of one and two feet. Should this development be made, the East Outlet Dam should be constructed at a site called High Landing about 0.7 miles below the present dam, and it would be desirable to consider the construction of the West Outlet dam of earth without gates and with provision for a roadway on its crest.

The development of Wood and Attean Ponds by a dam at Jackman impounding 2.3 billion cubic feet at an approximate cost of \$70 per million cubic feet is not recommended, should the Brassua development be made. It could be considered if additional storage should be needed at some future time.

Mention may be made of the development of the Long Falls site on Dead River on the public lots in Dead River Plantation as recommended in a recent report to the Kennebec Water Power Company. Surveys were made by this Commission in 1920 (reported in the First Report of the Commission) on the basis of a possible power development which could be interconnected with Kennebec developments and use both primary and secondary power. The report to the Kennebec Water Power Company recommends a development for ten billion cubic feet storage, flowing out the town of Flagstaff and the highway from Dead River Post Office to Stratton, at a cost of \$985,000 or \$98.50 per million cubic feet. This cost is considerably more for the increased storage than that proposed for Brassua Lake and would confer no benefit on future developments on the Kennebec between The Forks and Moosehead Lake, which amount to a total of 69,700 horsepower, 60% of time, without additional storage or 85,400 horsepower with the Brassua regulation.

In connection with the Brassua Lake development new maps have become available which necessitate a revision of the area capacity table published on page 47 of our 1920 report as follows:

Brassua Lake - Area and Capacity

Eleva. Ft. M.S.L.	Area Sq.Mi.	Total Capacity above El. 1041 Bill.Cu.Ft.
1060	11.3	4.4
1065	12.5	6.0
1070	15.3	7.8
1075	14.5	9.8
1080	15.7	11.9
1085	17.3	14.2

New cost estimates, based on the type of dam recommended in our 1920 report, an earth dam with a reinforced concrete spillway section, are as follows:

Dam Construction	\$601,000.00
Interest, Engineering and Contingencies 15%	90,000.00
C. F. R. damages	42,000.00
Flowage	110,000.00
Total Cost	\$843,000.00
Storage, billion cubic feet	11.9
Cost per million cubic feet	\$71.00

From a superficial examination it seems improbable that there exists a suitable ledge foundation, and a reinforced concrete spillway section with the addition of anchoring walls similar in principal to those used in the repairs to the Stony River Dam (described Trans. Am. Soc. C. E. 1917, pp. 947-974) is recommended should these conditions be found to exist.

The Commission has not at its command the funds for making borings at this site and accurate estimates of the cost of the dam cannot be made without additional knowledge of the underlying strata. It is believed, however, that the above estimates are ample.

A statement made in the report to the Kennebec Water Power Company that the Brassua Reservoir cannot be filled each year does not appear to be substantiated by the data available. Our records show an average yearly run-off for the entire period of record of 55.7 billion cubic feet. The lowest year recorded in Maine, 1911-1912, shows an annual run-off of 20 billion cubic feet and in this year the months of April, May and June gave a run-off greater than the capacity (12 billion cubic feet) of the proposed reservoir.

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The statement is also made that a development of Brassua Lake for 8 billion cubic feet would supply existing power demands on the Kennebec. While this is true, it is not believed that it is either economical or desirable to construct a reservoir at this location at a cost but little less than that of the complete development. It cannot be assumed that a development for 8 billion cubic feet would meet future power demands on the Kennebec and an increase of the dam elevation from 1070 to 1080 would be either impossible or very expensive, depending on the location and design of the existing dam.

Mention should be made of the fact that the proposed state highway from Jackman to Rockwood lies for about 14,700 feet below elevation 1085 along the southeastern shore of Brassua Lake. Should this highway be built as located, it would needlessly increase the cost of storage in addition to the necessity for rebuilding the highway. For obvious reasons the highway should be relocated before construction so as to clear the reservoir area.

SAGO RIVER STORAGE

Funds have not been available for the expensive surveys required in connection with the proposed development at Hiram.

Little storage exists on this river and the power demands are such that they cannot be met during periods of low water flow. The present need of storage is greater here than on any other river in the State and a development for 10 billion cubic feet ~~greatly~~ would greatly increase the available power in the vicinity of Portland.

KANAWHA RIVER POWER AND STORAGE

Location	Head	Present Wheels rated H.P.	Drain- age Area	Present Conditions		Horsepower	
				Flow 90%	Flow 60%	90%	60%
1 Solon	28	4,060	2,740	1,260	2,660	3,530	7,450
2 Madison (upper dam)	20	7,020	3,250	1,450	3,100	2,900	6,200
3 " (H. & W.)	42	13,600	3,330	1,450	3,100	6,080	13,000
4 Snowhogan	32	17,000	3,950	1,700	3,440	5,440	11,000
5 Shawmut	20	6,000	4,250	1,630	3,700	3,660	7,400
6 Fairfield	12	3,430	4,260	1,850	3,700	2,200	4,440
7 Waterville (H. & W.)	25	6,580	4,270	1,840	3,710	4,280	8,540
8 " (Lockwood)	21	10,000	4,270	1,840	3,710	3,860	7,790
9 Augusta	17	8,420	3,560	2,320	4,720	2,960	3,030
Total Developed	215	77,620				55,660	73,630
10 Hooseland	50		1,240	657	1,440	1,970	4,320
11 Lodge Falls	25		1,250	662	1,450	1,650	3,620
12 Indian Pond	20		1,250	662	1,450	1,320	2,900
13 Bowhog Eddy	20		1,250	716	1,570	5,750	12,600
14 Chase Stream	114		1,570	726	1,590	3,280	13,100
15 Steepside	165		1,570	622	1,620	12,900	22,200
16 The Forks	60		2,470	1,110	2,370	6,660	14,200
17 Carrying Place	66		2,540	1,140	2,440	9,700	20,700
18 Bingham	65		2,710	1,250	2,540	10,500	22,400
19 above Solon	22		2,740	1,260	2,560	4,080	8,450
20 North Anson	22		2,820	1,200	2,720	4,160	8,720
21 Sandy River	20		3,240	1,460	3,080	2,920	6,160
22 Big Eddy	10		3,950	1,700	3,440	1,700	3,440
23 Augusta (increase)	5		3,550	2,320	4,720	1,160	3,560
Total Undeveloped	753					72,780	156,100
Grand Total	968					108,440	230,030

KEMMEREC RIVER POWER AND STORAGE

With 12 b.c.f. Brassua L. Storage

Location	Flow		Horsepower		Increase due to storage	
	90%	80%	90%	80%	Mill. K.W.H. per yr.	Primary H.P.
1	2,740	2,880	7,670	8,070	6.8	4,140
2	2,280	2,590	6,460	6,780	5.9	3,560
3	2,230	2,590	13,600	14,200	12.8	7,320
4	2,080	2,650	9,860	11,600	6.7	4,420
5	2,310	2,910	6,620	7,820	4.6	2,960
6	2,320	2,920	3,980	4,700	2.7	1,780
7	2,330	2,930	7,660	9,040	5.2	3,430
8	2,330	2,930	7,000	8,260	4.9	3,140
9	2,860	4,990	6,600	6,490	4.9	2,640
Total Developed			69,430	78,960	64.4	33,590
10	1,610	1,760	4,330	5,280	6.4	2,860
11	1,620	1,770	4,050	4,420	5.3	2,400
12	1,620	1,770	3,240	3,540	4.2	1,920
13	1,760	1,920	14,100	15,400	16.2	8,370
14	1,780	1,950	20,300	22,200	27.5	12,020
15	2,040	2,220	31,600	34,600	42.9	19,700
16	2,470	2,590	14,300	15,500	13.2	8,140
17	2,540	2,670	21,600	22,700	20.6	11,900
18	2,710	2,850	23,000	24,200	20.0	12,400
19	2,740	2,880	8,760	9,320	8.0	4,750
20	2,820	2,960	9,020	9,470	8.0	4,860
21	2,240	2,400	6,460	6,800	6.1	3,560
22	2,080	2,650	3,080	3,650	2.1	1,380
23	2,660	4,990	1,940	2,500	1.5	780
Total Undeveloped			166,820	179,460	162.2	94,040
Grand Total			236,270	258,420	226.6	127,630

(a) Assuming a capital cost of \$800,000 and an annual charge of \$80,000 the increased power due to the Brassua storage development will be as follows:

Cost on basis of increase at developed sites only - \$6.71 per H. P. Yr. or 0.147¢ per K.W.H.

Cost on basis of increase at developed and undeveloped sites - \$1.54 per H. P. Yr. or 0.034¢ per K.W.H.

(b) The column giving million K.W.H. per year increase due to storage is based on 75% utilization of capacity in previous column, and 93% generator efficiency.

The following outline of legislation is suggested as possible under the proposed constitutional amendment. It has certain points of fundamental resemblance to the New York legislation of 1915, as amended, under which the Black River Regulating District was formed. This is given as a suggestion only. The proposed constitutional amendment will permit direct development by the State without the creation of such districts as are here suggested, or by private corporations or associations. It may be noted, however, that this legislation if enacted does not create regulating districts. Its purpose is to provide the machinery for their creation when storage becomes economically desirable in the opinion of those who are to use and pay for the additional power.

AN ACT RELATING TO THE CONSERVATION OF NAVIGATION AND
HYDRAULIC POWER AND THE PREVENTION OF FLOODS.

RIVER REGULATION BY STORAGE RESERVOIRS.

#2. Any watershed or integral part of watershed may be created a river regulating district which will be a public corporation authorized to construct and operate storage reservoirs with right of eminent domain and assessment, to issue bonds and incur obligations.

#3. 25% measured in gross workable head of owners of water mills, dams and undeveloped water powers within the district may petition for creation of a regulating district, or the Commission may act on its own initiative.

#5. Hearing. Any person affected may file objections. If the purpose of this act is subserved by creation of the district the Commission* will so determine and unless within 60 days proceedings to review this determination in the courts are taken it shall be final.

#6. Within 70 days after incorporation of district, the governor with advice and consent of council shall appoint three persons as the Board of the Regulating District, one for three, one for four and one for five years and thereafter for five years, two to be selected from six or more names chosen by vote of owners of water mills or dams on the river. If within fifty days after incorporation nominations have not been filed the governor may appoint, but two shall be residents of the district.

#7. Compensation of board.....per diem and expenses.

#10. Board may employ, with approval of Commission, such engineers and assistants as necessary.

#12. Board to prepare plan showing available reservoirs, whether existing reservoirs should be enlarged, land flowed, etc. Plan certified to Commission and approved with or without modifications within sixty days.

#14. Board to exercise powers given by Sec. 2 and to have charge of operation of all reservoirs now in existence or hereafter constructed within district. Dominant right of eminent domain over that of public corporations except cities, and power to contract for sale or lease of power incidental to storage development.

#15. Right to condemn real estate necessary for provisions of this act and may use lands of State. Title acquired in name of District and lands deemed to be taken for public use.

#18. If Board determines reservoir is to be built, thereafter no railroad, building, or other structure to be built within high flow line except under permit from Commission. Statement to be prepared of incidental power available and lands benefited.

#19. Hearing by Board to all persons interested to determine whether public welfare requires development. Plans certified to Commission who may approve with or without modification after hearing the Board.

#20. Any person or corporation affected or Attorney General of the State may petition for review by courts. Unless review asked for within sixty days, determination to be final.

- #22. If any charge is against the State, appropriation to be made therefor by the Legislature and no bonds issued until such appropriation.
- #23. Payment for real estate from General Fund of District.
- #25. If no proceedings to review within thirty days of filing final order, Board to apportion assessment among corporations and real estate benefited as according to their judgment they may be respectively benefited, and to be based on the cost of interest, maintenance and a sinking fund to retire the bond issue for construction in 30 years. These charges may be revised as necessary in accordance with the above requirements. Apportionment to be approved by the Commission. After filing, Board to hear any person or corporation aggrieved. Determination of Board may be reviewed.
- #26. County Commissioners to levy and assess amounts charged against real estate in that county by same procedure as general taxes, amounts apportioned to be liens on properties until paid.
- #29. Board may issue bonds to pay costs of construction. Proceeds of assessments and revenues from leases of water or water power pledged for payment of bonds; not to be construed as bonds or indebtedness of State. Due in thirty years and exempt from taxation. Lawful investment for trustees and savings banks. To be approved as to amount, term and form, by Commission.
- #31. Certificates of indebtedness authorized for temporary financing to be used only for liabilities in anticipation of sale of bonds and levying and collecting assessment.

- #33. To operate reservoirs for greatest common advantage of owners below. Commission may modify methods of operation on petition of interested party and after hearing Board. Commission to determine height to which water may be raised and mark by permanent marks.
- #35. If flow at any power plant falls below normal flow, natural flow at reservoir not to be restricted without consent of owner.
- #36. Provides for cooperation with New Hampshire and joint supervision of rivers common to the two states.

* In the legislation suggested above the word Commission refers to whatever existing or specially created state department shall have jurisdiction.

FEDERAL LEGISLATION.

The Federal Power Act of June 10, 1920 has many features which seem to us to be objectionable to Maine and to the United States. While it is the result of attempts to facilitate power development through federal legislation, it does not seem as though the present form of the Act will encourage such development in the eastern states and we do not believe that the attempt to bring power developments on intra-state non-navigable streams under federal control is within the powers conferred by the commerce clause of the constitution.

The Federal Power Act is predicated on the broad wording of the commerce clause of the Federal constitution. It seems clear that under Sec. 4 (d) of the Act, all dams and power developments on navigable streams come under the jurisdiction of the Federal Power Commission, not excepting those streams the navigable portion of which lies entirely within the limits of a single state. (It seems probable that the Act repeals Sec. 9 of the Rivers and Harbors Act of March 3, 1899, covering cases where a stream is navigable only in one State). And, under the second paragraph of Sec. 25 the jurisdiction of the Federal Commission is extended to non-navigable waters, provided only that

"upon investigation it (the Commission) shall find that the interests of interstate or foreign commerce would be affected by such proposed construction."

Storage reservoirs and power developments generally do affect navigation on the stream below even though there may be no navigation at the power site itself.

In such cases the initiative lies with the proposed developers who "may in their discretion file declaration of such intention with the Commission, where-upon the Commission" makes investigation as to whether interstate or foreign commerce would be affected. Prospective developers will choose to deal with that authority, State or Federal, which offers the fairest and most practical conditions for development. It would seem greatly to the advantage of the State to enact such legislation as will attract prospective developers on non-navigable streams to operate without applying for a federal license, keeping in mind the necessity of so stabilizing conditions and legal requirements affecting development that the present disinclination to invest funds in water power projects will disappear.

If a prospective developer on a non-navigable stream receives a Federal license he will be primarily under Federal jurisdiction and only incidentally under State jurisdiction. The State will control as to intra-state power rates and in the unlikely event that there are "excess profits" under the provisions of the Act (Sec. 10-a) the State may share in those profits during the first twenty years. The right to purchase on agreed basis will run only to the Federal Government (Sec. 14).

Attention may be called to the fact that Sec. 25 of the Act provides a means for determining the question of jurisdiction. Application to the Commission for the ruling here provided might be useful to companies desiring to remain outside federal control. Should a decision be rendered stating the site to be without their jurisdiction it would be final for the site in question and a strong precedent for any other site on the same river. Such a decision has already been obtained for the Saco River above Biddeford.

Under Section 9-b and 27 the Act requires that prospective developers comply with State laws with respect to the bed and banks of streams, to the control, appropriation and use of water and to incorporation. The proviso regarding the bed and banks of streams is important in the far western states where the common law doctrine of riparian rights does not obtain and the states have in general reserved to themselves the disposition of water and water rights regardless of the ownership of the banks.

In the eastern states the doctrine of riparian rights does obtain and has been upheld by the courts and there can be little comfort to riparian right states in Section 9-b and 27.

It may be noted that the Federal Act even grants the right of eminent domain to a licensee on non-navigable as well as navigable streams provided only that the proposed development "in the judgment of the Commission is desirable and justified in the public interest for the purpose of improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce" (Sec. 21). The stream on which the dam is to be built is not necessarily the same as the "waterway" to be improved by the construction. In other words the dam may be on the head waters.

It seems also probable that where there is a question of jurisdiction the Courts will hold the Federal jurisdiction to be paramount inasmuch as in the case of such non-navigable streams the Federal Commission would have stepped in only on the strength of its finding that interstate commerce is affected.

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SUGGESTED AMENDMENTS TO FEDERAL POWER ACT OF JUNE 10, 1930.

1. That the present form of commission of cabinet officers (Sec.1) be abolished and the work placed in a suitable department for administrative purposes.
2. Change the definition of navigable waters (Sec.5) so that Federal jurisdiction will be limited to waters actually and commercially navigable. Rewrite the definition given in paragraph seven, Section 5, to read as follows: "Navigable Waters" means those parts of streams or other bodies of water over which Congress has jurisdiction under its authority to regulate commerce with foreign nations and among the several states, which either in their natural or improved condition are in fact commercially navigable by boats or other vessels, but not above the lowest interruption by falls, shallows, rapids or lawfully existing obstructions compelling land carriage, together with such other parts of streams as have been authorized by Congress for improvement by the United States.
3. To remove from (Sec.10c) any possibility of the licensee being required to maintain navigation structures excepting such as may be a part of the dam or project of the licensee.
4. That (Sec.10c) be amended by substituting for the words "adequate depreciation reserves" in line 5 the words "such reserves as may be reasonably necessary" and by providing that excepting where reserves are controlled by State regulation the amount of reserves shall be determined in the first instance and annually by the licensee subject to approval by the commission and that in case of inability to reach an agreement the above mentioned amounts shall be determined by appeal to the district court of the United States for the district in which the project may be located.
5. That (Sec.10d) should provide that earnings of companies whose rates are controlled by State Public Service Commissions shall be assumed to be not in excess of "a reasonable rate of return."
6. To abolish the right of the Commission (Sec.11b) to demand that "power" be furnished free of charge for the operation of navigation structures, substituting therefor the word "water."
7. That (Sec.12) be so amended as to prevent dams being constructed in a navigable river without provisions for such locks as may become necessary to conserve navigation.
8. That (Sec.14) be so amended as to provide that at least ten (10) years' notice be given of intention to take over the plant.
9. That (Sec.14) provide that the fair value at the time of taking over be paid for lands, rights of way, water rights, etc., instead of the value at the time of acquisition.
10. That (Sec.15) should provide for an extension of at least ten (10) years in place of the annual extension here provided for.

DAM CONSTRUCTION

Many states have recently discarded old legislation concerning state supervision of dam construction passed in many cases when such construction was usually of the timber crib type for log driving or small saw or grist mills. Now legislation has provided in most cases for approval by state officials before construction and a few states, notably Pennsylvania, have placed the question of the safety of all existing dams in the hands of a state commission.

Maine legislation in regard to dams is embodied in sections 43-45, chap. 97, R. S. 1916, with the additional provisions in the laws creating the State Water Storage Commission in 1909 and the Maine Water Power Commission in 1919 for the filing of plans with these commissions before construction.

The earlier legislation, passed in 1875, provides for an Inspector of Dams and Reservoirs, appointed by the Governor, who is required to inspect dams and take the necessary action to insure their safety on receipt of a petition from ten resident taxpayers, the selectmen or assessors of any town or county commissioners of any county, with a compensation of \$5 a day while actually employed.

At the present time the Chief Engineer of this Commission is Inspector of Dams and Reservoirs, and no application for payment by the state under the provisions of this act has been made. It is believed, however, that this work should be in the hands of a permanent state official without provision for additional compensation. Five dollars is not sufficient to obtain ordinary skilled labor at the present time and certainly inadequate to obtain an engineer with the training and experience necessary to pass on the safety of such dams as are now being built.

It would also seem desirable for the law to provide for action to be taken by the state on its own initiative. In a recent case of a concrete dam constructed in 1921 the plans filed in this office showed inadequate provisions for safety. The facts were brought to the attention of the firm constructing the dam but no action could be taken under the present law and the dam failed in the spring of 1922. Fortunately, the dam was so situated that its failure did not cause large loss of life or property.

The present law requiring the filing of plans of dams with the Commission before construction has rarely been complied with until the Commission learned that construction had started and requested that plans be furnished. In one instance the request for plans after a dam was approximately one third completed was refused with the statement that the law provided no penalty in case of non-compliance.

RIVER DISCHARGE

The river discharge work in Maine, started in a small way by the U. S. Geological Survey, was considerably enlarged by the Water Storage Commission created by the legislature of 1909. During the following years ~~the~~ standardized methods gradually came into use throughout the United States which furnish results of a high degree of accuracy.

Such records are of fundamental importance in connection with power and storage development. For such developments to be made with a reasonable degree of safety it is of the utmost importance that accurate information be available concerning the dependable flow of the river. In the case of a public utility the future cost of power must depend much on the accuracy with which the power equipment may be fitted to the physical and hydrological conditions at the site in question.

To furnish the required data the river stations must be maintained for a period of years and at important locations should be maintained permanently. In order that data may be available when required the establishment of stations should precede development by a sufficient number of years to furnish the necessary information.

The Commission now maintains twenty-six gaging stations. The number, however, should be materially increased to provide for future development in the northern half of the State.

The older records have been brought up to date in the 1920 report and it is planned to publish in the future such additional records as become available. Data for stations maintained during the past two years is printed in the appendix of the present report.

Cooperation with the Water Resources Branch of the U. S. Geological Survey, under H. C. Grover, Chief Hydraulic Engineer and C. H. Pierce, District Engineer for New England, has been continued and should be permanent in order that the high standards maintained by the Survey may be ensured in this State. Under the present agreement this cooperation will be withdrawn should the Maine work fail to meet with the approval of the Federal Bureau.

In connection with this work, Dr. George F. Swain of the Harvard Engineering School, a consulting engineer of international reputation, stated in an address to the Maine legislature March 10, 1921: "You must continue this work if you wish to take advantage of this great source of power of which you have more than your share in the State of Maine. You must know continuously without a break the flow of your streams in order to develop the power properly and economically and so it will not result in loss.....There must be careful surveys and studies of all the hydraulic and external features involved in storage development.....You should know where your developed powers are, how much power is developed at each one and how much power can be developed. No private concern can do work of that kind...Every investigation I know of has been made by some public authority."

TOPOGRAPHIC WORK

Five thousand dollars a year was appropriated for the two and one half years ending June 30, 1923. While this Commission is consulted concerning areas to be surveyed, the various amounts appropriated are turned over to the U. S. Geological Survey by whom the work is done.

During the years 1921 and 1922 final sheets (scale 1:62,500) were issued for the Columbia Falls, Great Sand Island and Moosehead quadrangles, and a reprint of parts of the Mt. Desert and Bay Harbor sheets showing the Lafayette National Park. Advance sheets (scale 1:48,000) have been issued of the Brasema Lake quadrangle. The field work has been completed on the Farmington and Long Pond sheets and partially completed on the Holeb sheet.

Surveys have been made and maps published for sixty-seven quadrangles during the past thirty-four years -- 34.9% of the total of 192 sheets required to complete the State Map. It is unnecessary to repeat statements concerning the vital importance of this map work to any development of the state's natural resources which were given on page 91 of the First Report of the Commission for 1920. The following statement of the percentage of area mapped in the New England States may, however, be of interest. Figures given are those of the U. S. Geological Survey for June 30, 1920.

Maine	52	Massachusetts	100
New Hampshire	46	Rhode Island	100
Vermont	51	Connecticut	100
Whole United States including		desert lands of the West	43%

It should be noted that an actual saving of between 5% and 10% on the total cost of the work could be made (this saving amounting to about \$80,000) if appropriations were available for the survey of ten or eleven quadrangles a year, completing the work in about ten years. The present rate provides for completion in 2005.

The Commission has recommended an appropriation of \$25,000 a year for 1923 and 1924 provided a similar appropriation by the Federal Government shall be made. This appropriation for twenty years would complete the State Map; continued for ten years would double the area now mapped and obtain accurate data concerning the most important areas adding slightly over six quadrangles a year.

In the State of Texas the Governor has asked for a minimum of \$100,000 for topographic work for the coming year. Many other states are appropriating such large amounts that there is a probability that the Federal government will be unable to extend all the cooperation asked for in duplicating state appropriations owing to the refusal of the Budget Committee to sanction the \$750,000 asked for ~~for~~ this work. It is, therefore, urged that every means possible be taken to insure passage of the Temple bill, now pending in Congress, to provide for completion of this work in twenty years.

TOPOGRAPHIC SHEETS ISSUED

Anson	Lafayette National Park
Augusta	Lewiston
Bangor	Liberty
Bar Harbor	Livernore
Bath	Long Pond (F)
Belmont	Machias
Berwick	Matticus
Bethel	Mattawamkeag (E)
Bideford	Monhegan
Bingham	Moosehead
Bluehill	Mt. Desert
Boothbay	Howfield
Brassna Lake (A)	Horridgewock
Bryant Pond	Ho. Conway, N. H.
Buckfield	Norway
Bucksport	Orland
Buxton	Orono
Casco Bay (resurvey)	Pascadunkong
Castine	Penobscot Bay (1:125,000) (G)
Cherryfield	Petit Manan
Columbia Falls	Poland
Cutler	Portland (resurvey)
Deer Isle	Rockland (G)
Dover (resurvey)	Sebago
Eastport (G)	Sebocic (E)
Ellsworth	Skowhegan
Farmington (F)	Small Point
Freeport	Swan Island
Fryeburg	Tenants Harbor
Gardiner	The Forks
Gorham, N. H.	Vassalboro
Gray	Vinalhaven
Great Wass Island	Waldoboro
Holeb (E)	Waterville
Kennebunk	Winn
Kenar Falls	Wiscasset
	York (resurvey)

- F Field work completed.
 A Advance sheets only.
 G Geologic folio and topographic sheets.
 P Field work partially completed.
 E Triangulation completed.

MAP OF MAINE

Date in regard to the River and Lake Maps available for distribution and the Map of Maine prepared by the Commission appear on pages 97 and 101 of the Report of the Commission for 1930.

Corrections have been made to the Map of Maine (scale 3 inches = 1 mile) so that it is believed to be as accurate a map of the State as can be made from information available at the present time and the map is ready for publication.

Now areas of the different drainage basins and of the entire State have been measured on this map with results as given below:

Basin	Total Area Square Miles	% of Water Surface to Total Area
Coastal Basin #1	646	6.2
" " #2	1,039	5.1
" " #3	936	4.9
" " #4	541	3.3
Royal	394	0.6
St. John	7,356	3.2
St. Croix	986	12.6
Machias	852	6.3
Union	714	5.9
Penobscot	6,937	4.6
Kennebec	6,190	5.1
Androscoggin	2,732	3.3
Presumpscot	727	10.7
Saco	900	3.0
Total	32,610	4.32

Total State Area in acres	20,870,400
Area Water Surface in acres	902,400
Area Water Surface in square miles	1,410

Seventy-three per cent of the area was in fifteen minute quadrangles and was computed from the Geographical Tables of the U. S. Geological Survey (Bulletin 650). The remaining twenty-seven per cent was measured by planimeter and the totals were carefully checked and adjusted.

GEOLOGY

No geologic field work by the U. S. Geological Survey has been carried on in Maine during the past two years. The Survey is, however, working on the contoured base map of Maine for the Handbook of New England Geography and Geology which is in preparation.

There is a large field for the study of minerals having an industrial value in Maine. In the last report of the Commission it was recommended that a State Geologist be appointed who could give his entire time to the work. Many inquiries from outside the State are received in regard to raw materials for industries which could be more adequately answered from an office which was able to gather together the various scattered sources of information not available to this Commission. Investigation of materials for use in the electro-chemical industries should be undertaken with particular reference to the use of off peak electric power loads.

Many samples of materials supposed to contain valuable minerals have been analyzed by the Chief Engineer but neither equipment nor time are available to carry on such work as it should be done.

COAL AND OIL IN MAINE

The probabilities in regard to the existence of oil in Maine have been amply covered in the report of the Commission for 1920.

The geological structure in Maine is not such as to permit a belief that either coal or oil exist. A company was formed in 1921 to drill for oil at Dover but although it is reported that the drills have gone to a depth of over 2,000 feet, oil does not appear to have been found.

Discoveries of coal have been reported from Dover and Scarborough. Samples of the so called coal from both these localities have been received by the Commission and analysis has shown that neither of the samples contain coal in any form.

PRECIPITATION

In the first annual report of the State Water Storage Commission, complete records of rainfall, to include 1910 for weather bureau stations in this State were published, and records for 1911 and 1912 were published in the second and third reports of that Commission. The records for 1913, 1914, 1915, were published in Vol. 2 of the first annual report of the Public Utilities Commission for 1915, and the records for 1916 were included in Vol. 2 of the 1916 report of that Commission. The records for the years ending September 30, 1917, 1918, 1919 and 1920 appear in the first report of this Commission, 1920.

The tables below include all the rainfall records that were known to be available in the State. Each after date indicates that station was being maintained September 30, 1922.

List of Rainfall Stations

Coastal Basins

Bay Harbor, 1885-1930
 Beddington, 1922-
 Mirror Lake, 1912-

St. John River Basin

Ashland, 1912-
 Beattie Mountain, 1922-
 Pt. Fairfield, 1905-1906
 Pt. Kent, 1844-1894
 Houlton, 1892-
 Howe Brook, 1912-1916
 Presque Isle, 1910-
 Soldier Pond, 1905-1913
 Van Buren, 1902-

St. Croix River Basin

Eastport, 1853-
 Vanceboro, 1916-
 Woodland, 1912-

Union River Basin

Elleworth, 1908-

Penobscot River Basin

Belfast, 1859-1904
 Carmel, 1900-1902
 Chesuncook Dam, 1905-1916
 Chesuncook F. O., 1904-1906
 Danforth, 1902-1917
 Debsconog, 1905-1909
 Grant Farm, 1904-1906
 Mayfield, 1885-1908
 Millinecket, 1909-
 Milo, 1921-
 Old Town, 1916-
 Orono, 1869-
 Patten, 1902-1919
 Ripogenus, 1916-
 South Lagrange, 1902-1906
 Wytopitlock, 1917-

Kennebec River Basin

Augusta, 1841-1916, 1922.
 Cambridge, 1912-1916
 Rustic, 1911-
 Fairfield, 1886-1916
 Farmington, 1891-
 Flagstaff, 1895-1901
 Gardiner, 1837-
 Greenville, 1898-
 Jackman, 1894-1906, 1921-
 Kent's Mill, 1891-1894
 Madison, 1894-
 Roach River, 1901-1906
 Sebasticook, 1922-
 Solon, 1902-1906
 The Perks, 1901-
 Winslow, 1895-

Androscoggin River Basin

Asiscochos, 1911-
 Exrel, N. H., 1885-
 Lewiston, 1875-
 Livermore Falls, 1909-
 Middle Dam, 1905-
 Oquossoc, 1900-
 Pentecock, N. H., 1911-
 Rumford Falls, 1894-
 Upper Dam, 1885-
 West Kennebago Mt., 1922-

Presumpscot River Basin

North Bridgton, 1861-
 Portland, 1856-
 Songo, 1900-

Saco River Basin

Biddeford, 1881-
 Cornish, 1857-
 Union Falls, 1904-

EVAPORATION

On June 4, 1915, an evaporation station was established near the Cobbessecontee Stream at Gardiner, lat. 44° 14' N, long. 69° 46' W. The actual evaporation from a standard U. S. Weather Bureau tank was measured, and meteorological data kept.

The Weather Bureau tank is of galvanized iron, 48 inches in diameter and 10 inches deep, set on a timber frame. There is no ventilation underneath the tank and it is kept filled to an approximate depth of 3 inches. Measurements of evaporation are made with a hook gage. Elevation 140 M. S. L. Anemometer 7 inches above pan.

In June 1921 this tank and the rain gage were moved about 120 feet to within about 15 feet of the auxiliary tank in the stream. Elevation 139.7 M. S. L.

An auxiliary tank, a square galvanized pan 36 by 36½ inches by 36 inches deep, supported by posts in the stream, was installed July 1, 1917. The evaporation is measured by a dipper holding 0.01 inch. Elevation about 135 M. S. L. Anemometer 14 inches above pan.

The records consist of observations of humidity and water temperatures at 7 A. M. and 5 P. M., anemometer, maximum and minimum air temperatures, evaporation and precipitation at 5 P. M.

Mean annual precipitation at station	42.7
Mean temperature Fahrenheit	42.9

RIVER DISCHARGE TABLES

Descriptions, lists of discharge measurements and tables of daily and monthly discharge are published in the Water Supply Papers of the United States Geological Survey as follows:

1898:	27	1905:	165	1913:	351
1899:	35	1906:	201	1914:	391
1900:	47	1907-8:	241	1915:	401
1901:	65,75	1909:	261	1916:	431
1902:	82	1910:	281	1917:	451
1903:	97	1911:	301	1918:	471
1904:	124	1912:	321	*1919:	501
				*1920:	501
				*1921:	521

* In press.

Additional data concerning work during the years 1887 to 1900 are contained in Part IV of the 19th, 20th, 21st and 22d Annual Reports of the Geological Survey. Special Reports have been issued as follows:

- W. S. P. 69 Water Powers of Maine, by H. A. Pressey.
- W. S. P. 198 Water Resources of the Kennebec River Basin, by H. K. Barrows and G. C. Whipple.
- W. S. P. 279 Water Resources of the Penobscot River Basin, by H. K. Barrows and C. C. Babb.
- 10th Census of the United States, Vol. XVI, 1880. The Water Power of the Streams of Eastern New England, by Prof. George F. Swain.

PER CENT OF TIME DURATION TABLES

For all the gaging stations for which fairly accurate daily flows were available, and for those stations for which no daily discharge figures had been published for the winter periods but for which there was sufficient information available to work up mean daily discharges for the missing periods by modern methods, per cent of time duration tables based on observed flows have been prepared and were published in the 1930 report of the Commission. The tables show for each year of the record, the per cent of time for which various flows in second-feet per square mile occurred and also in the column at the extreme right the per cent of time for the entire period of record for which those same flows in second-feet per square mile occurred. In the present report values for the years ending September 30, 1921 and September 30, 1922 are given, together with the new mean for the entire record.

These values can be safely used at other points on the same stream not too far distant from the gaging station by multiplying the values in second-feet per square mile by the drainage area at the point under consideration, giving due consideration to important tributaries, the flow of which may be included or excluded in the run-off at the point under consideration and which may have a higher or a lower unit run-off than the main river at the gaging station.

These tables can be shown graphically by plotting the values in the tables for any one year or the mean for the entire period of record, with values of second-feet per square mile as ordinates and per cent of time as abscissae and drawing a smooth curve through the points plotted.

Duration curves are useful in determining the amount of storage or auxiliary power needed to supply a constant demand. When plotted so that one inch vertically represents 0.5 second-feet per square mile, and one inch horizontally represents 10% of one year, then one square inch area will represent 1.58 million cubic feet per square mile of drainage area or for each foot of fall will be equivalent to 49.7 theoretical horsepower hours per square mile of drainage area. Then by plotting on the curve a horizontal line representing the desired plant capacity, and finding the square inches below this line and above the duration curve, we can find the number of

$$\left. \begin{array}{l} \text{Million cubic feet} \\ \text{storage required yearly} \end{array} \right\} = \text{square inches} \times 1.58 \times \text{drainage area.}$$

or

$$\left. \begin{array}{l} \text{Auxiliary steam} \\ \text{power required} \end{array} \right\} = \text{square inches} \times 49.7 \times \text{drainage area} \times \text{head} \times \text{efficiency.}$$

MAXIMUM AND MINIMUM DISCHARGE

The record of extremes of discharge is important for use in the design of spillway capacity to be allowed for dams, for studies of backwater, dependable power output and amounts of storage or auxiliary power capacity to be provided.

Care should be exercised in the use of minimum discharge figures as in certain cases where storage is not used on Sundays it does not represent the natural flow.