FLOW REGULATION ON THE GRAND RIVER.

THE Grand River Valley, in Ontario, is well noted for its natural production and resources, its manufactures and trade, and its density of population. It is not the earliest settled part of the province, the eastern counties along Lake Ontario claiming that distinction. But with the advent of transportation facilities, the southwestern peninsula progressed and later surpassed the older settlement.

In line with its development, however, has been the partial sacrifice of one of the country's great natural resources—timber growth. Agriculture occasioned heavy invasions into magnificently wooded districts.

Another great natural resource is the perennial, never-failing, precipitation ensuring, with proper husbandry, the continuing productivity of the soil, and ensuring as well stream flow, ground water, water supply as required by large communities, and water power developments.

That the wasteful destruction of forest growth would have produced a marked effect on precipitation, is to be expected, from prevalent ideas of similar conditions elsewhere. That this is not the case, however, but that the effect has been rather on stream flow itself, is brought out in the following article. How the seriousness of the situation has aroused action to prevent damage by spring flood, and what steps are being contemplated to compensate for the axeman's intrusion upon Nature's mode of regulation was brought out in a most interesting manner before the Galt Board of Trade on November 27th, 1914, by W. H. Breithaupt, C.E., Mem. Can. Soc. C.E., Mem. Inst. C.E. Regarding the effect of land denudation, Mr. Breithaupt has this to say:

"Since the beginning of continuous observations, seventy and more years ago, in various parts of the peninsula, (at not many places but at enough to establish the fact), precipitation has remained practically constant, varying somewhat from period to period, but on the whole remaining about the same. Destruction of the great forests has not, as is sometimes erroneously held, diminished rainfall or snowfall. It has, however, caused great change in the flow of streams, the former characteristics of which, moderate floods on snow melting in the spring and well sustained flow throughout the year, having changed to destructive floods, and dwindling, almost disappearing, flow, in the low-water months of the year. The greatest factor of change in the run-off rate of a number of rivers in the Ontario Peninsula has been the drainage of the hundreds of square miles of swamps on the table land of the headwater area.

"With the destruction along the whole course of the river, particularly in the cities and towns along its banks, caused by the spring floods, now almost an annual occurrence, and the small flow of polluted river during the summer months, flood control, and regulation of flow, have become the most important conservation questions immediately concerning us in the Grand River Valley."

These matters were brought to the notice of the Provincial Government at various times. The result has been that for the past two seasons the engineering staff of the Hydro-Electric Power Commission of Ontario has been carrying on an investigation, by topographical survey and by precipitation and stream flow observations preliminary to the adoption of a plan of construction whereby future danger will be minimized. We abstract the following from Mr. Breithaupt's address, concerning the favorable results so far attained and concerning what, illustrated by existing cases of a similar nature, may be expected when the river has been subjected to a system of storage:

There are two main methods of preventing the overflow of a river channel: (1) By making such channel of sufficient cross-section and declivity, by means of walls or dykes on the banks, deepening and removal of obstructions in the channel, cutting off detours and otherwise straightening the channel so as to make it shorter and therefore its declivity greater. (2) By impounding water in excess of the capacity of the channel by means of reservoirs, or by retardation of flow on sufficiently large areas of the watershed by forestation.

When floods on a river are very large as compared to the normal flow the first method requires a relatively large channel, and has the further disadvantages that any improvements benefit only their immediate vicinity and may very detrimentally affect the country further down stream in that the velocity of delivery has been increased, and that the water which might have been held further upstream for sustained flow is wasted. The method of impounding excess waters, on the other hand, benefits the entire river below the reservoir, both in flood control and in sustained flow obtained by the gradual release of the impounded waters.

The St. Lawrence River, with its vast natural regulating basins, the Great Lakes, exemplifies on the largest scale the flow-regulating effect of large impounding reservoirs in the course of the river. On its largest tributary, the Ottawa, greatly increased storage is being obtained by raising the outlets of a number of lakes in the upper part of the watershed of the river.*

The work has been in progress since 1909 and material benefit has already resulted. When completed it will give an increase of low-water flow at the city of Ottawa of from 10,000 to 12,000 cu. ft. per second, bringing the flow for this period to a minimum of somewhat under 40,000 c.f.s. The great benefit of this conservation, in flood relief, equalization of flow and the raising of water level for navigation purposes, will, owing to very favorable natural conditions, be secured at an estimated total cost of less than one million dollars.

In general, the regulation of a river by means of storage reservoirs is more applicable on smaller rivers. On such rivers it has become a well recognized method, and has had numerous successful and highly beneficial applications. I shall here mention two, selected on account of their similarity in many respects to the Grand River regulation scheme, both of them in Germany.

The dam on the Eder River in the principality of Waldeck is 160 ft. high, above foundations, and makes a reservoir with storage capacity of 7,350,000,000 cu. ft., a little over 4½ sq. miles in area. The drainage area above the dam is 542 sq. miles, of which 40% is wooded. Average rainfall on the drainage area is 33 in. in the year. With only 10% of the capacity of the reservoir held as reserve the minimum flow is six times what it had been. The total cost of this undertaking was $4,902,380, of which $2,142,850 was for land and damages. Several small villages and many farms are flooded by the reservoir. One main purpose, beside flood prevention, was the development of water power. The large expenditure has already been found to be an excellent investment.

The largest dam in Europe is on the Bober River, a tributary of the Oder, and was completed in November, 1912. In keeping with its importance as an economic

*This storage on the Upper Ottawa was described in August 7, 1913, and December 4, 1913, issues of *The Canadian Engineer.*