

RIVER REGULATION, WITH SPECIAL REFERENCE TO THE ONTARIO PENINSULA AND TO THE GRAND RIVER.*

The flow of streams is due to a variety of causes; primarily precipitation, rainfall and snowfall; extent and declivity of the drainage area; nature of the ground, rocky or soil, and condition of the soil; condition of the surface, the chief element being whether it is forested or clear; the presence of lakes or large collecting basins in the stream. A steep rocky drainage area will give the greatest run-off in the shortest time. There is great difference in the nature of soils and in their permeability, as for instance between clay and loam, or gravel.

Whether forestation has, much influence on precipitation is not entirely clear. There are generally other governing conditions. As to the Ontario Peninsula there are the vast adjacent bodies of water—the Great Lakes. As far as records go it appears that precipitation has not decreased in Ontario with deforestation. The influence of forestation is in retarding and diverting. The forest floor is more or less obstructed with litter, and is soft and permeable. Water finds its way into creeks and rivers, much disappears into the ground to come up lower on the slope in the form of springs. A large part evaporates, and vegetation, tree growth, by transpiration, absorbs a large amount of water. Owing to evaporation and transpiration together the total run-off from a forested area is, in fact, somewhat less than from a non-forested one. Conservation and continuation of the flow, with ground water, and slow melting of the snow, are, however, very much better with the forested watershed. The forest acts as an equalizer, being a check both on extremely high and on extremely low water. Where the ground is bare and compact the water rushes quickly over the surface, forming torrents, washouts, and floods.

Large basins or lakes in the course of a river exercise an important function in its regulation. Water, though in great quantity, will increase the depth of a basin of large area very little; the head of water at its outlet will also be but little increased, and the flow will be long-sustained. With artificial control of the outlet the natural automatic regulating value of a large storage basin in a stream can be much enhanced.

The percentage of precipitation that reaches the streams, that is the percentage of run-off to rainfall, after evaporation, transpiration, etc., varies greatly with the nature of the drainage area, and may be anywhere from 40 to 60 per cent., and less or more in exceptional cases. There is also variation with meteorological conditions. After a long dry period a very heavy precipitation may not show much in the streams, while after a wet season a smaller precipitation may give a much larger run-off.

The requirement then for river regulation is to retard and conserve the water after rain-fall or snow-fall, and this is done either by forestation, including timbered swamp areas as forest, and is most effectively and to the best general benefit done in this way; or by storage on a large scale. Ground water, which for its up-keep depends so directly on forest area, is one of the most important features of general benefit due to forestation. Various towns in the Ontario peninsula, for instance, and fairly large centres of population, depend for their water supply on deep wells. Impair the supply of ground water and the water available from such wells must inevitably be largely reduced.

All larger streams normally originate in mountains or uplands, and the relatively most important areas for up-keep of the flow of a stream are the mountain slopes or upland drainage areas proximate to its source. To have such areas in forest is therefore of the first importance. In older countries, in Europe, this is effectively done, and in the United States the Federal Government is now, in the Appalachian and White Mountains Bill before Congress, giving particular attention to this question. In Germany the forest covers 26

per cent. of the surface, mountain slopes and headwaters of streams being as much as possible in forest, and, incidentally, the forests are one of the most prolific sources of public revenue. The Ontario Peninsula, only a short time ago, not much over 50 years for the greater part of it, one of the most densely forested areas in either temperate zone, now shows, as far as can be ascertained from the Government returns, which are very defective, under 15 per cent.—it is actually probably nearer 12 per cent.—of the surface as woodland. With deforestation stream flow in the Peninsula has greatly changed. Spring floods are very much higher, and there are floods on heavy rains, while during the season of minimum flow many streams, which were formerly considerable throughout the year practically disappear.

Practically no topographical survey, further than a little unimportant work along the frontiers by the Department of Militia and Defence, is on record for the Ontario Peninsula. The elevations of all railway stations, however, and they are fairly well distributed, together with other general data, give a good idea of the broad, general features of the topography. The contour map, Pl. 1, has been constructed from these data. The contours are at 100 ft. intervals. The striking feature is what may be called a table-land or plateau varying not more than 200 ft. in elevation above sea-level, from 1,500 to 1,700 ft., near the northerly limit of the peninsula, with slopes abrupt to the east and north, abrupt also for the first few contours to the west and south, but after that gradual to the west and more gradual to the south-west and south. The river of water, with its very extended shore line of lakes and connected channels is, not considering the Niagara River or Lake Ontario, almost level, varying only about 9 ft. from Georgian Bay, El. 581, to Lake Erie, El. 572. The 1,500 ft. contour encloses only about 550 square miles. Practically all of the larger rivers of the Peninsula but one rise within or near this contour; the Nottawasaga and branches, and the Beaver to the north, the Saugeen and branches, and the Maitland to the west, and the Grand River and its tributaries to the south. The uppermost branch of the Thames rises further down the slope, about at the 1,300 ft. contour. A smaller but important river, to the north, is the Sydenham, which rises between the 1,100 and the 1,200 ft. contours, and there is another Sydenham River in the flat country of Lambton and Middlesex counties, a sluggish stream rising a little above the 800 ft. contour.

The characteristic of the rivers of the Peninsula is that their drainage areas are most extensive toward their sources, and narrower and smaller in the lower, flatter country where many smaller streams flow directly to the lakes; and that their declivity, after leaving the head plateau, is also greatest in the upper part of their course. The headwater drainage areas are the chief factors in governing flow; a large run-off there is quickly carried down and overflows the river's banks in the lower country.

Precipitation appears to be largest on the western slope of the Peninsula, over 400 inches of water per annum, due to the prevailing west winds. The air is saturated with moisture in its travels over the lakes strikes the up-slopes of the ground, is deflected to colder strata, and rain or snow results. There is larger precipitation, especially snowfall also on the head plateau. Before settlement this was covered to great extent with dense, heavily wooded swamps, retainers of snow until late in the spring and natural slowly drainage reservoirs, replenished with each rainfall, giving ideal condition for conservation of stream flow. The swamps have now been mostly drained and other forestation removed. The cleared and drained land, appears, most of it, not to be of great agricultural value, and might in itself give as good or better economic return as forest, including swamps with good tree growth under this classification. The general result is, however, the consideration. The table land should revert to its former condition. It is difficult to imagine so comparatively small an area elsewhere the reforestation of which would have such far reaching results. The area in question comprises the greater part of Artemesia, Egremont, Proton, Melancthon, Arthur, West and East Luther, and East Garafraxa Townships.

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*Paper read at Engineers' Club, Toronto, March 5th, 1908, by W. H. Breithaupt, M. Inst. C.E.