Discharge of Filtered Sewage into an Otherwise Unpolluted Stream*

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THE sewage of Brockton, Mass., receives treatment at a plant located in the southwestern part of that city near the line between the city and West Bridgewater. The treatment plant consists of sedimentation tanks, trickling filters and sand filter beds. The effluent is discharged into the Cowesett Brook, which in turn is joined by the Ames Stream, coming in from the west, the two forming the Hockomock River.

The water supply of Brockton is derived from a watershed not tributary to the Hockomock River. It follows that the discharge of sewage effluent into Cowesett Brook increases the natural flow of that stream and of the Hockomock River in proportion to the quantity discharged.

It is claimed by lower riparian farmers that as a result of the discharge of effluent into the stream there is in summer such stimulation of aquatic growths along the banks and in the bed as to retard greatly the combined flow; and, further, that the increase in normal discharge, with the obstruction of the channel, results in the maintenance of such high ground water levels in certain low lands bordering the streams as to render them practically worthless for agricultural purposes.

Action to recover damages was brought in the Superior Court of Plymouth County by a group of riparian owners. An auditor was appointed by the court, who heard the evidence and made a view of the Brockton sewage works, streams and lands involved. The report of this auditor was presented recently to the court, and a review of the case is of considerable interest from the standpoint of the sanitary engineer.

Below the junction of the Ames Stream and the Cowesett Brook, the Hockomock River flows in a general southerly direction for several miles, then turns east to form, with Nippenicket Brook, the Town

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River, which flows east, then south, until it joins the Taunton River, which in turn empties into Narragansett Bay. The upper portion of the watershed above West Bridgewater is gently rolling farm land upon which are scattered several small villages, none of which is supplied with a sewerage system. Along the lower course of the Hockomock and in the vicinity of the Nippenicket Pond, from which the Nippenicket Brook flows, there is an extensive area of low land known as Great Cedar Swamp. The watershed areas of the several streams above certain significant points have been determined from the U. S. Geological Survey maps as follows:

Cowesett Brook at confluence with Ames Stream, 7.9 square miles
Ames Stream at confluence with Cowesett Brook, 9.6 square miles
Hockomock River at West Center Street, 20.1 square miles
Town River at Ames Dam, 52.8 square miles

HISTORY OF THE USES OF THE HOCKOMOCK RIVER

For many years the Ames Stream and Cowesett Brook have been used as sources of water power, and dams and mills have been constructed upon them. The milldams on the Cowesett Brook have ceased to function as such, but the small ponds formed thereby are used for ice harvesting. The Ames Stream is still used to some extent for water power. In the Town of Easton, the Ames Agricultural Implement Company maintains a small shovel mill operated by water power, which has been in existence for many years. The water of this stream is again used for power at three different points. Below the Ames Company two other water powers are utilized during four or five months of the year. No milldam or pond occurs below the junction of the Ames Stream and the Cowesett Brook until the Village of West Bridgewater is reached, about 10 miles downstream, where there is an old dam called the Ames Dam, located across the Town River.

The stream and its tributaries have been used for water power for many years and the flow controlled according to such use, this being by riparian owners and within their rights. The utilization of the streams for power is of significance in connection with the claims and counterclaims during the legal proceedings described later.

Brockton Sewage Treatment Plant—In 1893, the city of Brockton began the construction of a sewerage system and in 1894 a sewage treatment plant consisting of intermittent sand filters was built. These were located in the extreme southwest corner of the city and the effluent discharged into Cowesett Brook. The present plant consists in part of the original filters, with sedimentation tanks and trickling filters constructed during the past 16 years.

The sewage flows at Brockton have in general steadily increased from about ⅓ m.g.d. in 1896 to over 3½ m.g.d. in 1927. This fact is of particular significance as regards the changes in the character of Cowesett Brook and Hockomock River by the discharge of sewage effluents.

Effect of Discharge of Brockton Sewage Effluent—The first effect of the discharge of the effluent is to increase the normal flow of the streams into which it enters. In winter, this is materially less in proportion than in summer, due to the greater natural run-off. The effect is proportionately less in a wet than in a dry year. The proportions of effluent in the Cowesett Brook below the treatment plant for the months of July to October, inclusive, 1923, computed on the basis of data presented during the hearings, are given in Table I.

TABLE I

PER CENT INCREASE IN NORMAL STREAM FLOW DUE TO DISCHARGE OF BROCKTON SEWAGE EFFLUENT

1923 Month	Sewage Flow	Normal Stream Flow Cowesett Sta. 4	Normal Stream Flow Hockomock Sta. 5	Per Cent Increase due to Sewage Effluent at Sta. 4	Per Cent Increase due to Sewage Effluent at Sta. 5
	c.f.s.	c.f.s.	c.f.s.		
July	3.92	2.22	9.78	177	40
August	3.18	1.56	7.89	204	42
Sept.	3.11	0.75	5.43	415	57
Oct.	3.02	2.29	9.98	132	30

It will be seen that in the summer of 1923 a large proportion of the average monthly flows of Cowesett Brook and Hockomock River consisted of effluent from the Brockton plant.

One of the most serious effects of effluent, as claimed by the plaintiffs, is the stimulation of aquatic growths and the resultant clogging of the channels by the growths and by banks of silt and sand, the formation of which is fostered by these growths. Plant growths are stimulated by nitrogen in the form of nitrates and by carbon dioxide, both of which are present in considerable quantity in sewage effluents. The very heavy growth of vegetation in the Hockomock River below the plant at Brockton aggravates materially the effect of the augmented stream flows.

The combination, therefore, of channel obstruction with abnormal flow during the summer months results in the maintenance of high water levels in the stream and high ground water levels in the low lands along the stream so that it is impossible to secure proper drainage of these lands. Much of the land adjacent to the stream is subject to flooding under normal conditions in winter and spring, but in summer in earlier years has been cultivated and crops grown thereon.

Another effect of the discharge of sewage effluent has been to change the physical appearance of the stream as regards color and turbidity. In the early days of operation of the intermittent sand filters, the effluent was practically clear and colorless and had little effect upon the stream into which it was discharged. As these filters became inadequate to care for the entire sewage flow, trickling filters were built, part of whose effluent after sedimentation was discharged directly into the stream, and part upon sand beds. The turbid character of that part of the effluent not passed through the sand beds brought about an increase in turbidity and color in the stream receiving it. Above the entrance of the sewage effluent, the stream is ordinarily clear, with a slight natural brown color, and odorless. Below, the stream became gray or gray-brown in color, turbid, and at times slightly odorous. The character of the stream bottom changed from clean sand or gravel to black humus-like material, and at times masses of worms similar to those found in trickling filter media were noted.

Analyses have shown a marked increase in organic constituents and in bacterial content in the stream waters below the treatment plant. The organic matter has been sufficient in summer to bring about a marked reduction in the dissolved oxygen content of the stream. Such reduction, however, has not been sufficient to bring about putrefactive conditions of the stream water. Offensive conditions, however, have been caused, due to the stimulation of large growths of duckweed which at times have collected in masses, died and decayed, with the production of offensive odors.

Hearings before Auditor—During the hearings, which consumed about 20 days, much evidence, both technical and lay, was presented by plaintiffs and defendants. Some of this is summarized in the following paragraphs:

The sewerage system and method of sewage disposal adopted by Brockton were authorized by an Act of the Massachusetts Legislature in 1890.* Section 2 of this Act referring to the Board of Commissioners of sewerage construction authorized by the Act reads in part: " said Board of Commissioners shall have exclusive authority to construct, maintain and operate the system of sewerage and of sewage disposal adopted by the City Council. . . . "

On May 28, 1890, the City Council of Brockton adopted a system of sewage disposal in an order reading as follows: " Ordered, that a system of sewerage be, and the same is hereby adopted for the whole territory of the City of Brockton, with mains, pumping stations and

* Chapter 248 of the Acts and Resolves of 1890 of the Massachusetts General Court.

irrigation lands, as may be necessary to successfully operate a system of sewage disposal by ' downward filtration,' which system of sewage disposal is also hereby adopted."

This order, and particularly the description of the system of sewage disposal as " downward filtration," assumed some importance in the course of the case. It was claimed by the plaintiffs that the trickling filters did not comply with the original plan and scheme adopted and authorized by the city council. No record of the adoption of any other method of disposal was produced by the city. The plaintiffs' contention that there was a departure from the original plan and scheme was based upon the interpretation that in 1890 the term " downward filtration " referred to intermittent sand filtration, that trickling filters had not been devised at that time and being a subsequent invention could not have been the method of sewage disposal then adopted. The defense claimed that " downward filtration " was a general term applicable to any kind of filtration, trickling filters or intermittent sand filters. The plaintiffs in turn pointed out that in the records of the original order the term " downward filtration " was set off by quotation marks, showing that a specific kind of filtration was meant and that the intermittent sand filters installed were in compliance with the meaning of the order. The contention of the plaintiffs in this matter was upheld by the auditor in his report.

It was brought out that in time the original filter beds became overtaxed, resulting in a deterioration in the quality of the effluent. Due to the inadequacy of available areas for extension of the sand beds, it became necessary to adopt a different system of treatment. After studies and experiments trickling filters with preliminary and secondary sedimentation tanks were adopted by the sewage commission but without formal adoption by the city council.

From the correspondence passing between the city authorities and the State Health Department, it appeared evident that treatment of the final effluent from the trickling filters upon the old sand beds was contemplated. As a matter of fact, certain of the sand beds were set aside for this purpose but, as was brought out in the testimony, only a portion of the trickling filter effluent was thus treated, although steps were under way to make available more sand bed area so that the entire trickling filter effluent could be treated thereon. The auditor found that if the trickling filter effluent were passed through the sand beds, the city would be treating the sewage in accordance with the original method adopted by the city council in 1890 but that it failed to treat according to the method adopted when trickling filter effluent was discharged directly into the stream.

Evidence was given to the effect that stimulation of aquatic growths would occur whether trickling filter effluent or sand bed effluent were discharged, and that good sand bed effluent might result in even greater stimulation of growths due to its more highly nitrified character.

The defense claimed that the regulation of the Ames Stream for power purposes was an important factor in the maintenance of high water levels in the Hockomock River but presented as evidence a maximum observed effect of only about 6 inches at the property of the owner of the largest areas involved. As power regulation had existed for many years, the contention that it was a material factor apparently received little attention on the part of the auditor.

It was difficult to estimate the rise in water levels as a result of the obstruction by excessive aquatic growths. This difficulty was due in part to the fact that no hydraulic study of the stream had been made prior to the time it became affected by the vegetation. Furthermore, the course of the stream is meandering and its cross-section varies materially from point to point, making hydraulic measurements of doubtful significance. Based on judgment and a few actual measurements, it was estimated by the engineers for the plaintiff that the normal water level in the stream during the summer months had been increased from 1½ ft. to 2 ft. by the excessive vegetation in the stream. This estimate was accepted by the auditor, who found that the land involved had been rendered worthless as a result of the increase in water levels resulting directly and indirectly from the discharge of the effluent from the Brockton sewage treatment works. The several plaintiffs were awarded damages amounting to the fair market value of their lands as of 1914 together with interest from the date of the writ.

CONCLUSION

This case is illuminating as to the results which may follow the discharge of effluents from sewage treatment plants into streams where the natural flow available for dilution compared with the volume of effluent is small. Two lessons are taught: (1) Well purified effluents require substantial dilution. (2) Extensive easements may be necessary where adequate dilution is not available.