SEWER SYSTEM AND PURIFICATION PLANT

AT

STATE SCHOOL OF AGRICULTURE AND EXPERIMENT STATION.

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The State School of Agriculture and Experiment Station is, as the name implies, an institution supported and controlled by the state, under the immediate supervision of the State University.

The growth of the institution has been almost phenomenal as shown by a brief review of the building record. The first buildings of any note were the Farm House and Main Barn built in 1884 at a combined cost of forty thousand dollars. Later followed the Home Building, Pendergast Hall, Home Economics, Dairy Hall, Drill Hall, Dining Hall, etc., so that at the end of 1895 the cost of building construction had mounted up to two hundred and one thousand four hundred dollars. Then in 1897 came the Power House and Girls Building, later the Horticulture Building, Chemistry Building, Boys Dormitory, Live-stock Pavillion, Main Building, and Dairy Barn, bringing the grand total for building expenditures up to seven hundred and five thousand nine hundred dollars; or more than three and one-half times what it was ten years ago.

The names of the various buildings are so suggestive as to their functions, it would seem hardly necessary to dwell at any length upon the service rendered by each. The Home Building, Pendergast, Boys Dormitory, Girls Building, and part of Dining Hall are used almost exclusively as living compartments for the students while attending the school. The Farm House serves as a home for the farm hands and attendants at the Experiment Station. The Main Building is the general office building and together with Dining Hall, Farm House, Veterinary Building, and Live Stock Pavillion is occupied throughout the whole year. The Veterinary Building is devoted to the treatment of diseases of domestic animals, and does much research in that line, thus using a considerable quantity of bichloride of mercury and carbolic acid. This is especially large at times of a post mortem examination. The meat house serves also as a slaughter house and upon certain days of the week contributes largely to the sewer.

The school has its own water system and secures the supply from two deep wells, one located in the power house, and the other in the dairy building. Some time ago an epidemic broke out in the school, which seemed to indicate that the water supply was being contaminated. By a simple experiment it was proved that it was quite possible at times for the sewage to enter the well, and while not certain, it was probable that this had happened. It was then determined to build an entirely new system, using the old as far as it could be worked in to an advantage, and the remainder should serve as a storm sewer.

The sewage had always flowed into some little lakes situated in the dairy pasture, and as the cattle drank the water from these same lakes, it was necessary to treat the sewage thoroughly.

The sewage to be treated was largely of a domestic nature, that from the Chemistry Building was turned out with the storm water for fear the chemicals might interfere with the purification plant. This, as will appear later, was probably quite an unnecessary precaution. Everything from the Veterinary Building was allowed to pass into the system, as well as the wash from the creamery, aside from these everything was purely domestic.

The old system of sewers had been laid from time to time as necessity required, with little regard for existing conditions and none whatever for the future. They were laid of whatever tile came most convenient, and seemed to have followed the line of least resistance, rather than with any respect to proper line or grade. No records were ever kept, leaving the present management totally in the dark as to their whereabouts. For example, when laying the new line an old twelve-inch sewer was found, which after connecting with several other branches, emptied into an eight-inch ~~one~~. A few lamp holes were provided, but not a single man-hole on the whole system. So it is not al all surprising that it should give considerable trouble, and that the new line should be rather extensive.

The new system was designed by Prof.F.H.Bass who sought to remedy the defects in the old, and at the same time provide for the best purification that could be reasonably expected.

The new sewer,as will be seen on the map,consisted of about six hundred feet of ten-inch sewer, thirteen hundred feet of eight-inch, and some six-inch connections, together with thirteen man-holes.

The purification plant as shown by the drawings and photographs, consisted of septic tank, percolating filter, sand filter, and a small sludge bed.

The construction was commenced about July first, at the following contract prices; ten-inch sewer $0.90 per lin.ft., eight-inch $0.98, six-inch $0.74, man-holes $50.00 each, septic tank $2400.00, percolating filter $3650.00, sand filter $700.00, and all extra work actual cost plus 15% for profit.

The sewer was all of salt-glazed vitrified pipe laid with portland cement mortar. The man-holes were built of good quality,hard burned brick laid up with natural cement mortar. As the work progressed a force account was kept endeavoring to get at the actual cost of the different items. This was not as satisfactory as it might have been, due to the contractor not wishing to cooperate. Like many others, he construed it as an attempt to pry into his private affairs, instead of considering it of equal, if not more, value to himself than anyone else.

As far as could be ascertained the unit prices paid by him were as follows: foreman $4.00 per day, tileman $3.00, tileman's helper $2.50, carpenters $2.50, engineer $2.50, head ditchman $2.50, laborers $2.25, water boy $0.75 per day. Toward the last some of the common laborers were also getting $2.50. This rather high price of labor was due in part to the fact that the greater share of the work was being done at a time when harvest hands were in most demand, and also to the fact that the school is located at some distance from the city, and laborers did not care to go so far when plenty of work could be secured nearer by.

The cost of sewer pipe was about as follows:

6-inch	$0.096	per	ft.	+	$0.009	freight	and	storage	$0.105
8-inch	.15	"	"	+	.025	"	"	"	.175
10-inch	.20	"	"	+	.025	"	"	"	.225
12-inch	.27	"	"	+	.03	"	"	"	.30

10-inch T's $.90 each

10-inch 2 T's $1.20 each.

Portland cement cost $2.20 per barrel to which should be added $.20 for freighting and storage, making net cost $2.40 per barrel. One sack of cement would lay about seventy-five feet of 8-inch sewer, and about fifty feet of 10-inch.

It will be noticed that the contract price for 8-inch sewer was $0.08 more than that for the 10-inch sewer.

This was due to the original plans showing the 8-inch deeper in the ground than the 10-inch, but as will be seen by the profile the actual construction was just the reverse. These changes were necessary in order to make proper connections with the old line and to avoid water-pipe tunnels,etc. Two hundred and ninety-eight feet of the 10-inch as laid was paid at the rate of $1.03 per foot because the original design showed an 8-inch, and 10-inch pipe cost five cents per foot more than 8-inch.

The depth of the 8-inch sewer averaged about seven feet while that of the 10-inch was about nine feet,making a total average of seven and one-half feet.

The ground was of a loose sandy nature and anything over seven feet had to be sheeted, but on the whole was easy digging. The force of men was often two small to work to an advantage, sometimes no more than six.

The cost to the contractor of furnishing,laying and back-filling was about $.825 per foot for the 10-inch, and $.72 for the 8-inch, giving him a profit on the 10-inch of 14.2% and on the 8-inch 36%.

The man-holes were the common 4-foot man-holes. One mason with three helpers would build two per day. This indeed was very rapid work. The cost per man-hole was as follows:

One mason at $4.00 per day.	$2.00
Three laborers at $2.25	3.37
Foreman about....	.50
1150 brick at $10....	11.50
2-1/2 barrels cement at $1.50.	3.75
Cover....	6.50
5 steps	.80
	$ 28.42

Making a profit of 82.9%. The sand used was that taken from the hole and the only cost was that of screening.

An 8-inch line one hundred feet long was laid around the front of the power house to care for the roof water and that from the chemistry building. This had to pass under a tunnel,an existing sewer line, and the driveway, to the coal bins. When this line was proposed the contractor objected and said it must be paid for as extra work and not at contract rate. This was readily agreed to. And when the work was completed the actual cost plus 15% was $66.03, or $31.97 less than it would have been at contract price, and then this was about $6.00 higher than it should have been, as one of the inexperianced men turned the sewage into the ditch before the sewer was laid, causing considerable trouble.

<u>Purification Plant</u>

The construction of the purification plant was somewhat more complicated than that of the sewer, however a pretty close estimate can be made as to its cost.

The plant was built as shown in accompanying drawing. The side walls of the tank, were built 1 of cement and 7 of gravel, using the gravel as it came from excavation: the center wall 1 - 2 - 4, using screened gravel of which the maximum size was 3/4-inch. The roof 1 - 1-1/2 - 4, using binder stone. This stone contained considerable dust which upon examination amounted to about one-half part in four,thence the reduction in sand. The gravel for the center wall cost about $5.00 per yard to screen it; this high cost was due more to excessive conversation on the part of the two men doing the work than to any deficiency in the gravel. The binder stone cost $1.15 per yard and freighting cost about $1.25. The hauling was done by the day for a distance of a little over a mile. All mixing was done with a one-fourth yard "Smith Mixer" and mixed wet. The material in septic tank cost $584.10; labor,etc. $1066.72, giving a total of $1650.82 This gave a profit of $749. or 45.3%.

The percolating filter was built as shown, the first foot over the underdrains being composed of screened gravel from three to six inches in diameter; that above on the south side, of screened gravel from one to three inches, with six inches on top of small gravel;that on the north side, of screened broken stone one to three inches. This gauging proved to be so well proportioned to the size of the stone, that not a bit of gravel was left over upon completing the work.

The gravel was first screened at the pits; but was so poorly done that it had to be all done over again before being placed in the filter. The cost of screening amounted to nearly $3.00 per yard for which reason broken stone was used on the north side.

The stone cost $1.15 per yard and about $1.00 to deliver at the work. This time the hauling was let to contract, and the same man was now able to make three trips, where he could only make two before while working by the day.

The cement floor and walls of settling basin were of the same mixture as the side walls of the tank. And the only cost was that of cement and labor. The underdrains cost about $0.30 per lin. ft.

In the original plans but half the filter was to be covered. But it was later decided to cover the whole filter. The covering was then let to contract, the Board going halves with the contractor. The contract price was $640.00 Much of the lumber used was that which had formerly been used in concrete work, and while as good as new, the actual value would be somewhat less, making a close estimate of cost difficult.

The cost of the distributing system was excessive. On this union carpenters were employed at a rather unreasonable rate of $4.80 per day. Then for the strap iron used in holding splashers, the Hardware Co. turned in a bill at $.05 per foot which was equal to $.25 per pound, fully four times too high. They were finally paid $.04 per foot. The 132 splashers cost $0.05 apiece. The total cost was $235.80

The total cost of the percolating filter was $3306.85. This was too high and could have been materially reduced by a more scientific method. Nevertheless we see a profit of $690.40 or 20.8% on cost price.

The sand filter is an example of rather loose work.

Part of the sand used was that taken from the excavation and the rest was hauled about one-half mile. The tile under drains cost about $.07 per foot which was rather high. The distributing pipe was secured at the rate already mentioned. Short pieces of plank were placed under the distributing mains at each set of T's to prevent the sand from being washed away, which cost was $3.16. All together the sand filter cost was $427.00, giving a profit of $273.00 or 63.9%. This work was too cheap and if the work had been of a higher grade it would have cost more. The siphons were furnished at $100.00 each. This rather high price was due to their being specials and also alternating siphons.

The work was finally finished leaving over four hundred dollars of the $12,000.00 appropriation on hand. In considering the costs and profits previously mentioned, it must be borne in mind that there were a number of minor expenses that would not appear on a force account, and of which no one but the contractor would know anything definitely about. A conservative estimate of these might be about 7% which should be added to the costs. The large profits to the contractor were what one might vulgarly call luck. Many of the changes in the sewer required raising the grade line, and the digging was exceptionally easy. The weather conditions were also favorable. And then the fact that the gravel was of such a nature, that the excavated material could be returned as concrete was also quite an item in the contractor's favor. These are things which cannot always be foreseen, and if reversed would have changed large profits into very small ones, if not a loss.

Sewage Analysis.

A series of chemical and bacteriological analyses were made during the winter and spring with the idea of determining the efficiency of the plant, as well as the best methods of operation. The analyses made were those recommended by the committee of the American Public Health Association. And as far as was practical their methods of procedure were followed.

The temperaturesof the samples were always taken at the time of collection. Temperature of the air was also taken, as certain conditions of temperature are more favorable than others for bacterial putrefaction of sewage, and it is obvious that poor nitrification can be accounted for by temperature which could not be otherwise explained.

Turbidity, while it cannot be called a very valuable test, is very easily made, and is an index to the amount of finely disseminated matter in suspension.

The test for putrefaction was made with methylene blue. This test has been recommended by some experts as"the test". It is indeed a very delicate indicator as to the ratio of oxidizable matter to that of available oxygen. If the oxidizable material is in excess of the available oxygen as nitrites, nitrates and dissolved oxygen, then the blue will fade, and the sample may putrefy. On the other hand, if the available oxygen is in excess of the oxidizable material, the blue will retain its color and the sample will not putrefy. 1 cc. of a 0.1% solution was used to 100 cc. of the sample. This was then corked up and allowed to stand at room temperature, and the time of retaining its color noted.

The usual nitrogen tests were made according to standard methods with the exception of organic nitrogen which was made direct by a method devised by Mr.M.G.Roberts and used at Columbus. This method proved superior in every way to the old distillation method,is much simpler in manipulation, requiries much less time, and avoids the embarrasment often incurred by losing small amounts of ammonia in distilling.

The nitrogen determinations are perhaps the most important test of all in ascertaining the efficiency of a plant. It is not the purpose here to go into the chemistry of sewage purification, but a brief review of the process of nitrification may not be out of place.

The process of nitrification is affected by two stages; first the formation of nitrites from nitrous acid, and second the formation of nitrates from the combination of nitric acid, oxygen, and an alkaline base. The first requisite for good nitrification is a suitable food for the nitrifying organisms. While these organisms can thrive with equal ease on organic or inorganic matter, they cannot thrive in the presence of large quantities of organic matter. A second requisite is plenty of oxygen. If the supply of oxygen is small, and the amount of organic matter is sufficient to support the denitrifying organisms, we get a reverse process with an evolution of nitrogen gas. A further condition for nitrification is the presence of an alkaline base, with which the nitric acid may combine to form nitrates. An excess of alkalinity will, however, retard the action of nitrification.

Experiments with English sewage show that, if lime is added in excess of the amount required to neutralize the acidity, no nitrification takes place. At the University of Wisconsin it was found that in cases of soils giving a strong acid reaction, the addition of lime had the following effect. The amount of nitric nitrogen found in the jar to which no lime was added was 891 parts per million of dry soil, that receiving one-fourth the amount of lime needed to neutralize the acidity had 1,055 parts per million; that receiving just the calculated amount necessary to neutralize the acidity 1,532 parts per million; while that which received one and three-fourths parts of the calculated amount, had 2,106 parts per million. From this it will be seen that the application of lime greatly accelerated nitrification, in fact, it was more than doubled by the heavier application. While this experiment was in connection with soils, the principal would,no doubt hold in sewage purification. The final requirement of nitrifying organisms is a favorable temperature. Nitrifying organisms can act at as low a temperature as 3°C.; but do not become sufficiently active for ordinary nitrification below 12°C. and reach the maximum at about 37°C. Strong light is also injurious to the process.

Chlorine analysis, while of no value in itself, in sewage purification, is a valuable index to the strength of the sewage. And in case the effluent shows less chlorine than the sewage, the amount of dilution by ground water may be ascertained by the application of the following formula: let x = volume of ground water diluting a volume of sewage; let a = parts per million of chlorine in sewage; let b = parts per million of chlorine in effluent; let c = parts per million in ground water; then $x = \frac{a - b}{b - c}$.

The residue tests are of much more value in connection with sewage from a combined system, than that of a separate system, especially when it is strictly a domestic sewage. A large amount of suspended matter in the tank effluent shows that the tank needs cleaning, or surface baffles and should also be taken into consideration with respect to filtration.

In making the residue tests a Gooch crucible was used, to filter out the suspended matter, this was weighed as such, and then ingnited for loss on ignition. The filtered sewage was then evaporated in a platinum dish, and weighed as dissolved residue, then ignited for loss on ignition. This loss on ignition was then added to the loss on ignition of the suspended matter, which gave the total loss on ignition. The total residue is the sum of the suspended residue and the dissolved residue; while the fixed residue, is the total residue less the loss on ignition.

The test for iron is important only when in sufficiently large quantities to cause clogging in the filters.

The test for alkalinity,as has already been shown, is very important. If nitrification is poor, or the tank effluent cloudy, lack of nitrification or poor liquefaction in the tank, might be explained by, either a lack or excess of alkalinity.

The amount of dissolved oxygen should always be made, as it is an index to the efficiency of the areating system, as to whether the filters are being properly ventilated or not.

The only test made to determine the amount of carbonacious material present is that of oxygen consumed. It is therefore an important test to make. This was done as reccommended by the committee, boiling for five minutes with acid permanganate.

A sewage containing a large amount of fats, such as come from a creamery or cheese factory, is one of the hardest sewages to treat. And when an analysis shows a large amount, it should be given due consideration.

Free carbonic acid gives some indication of the oxidation and other changes that are taking place.

The samples for chemical analysis were collected in such order that they represented as near as possible the same identical sewage from tank effluent, percolating filter, and sand filter. The raw sewage was collected without any such consideration. The analyses were started at once upon reaching the laboratory and if for any reason could not be completed in a reasonable time were chloroformed.

Bacteriological Analysis.

The bacteriological work consisted only in making the counts and examining the effluent from the sand filter for colon. The counts were made on agar agar, incubated forty-eight hours. The colon was determined by the Standard Methods. All samples were collected in sterile bottles and plating was done as quickly as possible after collecting the samples and it was seldom, if ever, over an hour.

Experiments.

The first data to be collected in connection with the experiments was the amount of sewage treated. To do this a simple devise was constructed by which an autographic record could be secured of the discharging of the siphons. The workings of an ordinary alarm clock were secured, the hour hand removed and a cog wheel two inches in diameter placed on the hour hand shaft. This meshed with another wheel four inches in diameter attached to a cylinder, which carried the record. Arranged thus, the cylinder would revolve once in twenty-four hours, or one inch on the record would be very close to two hours. A pencil which rested on the record was moved upward or downward by a float in the dosing chamber. The movement of the pencil was just about one-tenth that of the float. This apparatus gave all the data desired. The maximum rate of flow thus recorded, was 90,000 gallons per day, while the school was in session, and in fact seldom fell more than 1000 gallons below this figure. After the school had closed the flow was about 65,000 gallons per day. In the first case we have a flow of 150 gallons per capita, in the second case from 600 to 1000 gallons per capita per day. Iowa State College contributes about one-third as much while the school is in session. No explanation for this large amount of sewage can be given, other than the extravgent use of water at Main Building, Dining Hall, and Farm House. That no ground water enters the sewer to any extent, is quite evident. In fact the pumping records correspond quite closely with the sewage records, which is quite conclusive proof. The plant was not put into final operation until about Jan.7, due to various delays in getting the siphons to work properly, stopping leaks around septic tank, etc.

At this time the weather conditions were not favorable to biological activity, and it was obviously slow in getting into good condition.

Septic Tank.

At first no baffles were used in the tank; but as a great deal of large suspended matter such as orange peel was coming over the weirs and no scum was being formed, floating baffles were placed about a foot back of the weirs. These baffles did their work nicely, and the scum began to form at once.

On Feb.17 a chlorine test was run on the tank effluent with the object of ascertaining the actual rest period. Twenty pounds of common salt was dissolved in water, and then emptied into the sewer at the first man-hole back of the tank. Analyses for chlorine were then made at the weirs. As will be seen by the curves for that day, nothing definite was determined, as most of the salt seemed to have remained in the tank. Two slight rises are noticeable, one at an hour and a half, and the other at four and a half, either one of which might have been due to the salt added.

On Feb.20 the same tests were made, only this time no salt was added and analyses were also made on the raw sewage. It will be noticed that where there was an increase of chlorine in the sewage there was a corresponding increase in tank effluent about an hour and a half later. The following day 80 pounds of salt were introduced into the sewer and the same analyses made as on the preceding day. This time the salt was mixed in a barrel and allowed to stand over night to insure perfect solution. The test was quite conclusive and confirmed the preceding ones. The salt began to appear in one hour and reached its maximum in two hours. The flow in that day was such that it should have been eleven hours, assuming the sewage to move forward in mass. Of course this can never be expected nor is it desirable, as some of the suspended matter should remain in the tank several days if not weeks. Nevertheless, a somewhat longer period than two hours might be expected. So on March 12 all the contents of the tank were drawn down to within a foot of the bottom, and baffles put in at the entrance, and also where the tank gains its greatest width. The latter extended about three feet below the surface.

On March 19, 80 pounds of salt solutionwere again emptied into the sewer, and analyses made as formerly to see what effect the baffles would have on the period of rest. A slight obstruction at the entrance seemed to have caused most of the salt to pass into the small tank. The results, however, were quite satisfactory. They showed that the period had been almost doubled, the maximum not being reached until almost three and a half hours.

One interesting point to note is that at no time did all the chlorine introduced show up at the weir, but a great share of it seemed to have remained in the tank. The rates of flow were about the same, each time these experiments were performed.

After the placing of the baffles there was a decided increase in the number of bacteria, as will be noticed in the bacteriological curves and tables. This was due no doubt to the stirring up occasioned by drawing off the contents. The surface scum and quite a good deal of sludge were not drawn off, the idea being that these would reseed the tank when refilled. It is not surprising, therefore, that there should be a large increase in the number of bacteria. The chemical analyses show quite an improvement, this may have been due quite as much to the improved weather conditions as to the use of baffles.

An attempt was also made to determine the best rate of flow, but with no definite result. The only marked change was that in dissolved oxygen, which was present only when the tank was being operated at a rate of about four hours, This would show that anerobic action was not well established.

The final experiment with the tank was to determine the effect of standing, the inlet being closed. This was first tried on the small tank. When the experiment was started the effluent contained 340,000. bacteria per cc., colon present in 1 cc., alkalinity 234. At the end of eight days, the effluent contained 189,500 bacteria per cc., colon present in 1 cc.,alkalinity 260, At the end of two weeks there were 108,000 bacteria per cc., colon present in 1 cc. and the alkalinity was 300. The whole contents were then drawn off. The effluent was very black, indicating good reduction in the carbohydrates, orange peel was in a pretty good state of preservation, the odor was strong of hydrogen sulphide, but only while the tank was being emptied. The same experiment was then made on the large tank with the following results.

At time of starting experiment there were 500,000 bacteria per cc., colon present in 1 cc,, alkalinity 244. Five days later there were 207,000 bacteria per cc., colon in 1 cc. questionable,but present in 100 cc., alkalinity 268. At the end of two weeks there were 690,000 bacteria per cc., colon not present in 1 cc. but present in 100 cc., alkalinity 256. This time two samples were taken, one just beneath the surface and the other five feet below. The number of bacteria was almost the same, the alkalinity was the same, and colon was present in 100 cc. only. Anerobic counts were also made at this time. The media with the culture from the deep sample fell into the acid and was worthless. That from the other sample developed at the end of a week, standing in the dark at room temperature, 22 colonies.- the dilution was 1000. One peculiarity which occurred previous to collecting the last sample should be noticed. A great deal of suspended matter rose to the surface, and formed a mass over two inches thick. This was probably due to the formation of gas, and may account for the increase in number of bacteria.

The change in alkalinity may have been due to anerobic action, or carbonates which had been precipitated in the tank, being redissolved; and in the last case might have been precipitated again after the general disturbance, thus decreasing the alkalinity somewhat. It had been the intention to continue the last experiment three weeks, but for some reason one of the siphons failed to work, and the sewage from the dosing chamber backed over the weir, making further analysis worthless. The contents were not, however, drawn off until the end of the three weeks. When drawn off the contents did not seem to differ in any respect from that drawn off previously from the small tank, except theorange peal was not in as good state of preservation.

From these experiments one would draw the conclusion first that surface baffles are advantageous in establishing septic action by holding the surface scum until it has had time to form, acquiring considerable strength of its own; they also prevent large suspended matter from leaving the tank before it has been decomposed. Second, that the rest period in the case of the State School should be longer than four hours: and lastly, that the contents of the tanks may be drawn off when cleaning is desired, without producing any nuisance if allowed to stand idle for a period of ten days to two weeks.

Percolating Filter.

The construction of the percolating filter is such, as to render it hardly susceptible to experiments, Nevertheless, it is unique and therefore very interesting.

The covering of the filter not only protects it from extreme cold during the winter, but also from direct sunlight during the summer. The ventilating doors provide an abundance of oxygen, all of which as we have already seen are conducive to good nitrification. One morning when the outside temperature was 6° below (F.), that on the inside was 50° above. The doors were all closed at this time and conditions on the inside were much the same as in a very poorly ventilated barn over-crowded with cattle. Chemical analyses always showed dissolved oxygen in about the same quantities as when the doors were open, which would indicate that there was sufficient oxygen for nitrification even if the ventilation was poor.

The distributing system is of the new gravity type and is for that reason of more than passing interest, and so far has given almost perfect satisfaction. At first the two sides of the filter were dosed separately, but later the divisions were removed in order that the whole bed should be dosed at once, thus applying a smaller dose each time and at about one-half the rate formerly. This was followed by a decided improvement as will be seen by comparing tables two and three. Organic nitrogen was less than one-third what it was formerly, the nitrates were doubled, and the dissolved oxygen increased. Of course conditions in the tank were also improved and account for some of the improvement in the filter. The holes in the bottom of the troughs were 1-1/4 inch;at the time of above change short pieces of 1-inch gas pipe were put into these holes to better direct the stream on to the splasher, and also reduce the rate of discharge. The distribution from the splashers was not as good as before, but was more than compensated for by the decrease in rate of application. The rate of discharge from the siphons was then diminished, but failed to give good distribution from the splasher, as the head on splashers was too little for such a small rate of flow.

The troughs require to be cleaned once in a while on account of the zooglea that forms on the interior, and also the carbonates that are precipitated and form balls sometimes as large as walnuts.

At the time the school closed the rate on the percolating filter was one and one-half million gallons per acre per day, and showed a slight pooling on the south side over the small stone, but shows none at the present time.

When the filter had been working but a short time, quite a good deal of matter accumulated in the top six inches which had a whitish color; this latter became dark and has now almost all disappeared.

It would seem from the operation of this filter during the past winter that the covering is a valuable feature in a climate like Minnesota; that small doses applied at frequent intervals give better results than large doses with longer periods of rest; and that the gravity system is possibly the best that has yet been devised.

The Sand Filter.

The sand filter has been the most troublesome of all. Its greatest defect seems to be in its size. The rate required of it during the winter months was 750,000 gallons per acre per day, and at the present time 500,000 gallons per acre per day. The rates can only be kept up by constant raking and scraping. Resting for a certain period and then working again was tried with varied success. At first two days rest would insure four days work, but at present three days rest, will scarcely insure two days run. Various systems of furrowing during the winter were tried, all of which had the desired effect of preventing freezing. The ice would form on the ridge and the warm sewage would readily thaw out the sand beneath. The best results seemed to have been secured with the ridges about ten inches high and thirty inches crest to crest. The ice could span this nicely, and at the same time give more surface for filtration than when placed closer together. In fact anything that would prevent the ice from anchoring and would allow the sewage to flow under seemed to give satisfaction. Of course the past winter was very mild for Minnesota - more intense cold might cause more trouble.

The Purification Plants at Iowa State College and Madison, Wis.

For the purpose of comparing the State School plant with the State Agricultural College of Iowa, and the purification plant at Madison, Wisconsin, a table has been prepared of each, selecting at random two sets of analyses; but taken about the same season of the year as the analyses at the State School were made.

The Iowa tank was not designed as a septic tank, but rather a settling basin and the effluent is screened as it passes over the weirs. As will be seen from the tables and diagram, this tank shows better results than the one at the State School. However, it seems to be mostly mechanical and not anerobic, as they have a good deal of nitrate in the effluent. The tank is cleaned about once a month. Their sand filter was working at about 125,000 gallons per acre per day, or about one-sixth of that at the State School. The effluent at the State School is, however, better than theirs.

The Madison tank was designed as a septic tank, is worked at about an eight-hour period, and is cleaned about every four months. Its action is more like that at the State School, being more anerobic and not simply mechanical. The filter might be called a fine grain percolating filter. It is composed of locomotive cinders from one-half to one inch in diameter and about four feet deep. It shows better results than the State School percolating filter, but not as good nitrification. The better nitrification at the State School may be due to better areation, as the Madison distributing system is on the surface of the filter and part of the year is covered with straw to prevent freezing. The rate of the Madison filter was 600,000 gallons per acre per day.

Suggested Improvements.

About the only change that would be suggested in connection with the septic tank, would be to put in a weir wall across the dosing chamber. The object of this would be to reduce the present dose of 3,900 gallons to about 2,000 gallons, making the siphon discharge every thirty minutes. This will allow the sewage more time in passing through the filter and also secure more uniform condition. Another wall might be built across the end of the settling basin of the percolating filter near the shear valve, to act as a weir when the sewage is being bypassed around the sand filter. This with the diminished dose from the septic tank would greatly improve sedimentation and incidently the effluent from the percolating filter when the sand filter is not being used.

The present sand filter should be extended about forty feet and two more filters of equal size built below them. The surface of the new filters might be about 18 inches lower than the present ones, and the pipes to these filters could pass under the surface of the present filters. Gate valves could be placed at the siphon's discharge, by which the flow could be directed on to either the new or on the present filters. We would then have two beds resting while the other two are working. The top six or eight inches of the present filters should be removed, and replaced with good coarse sand free from clay and gravel. The sand filter thus changed might give some trouble from freezing as the present dose which is 7,800 gallons would not be increased with the size of the beds and also the beds would have more time in which to freeze up between doses. This, however, would be for only a short period during the winter.

Form of Purification best adapted to Minnesota Conditions.

As to the form of purification best adapted to Minnesota conditions: some form of preliminary treatment such as received in the septic tank or settling basin followed by the percolating filter, perhaps a little deeper than the one at the State School and a rest of about two hours in a settling basin would seem to give the desired result. The filter should be covered, well under-drained and ventilated. The dose applied should be small and at frequent intervals. In case of large towns continuous application might be an advantage, the only value of intermittent dosing on a coarse percolating filter being that of distribution. A head on the splasher of at least four feet should be secured if possible. The rate at which these filters might be operated would depend largely on the size of the material used and the amount of suspended matter. But for ordinary sewage, stone or gravel from one and one-half to three inches, 2,000,000 gallons per acre per day would not seem too great. Only in cases where very high degree of purification is desired, should the sand filter be used and then very close supervision should be maintained.

Tables and Curves.

The tables and curves explain themselves and need little comment. From the tables it will be noticed that the chlorine decreased as it passed through the tank, percolating filter and sand filter. This may have been due to the general averaging up with the night flow which would naturally take place, and not to any dilution. A heavy rain preceding the collection of samples on May First may have caused the low chlorine of that set of analyses. This was very little higher than that of the water supply which contained three parts per million.

In the diagram making a graphical comparison with Iowa State College, and Madison, Wisconsin, the chlorine diagram shows nicely the relative strengths of the sewages, that of Madison being slightly stronger than that of Iowa, and both much stronger than that of the State School.

The Iowa State College and Madison both report albuminoid ammonia. As this usually runs about one-half as much as organic nitrogen, the lines have been extended so as to compare with the State College. The solid line in case of organic nitrogen for Iowa and Madison shows the albuminoid ammonia.

In connection with the residues it should be noted that the dissolved residues of the water were 296 parts per million, fixed residue 247 parts per million, loss on ignition 49 parts per million. The loss on ignition was no doubt due to the loss of water of crystalization. These results should be deducted from those in the tables in order to get at the amount due to the sewage. Thus, for the percolating filter on May First the dissolved residues would be only 19 parts per million instead of 315.

It is interesting to note the decrease of iron at the sand filter, while the percolating filter shows an increase. This increase was due to the difficulty of collecting samples without getting some of the iron that had been accumulating in the settling basin and on the surface of the sand filter. A matter which should be considered in connection with percolating filters followed by sand filters, is the decrease in the ca=acity of the sand filter due to the formation of ferric hydrate where the water contains much iron. The large amount of iron appearing on May 1 can be accounted for by the fact that three of the buildings which had been standing idle for six weeks were opened the day before and also that day for the purpose of cleaning, and the water and steam pipes which had been unused for that period were temporarly put in use. So that a great deal of iron rust was discharged into the sewer and appeared in the analyses.

The alkalinity results are quite interesting. At first they increase as the sewage passes from the tank to the percolating filter and on to the sand filter. This increase in alkalinity may have been caused by the lime stone in the percolating filter. As these became coated they ceased to be effected by the sewage. Toward the last the alkalinity seemed to decrease a little, which is the normal condition in sewage purification due to some of the carbonates being precipitated. The alkalinity of the water supply is 244 or practically the same as that of the sewage. The hardness of the water by the soap method was 210, so that both the hardness and alkalinity are about twice as high as the amount given by some authors as most conducive to nitrification. With this high alkalinity and the large dilution, it is not at all likely that the small amount of acids coming from the chemistry building would ever have much effect upon conditions in the tank.

On the oxygen consumed curves Madison is not shown as it was determined by a different method.

From a brief review of the tables we find the degree of purification from the standpoint of oxygen consumed nearly 95%, and from organic nitrogen about 90%.

The curves showing the number of bacteria contained in the sewage and effluent, are also very interesting. The number in the tank,at first high, began to fall off as the tank gets into shape, then it rose suddenly at the time of placing baffles, fell again, and again it went up at the time of changing from the large tank to the small which caused a good deal of disturbance.

A few of the curves from the autographic record are selected with the purpose of showing how the rate of flow varied throughout the day, the rate of flow being inversely as the distance between the points.

Conclusion.

In conclusion we wish to express our thanks to those in charge of the State Board of Health Laboratories, for their kindness and assistance in making the analyses, and for suggestions as to the cause of procedure; to Prof.Bass for arranging for the work; also to Mr.A.M.Bull of the State School, for many favors and his assistance in operating the plant and collecting data.

TABLE I.

2-11-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	13.	13.	12.	3.
Turbidity	240.	200.	100.	35.
Free NH_3	9.6	16.0	6.4	5.6
Organic N.	46.	42.	12.	2.9
Nitrites	0.0	0.0	0.9	.12
Nitrates	0.0	0.0	0.0	0.50
Total N.	55.6	58.	19.3	9.12
Chlorine	23.8	20.	18.7	17.5
Iron	0.15	0.20	0.12	0.15
Dissolved Oxygen	0.0	0.0	2.93	3.43
Oxygen consumed	78.	60.	42.	8.9
Fats	72.6	36.2	30.2	4.6
Count	1,410,000.	780,000.	770,000.	83,000.

TABLE II.

2-24-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	13.	11.	10.	6.
Turbidity	120.	220.	120.	5.
Free NH3	4.5	12.5	8.0	10.9
Organic N.	12.2	29.0	18.8	0.9
Nitrites	.012	.013	0.22	0.10
Nitrates	0.0	0.0	0.85	0.95
Total N.	16.71	41.51	27.87	12.8
Chlorine	17.5	20.	16.2	13.1
Iron	0.50	0.70	1.0	0.10
Alkalinity	280.	285.	273.	310.
Dissolved Oxygen	0.0	0.0	6.16	5.68
Oxygen Consumed	90.	62.	34.	5.5
Fats	16.0	33.	4.0	7.0
Free CO2	13.	43.	20.	25.
Count	520,000.	335,000.	300,000.	50,000.

TABLE III.

3-18-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	13.	12.	8.	4.
Turbidity	160.	120.	70.	10.
Putrefaction	12.hrs.-	12.hrs.-	15.hrs.	10.days+
Free NH3	12.	16.	10.	8.5
Organic N.	13.	9.0	5.5	1.7
Nitrites	.004	.030	0.120	.010
Nitrates	0.0	0.0	1.65	1.25
Total N.	25.004	25.03	17.27	11.50
Chlorine	32.0	23.5	20.2	19.5
Total Residue	795.	497.	440.	360.
Suspended Residue	377.	59.	24.	9.0
Dissolved "	418.	438.	416.	351.
Iron	0.80	0.70	0.40	0.20
Alkalinity	240.	242.	254.	270.
Dissolved Oxygen	2.7	0.0	7.2	6.2
Oxygen Consumed	75.0	46.0	33.0	5.3
Fats	66.6	27.	7.4	2.6
Free CO2	5.0	29.0	5.0	15.0
Count.	850,000.	605,000.	485,000.	83,000.

TABLE IV.

3-24-08.

	Sewage	Tank	Percolating F. Effluent	Sludge Bed Overflow
Temperature	13.	12.	11.	8.
Turbidity	50.	120.	90.	20.
Putrefaction	12 hrs.-	12 hrs.-	15 hrs.	24 hrs.
Free NH3	9.4	12.5	9.0	8.6
Organic N.	6.4	8.1	3.6	2.4
Nitrites	.03	.0065	.14	.15
Nitrates	0.25	0.0	0.85	1.5
Total N.	16.08	20.11	14.59	12.65
Chlorine	30.	14.	13.5	14.6
Total Residue	795.	539.	493.	429.
Fixed "	331.	328.	337.	322.
Suspended "	163.	97.	59.	22.
Dissolved "	732.	442.	434.	407.
Loss on Ignition	464.	211.	156.	107.
Iron	0.50	1.3	0.90	0.4
Alkalinity	237.	223.	254.	230.
Dissolved Oxygen	3.55	0.0	6.7	6.7
Oxygen Consumed	220.	46.	48.	34.
Fats	2.8	9.4	7.4	0.4
Free CO2	7.0	44.	11.	6.0
Count	275,000.	430,000.	840,000.	810,000.

TABLE V.

4-1-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	12.	11.	80.	5.0
Turbidity	60.	50.	30.	5.0
Free NH3	2.0	5.0	3.0	4.6
Organic N.	4.3	6.1	5.2	0.8
Nitrites	0.008	0.008	0.065	0.08 (?)
Nitrates	0.0	0.0	1.25	5.0
Total N.	6.3	11.1	9.51	10.48
Chlorine	10.5	13.3	12.7	13.0
Total Residue	387.	423.	474.	379.
Fixed "	254.	299.	362.	291.
Suspended "	38.	25.	105.	9.0
Dissolved "	349.	398.	369.	370.
Loss on Ignition	133.	124.	112.	88.
Iron	0.30	0.8	1.0	0.25
Alkalinity	240.	234.	240.	236.
Dissolved Oxygen	2.3	1.1	8.1	7.2
Oxygen Consumed	30.	27.	21.	5.7
Fats	10.6	10.0	1.4	0.6
Free CO2	5.5	15.0	4.0	10.0
Count	2,100,000.	340,000.	110,000.	4,000.

TABLE VI.

4-6-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	11.	10.	8.	8.
Turbidity	30.	35.	20.	3.0
Putrefaction	12 hrs.-	12 hrs -	36 hrs.	10.days+
Free NH3	5.0	4.6	2.2	2.6
Organic N.	4.5	3.3	4.9	1.2
Nitrites	0.01	0.003	0.80	0.02
Nitrates	0.0	0.0	1.5	3.0
Total N.	9.51	7.9	8.68	6.82
Chlorine	11.0	7.5	7.5	9.5
Total Residue	445.	393.	492.	359.
Fixed "	325.	269.	336.	290.
Suspended "	35.	27.	134.	21.
Dissolved "	408.	366.	358.	338.
Loss on Ignition	120.	124.	166.	69.
Iron	0.65	0.65	1.90	0.30
Alkalinity	228.	240.	240.	240.
Dissolved Oxygen	1.6	0.0	7.3	5.6
Oxygen Consumed	27.0	20.0	15.0	4.0
Fats	10.6	7.6	2.4	0.4
Free CO2	40.	22.	8.0	12.0
Count	220,000.	301,000.	239,000.	23,600.

TABLE VII.

4-10-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	13.	10.	10.	7.
Turbidity	80.	70.	12.	0.0
Putrefaction	12 hrs.-	12 hrs.-	24 hrs.	10.days+
Free NH3	3.2	5.2	3.1	1.9
Organic N.	1.5	3.5	4.0	0.1
Nitrites	0.01	.006	.08	.04
Nitrates	0.0	0.0	0.75	3.75
Total N.	4.701	8.7	7.858	5.754
Chlorine	5.0	9.0	9.0	13.0
Total Residue	398.	391.	449.	398.
Fixed "	304.	279.	331.	308.
Loss on Ignition	94.	112.	118.	90.
Suspended Residue	83.	35.	100.	1.5
Dissolved "	315.	356.	349.	397.
Iron	1.5	0.7	2.2	0.10
Alkalinity	238.	244.	242.	250.
Dissolved Oxygen	4.6	0.0	7.2	8.8
Oxygen Consumed	15.5	20.	16.5	3.5
Fats	7.0	7.6	16.6	6.0
Free CO2	14.	16.0	5.0	9.0
Count	145,000.	500,000.	136,000.	18,500.

TABLE VIII.

4-20-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	12.	11.	12.	12.
Turbidity	80.	70.	30.	0.0
Putrefaction	12 hrs.-	12 hrs.-	12 hrs.-	7.days+
Free NH3	4.0	3.0	4.0	1.0
Organic N.	8.0	5.7	3.5	0.5
Nitrites	0.018	0.002	0.08	0.02
Nitrates	0.0	0.0	0.80	3.25
Total N.	12.018	8.7	7.66	4.77
Chlorine	8.0	6.0	5.5	6.0
Total Residue	404.	462.	543.	364.
Fixed "	290.	313.	334.	289.
Suspended "	55.	44.	62.	3.0
Dissolved "	349.	418.	481.	361.
Loss on Ignition	114.	149.	209.	75.
Iron	0.75	1.2	1.4	0.06
Alkalinity	252.	196.	236.	248.
Dissolved Oxygen	3.7	2.3	7.8	5.3
Oxygen Consumed	20.0	26.5	14.0	2.4
Fats	12.6	18.4	3.4	1.8
Free CO2	6.0	14.0	2.0	7.0
Count	170,000.	1,780,000.	410,000.	2,100.

TABLE IX.

5-1-08.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	11.0	11.0	10.0	8.0
Turbidity	200.	30.	30.	0.0
Putrefaction	12 hrs.-	12 hrs.-	48 hrs.	10.days+
Free NH3	3.2	2.4	1.8	1.2
Organic N.	0.8	0.4	3.0	0.8
Nitrites	.016	.004	.050	.010
Nitrates	0.0	0.0	0.30	0.45
Total N.	4.016	2.804	5.15	2.46
Chlorine	5.0	3.7	5.0	8.5
Total Residue	544.	335.5	343.5	330.5
Fixed "	427.	237.	256.5	263.
Suspended "	217.	17.5	28.5	5.5
Dissolved "	327.	318.	315.	325.
Loss on Ignition	117.	98.5	87.0	67.5
Iron	6.4	3.6	4.4	3.6
Alkalinity	248.	244.	236.	236.
Dissolved Oxygen	5.4	4.7	8.9	6.3
Oxygen Consumed	18.8	4.8	8.0	2.6
Fats	6.2	0.2	5.8	0.2
Free CO2	1.0	2.5	1.5	2.0
Count	408,000.	155,000.	219,000.	25,000.

TABLE X.

Average of all Examinations.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	12.3	11.0	10.	7.0
Turbidity	113.	102.	68.	7.
Free NH3	5.9	8.6	5.3	4.5
Organic N.	10.7	11.9	6.7	1.1
Nitrites	.011	.006	.193	.050
Nitrates	.03	0.0	.88	2.27
Total N.	16.66	20.506	13.07	7.92
Chlorine	15.9	13.0	12.0	12.5
Total Residue	538.	434.	462.	372.
Fixed "	322.	287.	324.	264.
Suspended "	124.	43.5	73.2	8.1
Dissolved "	414.	391.	389.	357.
Loss on Ignition	174.	136.	141.	77.9
Iron	0.64	0.78	1.1	0.16
Alkalinity	245.	238.	247.	257.
Dissolved Oxygen	2.65	0.9	6.92	6.1
Oxygen Consumed	63.6	35.1	25.7	4.7
Fats	22.6	16.5	6.7	2.6
Free CO2	11.4	23.2	7.0	11.4

Note: Iron of last sample not counted in above average.

TABLE XI.

Average with School in Session.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	13.	12.	10.	4.3
Turbidity	142.	165.	95.	17.
Free NH3	8.9	14.2	8.3	8.33
Organic N.	19.4	22.0	9.97	1.8
Nitrites	0.011	0.012	0.340	0.077
Nitrates	0.06	0.0	.84	0.90
Total N.	28.37	36.21	19.45	11.13
Chlorine	25.8	19.3	17.1	16.7
Total Residue	795.	518.	466.	360.
Fixed "	331.	328.	337.	
Suspended "	220.	78.	41.	9.0
Dissolved "	575.	440.	425.	351.
Loss on Ignition	446.	211.	156.	
Iron	0.49	0.72	0.60	0.15
Alkalinity	252.	250.	260.	290.
Dissolved Oxygen	1.56	0.0	5.75	5.1
Oxygen Consumed	116.	53.5	39.2	6.6
Fats	39.0	21.4	12.2	4.7
Free CO2	8.0	38.7	12.0	20.0

TABLE XII.

Average after School had closed.

	Sewage	Tank	Percolating F.	Sand F.
Temperature	11.6	10.6	9.3	8.0
Turbidity	90.	51.	46.	2.0
Free NH3	3.4	4.04	2.82	2.26
Organic N.	3.8	3.8	4.10	0.68
Nitrites	0.011	.0055	.071	.034
Nitrates	0.0	0.0	0.92	3.09
Total N.	7.31	7.84	7.91	6.06
Chlorine	7.7	7.5	7.9	10.0
Total Residue	436.	401.	460.	374.
Fixed "	320.	275.	322.	264.
Suspended "	86.	29.7	85.9	8.0
Dissolved "	349.	371.	374.	358.
Loss on Ignition	116.	121.	138.	77.9
Iron	0.63	.67	1.30	0.14
Alkalinity	241.	232.	238.	246.
Dissolved Oxygen	3.52	1.60	7.90	6.64
Oxygen Consumed	22.3	20.4	14.9	3.64
Fats	9.4	8.6	5.9	1.8
Free CO2	13.3	13.9	4.0	8.0

Note: Iron of last samples not included in above average.

TABLE XIV.

Analysis of Sewage at the Iowa State College Sewer Plant
Feb.5,1901.

	Sewage	Tank	Filter.
Free Ammonia	19.7	9.7	0.94
Albuminoid Ammonia	25.3	8.5	1.2
Chlorine	40.	40.	45.
Solids on evaporation	1156.	696.	854.
Solids at 180°	1044.	662.	838.
Solids on Ignition	560.	516.	688.
Nitrites	0.40	0.30	Trace
Nitrates	1.0	1.0	2.0
Oxygen Consumed	155.6	31.6	10.
	March 4,1901		
Free Ammonia	24.	11.2	6.24
Albuminoid Ammonia	16.3	10.5	2.82
Chlorine	78.	59.0	65.0
Solids on Evaporation	1322.	1170.	1302.
Solids at 180°	1300.	1158.	1132.
Solids on Ignition	1078.	896.	1006.
Nitrites	.04	.08	.32
Nitrates	0.0	Trace	4.0
Oxygen Consumed	67.2	42.	18.

Analysis by:-

J.B.Weems

J.C.Brown.

R.C.Myers.

TABLE XV.

Analysis of Madison Sewage Jan.3,1902.

Total residue	860.	760.	620.
Suspended "	300.	60.	20.
Dissolved "	560.	700.	600.
Free Ammonia	22.4	34.	34.
Albuminoid Ammonia	11.2	9.0	1.2
Nitrites	0.0	0.0	0.2
Nitrates	0.0	0.0	0.0
Chlorine	66.	70.	68.
Oxygen consumed in 10 minutes	135.	115.	50.
	Jan.24,1902.		
Total residue	900.	600.	560.
Suspended "	430.	50.	30.
Dissolved "	470.	550.	530.
Free Ammonia	29.7	38.	40.
Albuminoid Ammonia	10.2	8.0	2.4
Nitrites	Trace	0.0	0.08
Nitrates	.00	0.0	0.0
Chlorine	61.		
Oxygen consumed in 10 minutes	105.	90.	42.

From analysis made by John Icke.

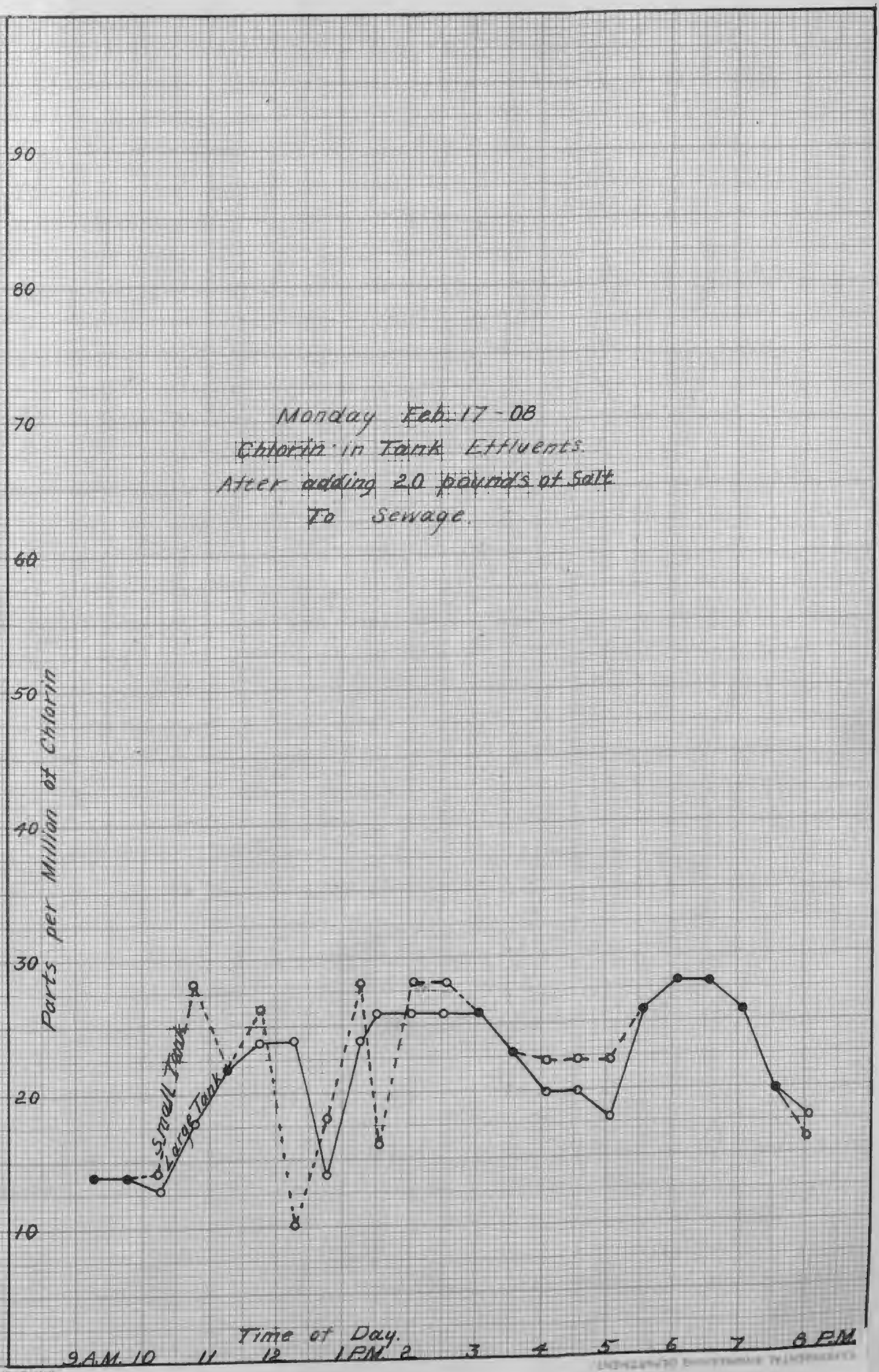
TABLE XIII.

Results of Bacteriological Analysis State Farm Sewage.

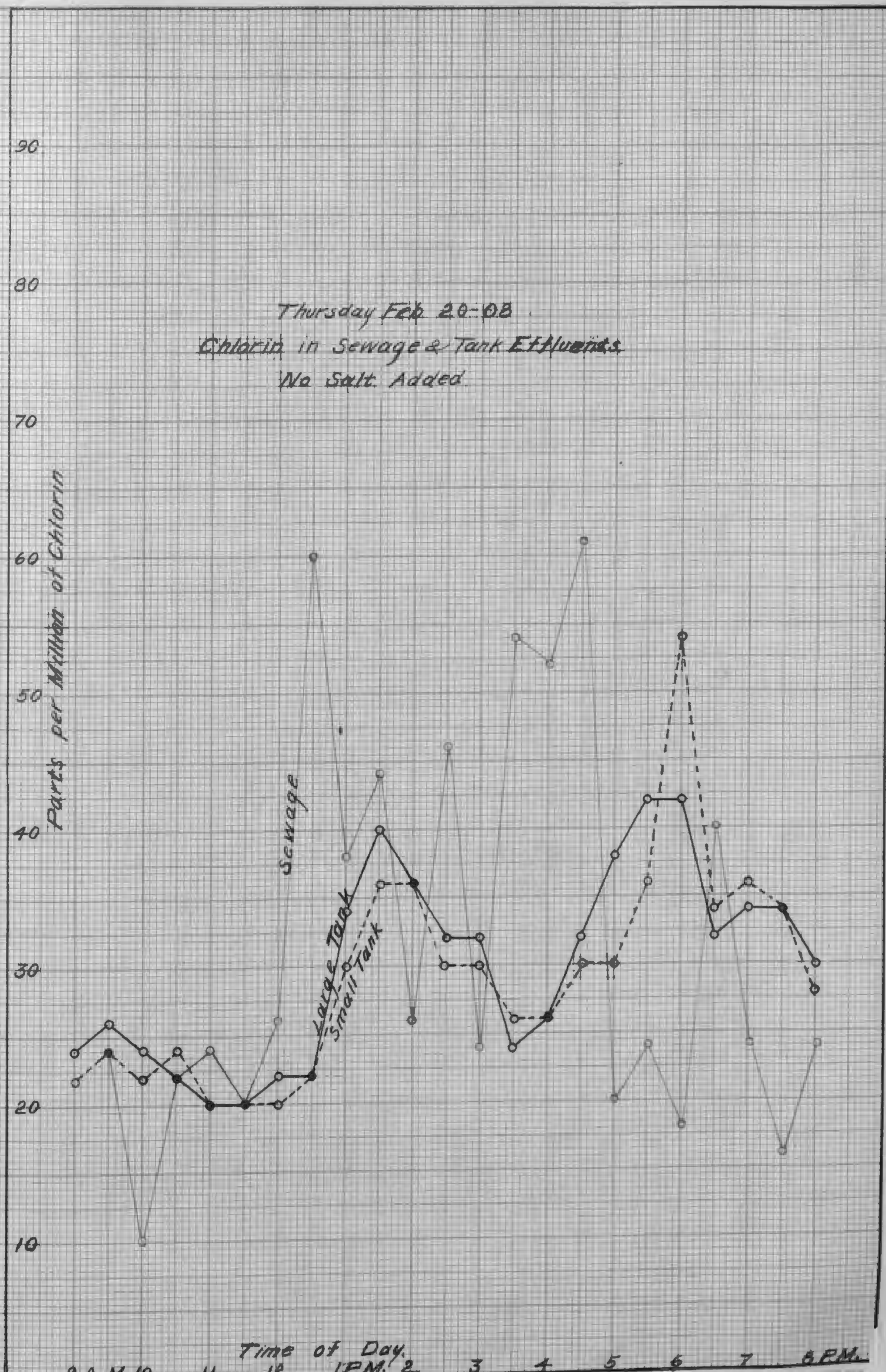
	Sewage	Tank	Percolating F.	Sand F.
Jan. 22	420,000.	820,000.		
Feb. 12	1,410,000.	780,000.	770,000.	83,000.
Feb. 24	520,000.	335,000.	300,000.	50,000.
March 4	230,000.	490,000.	460,000.	130,000.
March 10	235,000.	340,000.	250,000.	
March 13	580,000.	1,300,000.	835,000.	
March 18	850,000.	605,000.	485,000.	83,000.
March 24	275,000.	430,000.	840,000.	
April 1	2,100,000.	340,000.	110,000.	4,000.
April 6	220,000.	310,000.	239,000.	23,600.
April 10	145,000.	500,000.	136,000.	18,500.
April 20	170,000.	1,700,000.	410,000.	2,100.
May 1	408,000.	155,000.	219,000.	25,500.
Average	581,000.	623,000.	421,000.	37,600.

March 4	Sample taken from lake	37,000.
March 10	" from sludge bed	224,000.
March 13	" " " "	159,000.
March 24	" " " "	810,000.
Average	" " " "	377,000.

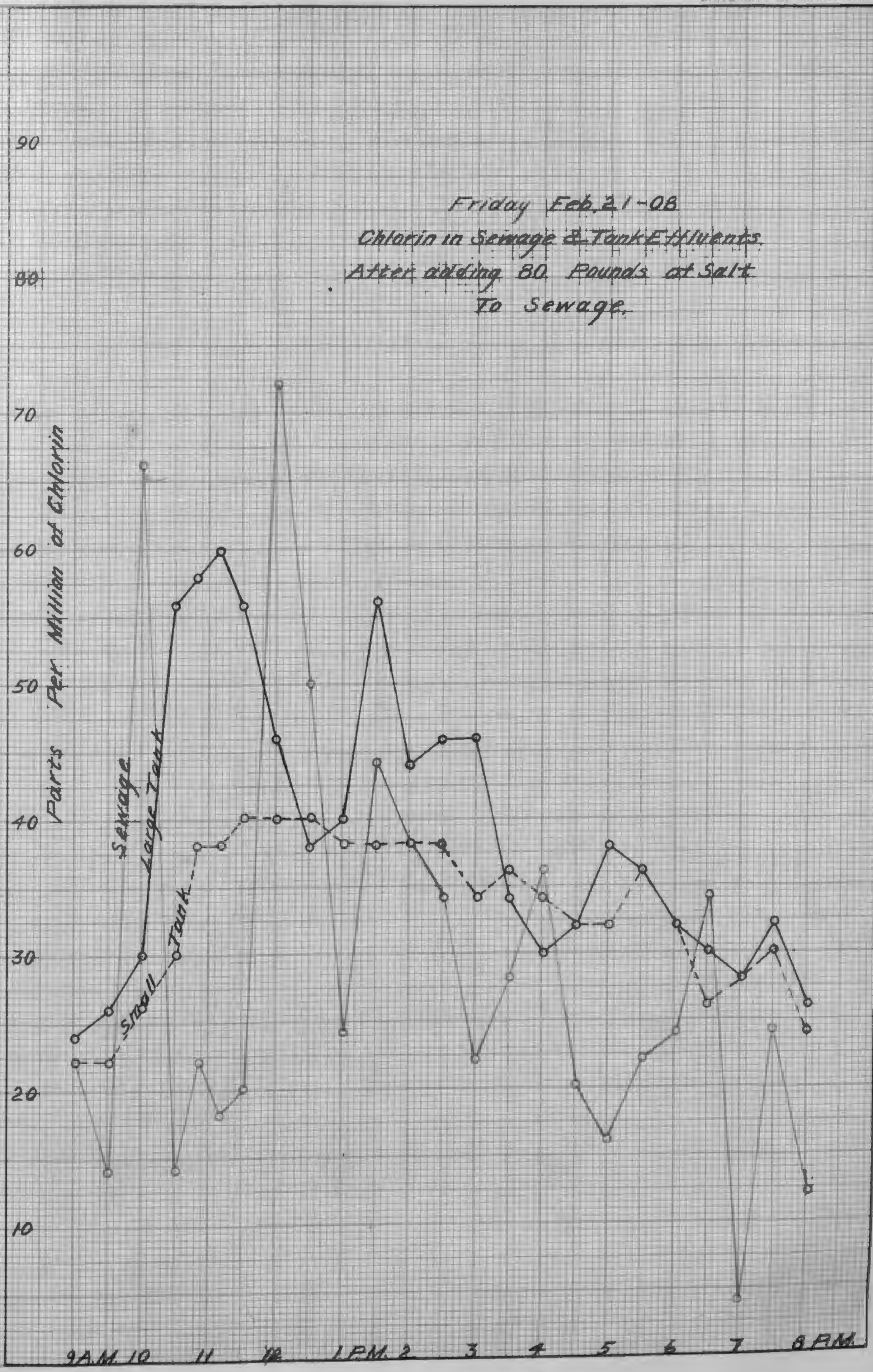
Note: colon always present in 1 cc. of sand filter effluent.



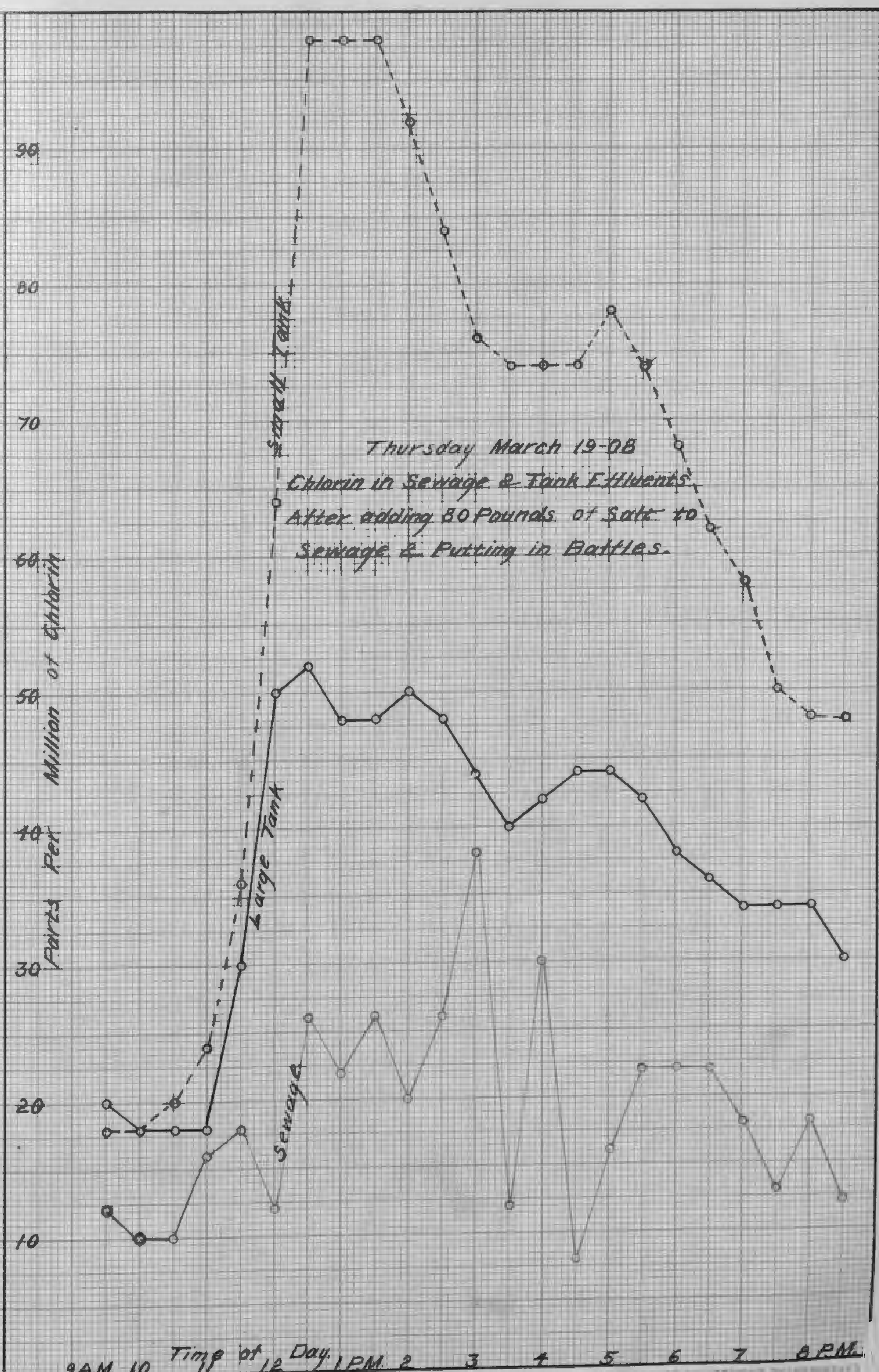
Monday Feb. 17 - 08
Chlorin in Tank Effluents.
After adding 20 pounds of Salt
To Sewage.
Parts per Million of Chlorin
90
80
70
60
50
40
30
20
10
Small Tank
Large Tank
Time of Day.
9 A.M. 10
11
12
1 P.M. 2
3
4
5
6
7
8 P.M.



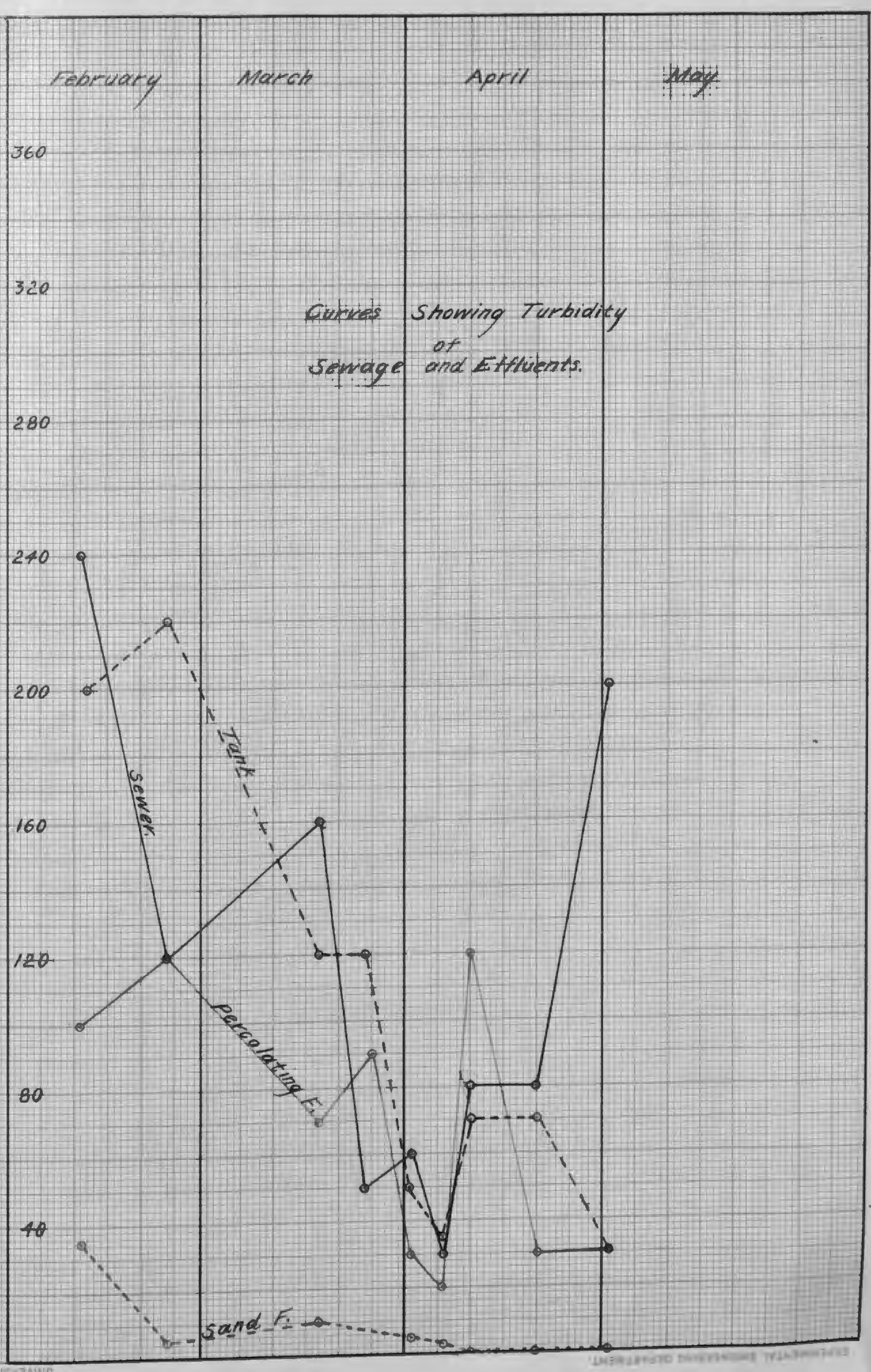
Thursday Feb. 20-08.
Chlorin in Sewage & Tank Effluents.
No Salt Added.
Parts per Million of Chlorin
90
80
70
60
50
40
30
20
10
Sewage
Large Tank
Small Tank
Time of Day.
9 A.M. 10
11
12
1 P.M. 2
3
4
5
6
7
8 P.M.

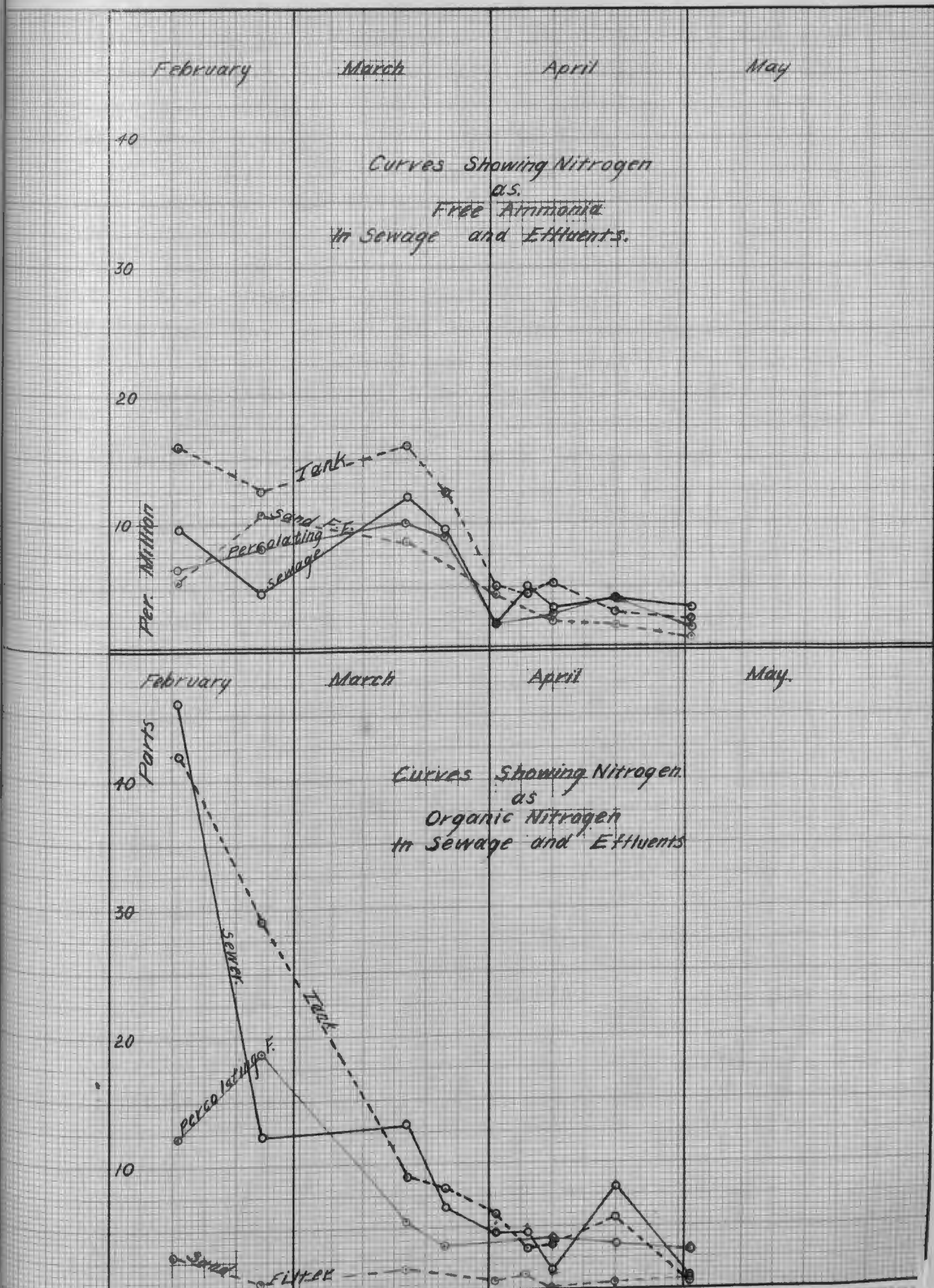


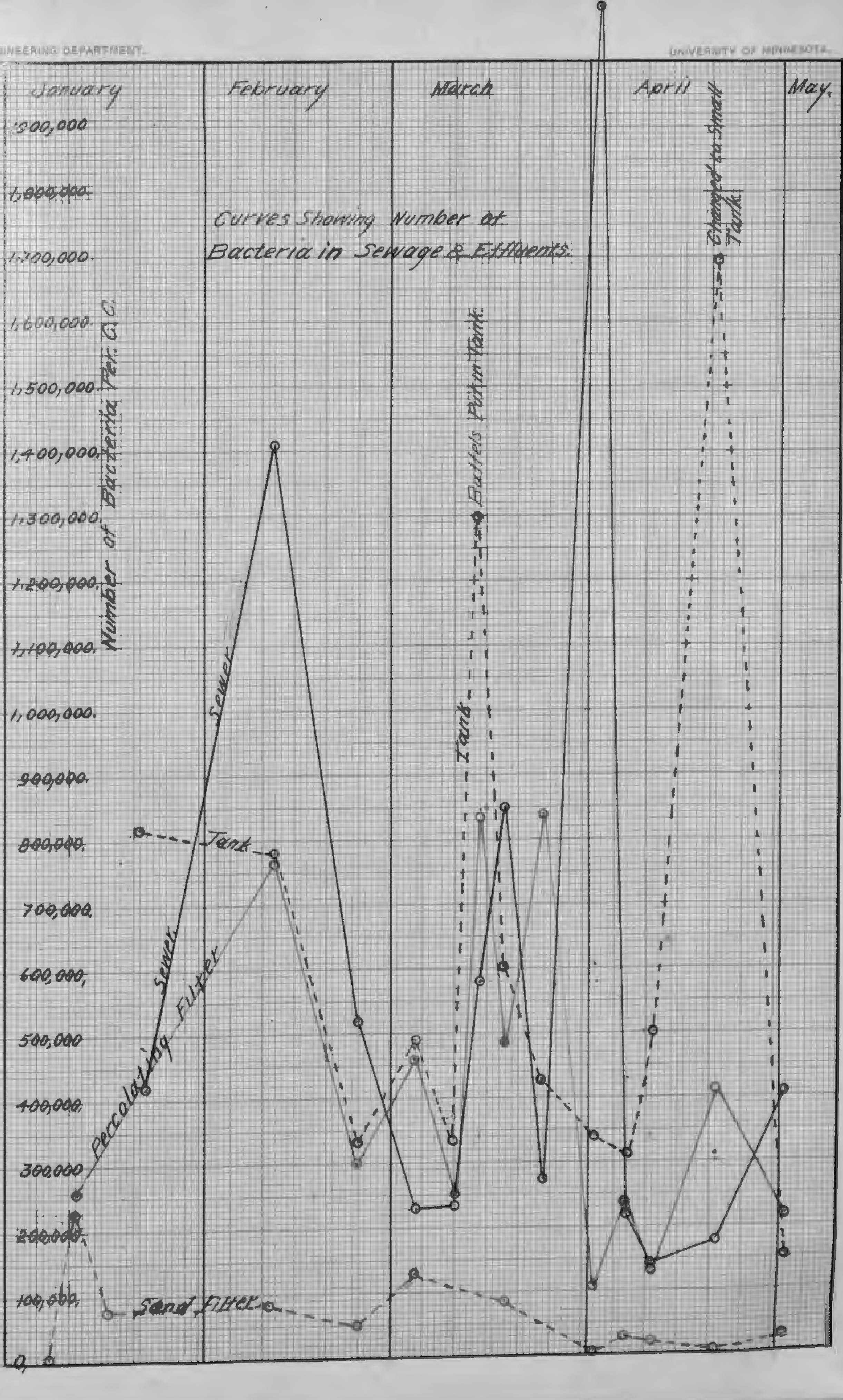
Friday Feb. 21-08
Chlorin in Sewage & Tank Effluents.
After adding 80 Pounds of Salt
To Sewage.
Parts Per Million of Chlorin
90
80
70
60
50
40
30
20
10
Sewage
Large Tank
Small Tank
9 A.M. 10
11
12
1 P.M. 2
3
4
5
6
7
8 P.M.

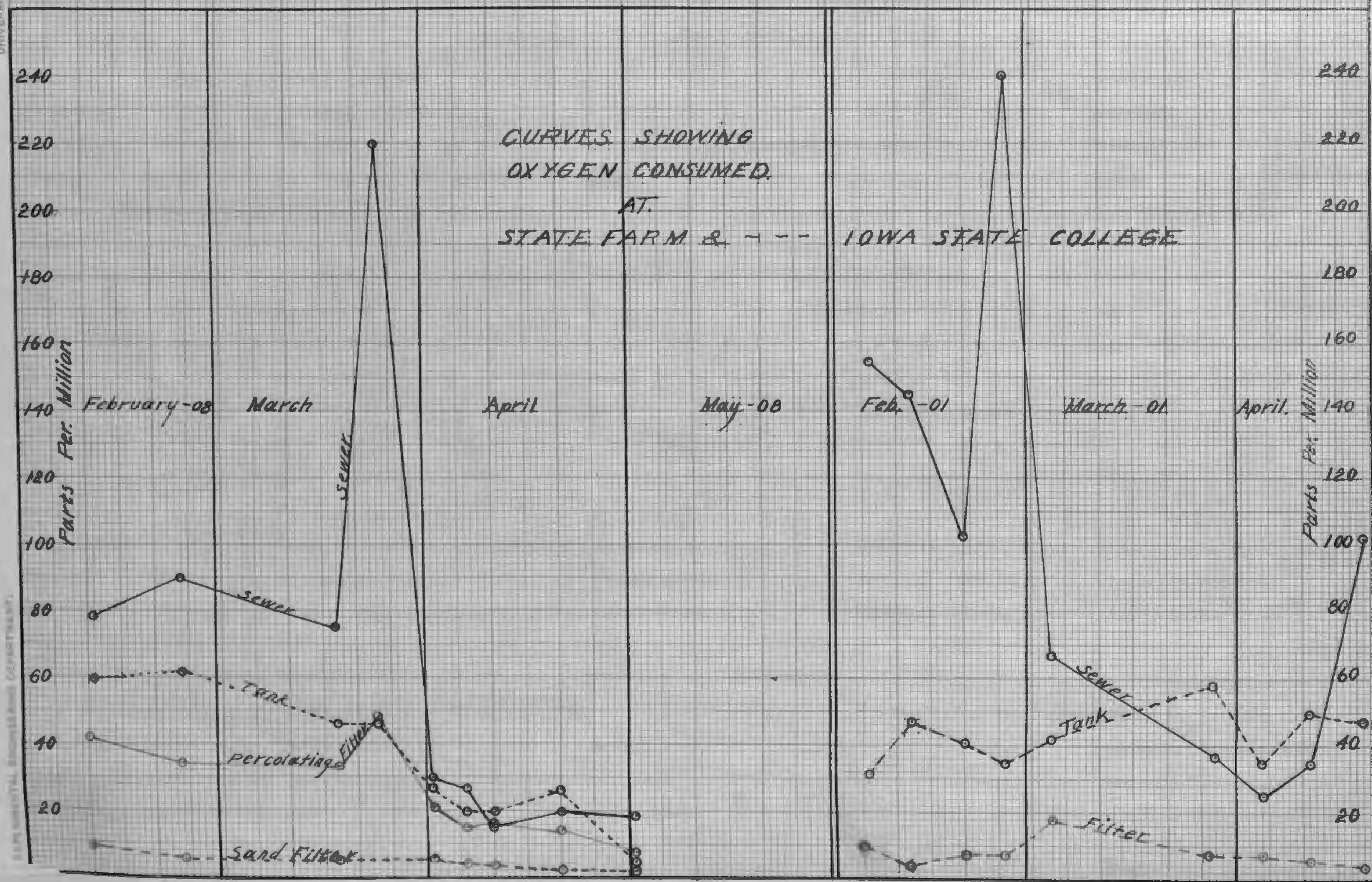


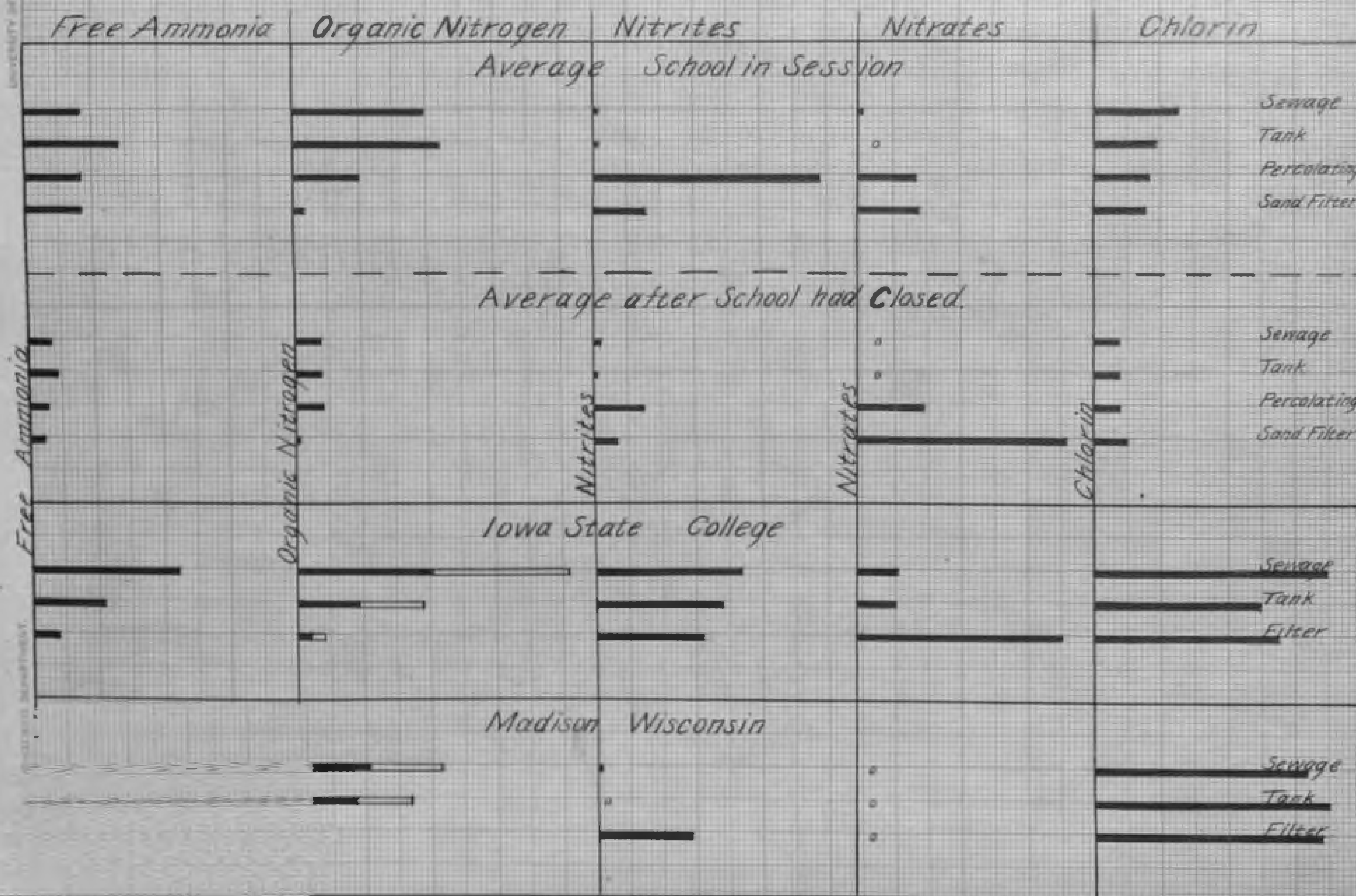
Thursday March 19-08
Chlorin in Sewage & Tank Effluents
After adding 80 Pounds of Salt to
Sewage & Putting in Battles.
Parts Per Million of Chlorin
90
80
70
60
50
40
30
20
10
Small Tank
Large Tank
Sewage
Time of Day.
9 AM. 10 11 12 1 P.M. 2 3 4 5 6 7 8 P.M.


February
March
April
May
360
320
280
240
200
160
120
80
40
Curves Showing Turbidity
of
Sewage and Effluents.
Sewer.
Tank
Percolating F.
Sand F.


February
March
April
May
Curves Showing Nitrogen
as.
Free Ammonia
In Sewage and Effluents.
40
30
20
10
Per Million
Tank
Sand F.E.
Percolating
Sewage
February
March
April
May.
Parts
Curves Showing Nitrogen
as
Organic Nitrogen
In Sewage and Effluents
40
30
20
10
Sewer
Tank
Percolating F.
Sand
Filter


January
February
March
April
May.
Curves Showing Number of
Bacteria in Sewage & Effluents.
Number of Bacteria Per C.C.
1,900,000
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Sewer
Sewer
Tank
Tank
Percolating Filter
Sand Filter
Baffels Put in Tank
Changed to Small Tank


CURVES SHOWING
OXYGEN CONSUMED.
AT.
STATE FARM & - - - IOWA STATE COLLEGE.
Parts Per Million
240
220
200
180
160
140
120
100
80
60
40
20
February-08
March
April
May-08
Feb.-01
March-01
April.
Sewer
Tank
Percolating
Filter
Sand Filter



Free Ammonia
Organic Nitrogen
Nitrites
Nitrates
Chlorin
Average School in Session
Sewage
Tank
Percolating
Sand Filter
Average after School had Closed.
Sewage
Tank
Percolating
Sand Filter
Free Ammonia
Organic Nitrogen
Nitrites
Nitrates
Chlorin
Iowa State College
Sewage
Tank
Filter
Madison Wisconsin
Sewage
Tank
Filter

STATE SCHOOL OF AGRICULTURE
DISPOSAL PLANT IN COURSE OF CONSTRUCTION

SETTLING BASIN
PERCOLATING FILTER BEFORE
BELL WAS PLACED ON SIPHON

PERCOLATING FILTER
SHOWING UNDERDRAINS

PERCOLATING FILTER READY FOR THE ROOF
ALSO SHOWS SIPHON CONNECTIONS

PERCOLATING FILTER
SIDE DOORS CLOSED

PERCOLATING FILTER SHOWING
DISTRIBUTING SYSTEM IN ACTION

SAND FILTER BEING DOSED
WHILE FURROWED FOR THE WINTER
ALSO SIDE DOOR ON PERCOLATING FILTER OPEN


STATE SCHOOL
OF
AGRICULTURE
AND
EXPERIMENT STATION
UNIVERSITY OF MINNESOTA
SCALE 1"=100'
JOHN WILSON
May 1908
LEGEND
New Sewer
Old " in use
Water Main
Man Hole
PENTERGAST
BOYS DOMITORY
HOME BLDG.
DINING HALL
FOOT BALL FIELD
MAIN BUILDING
ECONOMICS
GIRLS BUILDING
Walk
Tunnel
POULTRY
SHOP
DRILL HALL
POWER HOUSE
HORTICULTURAL BUILDING
CHEMISTRY BUILDING
Surface Drain
And Storm Sewer Outfall
SHOP
DAIRY BARN
DAIRY BUILDING
GREEN HOUSE
WATER TANK
FARM HOUSE
VETERINARY BUILDING
MEAT HOUSE
LIVE STOCK PAVILION
MAIN BARN
SEWAGE
DISPOSAL PLANT
HOG PEN
MACHINE SHOP
SHEEP BARN

Section on A-A
Plan of Septic Tank
Section B-B
Reinforced Roof
Reinforced Beam
Water Line
Brick Pier
12" Siphon
Section on H-H
Rubberoid
Stock Lumber
2x6 Joists
Main Distributor 12"x14"
Laterals
Plan Percolating Filter
Section on C-C
Radius
Detail of Splasher Scale 1"=2"
10" Distributor
6" Drain Tile
Plan Sand Filter
Section on H-H
12" Siphon
60'-0"
Section on H-H.
DETAILS
OF
Disposal Plant
State School of Agriculture
St Paul Minn.
Scale 1/8"=1'

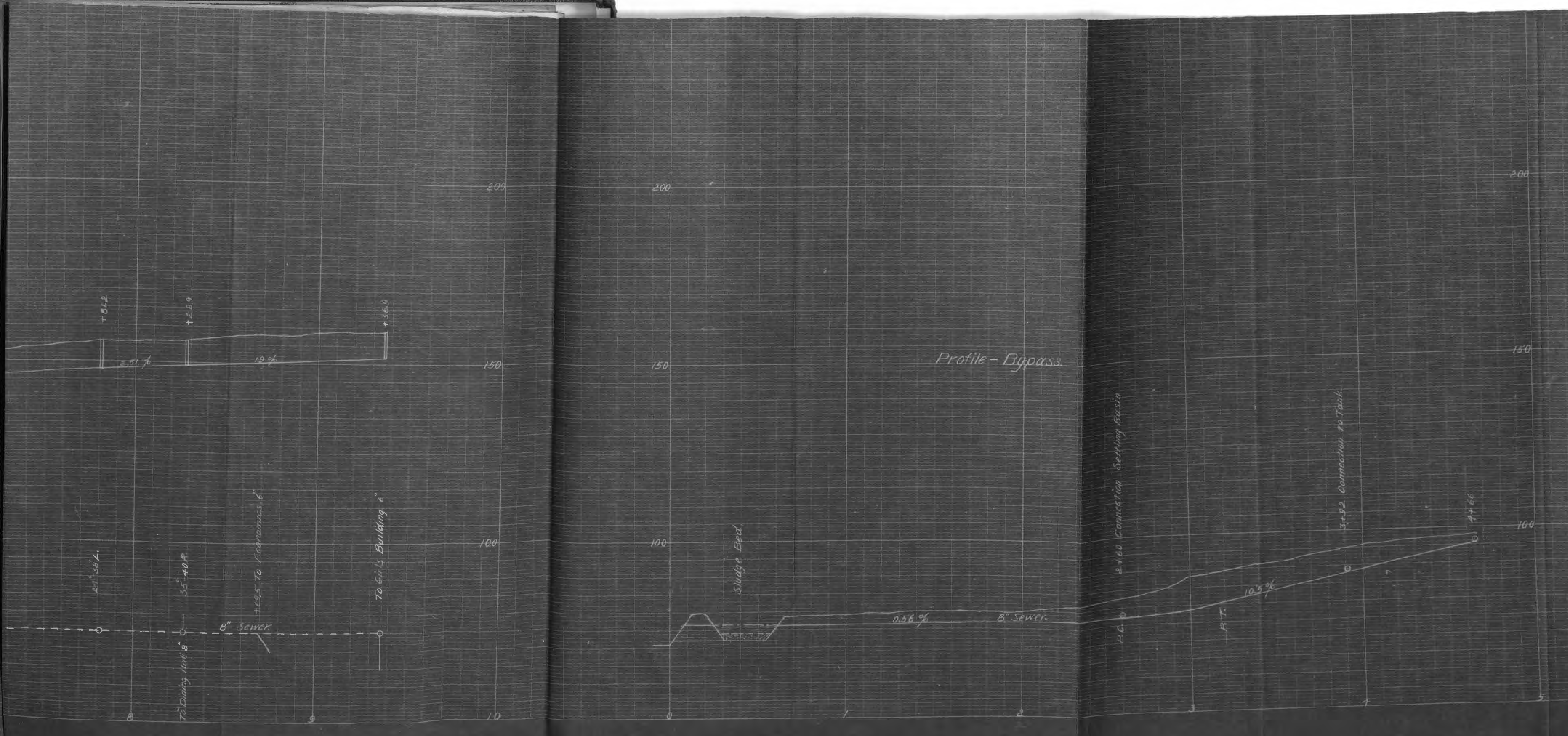
Section on A-A
Plan of Septic Tank
Section B-B
Section on H-H
Brick Pier
12" Siphon
Stock Lumber
Joists
Main Distributor 12" x 14"
Plan Percolating Filter
Section on H-H.
Detail of Splasher Scale 1"=1'
Plan Sand Filter
80'-0"
Section on C-C
Section on H-H
DETAILS
OF
Disposal Plant
State School of Agriculture
St Paul Minn.
Scale 1/8 = 1'


Profile
of
New Sewer System
at
State Farm
St Paul, Minn,
May 1908
John Wilson Del.
Profile – Tank to Chemistry Building
200
150
100
Inlet Septic Tank
10" Sewer
To Dairy Barn
To Veterinary Building
Old Sewer 10"
To Power House 10"
8" Sewer
Live Stock Pavillion 6"
Farm House 6"
8" Sewer
0
1
2
3
4
5
6
7
8
9

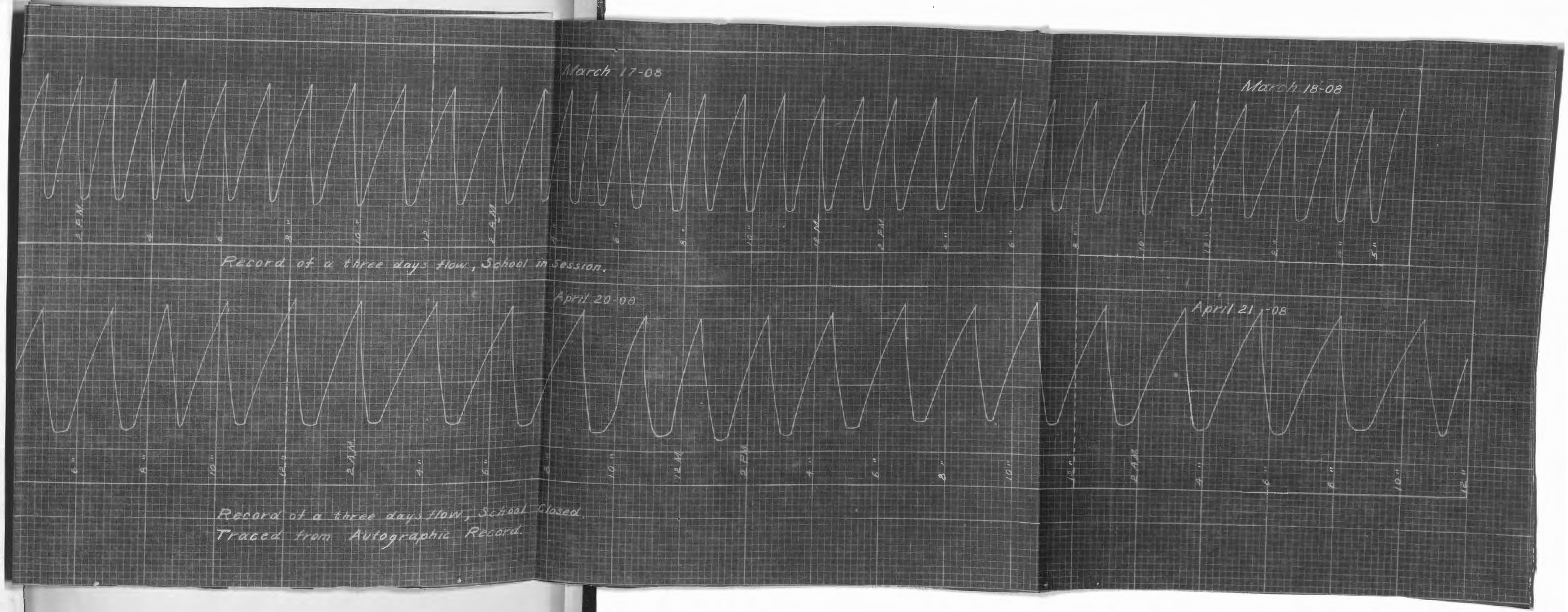

Profile— Tank to Chemistry Building
Old Sewer 10"
To Power House 10"
8" Sewer
8+33.5 To Live Stock Pavillion 6"
+46.0 To Farm House 6"
8" Sewer
+177 To Green House 6"
To Horticultural Building
6" Sewer
+81.6 To Chemistry Building
200
150
100
5
6
7
8
9
10
11
12
13
14


Profile — Power House to Economics
200
150
100
8" Sewer
+17.7 To Green House 6"
To Horticulture Building
8" Sewer
+81.6 To Chemistry Building
Power House To Main
10" Sewer
10" Sewer
8" Sewer
2.0 %
1.0 %
1.0 %
+67.7
+71.2
8°53' R.
11
12
13
14
0
1
2
3
4
5
6

Profile - Power House to Economics
+67.7
+98.2
+71.2
+81.2
+28.9
+36.9
1.0 %
1.0 %
2.7 %
2.51 %
1.9 %
10" Sewer
8" Sewer
8" Sewer
62° 26' R.
6° 53' R.
21° 38' L.
35° 40' R.
To Dining Hall 8"
+69.5 To Economics 6"
To Girl's Building 6"
Sludge Bed
0.56 %
200
150
100
2
3
4
5
6
7
8
9
10
0
1


Profile - Bypass.
200
150
100
+81.2
+28.9
+36.9
2.51 %
1.9 %
24°38'L.
35°40'R.
+69.5 To Economics 6"
To Girls Building 6"
To Dining Hall 8"
8" Sewer.
8
9
10
Sludge Bed.
0.56 %
8" Sewer.
2+60 Connection Settling Basin
P.C.
P.T.
10.5 %
3+92 Connection to Tank
4+66
0
1
2
3
4
5


March 15-08
March 16-08
March 17-08
Record of a three days flow, School in Session.
April 18 08
April 19-08
April 20-08
Rain; Roof Water Coming in
Record of a three days flow, School Closed.
Traced from Autographic Record



Record of a three days flow, School in Session.

Record of a three days flow, School Closed.
Traced from Autographic Record.