Va. State Water Control Board.

LOWER JAMES RIVER POLLUTION STUDY

CITY POINT to the CHICKAHOMINY

August 6 - September 6, 1961

A PRELIMINARY REPORT OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

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LOWER JAMES RIVER POLLUTION STUDY

REPORT

General Description of the Problem

Hopewell, Virginia is a highly industrialized city, the Celanese Corporation of America, the Continental Can Company, the Hercules Powder Company and the Solvay Process Division of Allied Chemical and Dye Corporation having plants there. All of these plants have industrial and human wastes, the combined amount of which is great from the standpoint of both volume and strength. In addition, there are human wastes from the City of Hopewell and its suburbs in Prince George County and from Camp Lee. All of these wastes, sewage and industrial, are discharged into the James River, Bailey Creek and into other tributaries of the two. Primary treatment is given the wastes at Camp Lee; the others are discharged untreated. The location of all discharges in the Hopewell vicinity are shown in Figure I.

With the exception of Bailey Creek, the impact of these wastes on the streams they enter was largely unknown, prior to this study. For many years Bailey Creek has bee recognized as an open sewer. Following passage of the Virginia State Water Control Law in 1946, the Hopewell industries all began programs leading to reduction of wastes they discharged. In order for them to determine the extent to which such reductions must ultimately be carried, it soon became apparent that information was needed regarding the effect of their wastes on the James River.

During the summer of 1951 the Hopewell industries, through the Hopewell Manufacturers Association requested the Water Control Board's help in making a study of the stream in the Hopewell vicinity in an attempt to answer this question. The Board's staff agreed to lend such assistance as was possible, and the initial phases of such a study were completed during the period August 6 - September 6, 1951.

Purpose

The purpose of this investigation is to determine the extent and degree of pollution in the James River and its tributaries in order that a comprehensive program for pollution abatement may be formulated by the several owners in the Hopewell area who jointly cause this pollution. Specifically, it has the following purposes:

1. To determine the course followed in the James River by industrial wastes and sewage from the Hopewell area,

2. To determine the extent and degree of pollution in the James River around the Hopewell area by means of physical, chemical, bacteriological and biological tests,

3. To determine the volume and strength of industrial wastes discharged into the James River and its tributaries in the Hopewell area,

4. To determine the effect of tidal variations and currents on the net movement of the wastes downstream from Hopewell,

5. To determine the assimilation capacity of the James River downstream from Hopewell in order to ascertain the permissible net waste load and still maintain prescribed levels of dissolved oxygen in the river,

6. To determine a minimum flow figure which might be expected to recur in the James River at Hopewell every 10 years,

7. To determine what further studies are necessary so the Board's and industries' technical staffs may formulate a comprehensive program for pollution abatement.

Regular River Sampling Stations

Since there is tidal action in the James River and since there are several paths the water may take downstream from Hopewell, it was considered advisable to try tracing the course of the wastes by means of conductivity measurements. To do this, a number of stations were selected in the James and Appomattox Rivers to cover the entire area where wastes might travel. The conductivity sampling stations are shown in Figure 2. At each station conductivity measurements were made from the river bottom to the water surface. On the basis of the conductivity data, tentative sampling stations were selected by the Board's staff. In addition, a boat trip was made down the James River on August 9, 1951 to obtain additional data to aid in the selection of stations. On August 15, 1951, members of each industry involved met on a boat and took a trip down the James River to see the tentative sampling stations. The group was shown the results to date and all agreed that analysis of samples taken at the stations selected by the Water Control Board's staff would give a representative picture of pollution in that stretch of the river to be studied. The stations were numbered 10 through 21. Two stations, 12A and 12B, were added to show conditions in Bailey Creek. The location of these sampling stations is shown in Table I and in figure 1.

Supplemental River Sampling Stations

On the August 15, 1951 boat trip, it was agreed that spot checks of dissolved oxygen and other constituents, as well as additional conductivity measurements, should be made. Spot samples were obtained, with additional dissolved oxygen (D.O.) determinations and conductivity measurements (1) in the area between City Point and Jordan's Point, north and south of the dredged channel, and (2) in the area between Jordan's Point and Coggin's Point, north and south of the dredged channel. These D.O. stations are shown in Table I and in figures 3 and 4. Samples at D.O. Stations 56, 57, 59, 60 and 61 were collected on August 24th. D.O. determinations throughout the Hopewell area were made on August 16, 17 and 24th. All river samples were analyzed by the Board's laboratory in Richmond, Virginia and unless otherwise specified were taken at half depth.

In addition to the samples taken at half depth between Fort Powhatan light and Weyanoke Points (Station 18) and between Kennon Marsh and Sturgeon Point light (Station 19), supplementary D.O. samples were taken at 10 to 15 feet under the surface. Only half depth D.O. readings are included in this report.

TABLE 1

Location of Sampling Stations

Sampling Stations	[illegible] (2) Ox[illegible] [illegible]ing Stations	Location (3)
10.		Mid-channel of James River, opposite nun buoy 122 above City Point, Hopewell
11		Mid-channel of Appromattox River just downstream from State Highway No. 10 bridge
12		Mid-channel of James River opposite nun buoy 118, approximately ½ mile below Station 10
12A		Mid-stream of Bailey Creek, sample taken by Hercules Powder Co. representatives from State Highway No. 10 bridge
12B		Mid-stream of Bailey Creek, sample taken by Hercules Powder Co. representatives from State Highway No. 154 bridg
13		Edge of channel of James River opposite Light (FlG) 111 approximately 2 miles below Station 10
14 (4)		Opposite ferry dock at Jordan's Point about 50 to 75 mil off shore, approximately 3½ miles from Station 10, south of dredged channel
15		In ferry channel opposite the dock across from Jordan's Point about 200 to 250 yards off shore, north of dredged channel.
16 ✓ (6)		Mid-channel of the abandoned channel, opposite Coggins Point and Can buoy 95, approximately 6½ miles from Stati 10
17 ✓ (5)		Between the shore and Light (Fl) 91, approximately 8 mil below Station 10
18 ✓ (4)		Mid-channel opposite Weyanoke Point and Fort Powhatan, approximately 13 miles below Station 10
19		Mid-channel opposite Sturgeon Point, approximately 17½ miles below Station 10
20		Mid-channel opposite Brandon (before Chippokes Creek joi James River) approximately 21 miles below Station 10
21. ✓ (3)		Mid-channel opposite Light (Fl) 69 (before Chickahominy joins James River) approximately 25 miles below Station
	56	Between City Point and Packs Point, north of the dredged channel
	57, 58, 59	Between City Point and Jordan's Point, in Bailey Bay sou of the dredged channel
	60, 61	Between City Point and Jordan's Point, north of the dred channel
	64, 67	Between Jordan's Point and Coggins Point, north of the dredged channel
	70	Opposite Coggins Point in the main channel
	77, 80	Between Jordan's Point and Coggins Point, south of the dredged channel in the abandoned channel

(1) See Figure 1
(2) See Figures 3 and 4
(3) All samples taken at approximately half depth
(4) All stations from 14 to 21 and dissolved oxygen stations are located in the James River
Location of conductivity stations is shown in figure 2, while biological sampling stations are shown in figure 1.

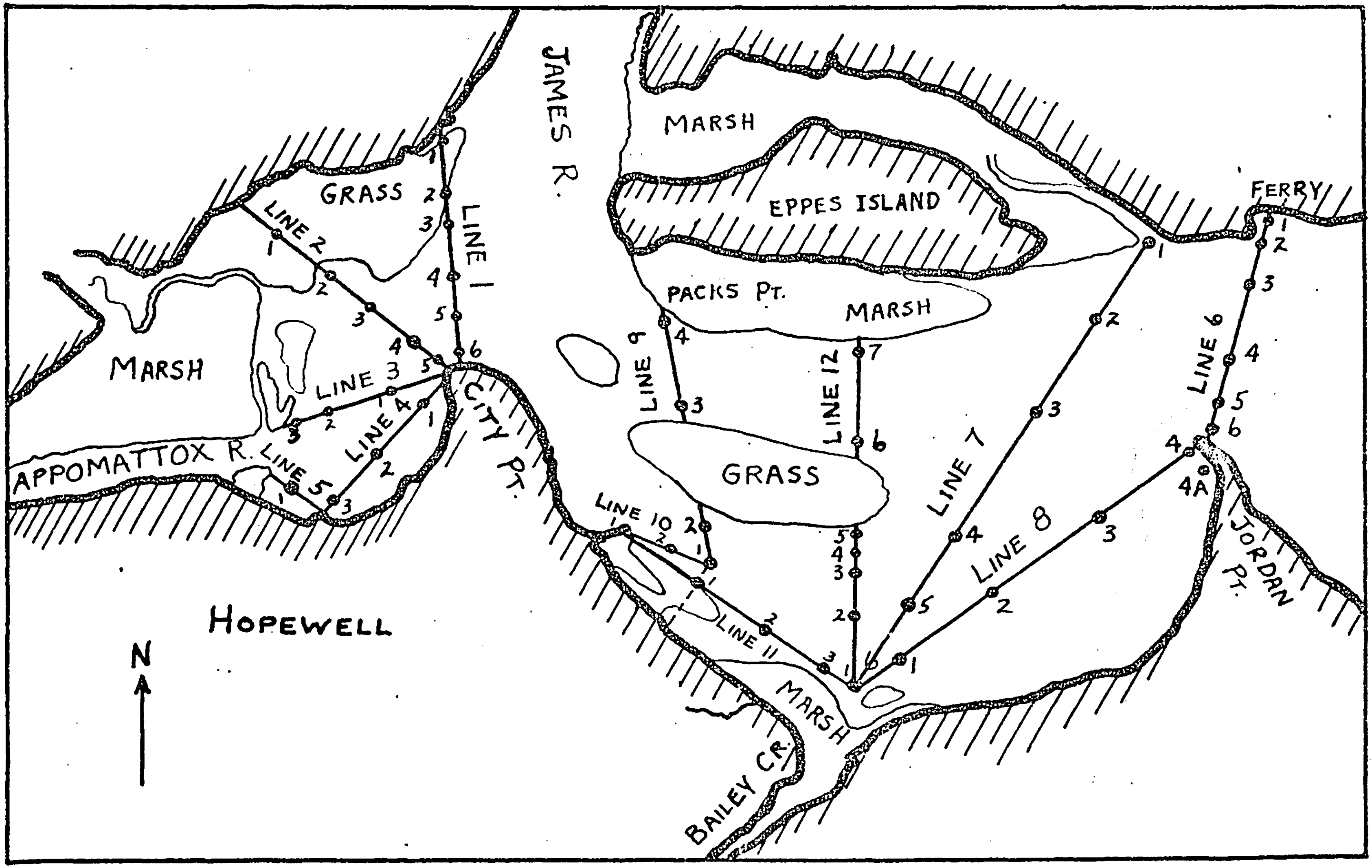

FIGURE 2
LOWER JAMES RIVER POLLUTION STUDY
LOCATION OF CONDUCTIVITY STATIONS

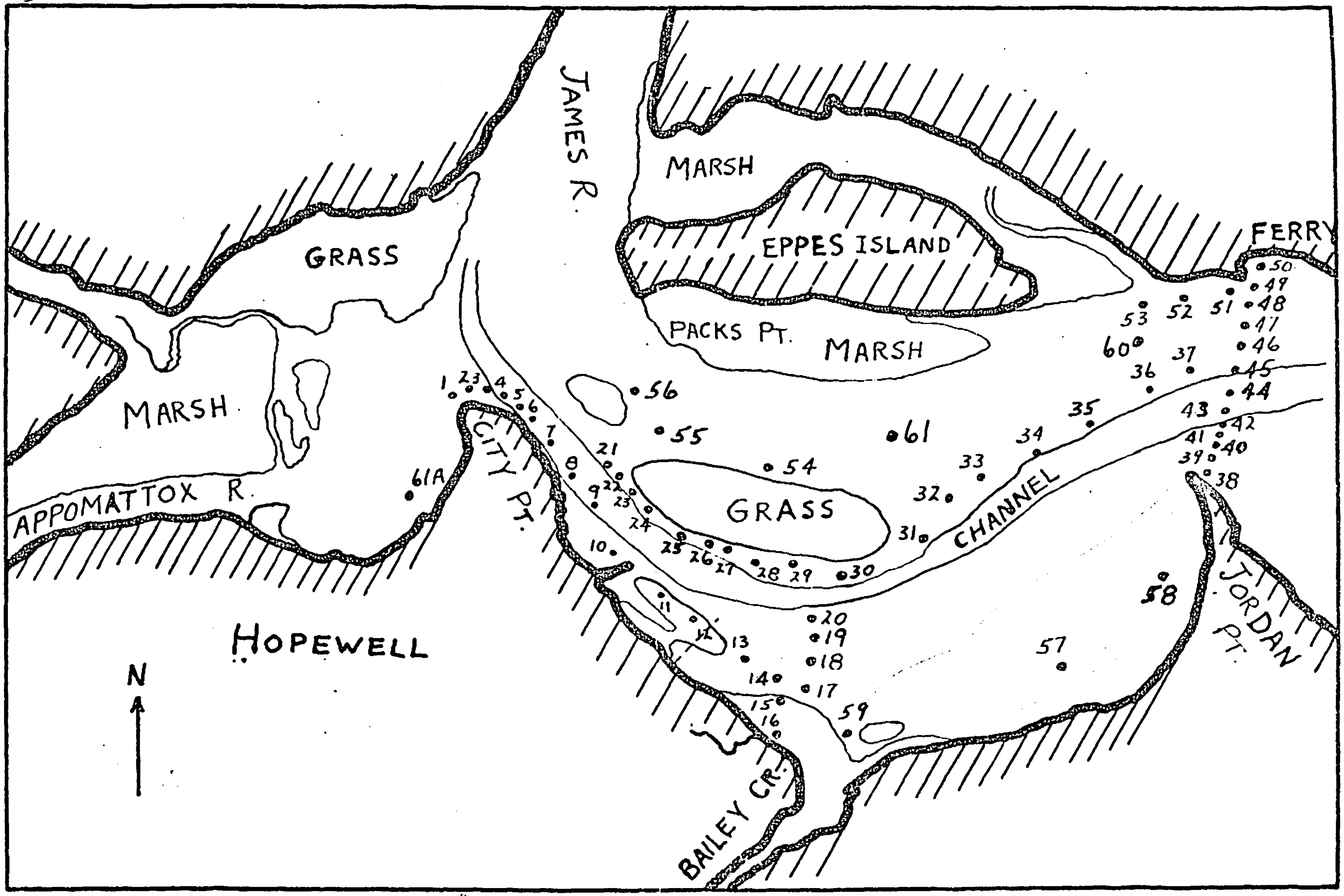

FIGURE 3

LOWER JAMES RIVER POLLUTION STUDY

LOCATION OF DISSOLVED OXYGEN STATIONS

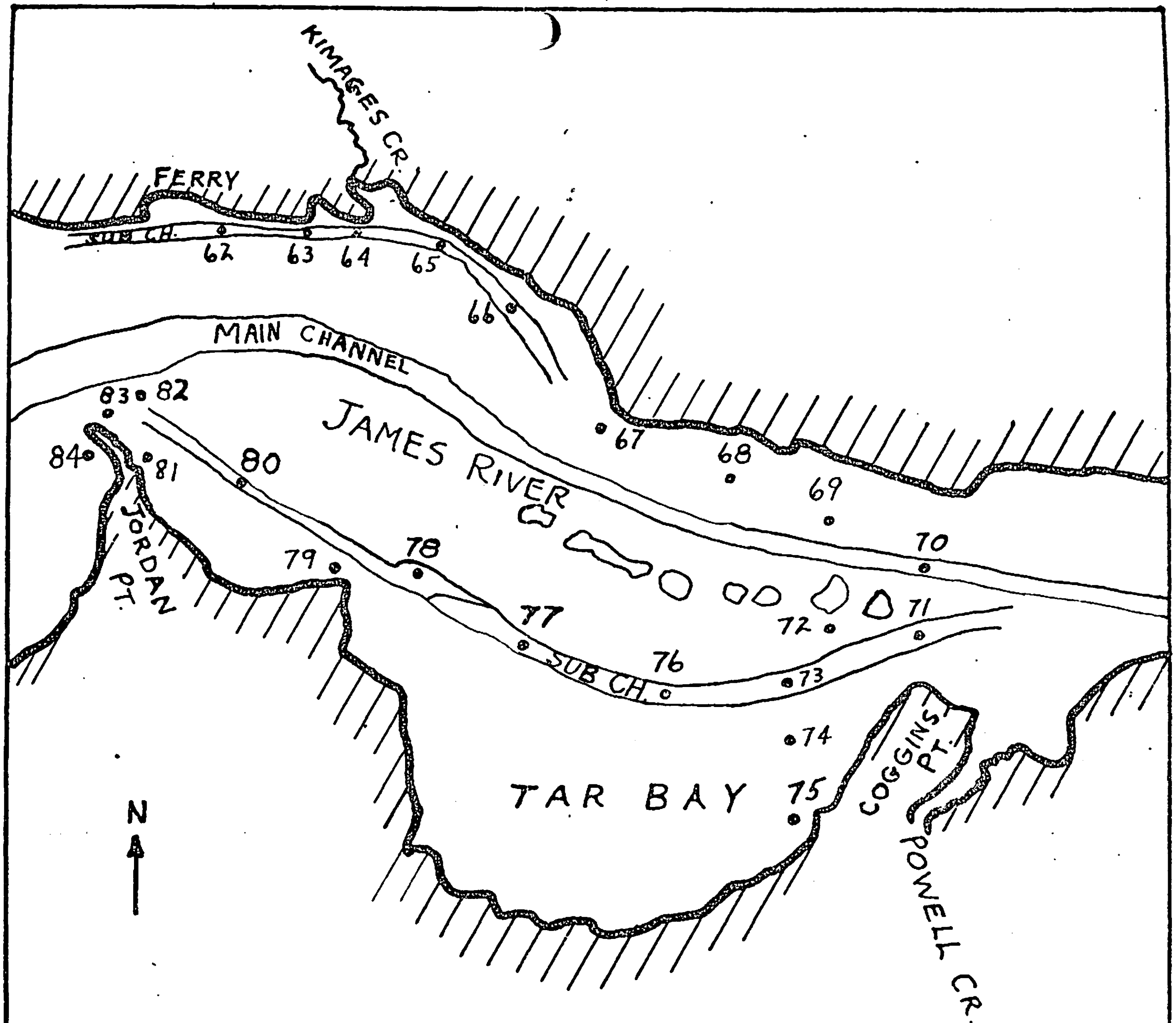

FIGURE 4

LOWER JAMES RIVER POLLUTION STUDY

LOCATION OF DISSOLVED OXYGEN STATIONS

Collection of Samples

Chemical and Bacteriological--All river samples were collected in a D.O. sampler ... e ... of the boat. When the boat stopped at each station, the sampler with D.O. bottle was lowered in the water to approximately half depth, as determined by the navigation chart, and allowed to fill. The sampler was then brought to the surface and on to the boat deck. The D.O. bottle was removed and the dissolved oxygen content determined. Then a 1/2 gallon jar was filled with the remaining water in the sampler. The temperature of the water in the jar was recorded alo with the time. The sewage D.O. sampler was lowered to approximately half depth again and allowed to fill, then brought to the boat deck as before. The second river sample at each station was poured into a small sterile bacteriological bottle. The 1/2 gallon jar of water and the bacteriological bottle were kept on ice until brought to Richmond by State Water Control Board personnel for immediate analysis.

Samples were collected at Stations 10 through 21 on August 15, 20, 21, 22, 27, 28, 29, and September 4, 5, and 6th by State Water Control Board personnel using a ... furnished by the Hopewell Manufacturers' Association in conjunction with the Water Control Board's small boat and motor. Samples at Station 12A and 12B, Bailey Creek, were collected on the same days as those of Stations 10-21, by the Hopewell Industries and delivered to the Hopewell Yacht Club. These samples were picked up by the State Water Control Board personnel, brought to Richmond, and immediately analyzed by the State Water Control Board personnel. All analyses by the State Water Control Board laboratory were in accordance with STANDARD METHODS with the exception of color, as explained in the appendix, on page 22 .

Biological--Dr. Weiss collected biological samples on August 27 and 30, 1951. His reports will be found on pages 14 to 19 and is summarized in the conclusions of this report. The large boat, made available by the Hopewell Manufacturers' Association, was used in conjunction with the State Water Control Board's small boat and motor by Dr. Weiss in obtaining his samples.

Messrs. Massmann and Ladd of the Virginia Fisheries Laboratory at Gloucester Point submitted a report, October 9, 1951, of fish collections made in the James River near Hopewell on August 30 and 31. The fish life studies carried out by the Virginia Fisheries Laboratory was a part of the biological study of the James River. The Virginia Fisheries Laboratory furnished their own equipment and personnel for this study. A summary of the fish-life studies is presented in the conclusions, and the complete report will be found on pages 20 to 22 .

The location of all sampling stations used by Dr. Weiss and Virginia Fisheries Laboratory are indicated on figure 1.

Industrial Waste--On August 19, 20, 21, 26, 27, 28 and September 3, 4, and 5, the Virginia Cellulose and Cellulose Products Divisions of Hercules Powder Company and Continental Can Company collected 24 hour composite samples of their several effluents. On August 20, 21, 22, 27, 28, 29 and September 4, 5, and 6 the Solvay Process Division and on August 20, 21, 22, 27, 28, 29 and September 5, 6, and 7 the Celanese Corporation of America collected 24 hour composite samples of their final effluents. Solvay's analyses included the James River water intake, the Poythress Run effluent, and the Gravelly Run effluent. All industrial samples were analyzed in ... respective plants in accordance with STANDARD METHODS. The Cellulose Product Division of the Hercules Powder Company submitted supplementary information on Stations 12A and 12 B to the State Water Control Board report on September 19, 1951.

Laboratory Work

The individual industries made all laboratory determinations on samples of their wastes collected during the study. The Water Control Board did all laboratory work on the river samples. Hercules also made some analyses on samples from Bailey Creek. Solvay also made the same analyses on raw river water as on effluent samples. The various analyses made by each participant are shown in Table 2.

TABLE 2

Analytical Determinations Performed by the Industries and the State Water Control Board

Samples (IW= Industrial Waste)	Celanese Corporation of America	Continental Can Company	Cellulose Products Div., Hercules Powder Co.	Virginia Cellulose Div., Hercules Powder Co.	Solvay Process Div., Allied Chemical & Dye Corp.	State Water Control Board
	IW	IW	IW	IW	IW	Stream
D.O., ppm	x	x			x	x
Alk. ($CaCO_3$, ppm)	x	x	x	x	x	x
pH	x	x	x	x	x	x
B.O.D., ppm	x	x	x	x		x
Total Solids, ppm (Total	x	x	x	x	x	x
Total Solids, ppm)Volatile	x		x	x		x
Total Solids, ppm (Fixed	x		x	x		x
Suspended Solids, ppm (Total	x	x	x	x	x	x
Suspended Solids, ppm)Volatile	x		x	x		x
Suspended Solids, ppm (Fixed	x		x	x		x
Sulfates (SO_4, ppm)						x
Chlorides (Cl, ppm)	x		x	x		x
Turbidity (SiO_2, ppm)						x
Color (K-S Readings #54 Filter)						x
NH_3 Nitrogen, ppm					x	x
NO_2 Nitrogen, ppm						x
NO_3 Nitrogen, ppm					x	x
C.O.D., ppm	x	x	x	x		x
Temperature, °C.					x	x
Settleable Solids, Ml/l	x	x	x	x		
MPN, Coliforms per 100 ml						x

Data and Results

All data and results are recorded in the appendix. These were considered by the study participants on January 15, 1952. In the graphs, figures 5 through 12, the average values of the various constituents are plotted against the distance between stations in nautical miles. The point between stations 14 and 15 is an average of the two. Figures 5 through 12 are on pages 23 through 30, inclusive. The results of all analyses arranged by stations will be found on tables 10 through 30, pages 31 through 51, inclusive.

Conclusions

1. Waste Load--The data tabulated in table 3 show the amounts of B.O.D., total soli suspended solids and alkalinity in pounds per day discharged to the various streams i the Hopewell vicinity.

TABLE 3
Waste Loads to Virginia State Waters at Hopewell

	B.O.D. Lbs/Day	Total Solids Lbs/Day	Suspended Solids Lbs/Day	Alkalinity Lbs/day
Allied Chemical & Dye Corp., Solvay Process Div.	Not Known	150,000(1)	44,000(1)	10,000(2)
Hercules Powder Co., Va. Cellulose Div.	54,200	272,000	26,000	66,000
Hercules Powder Co., Cellulose Products Div.	10,150	46,000	2,000	200
Continental Can Co.	29,500	150,000	34,000	28,000
Celanese Corp. of America	960	4,000	200	400
City of Hopewell	2,500	-	-	-
Camp Lee residual load in Bailey Creek and Hopewell suburban area	2,500	-	-	-
Total	99,810(3)	622,000	106,200	84,600

(1) Solvay uses untreated river water in its processes. This contains some of each of these constituents. These figures represent net amounts contributed.
(2) Alkalinity is removed from the untreated river water by Solvay's manufacturing processes
(3) 598,900 population equivalent

These loads account for the rises in concentration of these constituents at stations immediately below Hopewell, as shown by the figures.

2. B.O.D. and D.O--The curve of average B.O.D. values (figure 5) shows a steep ris from 2.2 ppm at station 10 and then a gradual drop to 1.3 ppm at station 21. Solvay did not make B.O.D. determinations on its wastes, and it is not known if ammonia in the wastes contributes significantly to the B.O.D. load on the James River. The average D.O. fell correspondingly from 5.8 ppm at station 10 to a low of 3.9 ppm at station 17 and then rose again to 6.7 at station 21. Individual D.O. values show quite low values at some stations. The low value at station 10 is attributable to residual upstream loads, from Richmond and its industries. D.O. was completely depleted at all times at station 12A in Bailey Creek. The low value at station 12B is due to the sewage load from Fort Lee. D.O. was completely or almost completely depleted at some times at some Bailey and Tar Bay stations. These areas serve as natural lagoons for biological decomposition of the organic wastes from Hopewell. D.O. determinations made at 10 to 15 foot depths at stations 18 and 19 showed values about 1 ppm higher than those taken at half-depth.

Average temperature did not vary greatly in the James River between stations 10 and 19. Insufficient samples were taken at stations 20 and 21 to obtain averages comparable with those at other stations. The temperature at station 12A was considerab above that of the other stations, due to the presence of hot industrial wastes from the Hopewell industries. Average temperature and D.O. saturation data are shown in table 4.

TABLE 4
Temperature and Dissolved Oxygen Saturation Data

Station	Temperature °C.	Observed D.O., ppm	Saturation D.O., ppm	% Saturation
10	27.2	5.8	8.04	73
11	28.4	7.1	7.98	89
12	27.8	5.7	8.19	69
12A	30.2	0	7.62	0
12B	22.1	2.8	8.84	32
13	27.4	5.2	8.13	64
14	27.6	2.2	8.16	28
15	27.1	6.5	8.08	80
16	28.2	4.2	7.95	53
17	28.1	3.9	7.93	49
18	28.0	4.1	7.92	52
19	28.3	4.7	7.96	59
20	(1)	5.1	-	-
21	(1)	6.7	-	-

(1) Insufficient number of observations made to obtain averages comparable with those at other stations.

3. Total and Suspended Solids and Turbidity--The abrupt rise at station 19 of total solids (figure 6) is probably due to a sand and gravel washing operation in the vicinity of station 18. The fact that total and fixed solids rise in greater proportion than volatile solids would bear out this assumption, as would also the curve for turbidity (figure 9), which shows a slight rise at station 20. Suspended solids (figure 7) do not fit into this picture as well as might be expected, though there is a disproportionate rise in fixed suspended solids at station 20. The abrupt rise in total solids at station 21 is due to the intrusion of salt water.

4. Chloride, Sulfate and Alkalinity (figure 8)--The rise in chloride immediately below Hopewell is due primarily to the discharge of 31 tons per day of sodium chloride from the Hercules plant. The rise at station 21 is due to salt water. The rises in alkalinity and sulfate below Hopewell are due to industrial waste discharges. The discharge by Continental Can Co. of salt cake, containing caustic, sulfide, carbonate and sulfate, probably accounts for some of the sulfate rise. No data is available regarding sulfate discharges from the other industries. The rises of these constituents under present conditions are not known to present any particular pollution problem.

5. Color (figure 9)--Though there is a slight, but perceptable, rise in color between stations 14 and 15, this constituent remains essentially unchanged over the stretch of river studied. In Bailey and Tar Bays there are areas of discoloration easily distinguishable to the eye.

6. C.O.D. (figure 5)--An insufficient number of C.O.D. determinations were made to draw any conclusions.

7. M.P.N. of Coliform Organisms--The curve of M.P.N. averages (figure 11) shows many, though not extreme, variations. Mean and geometric averages (figure 12) show other curves, though the rise at stations 19 and 20 are not fully explained. It is believed this rise is due to uninvestigated sewage discharges in the vicinity of an old brick plant near station 19.

8. pH--The variation in pH at the several stations are shown in table 5. These variations are not considered significant, except at station 12B.

TABLE 5
pH Variation

Station	Minimum pH	Maximum pH
10	7.4	7.85
11	7.2	8.2
12	7.3	8.1
12A	8.4	10.0
12B	7.1	8.0
13	7.2	8.2
14	7.2	8.1
15	7.2	8.1
16	7.4	8.1
17	7.25	8.3
18	7.2	8.3
19	7.35	8.2
20	7.4(1)	7.8(1)
21	7.4(1)	7.8(1)

(1) Range of 3 samples

9. Nitrogen Determinations (figure 10)--Nitrogen is contributed to the James River in the Hopewell vicinity principally by sanitary sewage and industrial wastes from Solvay. This contribution probably is of no great pollution significance, excej that the ammonia may exert a B.O.D. on the stream.

10. Conductivity Data (tables 6-11)--Conductivity data shows that the wastes fı Hopewell do not travel far upstream from Bailey Creek, and that they travel downstreı through Bailey and Tar Bays rather than through the main channel. Supplementary analytical data (table 26) on miscellaneous samples confirms this.

11. Biological Data--On the basis of algael, plankton and bottom organisms colle ted and studied by Dr. Weiss, it was concluded that septic conditions exist in Baile Creek and nearly all of Bailey Bay, and these bodies are not capable of satisfactori supporting aquatic plant and animal life. Pollution reaching the main channel of the James River from Bailey Creek does not appear to affect significantly the biology in the waters downstream from Jordan Point.

Definite conclusions cannot be drawn from the studies of the Virginia Fisheries Laboratory since (1) the survey was not sufficiently extensive in time or space, (2) the use of a small haul-seine limited sampling to areas near shore, and to beaches with suitable bottom.

The hauls were rather productive as compared with similar collections made in ot Virginia rivers. This seemed to be due chiefly to the great abundance of silverside (Menidia beryllina). Very few fishes were taken along the southern side of the rive from City Point to Jordan Point, but the region of low abundance seemed to be restric to the Hopewell area.

A considerable fish kill was observed in the region just west of Jordan Point. Fish mortalities in this area have been investigated by the Laboratory several times the past. Available information indicates that most shad spawning in the James, exclusive of its tributaries, takes place in the Hopewell area. The existing pollutior ay therefore affect the production of this commercial species. Few commercial fishermen operate in the immediate vicinity of Hopewell, but this does not indicate that the region is potentially unproductive. Fishermen say that fish caught in this area are poor in quality and are not commercially desirable.

Recommendations

1. River Cross Section Study--A detailed cross-sectional and depth sampling study should be made between Stations 14 and 15 over a tidal cycle, at as many points as possible along the line between the stations. At each point, D.O. determinations should be made at 1/2 and 2/3 depth at each hour. A composite of the two samples should be made and the composite analyzed for B.O.D., pH, color, temperature, and nitrogens.

2. Float Studies--Float studies should be made to determine the effect of tidal variations and currents on the net movement of wastes downstream from Hopewell, in such areas as Bailey Creek and Bay, Jordan Point, Tar Bay and Coggin Point. In addition, a study should be made of tidal actions in the main channel in the Hopewell area.

3. Regular Sampling Stations--Analyses of samples from Stations 10 through 17 should be continued until enough samples have been obtained to average the various constituents by tide - incoming, outgoing and slack. Studies at stations 18 and 19 should be made to determine the effect of sand and gravel operations in the James River in the vicinity of Station 18. Efforts should also be made to trace the source of the wage outlet at Station 19, and to determine if this is the cause of the M.P.N. curve jump at station 19.

4. Miscellaneous Studies--Conductivity and D.O. determinations, temperature, and bottom studies should be continued or instituted in the Hopewell area from City Point to Coggins Point, north and south of the dredged channel, to help round out the pollutional picture. Further biological studies should be made to determine the exact location of the shad spawning in the James River, and to provide further data on the effect of the wastes on the aquatic life in the James River.

5. Waste Assimilation Capacity--The waste assimilation capacity of the James River should be determined in order to ascertain the maximum waste load it may carry and still maintain prescribed levels of dissolved oxygen in the river. This will require a calculation of the time it takes the wastes to travel downstream and a determination of the rate at which the wastes decompose.

6. Solvay's B.O.D.-- Solvay should determine the B.O.D. of its effluents to find whether the ammonia present in the waste exerts any B.O.D. on the stream.

7. Pollutional Load of Hopewell and Camp Lee--Studies should be made to determine the pollutional load added to the James River by sewage from Hopewell and Camp Lee.

APPENDIX

Biological Studies

Report of Dr. Charles M. Weiss
on
Samples of Plankton, Algae and Bottom Organisms

The biological studies on the James River, reported herein, are part of an overall pollution survey to determine the extent and degree of pollution in the James in the vicinity of Hopewell, Virginia. Other phases of this survey include the chemical and bacteriological sampling by the Virginia Water Control Board, the industrial sampling by the Hopewell industries and the fish-life sampling by the Virginia Fisheries Laboratory.

The biological investigations are concerned principally with the plankton, the attached algae, and the bottom organisms of the James River in the area under survey. The plankton of the river was analyzed as to major groups. The attached algae on the channel buoys were sampled and reported with respect to the dominant types. Bottom samples were taken from the river above and below the City of Hopewell to possibly determine the distribution of the pollution discharges and their effect on the bottom organisms.

The sampling techniques employed were standard and will only be briefly summarized. The plankton samples were taken with a Foerst water sampling bottle and preserved in 5% formalin.

In the laboratory the plankton was concentrated by centrifuging for 5 minutes at about 1500 r.p.m. The plankton count was made using the Lackey drop method and the final counts reported as number per milliliter. (Table 6)

The attachment forms on the channel buoys were sampled qualitatively. This was accomplished by scraping from appropriate submerged areas on the buoys. These areas were a band at the waterline, consisting principally of a bacterial and diatom slime film and a band about 6 inches below this surface where a more luxuriant growth of filamentous algae was found. Buoys above and below Hopewell were sampled as indicat in Table 7. The forms reported are the dominant type observed in each sampled area.

Both Eckman and Peterson dredges were used in the bottom sampling depending on the nature of the bottom and the strength of the current. Soft bottoms were usually sampled with the Eckman dredge and the hard bottoms with the Peterson dredge. However, where the current was running strong it was necessary to use the heavier Peterson dredge to obtain a satisfactory bottom grab. The bottom samples were examined in the field and in many cases an appropriate portion returned to the laboratory for further analyses. The samples were washed through a 30 mesh sieve and the residue on the sieve used in the description of the particulate matter and living organisms. (Table 8)

On the attached map only those sampling buoys and station locations are marked where samples were taken for the biological survey. The marked buoys may represent both a sample taken from the buoy and/or or a location where a bottom sample was taken. The term Bailey Bay has been used to describe that embayment in the James River where Bailey Creek discharges.

The plankton samples, because they are subject to considerable natural variability due to the river flow and tidal circulation in the James at this point, and having been sampled on only one date are not representative of several tidal cycles, can only be discussed in the broadest terms. However, the plankton analysis is indicative of several features. In general it can be interpreted that a comparatively large number of blue-green algae and flagellates are indicators of organic pollution. One item that is noteworthy is that the top and bottom samples have fairly similar counts. The differences are hardly significant and it can be assumed that the water is uniformly mixed. It might be expected that due to the high turbidity of the river there might be some stratification of the photo-synthetic forms. However, the day of sampling, August 27, was cloudy and overcast and may have resulted in a more uniform distribution than on a sunny day. On a sunny day the tendency would be for the photo-synthetic forms to gather in higher concentration toward the water surface.

The decrease in both the green and the blue-green algae from the farthest upstream station to the farthest downstream station is fairly consistent. The high count of green algae that is found at Station #10 is probably due to the fertilization effect by the sewage discharges of the City of Hopewell. The decrease downstream may or may not be due to influences of the Hopewell industrial discharges. More likely it is the result of dilution of the fertilizing substances. The effluent from the industrial discharges does not appear to have a significant effect although the rapid decrease in plankton concentration between Stations 10 to 14 may be in part due to these discharges. No attempt was made to identify specific types in this plankton analysis due to the fact that material had to be preserved, and preserved specimens are rather difficult to identify even by the specialist.

The analysis of the algae attachment on the channel buoys is of more significance in that it was possible to be more specific in the identification of the algae and some are known to have rather specific relationships to polluted or non-polluted waters. The algae at the water line were growing on the rather heavy bacterial slime film in which many diatoms were embedded. The surface had a dark greenish appearance. In downstream progression the dominant species on the slime film changed from the blue-green algae Oscillatoria to the green algae Cladophora. The former is generally associated with polluted conditions while the latter is found in non-polluted waters. The algae growing in rather luxurient fashion about 6 inches below the water line were dominated initially by Spirogyra and Stigeoclonium both pollution favoring forms and then changing to Cladophora. The change in prevailing type occurred at Buoy N 108. This change in dominance of the attached algae probably occurs at a point where the sewage effluent from Hopewell reaches a dilution that no longer affects the growth of the algae.

The results of the extensive bottom sampling have shown an interesting picture of bottom conditions, organism association and effect of the industrial effluents.

(Table 8). The area north of the ship channel generally has a bottom of fine sand mixed with clay in contrast to the mud bottom south of the channel. This difference alone is sufficient to produce a different organism association without the added factor of pollution. However, comparison of bottom conditions up and downstream of Jordon Point on the south side of the channel can be used to evaluate the effect of pollution. The presence of the bottom organisms noted as tubificids and chironomids are indicative of bottom conditions where the mud contains large quantities of readily utilizeable organic matter. The organisms, the former an oligochaete worm and the latter the larval stage of a midge fly, are usually found in the zones of pollution described as degredation, decomposition and recovery. Since they require dissolved oxygen they are absent from the septic zone. The chironomids usually reach their peak in abundance in the zone of recovery whereas the tubificids are found in greatest numbers in the zone of decomposition. Both forms will be found utilizing organic material from natural sources; e.g. plant debris, and their presence does not necessarily imply pollution. However, the presence of large numbers of these forms usually implies organic matter of pollution origin.

The several types of molluscs found in the bottom collections can also be used as pollution indicators. The finger-nail clams (Sphaeriidae) are more tolerant of pollution than the larger fresh water mussels. The snail genus Goniobasis belongs to the group of gilled forms (Prosobranchia) which require water with a high oxygen content whereas the snails of the genus Planorbis are air-breathing forms and are therefore more tolerant of pollution. The presence of Bryozoa can also be used as an indicator of satisfactory water conditions since they are usually found only in non-polluted waters.

Debris noted for the various stations, particularly in the Bailey Bay area, shows a rather high concentration of wood chips and fibrous material increasing to a peak at station BB#4 where the bottom sample was practically 100% wood chips. On a line running directly out from the mouth of Gravelly Run, the bottom samples containing wood chips in large quantities were found nearly half way to the ship channel. In general nearly all the Bailey Bay bottom samples contained woody fibrous material in addition to the natural plant debris. The stream bottoms at the mouths of Gravelly Run and Bailey Creek were in septic condition as well as the bottom of Bailey Creek at the Route 10 bridge. The Bailey Creek bottom at the Route 154 bridge was aerobic and was being actively worked over by the tubificid worms and chironomid larvae.

The results of the biological survey indicate that the severest effects of the industrial pollution from the Hopewell area are limited to Bailey Bay. Sanitary sewage discharges from the City of Hopewell affect the river for only a comparatively short distance and little or no effect from either source of pollution is evident for any significant distance east of Jordan Point.

TABLE 6

Plankton (no./ml)(1)

Sampling Location	Desmids	Diatoms	Blue Green Algae	Green Algae	Flagellates	Protozoans	Miscellaneous
Buoy N 126							
Top	-	32	24	292	12	-	-
Bottom	-	24	12	392	4	-	-
Station #10							
Top	-	24	24	432	4	-	-
Bottom	-	20	16	440	16	-	4
Station #13							
Top	-	24	4	112	20	4	4
Bottom	-	32	12	180	4	4	-
Station #14							
Top	-	16	8	172	16	-	-
Station #15							
Top	-	24	8	112	4	-	-
Buoy C95							
Top	-	12	-	80	8	4	-
Bottom	-	16	4	88	16	4	-
Station #18							
Top	-	24	-	72	16	4	-
Bottom	4	8	8	56	4	-	-

(1) Sampled 27 Aug. 1951 - 11:15 am - 2:45 pm

TABLE 7

Algal Attachment to Channel Buoys(1)

Buoy	Dominant Types: Algae of Waterline Film	Dominant Types: Algae of Subsurface Growth
N 126	Oscillatoria	Spirogyra
N 120	Oscillatoria	Stigeoclonium (?), Spirogyra
N 118	Oscillatoria	Spirogyra
Fl G 111	Spirogyra, Oscillatoria	Spirogyra
N 108	Cladophora	Cladophora
Fl R 106	Oscillatoria	Cladophora
N 98	Cladophora	Cladophora, Spirogyra
N 94	Cladophora	Cladophora
N 84	Cladophora	Cladophora

(1) Sampled 30 Aug. 1951 9:55 am - 12:20 pm

TABLE 8

Bottom Samples

Sampling Location	Sampling Date - 1951 8-27	8-30	Physical Characteristics	Sieved Debris: Description	% of Original Sample Volume	Organisms
Buoy N126	x	x	Fine sand, nearly all through 30 mesh sieve	No organic debris	-	None
Station # 10	x		Fine sand, gray clay	Twigs & leaf debris	-	None
Station # 12	x		Gray clay	Leaf and twig debris	-	None
Buoy N114		x	Fine sand	Very little organic debris	-	None
Station # 13	x		Fine sand	Bark pieces	-	None (dead white perch in area on 8/27/51)
Buoy Fl G 111		x	Sand-mud, sticky	Fine organic debris	10-25	Many tubificids and chironomids
Station # 14	x		Clay-mud	Organic debris principally bark pieces	-	One fingernail clam shell (Sphaeriidae)
		x	Fine mud	Plant debris, bark	25-50	Mussel shell
Station # 15	x		Brown mud, soft	Considerable leaf debris		Several tubificids and chironomids
		x	No mud	Plant debris & bark	95	None
Buoy N 98		x	Pebbles	None		Bryozoans
Buoy C 95	x		Soft mud	Plant debris		Many tubificids broken mussel shells, fingernail clam shells
Buoy N 94		x	Fine mud and sand, soft	Plant debris, bark	5-10	None
Station #17	x		Soft mud	Plant debris, bark	-	Many tubificids and chironomids
Buoy C 87	x		Very soft mud	Plant debris, bark	-	Few tubificids and chironomids
Station # 18	x		Pebbles	-	-	Many snails (Goniobasis) Bryozoans
Station # 19	x		Pebbles	Little organic debris	-	Snails, bryozoans (2 species)

TABLE 8 - Continued

Bottom Samples

Sampling Location	Sampling Date - 1951 8-27	8-30	Physical Characteristics	Sieved Debris: Description	Sieved Debris: % of Original Sample Volume	Organisms
Tar Bay #1	x		Pebbles	Little organic debris	-	Snails, bryozoans (2 species)
Tar Bay #1		x	Sticky, jelly like gray-black mud	Plant debris, worm casts	less than 2	Few tubificids, chironomids, snails (Planorbis)
Tar Bay #2		x	Sticky, firmer than TB #1 More sand	Plant debris, worm casts	1-5	Few tubificids, chironomids
Tar Bay #3		x	Sticky gray mud, firm	Plant debris	10	Several tubificids, chironomids
Bailey Bay#1		x	Sticky soft mud	Plant debris woody fibrous material, wood chips	5-10	Few tubificids and chironomids
Bailey Bay#2		x	Sticky, soft mud jelly like on top	Plant debris, woody fibrous material, wood chips	1-5	Few tubificids and chironomids
Bailey Bay #3		x	Black soft mud, anerobic	Plant debris, wood chips, fibrous material	5-10	None
Bailey Bay #4		x	No natural bottom	Wood chips	95-100	None
Bailey Bay #5		x	Soft mud	Wood chips	50*	None
Bailey Bay #6		x	Soft mud	Fibrous material	10*	Few tubificids
Bailey Creek Rt. 10		x	Very fine sticky mud, black, anerobic	Plant debris, no fibrous material	10	None (one turtle)
Bailey Creek Rt. 154		x	Gray soft mud	Plant debris	10	Many tubificids, chironomids and unidentified fly larvae. Many turtles.

*Estimate in field

Report of Virginia Fisheries Laboratory
on Fish Sampling, by W. H. Massmann and E. C. Ladd

This brief survey was conducted as a part of the biological study of the James River to determine the extent and degree of pollution in the vicinity of Hopewell, Virginia.

The samples were taken with a small haul-seine in suitable areas along the shores of the river. The method requires that the bottom be relatively smooth and firm and free from snags. Fifty-six hauls were made at eighteen stations. Seventeen of these stations are shown on the accompanying chart; the eighteenth, station 208, was at Drewry's Bluff, about six miles below Richmond.

In general, compared with similar samples taken in other Virginia rivers, the hauls were rather productive. Altogether, 2,438 fish belonging to 19 species were taken, an average of 43 fish per haul or 32 fish per 100-foot haul. Dividing the section of river surveyed into three areas: above City Point, City Point to Jordan Point, and below Jordan Point, the following average numbers of fish were taken per 100-foot haul: 33.5, 1 .3, and 34.2 respectively. The relative numbers captured in the Hopewell vicinity would be much less if station 203 were omitted. There would be considerable justification for this omission, for this station is across the channel and therefore outside the region of greatest pollution. In general, fishes appeared to be less abundant, and fewer species were taken, along the south bank of the river from City Point to Jordan Point.

Station 198 represents the location of an observed fish mortality: silversides, white catfish, alewives, and hogchokers were picked up at the surface in a dying or dead condition. Dead menhaden were also seen on the beach at station 197. It was in this region (Jordan's Point) that similar mass mortalities of fish were reported to the Virginia Fisheries Laboratory in May and in July, 1951.

Details of collections at each station are given in table 9.

Color Determination. The color test, as developed by the State Water Control Board laboratory, was a relative one to point out variations in river color. The Klett-Summerson photo-electric colorimeter was used, with #54 green filter and a 10 mm cell to give the best range of readings.

Each sample was thoroughly centrifuged for 20 minutes, or longer, at 1500-1700 r.p.m. in a Precision Scientific No. 67643 centrifuge. The centrifuging eliminates turbidity and attempts to show only "true color". After the Klett-Summerson colorimeter was standardized to zero with distilled water, the series of samples were run through. The readings are in inmerse proportion to the intensity of the colors.

Data and Results

In the pages followings are graphs and tables of all analytical and other data collected during the survey.

TABLE 9

Identification of Fish Collected by Virginia Fisheries Laboratory

SPECIES	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	208	No.of Fish
Alosa sapidissima, Shad						2														2
Pomolobus pseudoharengus, Alewife	2	6				7		2		x										17
Pomolubus aestivalis, Glut herring	7	91	95	1	58	6									1					259
Brevoortia tyrannus Menhaden			1																	1
Anchoa mitchilli, Anchovy												2					8			10
Notropis hudsonius, Spottail	4		17		9	1	23	9	7			1					3		16	90
Notropis analostanus, Satinfin	7	2				3					1				2					15
Ictalurus catus, White catfish				1		1			1	x	1									4
Ictalurus lacustris, Channel catfish	3	3	2					1								1				10
Ameiurus nebulosus Brown bullhead	1								3											4
Fundulus diaphanus Barred Killifish				4	4	2	1		2		3				4		5			25
Fundulus heteroclitus Mud Minnow					1		1				1	2	1		51	2	6			65
Strongylura marinus Needlefish																	1			1
Trinectes maculatus Hogchoker		1					1		10		1									13
Menidia beryllina Silverside	41	68	67	224	80	108	257	107	302	x	56	29			88	5	136	42		1610
Boleosoma nigrum Johnny darter		1															2			3
Leopomis gibbosus Pumpkinseed																1				2

TABLE 9 (Con't)

SPECIES	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	208	No. of Fish
Morone americana, White perch	3	1	8	13	9	17	175	31	17		8	2			9		11			304
Roccus saxatilis, Striped bass or rock			1		1						1									3
Number of hauls	4	5	6	3	4	4	3	4	3	-	3	3	2	2	2	2	3	1	2	56
Distance hauled (feet)	800	500	1200	600	400	400	400	400	300	-	500	600	400	200	200	100	400	100	200	7700
Number of fish	68	173	191	243	162	147	458	150	343	-	72	36	1	0	155	9	172	42	16	2438
Number of species	8	8	7	5	7	9	6	5	8	4	8	5	1	0	6	4	8	1	1	19
Fish per haul	19	35	33	83	42	37	155	38	114	-	27	12	0.5	0	78	4	57	42	8	43
Fish per 100-foot haul	8.5	34.6	15.9	40.5	40.5	36.8	114.5	37.5	114.3	-	14.4	6	0.25	0	77.5	4	43	42	8	32

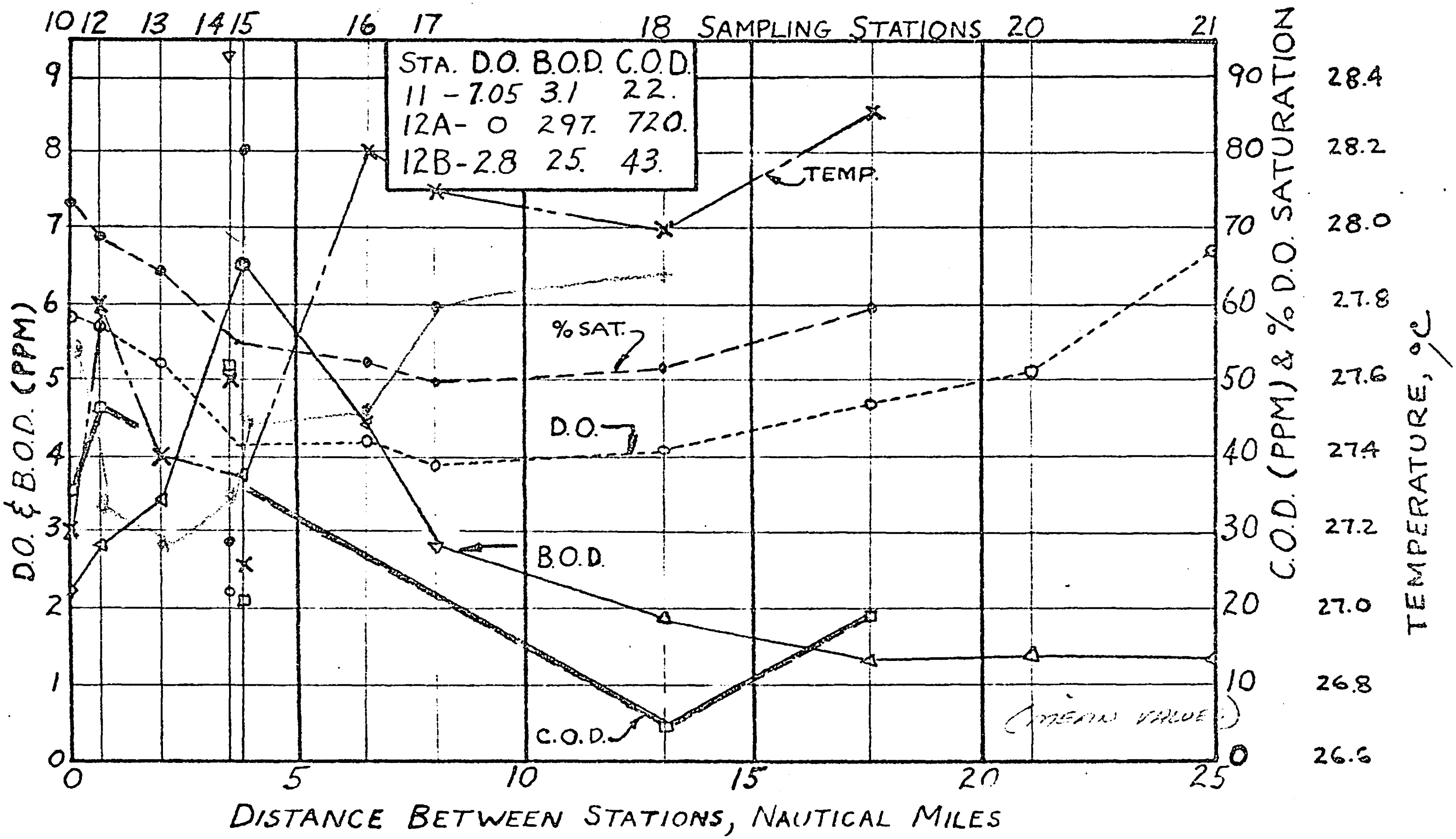

FIGURE 5

LOWER JAMES RIVER POLLUTION STUDY

AVERAGE RESULTS OF LABORATORY ANALYSES

VARIATION OF D.O., B.O.D., & C.O.D. AT STATIONS

1951 VARIATION OF ...

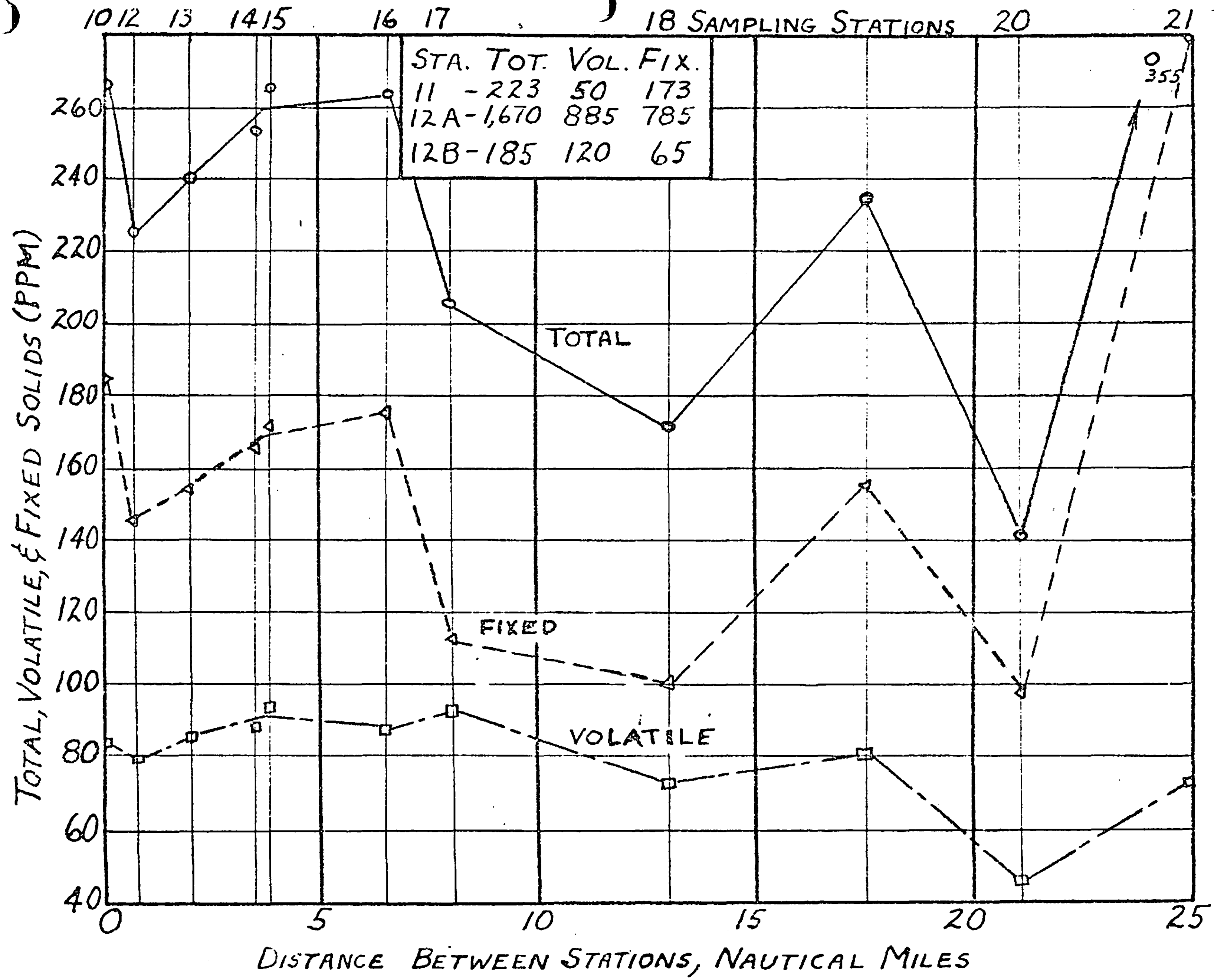

FIGURE 6
LOWER JAMES RIVER POLLUTION STUDY
AVERAGE RESULTS OF LABORATORY ANALYSES
VARIATION OF TOTAL SOLIDS AT STATIONS

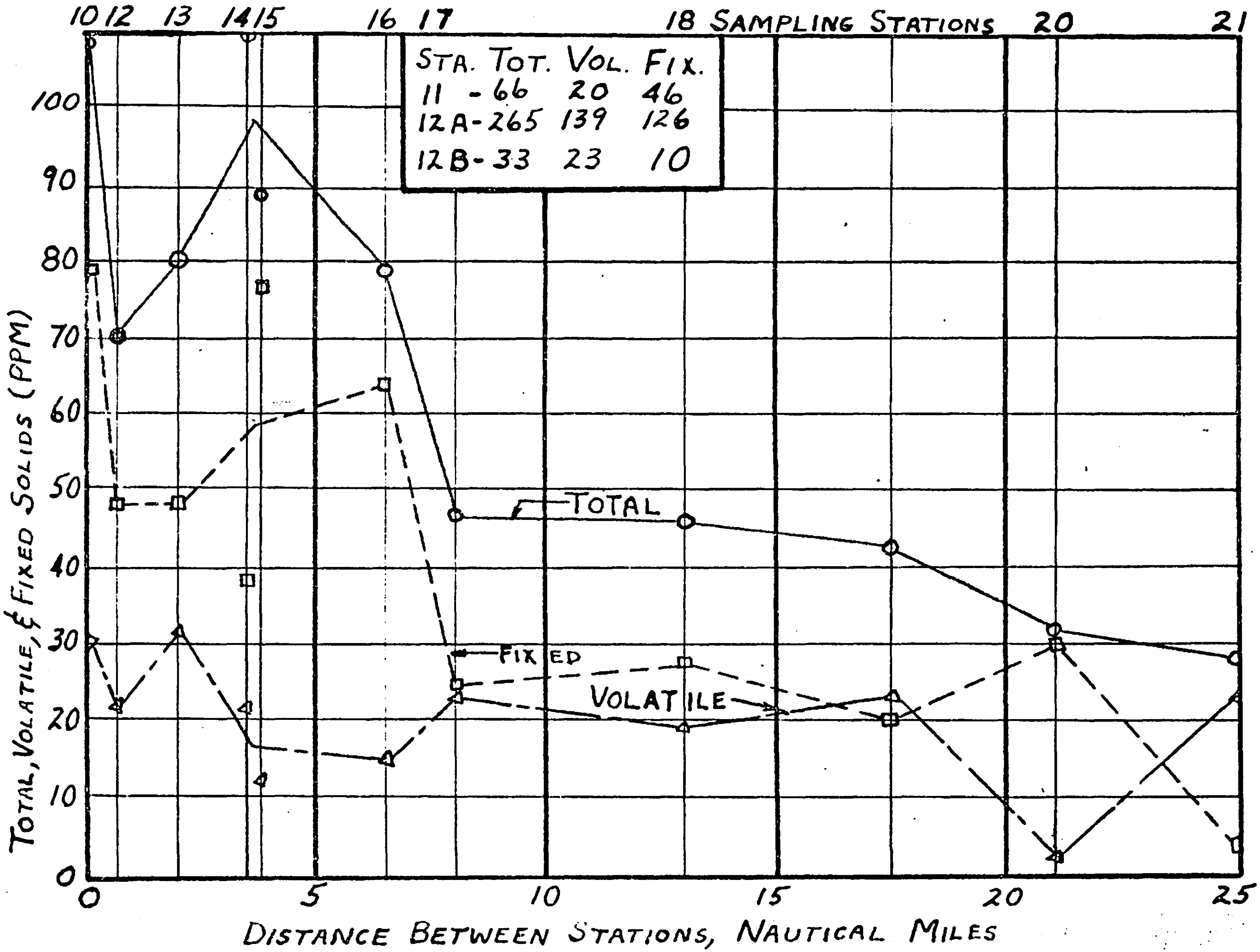

FIGURE 7
LOWER JAMES RIVER POLLUTION STUDY
AVERAGE RESULTS OF LABORATORY ANALYSES
VARIATION OF SUSPENDED SOLIDS AT STATIONS

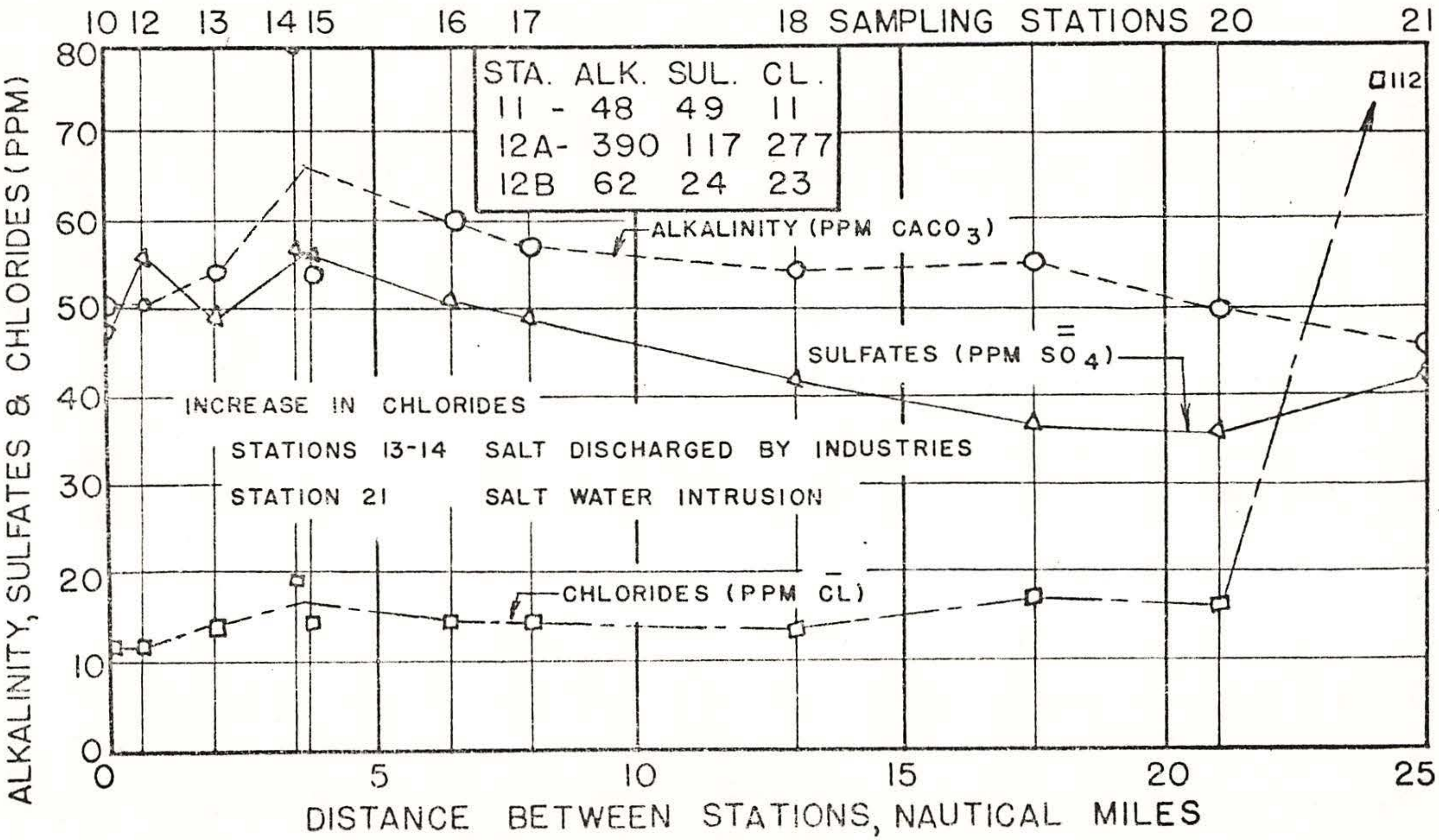

FIGURE 8

LOWER JAMES RIVER POLLUTION STUDY
AVERAGE RESULTS OF LABORATORY ANALYSES

VARIATION OF ALKALINITY, SULFATES & CHLORIDES BETWEEN STATIONS

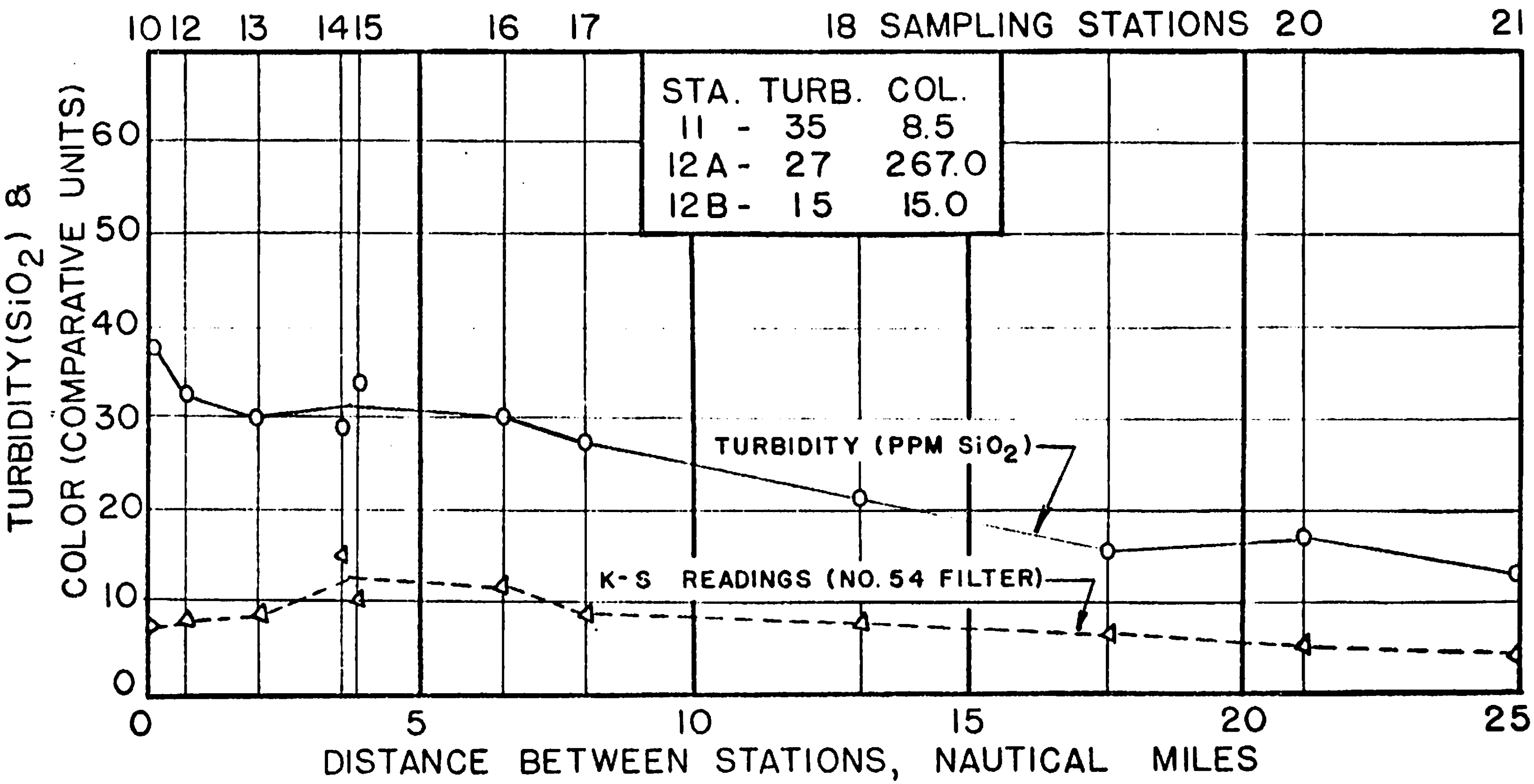

FIGURE 9
LOWER JAMES RIVER POLLUTION STUDY
AVERAGE RESULTS OF LABORATORY ANALYSES
VARIATION OF TURBIDITY & COLOR BETWEEN STATIONS

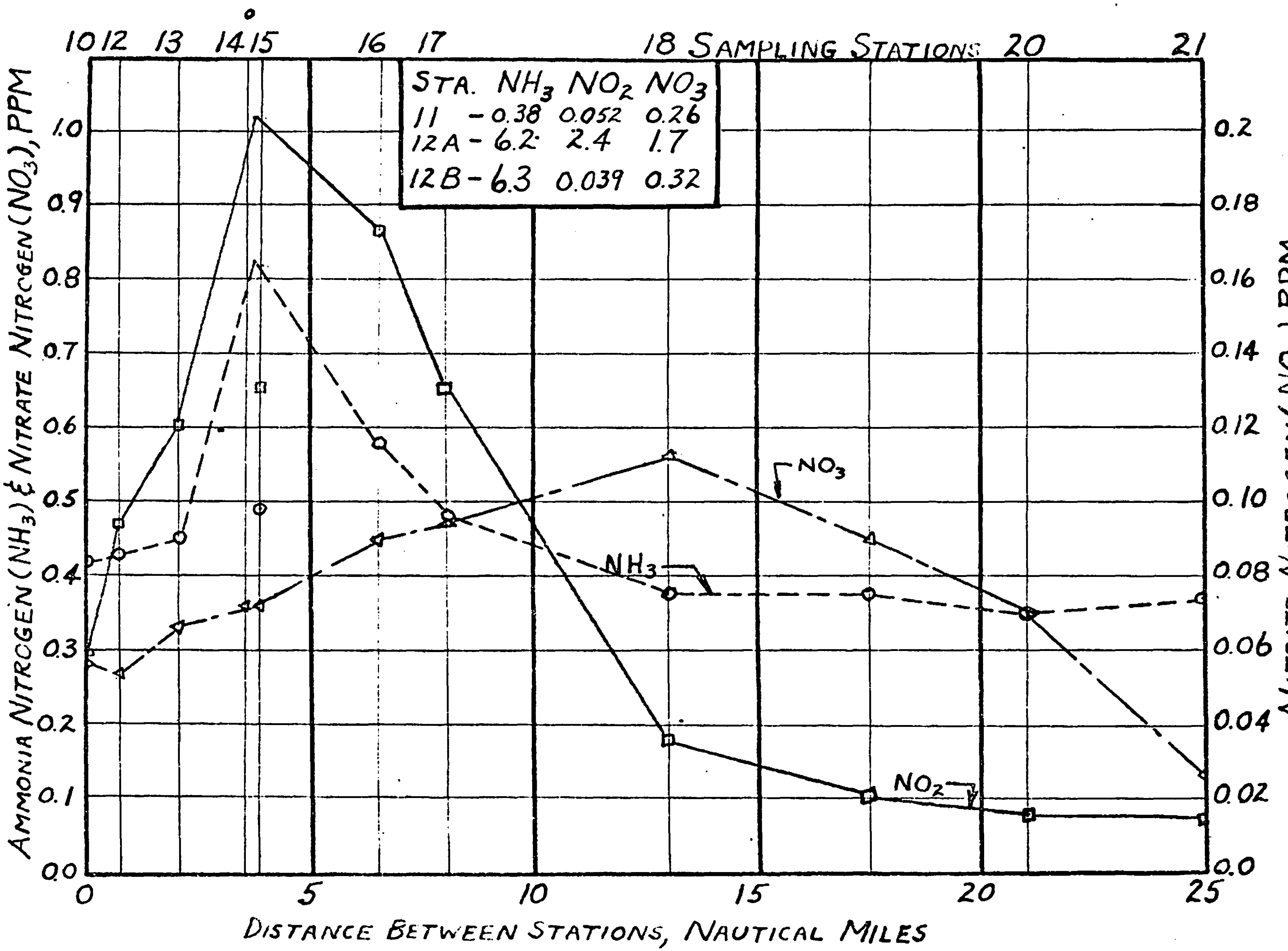

FIGURE 10

LOWER JAMES RIVER POLLUTION STUDY

AVERAGE RESULTS OF LABORATORY ANALYSES

VARIATION OF NH_3, NO_2 & NO_3 AT STATIONS

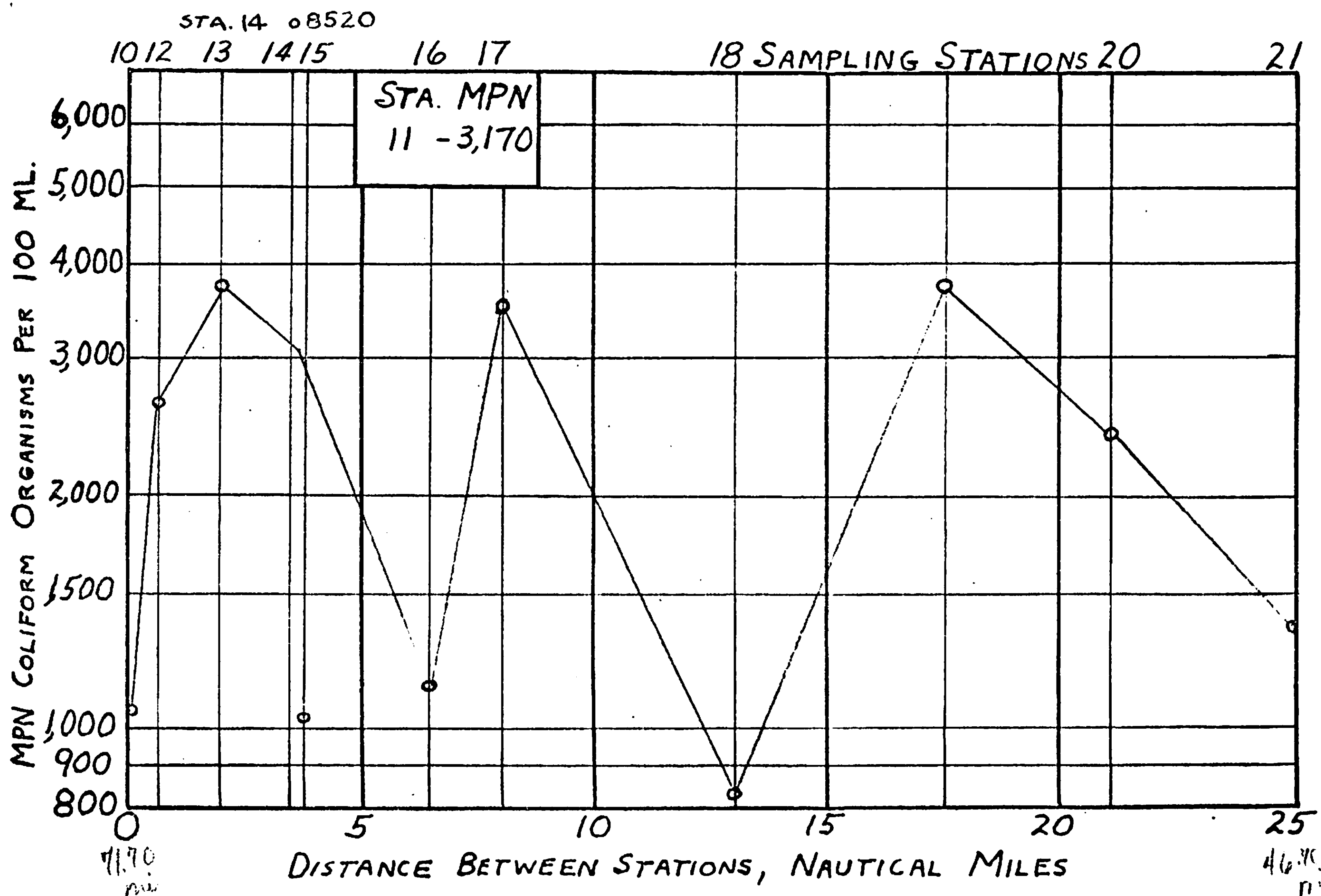

FIGURE 11
LOWER JAMES RIVER POLLUTION STUDY
AVERAGE RESULTS OF LABORATORY ANALYSES
VARIATION OF COLIFORM ORGANISMS AT STATIONS

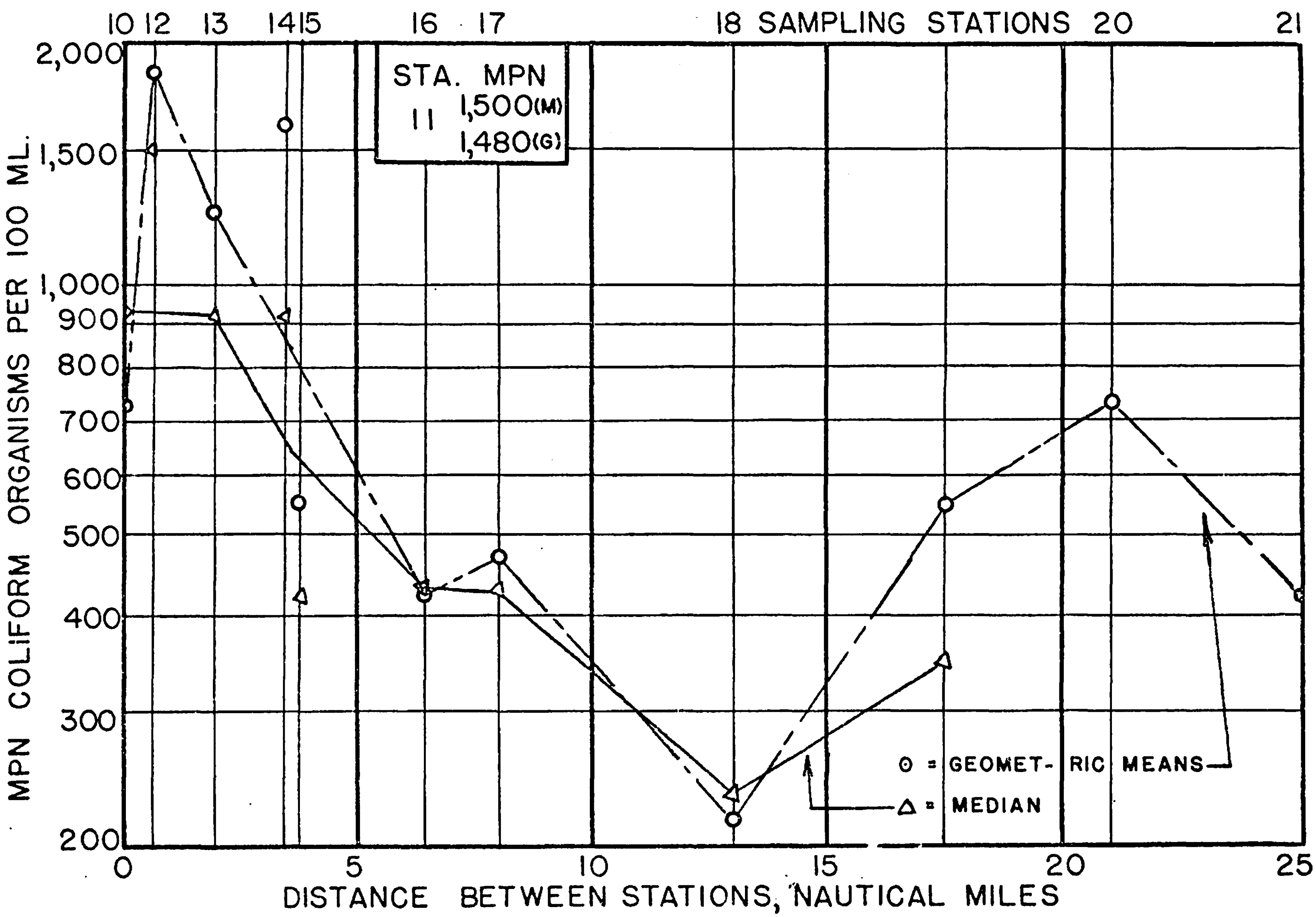

FIGURE 12

LOWER JAMES RIVER POLLUTION STUDY

AVERAGE RESULTS OF LABORATORY ANALYSES

VARIATION OF COLIFORM ORGANISMS BETWEEN STATIONS

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 10

TABLE 10
Page 31

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	6.0	5.6	5.6	6.2	5.6	5.3	6.0	5.2	6.4	6.2	5.8	64.0	5.8	6.4	5.2
Alk. ppm $CaCO_3$	48	42	46	47	48	56	48	52	52	57	56	562	51	56	42
pH	7.4	7.65	7.8	7.5	7.55	7.8	7.85	7.8	7.7	8.3	8.1			7.85	7.4
B.O.D. ppm	2.73	3.6	3.2	1.6	2.5	2.8	0.25*	0.73*	2.7	2.3	3.0	24.4	2.2	3.6	0.25
Total - Total	171	79	289	263	415	(	381	)	(	270	)	1868	267	415	79
Solids - Volatile	61	18	16	106	0	)	273	(	)	105	(	579	83	273	0
ppm - Fixed	110	61	273	157	415	(	108	)	(	165	)	1289	184	415	61
Suspended - Total	49	41	134	119	283	(	46	)	(	90	)	762	109	283	41
Solids - Volatile	44	16	32	85	0	)	10	(	)	21	(	208	30	85	0
ppm - Fixed	5	25	102	84	283	(	286	)	(	69	)	554	79	283	5
Sulfates (SO_4 ppm)	49	53	40	48	126	59	49	78	70	50	43	523	48	126	40
Chlorides (Cl ppm)	11	10	11	10	14	13	11	11	13	13	13	131	12	14	10
Turbidity (SiO_2 ppm)		34	41	50	80	32	29	10	28	48	28	380	38	80	10
Color K-S Reading No. 54 Filter	-	-	8	7	8	7	6	6	7	7	6	62	7	8	6
NH_3 Nitrogen ppm		0.4	0.5	0.45	0.17	0.224	0.7	0.224	0.504	0.616	0.392	4.18	0.42	0.7	0.17
NO_2 Nitrogen ppm		0.028	0.32	0.067	0.028	0.9	0.4	0.03	0.084	0.086	0.106	0.591	0.059	0.09	0.028
NO_3 Nitrogen ppm		0.14	0.25	0.37	0.58	0.288	0.256	0.208	0.240	0.256	0.256	2.84	0.284	0.58	0.14
C.O.D. ppm			41			33			32			106	35	41	32
Temperature °C.	23°	28°	29°	30°	29.5°	27°	26°	26°	28°	27°	26°			30°	23°
Time 0 to 2300	10:00	10:20	10:30	10:30	10:15	11:40	9:30	9:00	10:00	8:15	8;25				
MPN Coliform per 100 cc.	2300	930	930	430	2400	230	430	91	430	1500	2400	12071	1100	2400	91
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1)
(2), (3), (4), (5) Muddy, but no apparent color from waste. No scum or sludge observed.
(6) Very muddy but no apparent color from waste. Much sludge and bark observed in this area.
(7) Slightly muddy but no apparent color from waste. Some trash noted.
(8), (9), (11) Slightly muddy but no apparent color from waste. No bark, sludge, scum or trash noted.
(10) Muddy but no apparent color from waste. Some scum and trash on surface. No sludge or bark noted.

*Questionable

[illegible] OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 11

[illegible] 11
[illegible] 3[illegible]

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	7.2	6.8	6.5	6.8	6.4	8.2	7.6	7.8	8.0	6.6	5.7	77.6	7.05	8.2	6.4
Alk. ppm $CaCO_3$	36	42	50	45	40	45	49	45	59	65	49	525	48	65	36
pH	7.2	7.65	7.6	7.2	7.4	7.5	7.7	7.35	7.6	8.2	8.1			8.2	72
B.O.D. ppm	3.84	3.9	3.1	1.2	1.8	4.6	4.6	2.5	3.8	2.9	2.4	34.6	3.1	3.9	1.2
Total Solids ppm - Total	180	175	318	193	287	(	153	)	(	254	)	1560	223	318	153
Total Solids ppm - Volatile	29	84	124	5	43	)	10	(	)	58	(	353	50	124	5
Total Solids ppm - Fixed	151	91	191	188	244	(	143	)	(	196	)	1204	173	244	91
Suspended Solids ppm - Total	50	40	59	75	115	(	44	)	(	75	)	458	66	115	40
Suspended Solids ppm - Volatile	5	0	49	30	19	)	16	(	)	19	(	138	20	49	0
Suspended Solids ppm - Fixed	45	40	10	45	96	(	28	)	(	56	)	320	46	96	10
Sulfates (SO_4 ppm)	36	41	61	58	70	31	38	53	61	47	45	541	49	70	31
Chlorides (Cl ppm)	7	9	15	10	13	7	9	12	12	12	13	119	11	15	7
Turbidity (SiO_2 ppm)	[illegible]	65	30	35	45	38	25	10	22	48	32	350	35	65	10
Color-K-S Reading #54 Filter			9	8	7	11	8	8	8	9	8	76	8.5	11	7
NH_3 Nitrogen ppm		0.45	0.40	0.50	0.17	0	0.50	0.280	0.504	0.56	0.448	3.81	0.35	0.56	0
NO_2 Nitrogen ppm		0.024	0.056	0.07	0.003	0.01	0.03	0.09	0.099	0.046	0.062	0.517	0.052	0.099	0.01
NO_3 Nitrogen ppm		0.14	0.30	0.40	0.26	0.224	0.288	0.288	0.256	0.224	0.24	2.62	0.26	0.4	0.14
C.O.D. ppm				17			16			32		65	22	32	16
Temperature $^{o}C.$	28°	30°	31°	30.5°	30°	25.5°	26°	27°	29°		27°			30.5°	25.5°
Time(0 to 2300)	16:10	17:45	18:10	16:40	15:30	18:20	16:10	15:35	16:40	14:30	14:45				
MPN Coliform per 100 cc	360	9300	280	4600	930	1500	4600	430	430	11000	1500	34930	3170	11000	280
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1), (2), (3) --

(4) Scum noted on surface of water.

(5), (6), (7), (8), (9), (10) Water clear. No obvious scum or trash.

(11) --

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 12

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	6.1	5.9	5.6	6.2	5.9	3.8	5.8	5.5	6.4	6.2	5.2	62.6	5.7	6.4	3.8
Alk. ppm $CaCO_3$		44	44	46	44	61	54	48	51	61	5.7	510	51	61	44
pH	B	7.65	7.5	7.35	7.3	7.45	7.55	7.55	7.6	8.0	8.1			8.1	7.3
B.O.D. ppm		3.3	2.3	0.9	1.0	6.9	Unsat.	Unsat.	1.7	2.6	2.5	22.2	2.8	6.9	0.9
Total Solids ppm - Total	R	207	303	314	151	(	194	)	(	181	)	1350	225	314	151
Total Solids ppm - Volatile		28	174	118	51	)	29	(	)	72	(	472	79	174	28
Total Solids ppm - Fixed	O	179	129	196	100	(	165	)	(	109	)	878	146	196	100
Suspended Solids ppm - Total		48	79	77	122	(	0	)	(	94	)	420	70	122	0
Suspended Solids ppm - Volatile	K	40	20	7	49	)	0	(	)	18	(	134	22	49	0
Suspended Solids ppm - Fixed		8	59	70	73	(	0	)	(	76	)	286	48	76	0
Sulfates (SO_4 ppm)	E	56	61	46	66	58	48	51	70	50	56	562	56	70	46
Chlorides (Cl ppm)		11	12	11	15	14	11	11	12	13	14	124	12	15	11
Turbidity (SiO_2 ppm)	N	65	50	35	35	20	33	6	28	36	22	330	33	65	6
Color-K-S Reading #54 Filter			9	8	10	9	6	8	8	9	7	74	8	10	6
NH_3 Nitrogen ppm		0.35	0.40	0.56	0.11	0.392	0.3	0.28	0.504	0.78	0.616	4.29	0.43	0.78	0.11
NO_2 Nitrogen ppm		0.03	0.034	0.027	0.04	0.24	0.08	0.06	0.116	0.128	0.188	0.94	0.094	0.24	0.027
NO_3 Nitrogen ppm		0.16	0.25	0.33	0.29	0.304	0.320	0.256	0.256	0.256	0.27	2.69	0.27	0.33	0.16
C.O.D. ppm					67						24	91	46	67	24
Temperature °C.		29.5°	29°	30°	29°	27°	26°	26°	27°	28°	26°			30°	26°
Time (0 to 2300)	10:15	10:30	10:45	10:10	10:25	11:55	9:45	9:10	10:25	8:30	8:35				
MPN Coliform per 100 cc	3900	4300	1400	430	930	730	11000	2400	1500	1200	2400	30190	2740	11000	430
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1) --

(2) Sludge, Scum & Bark noted to be more abundant in area between Station 10 and 12 than at Station 12

(3) Bark on surface of slightly muddy water.

(4) Scum on surface or trash noted.

(5), (7), (8), (9), (10) No scum, sludge or trash noted.

(6) Water has unusual dirty appearance with much sludge and bark with an occasional dead fish.

(11) Trash and bark noted but no signs of sludge or scum.

TABLE 13
RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 12A

Date	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	0	0	0	0	0	0.3	0	0	0	0	0	0.3	0
Alk. ppm $CaCO_3$	267	408	312	422	318	168	540	472	504	3411	390	422	168
pH	8.4	9.65	9.6	9.25	8.9	8.3	10.0	8.6	9.2			10.0	84
.O.D. ppm	201	410	360	282	220	92	390	410	300	2665	297	410	92
Total Solids ppm - Total	991	2105	1658	(	1288	)	(	2300	)	8342	1670	2300	991
Total Solids ppm - Volatile	364	1001	1592	)	496	(	)	972	(	4425	885	1592	364
Total Solids ppm - Fixed	627	1104	66	(	792	)	(	1328	)	3917	785	1328	66
Suspended Solids ppm - Total	97	145	252	(	108	)	(	726	)	1328	265	726	97
Suspended Solids ppm - Volatile	38	126	173	)	79	(	)	276	(	692	139	276	38
Suspended Solids ppm - Fixed	59	19	79	(	29	)	(	450	)	636	126	450	29
Sulfates (SO_4 ppm)	80	143	14	122	115	80	172	161	162	1049	117	172	14
Chlorides (Cl ppm)	198	355	300	380	323	83	295	273	290	2497	277	380	83
Turbidity ($SiSO_2$ ppm)	10	5	10	4	7	6	4	190	8	244	27	190	4
Color K-S Readings #54 Filter	180	445	262	236	264	83	375	276	280	2401	267	445	83
NH_3 Nitrogen ppm	2.4	7.2	6.3	4.8	6.2	8.4	7.6	3.6	9.2	55.7	6.2	9.2	24
NO_2 Nitrogen ppm	0.85	0.02	Unsat.	1.6	0.03	9.6	Unsat.	Unsat.	Unsat.	12.1	2.4	9.6	0.02
NO_3 Nitrogen ppm	1.0	1.4	Unsat	1.7	1.36	3.2	1.52	Unsat.	Unsat.	10.18	1.7	3.2	1.0
C.O.D. ppm	412	926	700	735	588	242	896	1156	839	6494	720	1150	242
Temperature °C.	35	31.5	32.3	27.4	27.4	31.2	30.4	28.7	27.6			35	27.4
Time (0 to 2300)	14:00	11:00	12:30	12:30	12:00	12:15	11:55	11:35	11:55				

Analytical Data on Duplicate Samples By Hercules

	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	nil	nil	nil	nil	nil	0.3	nil	nil	nil		nil	0.3	nil
Alk. ppm $CaCO_3$	261	417	323	429	337	187	585	466	500		389	585	187
B.O.D. ppm	-	-	-	-	-		-	-	317				
C.O.D. ppm	425	1042	794	825	660	220	979	1286	878		790	1286	220
Temperature, °C.	35	31.5	32.3	26.0	27.4	31.2	30.4	28.7	27.6		29.9	35.0	26.0
Time (0 to 2300)	14:00	11:00	12:30	12:30	12:00	12:15	11:55	11:35	11:55		-	-	-

TABLE 14
RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6 - September 6, 1951
STATION 12B

Date	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	3.9	2.5	2.0	3.1	2.3	3.1	2.3	0.8	0.3	8.4	2.3	3.9	0.3
Alk. ppm $CaCO_3$	46	63	57	51	58	64	62	78	79	558	62	64	46
pH	7.5	7.3	7.1	7.2	7.3	7.65	7.5	8.0	8.0			8.0	7.1
B.O.D. ppm	8.0	Unsat.	8.6	17.4	28	28	35	40	33	198	25	40	8.0
Total - Total		228	151	(	164	)	(	195	)	738	185	228	151
Solids - Volatile		198	142	)	54	(	)	85	(	479	120	198	54
ppm - Fixed		30	9	(	110	)	(	110	)	259	65	110	9
Suspended - Total	40	39	29	(	35	)	(	24	)	167	33	40	24
Solids - Volatile	40	22	24	)	15	(	)	14	(	115	23	40	14
ppm -Fixed	0	17	5	(	20	)	(	10	)	52	10	20	0
Sulfates (SO_4 ppm)	12	54	49	18	29	8	10	8	Unsat.	188	24	54	8
Chlorides (Cl ppm)	17	17	30	23	20	19	19	40	21	206	23	40	17
Turbidity ($SiSO_2$ ppm)	15	14	33	4	29	10	12	10	8	135	15	33	4
Color K-S Readings #54 Filter	10	12	23	10	13	12	16	19	17	132	15	23	10
NH_3 Nitrogen ppm	4.8	6.0	4.9	5.2	5.0	5.6	7.6	7.6	9.8	56.5	6.3	9.8	4.8
NO_2 Nitrogen ppm	0.01	0.01	0.06	0.09	0.08	0.04	0.022	0.019	0.019	0.35	0.039	0.09	0.01
NO_3 Nitrogen ppm	0.15	0.37	0.3	0.3	0.288	0.704	0.272	0.256	0.224	2.86	0.32	0.704	0.15
C.O.D. ppm	-	34		-	41	40	48	50	55	268	44.7	55	34
Temperature °C.	24	24	24	[illegible]	21	21.7	23.2	20.9	20.4			24	20
Time (0 to 2300)	14:00	11:00	12:00	10:30	10:40	10:30	10:30	10:20	10:30				
Analytical Data on Duplicate Samples By Hercules													
D.O. ppm	3.9	2.5	2.0	3.1	2.3	3.1	2.3	0.8	0.3		2.3	3.9	0.3
Alk., ppm $CaCO_3$	57	64	63	54	54	52	57	75	84		62	84	52
B.O.D. ppm	-	-	-	-	-	-	-	-	31				
C.O.D. ppm	38	71	68	59	76	52	64	85	94		67	94	38
Temperature °C.	24	24	24	20	21	21.7	23.2	20.9	20.4		22.6	24	20
Time (0 to 2300)	14:00	11:00	12:00	10:30	10:40	10:30	10:30	10:20	10:30				

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 13

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	5.2	5.2	6.1	5.9	6.0	3.2	5.0	4.8	6.6	4.6	4.4	57.0	5.2	6.1	3.2
Alk. ppm $CaCO_3$	52	50	47	47	48	62	64	50	53	62	61	596	54	64	47
pH	7.2	7.7	7.4	7.2	7.5	7.55	8.2	7.55	7.5	7.8	8.1			8.2	7.2
B.O.D. ppm	4.5	3.0	4.0	0.8	4.9	9.8	0.4*	1.6	1.6	2.3	3.7	36.6	3.4	9.8	0.4
Total Solids ppm - Total	280	234	209	222	230	(	235	)	(	266	)	1676	240	280	209
Total Solids ppm - Volatile	108	33	125	48	89	)	105	(	)	86	(	594	85	125	33
Total Solids ppm - Fixed	172	201	84	174	141	(	130	)	(	180	)	1082	155	201	84
Suspended Solids ppm - Total	30	49	33	195	78	(	52	)	(	76	)	480	80	195	30
Suspended Solids ppm - Volatile	6	17		124	12	)	15	(	)	16	(	190	32	124	6
Suspended Solids ppm - Fixed	24	32		71	66	(	37	)	(	60	)	290	48	71	24
Sulfates (SO_4 ppm)	50	62	54	13	61	46	43	46	66	51	40	539	49	66	13
Chlorides (Cl ppm)	12	11	11	11	18	24	12	12	12	14	15	152	14	24	11
Turbidity (SiO_2 ppm)		30	30	46	35	21	29	16	28	29	40	304	30	46	16
Color-K-S Reading #54 Filter			10	8	10	9	7	9	8	10	8	79	9	10	7
NH_3 Nitrogen ppm		0.45	0.60	0.34	0.224	0.392	0.30	0.280	0.56	0.784	0.616	4.54	0.45	.784	.224
NO_2 Nitrogen ppm		0.08	0.04	0.05	0.07	0.14	0.14	0.12	0.105	0.183	0.24	1.17	0.12	0.24	0.04
NO_3 Nitrogen ppm		0.30	0.35	0.45	0.37	0.320	0.320	0.320	0.256	0.304	0.32	3.31	0.33	.45	.30
C.O.D. ppm															
Temperature °C.	23°	29.5°	29°	30°	29°	27°	26°	26°	28°		26°			30°	23°
Time (0 to 2300)	10:30	10:45	10:55	10:50	10:30	12:10	10:00	9:25	10:35	8:50	8:50				
MPN Coliform per 100 cc	910	4300	Above) 11000)	11000	930	73	750	430	930	2400	930	42023	3830	11000	73
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1) --
(2), (3) Bark, sludge, scum and oil noted in area.
(4), (5), (7), (8), (9), (10) No bark, scum, sludge, or oil noted.
(6) Lots of sludge and bark; dead fish noted in area.
(11) Trash and scum noted.

*Questionable

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 14

[illegible]L 16
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Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	3.5	5.6	1.4	0.0	0.8	2.2	2.0	1.8	1.2	3.0	3.0	24.5	2.2	5.6	0
Alk. ppm Ca CO_3	64	64	100	108	84	67	75	76	88	77	71	874	80	108	64
pH	7.2	8.1	8.0	7.4	7.7	7.45	8.0	7.85	7.7	8.1	8.1			8.1	7.2
B.O.D. ppm	4.9	6.0	17	13	12	8.0	8.3	11	11.4	5.8	4.4	101.9	9.3	17	4.4
Total - Total	279	204	128	277	387	(	213	)	(	284	)	1772	254	387	128
Solids - Volatile	53	82	12	113	129	)	111	(	)	112	(	612	88	129	12
ppm - Fixed	226	122	116	164	258	(	102	)	(	172	)	1160	166	258	102
Suspended - Total	36	66	12	76	56	(	43	)	(	122	)	798	114	122	12
Solids - Volatile	1	7	0	76	20	)	19	(	)	23	(	146	21	76	0
ppm - Fixed	35	59	12	0	36	(	24	)	(	99	)	265	38	99	0
Sulfates (SO_4 ppm)	59	66	52	55	58	49	50	59	67	51	57	623	57	67	49
Chlorides (Cl ppm)	13	15	28	30	25	6	17	19	23	17	17	210	19	30	6
Turbidity (SiO_2 ppm)		30	11	11	25	25	12	16	40	24	98	292	29	98	11
Color-K-S Reading #54 Filter			21	23	21	11	11	12	18	12	10	139	15	23	10
NH_3 Nitrogen ppm		0.9	1.8	1.9	1.1	0.616	1.3	1.3	1.34	0.95	0.896	12.1	1.21	1.9	0.62
NO_2 Nitrogen ppm		0.2	0.12	0.1	0.12	0.14	0.4	1.1	0.21	0.261	0.255	2.80	0.28	0.4	0.012
NO_3 Nitrogen ppm		0.3	0.2	0.3	0.45	0.368	0.496	0.320	0.448	0.384	0.32	3.60	0.36	0.496	0.2
C.O.D. ppm			74		50	41	41	40	56	63	48	413	52	74	40
Temperature °C.	23°	31.5°	31°	31°	29°	27°	25°	26°	27°		25°			31.5°	23°
Time (0 to 2300)	10:40	11:00	11:15	11:15	10:45	12:35	10:40	10:00	11:15	9:00	9:15				
MPN Coliform per 100 cc	24000	7500	2400	Above 11000	46000	430	430	750	930	150	73	93663	8520	46000	73
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1) --

(2) Bark and Sludge more noticeable between Stations 13 and 14 than at Station 14. Water dark.

(3), (4), (5) Scum, bark, sludge and oil noted in area. Water dark.

(6) Scum and trash noted in area. Water dark with a heavy oil film on the surface approaching or at Stat. 14.

(7) No scum, bark, sludge or oil noted, approaching or at Stat. 14. Water dark.

(8) Scum and trash noted. Water dark. Water clear of foreign matter approaching Station 14.

(9), (10) Scum, trash and sludge noted. Water clear of foreign matter approaching Station 14. Water dark.

(11) Scum, trash and sludge noted approaching Station 14 as well as at Station 14. Water dark.

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 15

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	9.2	7.8	6.0	6.8	7.4	5.6	4.6	4.4	7.4	6.2	5.6	71	6.5	9.2	4.4
Alk. ppm $CaCO_3$	46	50	50	48	50	57	61	54	58	62	60	596	54	61	46
B.O.D. ppm	4.9	5.4	2.3	5.6	5.8	4.5	3.1	2.9	3.4	2.7	1.6	42.2	3.8	5.8	1.6
pH	7.2	8.0	7.4	7.5	7.6	7.45	7.8	7.7	7.6	7.9	8.1			8.1	7.2
Total Solids ppm - Total	250	238	245	295	320	(	197	)	(	310	)	1855	265	320	197
Total Solids ppm - Volatile	65	88	47	62	94	)(	73	)(	)(	218	)(	647	93	218	47
Total Solids ppm - Fixed	185	150	198	233	226	(	124	)	(	92	)	1208	172	233	92
Suspended Solids ppm - Total	101	60	127	168	99	(	91	)	(	78	)	624	89	127	60
Suspended Solids ppm - Volatile	26	9	9	0	7	)(	13	)(	)(	18	)(	82	12	26	0
Suspended Solids ppm - Fixed	75	51	118	68	92	(	78	)	(	60	)	542	77	118	51
Sulfates (SO_4 ppm)	59	61	75	57	57	48	44	56	63	48	48	616	56	63	44
Chlorides (Cl ppm)	10	12	12	12	16	14	13	14	14	14	24	155	14	24	10
Turbidity (SiO_2 ppm)		39	60	47	38	24	25	28	35	32	8	336	34	60	8
Color K-S Reading #54 Filter			11	10	10	9	9	9	11	11	14	94	10	14	9
NH_3 Nitrogen ppm		0.45	0.40	0.50	0.168	0.224	1.0	0.448	0.504	0.504	0.672	4.87	0.49	1.0	0.168
NO_2 Nitrogen ppm		0.056	0.06	0.08	0.05	0.12	0.1	0.2	0.233	0.183	0.194	1.28	0.13	0.233	0.05
NO_3 Nitrogen ppm		0.30	0.40	0.66	0.30	0.288	0.320	0.368	0.40	0.304	0.304	3.64	0.36	0.66	0.288
C.O.D. ppm			25		17									25	17
Temperature °C.	23°	30.5°	30°	30°	29°	25°	25°	25°	28°		25°			30.5°	23°
Time (0 to 2300)	10:55	11:15	11:25	11:00	11:00	12:50	10:25	10:10	10:55	9:10	9:05				
MPN Coliform per 100 cc	4600	910	2300	430	1400	430	280	430	36	430	430	11676	1060	4600	36
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1) --
(2) Sludge noted in area. Water muddy.
(3) Much bark and an occasional sludge deposit noted. Water muddy.
(4) No bark, sludge, scum or trash noted. Water muddy.
(5) Lots of wood chips noted approaching Station 15. Scum noted in area. Water muddy.
(6) (8) No bark, wood chips, sludge, trash, or scum noted.
(7) Bark, wood chips and trash more abundant approaching Station 15 than at Station 15.
(9) (11 Bark and trash noted in area.
(10) Bark and scum noted in area.

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 16

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	6.3	4.2	6.0	4.4	3.6	4.0	3.0	3.2	4.6	3.2	4.0	46.5	4.2	6.3	3.0
Alk. ppm $CaCO_3$	52	48	58	57	60	59	64	60	64	70	63	655	60	70	48
pH	7.4	8.0	7.9	7.7	7.8	7.45	7.7	7.65	7.6	7.9	8.1			8.1	7.4
B.O.D. ppm	4.9	4.1	3.2	6.1	5.2	2.9	5.8	3.1	4.5	4.8	3.4	48.0	4.4	6.1	2.9
Total - Total	335	200	203	264	269	(	278	)	(	297	)	1846	264	335	200
Solids - Volatile	36	153	48	105	114	)(	76	)(	)(	85	)(	617	88	153	36
ppm - Fixed	299	47	155	159	155	(	202	)	(	212	)	1229	176	299	47
Suspended - Total	111	86	29	51	123	(	53	)	(	100	)	553	79	123	29
Solids - Volatile	0	57	0	5	17	)(	12	)(	)(	17	)(	108	15	57	0
ppm - Fixed	111	29	29	46	106	(	41	)	(	83	)	445	64	111	29
Sulfates (SO_4 ppm)	81	54	44	50	60	43	41	46	53	50	41	563	51	81	41
Chlorides (Cl ppm)	12	13	14	12	19	13	13	14	16	15	15	156	14	19	12
Turbidity (SiO_2 ppm)		38	22	40	32	18	16	29	30	61	36	322	32	61	16
Color K-S Readings #54 Filter			10	10	12	9	7	8	12	12	9	89	10	12	7
NH_3 Nitrogen ppm		1.4	0.5	0.45	0.34	0.200	0.6	0.336	0.56	0.672	0.672	5.[illegible]	0.56	1.4	0.28
NO_2 Nitrogen ppm		0.14	0.1	0.1	0.18	0.10	0.16	0.2	0.283	0.238	0.227	1.73	0.173	0.283	0.10
NO_3 Nitrogen ppm		0.5	0.5	0.8	0.38	0.368	0.4	0.416	0.40	0.416	0.32	4.52	0.452	0.8	0.32
C.O.D. ppm															
Temperature °C.	30.5°	30°	31°	30°	29°	25°	25.5°	26°	29°		26°			31°	25°
Time (0 to 2300)	11:40	12:00	12:00	11:10	11:30	13:30	11:30	10:50	12:20	9:45	9:50				
MPN Coliform Per 100 cc	4600	4300	930	140	430	230	2400	36	73	73	930	14142	1285	4600	36
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1) --

(2) Sludge and bark more abundant between Station 14 and 16 than at Station 16.

(3) Section of dark water noted in main channel approaching Station 16. Sludge and bark noted in dark area. Station 16 area clear.

(4) Scum and sludge noted in sub-channel approaching Station 16. Dark water. Station 16 area clean.

(5), (6), (8) No scum, sludge, bark or trash noted.

(7), (11) Trash and scum noted in area.

(9) Trash noted. Dark sections in sub-channel noted approaching Station 16.

(1) Scum, trash, bark oil and sludge noted in sub-channel approaching Station 16 and at Sta. 16.

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 17

[illegible]L 19
P[illegible]ge 40

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	4.8	3.0	3.7	3.8	3.7	4.2	3.6	3.8	4.2	3.8	3.7	42.3	3.9	4.8	3.0
Alk. ppm $CaCO_3$	48	52	57	55	54	57	61	54	61	66	62	627	57	66	48
pH	7.4	7.8	7.9	7.25	7.4	7.55	7.85	7.45	7.6	7.9	8.3			8.3	7.25
B.O.D. ppm	4.4	3.5	2.2	2.4	3.8	1.3	1.35	2.45	2.0	3.0	3.8	30.2	2.8	4.4	1.3
Total Solids ppm - Total	236	299	187	252	82	(	130		)(	257	)	1443	206	299	82
Total Solids ppm - Volatile	148	125	48	127	82	)	6		()	118	(	654	93	148	6
Total Solids ppm - Fixed	88	174	139	125	0	(	124		)(	139	)	789	113	174	0
Suspended Solids ppm - Total	55	42	34	76	5	)	12		()	104	(	328	47	104	5
Suspended Solids ppm - Volatile	26	32	0	63	5	(	12		)(	23	)	161	23	63	0
Suspended Solids ppm - Fixed	29	10	34	13	0	)	0		()	81	(	167	24	81	0
Sulfates (SO_4 ppm)	60	49	43	47	54	53	39	48	52	42	51	538	49	60	39
Chlorides (Cl ppm)	11	11	13	14	19	15	12	13	14	15	15	152	14	19	11
Turbidity (SiO_2 ppm)		39	27	22	32	18	14	17	17	33	56	275	28	56	14
Color K-S Readings #54 Filter			10	10	11	8	7	8	11	11	9	85	9	11	7
NH_3 Nitrogen ppm		0.40	0.50	0.45	0.34	0.168	1.0	0.224	0.504	0.672	0.56	4.82	0.48	1.0	0.168
NO_2 Nitrogen ppm		0.06	0.1	0.1	0.18	0.08	0.13	0.06	0.195	0.205	0.20	1.31	0.13	0.205	0.06
NO_3 Nitorgen ppm		0.6	0.7	0.69	0.38	0.368	0.384	0.464	0.432	0.352	0.336	4.71	0.47	0.70	0.336
C.O.D. ppm															
Temperature °C.	28°	30.5°	30°	29.5°	29°	25.5°	26°	26°	29°		27°			30.5°	25.5°
Time (0 to 2300)	12:05	12:25	12:45	13:10	12:20	14:00	12:10	11:50	13:00	10:10	10:20				
MPN Coliform Per/100 cc	4600	9300	24000	430	230	910	430	less 30	36	73	140	40179	3660	24000	30
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1)-(8) & (11) No sludge, trash, scum, bark or oil noted in area
(9) Scum noted in area
(10) Scum, trash, bark noted approach Station 16 and at Station 16

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 18

TABLE 20
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Date		8-10	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
DO. ppm		4.4	3.8	4.0	3.0	3.2	4.6	4.4	4.4	5.0	3.8	4.4	45.0	4.1	5.0	3.0
Alk. ppm $CaCO_3$		44	52	51	30	50	55	63	53	58	76	58	590	54	76	30
pH		7.4	7.6	7.8	7.2	7.8	7.4	7.95	7.5	7.6	8.3	8.2			8.3	7.2
B.O.D. ppm		1.9	2.85	1.5	Uunsat	1.8	1.45	0.76	3.2	1.3	2.6	1.7	19.1	1.9	3.2	0.76
Total	Total	104	147	190	182	281	(	201	)(		205	)	1029	172	281	104
Solids	Volatile	86	140	22	73		)	47	()		62	(	430	72	140	22
ppm	Fixed	18	7	168	109		(	154	)(		143	)	599	100	168	7
Suspended-	Total	31	83	2	50	34	)	44	()		76	(	320	46	83	2
Solids	Volatile	2	51	0	41	10	(	12	)(		15	)	131	19	51	0
ppm	Fixed	29	32	2	9	24	)	32	()		61	(	189	27	61	2
Sulfates (SO_4 ppm)		54	49	29	37	48	43	49	41	43	41	28	462	42	54	28
Chlorides (Cl ppm)		10	12	12	12	16	12	13	13	14	14	15	143	13	16	10
Turbidity (SiO_2 ppm)			15	25	15	25	14	16	17	17	36	29	209	21	36	14
Color K-S Readings #54 Filter				8	8	10	6	o	6	10	8	7	69	8	10	6
NH_3 Nitrogen ppm			0.35	0.3	0.45	0.17	0.168	0.7	0.168	0.336	0.56	0.56	3.76	0.38	0.7	0.168
NO_2 Nitrogen ppm			0.02	0.02	0.03	0.07	0.03	0.04	0.04	0.014	0.035	0.062	0.361	0.036	0.07	0.014
NO_3 Nitrogen ppm			0.7	0.6	1.02	0.6	0.364	0.448	0.432	0.4	0.40	0.32	5.28	0.53	1.02	0.32
C.O.D. ppm					0					8			8	4	8	0
Temperature °C		29°	30°	29°	30°		26°	27°	27°	28°		26°			30°	26°
Time (0 to 2300)		12:40	13:00	13:30	13:45	13:00	14:50	12:55	12:30	13:55	10:45	11:00				
MPN Coliform Per/100 cc		4600	360	2100	230	140	430	210	36	36	30 less	910	9082	825	4600	30
Observations		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1),(2) (3),(4),(5),(7),(11) No scum, sludge, bark, trash or oil noted - water looked clear
(6) Scum noted between Station 17 and 18 - Station 18 area clear
(8) Water very rough at Station 18 area
(9) Water covered with green scum - no trash, sludge or bark noted
(10) Trash, scum noted between Stations 17 and 18 and at Station 18

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951
STATION 19

Date	8-10	8-15	8-20	8-21	8-22	8-27	8-28	2-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm	4.8	4.6	4.8	3.6	3.4	5.6	5.0	5.4	5.4	4.4	4.5	51.5	4.7	-5.6	3.4
Alk. ppm $CaCO_3$	48	52	50	52	46	54	62	55	57	76	55	607	55	76	46
pH	7.4	7.7	7.6	7.4	7.4	7.35	7.8	7.45	7.7	8.2	8.0			8.2	7.35
B.O.D. ppm	2.0	2.4	1.5	1.0	1.6	1.61	1.1	0.72	0.9	0.7	0.7	14.2	1.3	2.4	0.7
Total - Total	168	191	165		330	(	287		)(	210	)	1182	237	330	165
Solids - Volatile		71	51		110	(	79		()	89	(	400	80	110	51
ppm - Fixed		120	114		220	(	208		)(	121	)	782	157	220	114
Suspended- Total	62	49	20	66	32	(	25		()	47	(	301	43	66	20
Solids - Volatile	37	49	1	49	9	(	11		)(	7	)	163	23	49	1
ppm - Fixed	25	0	19	17	23	)	14		()	40	(	138	20	40	0
Sulfates (SO_4 ppm)	42	39	34	44	40	39	35	29	44	39	23	408	37	44	23
Chlorides (Cl ppm)	10	12	13	13	20	13	18	18	37	15	16	185	17	37	10
Turbidity (SiO_2 ppm)		16	15	22	21	14	5	4	21	13	22	153	15	22	4
Color K-8 Readings #54 Filter			10	6	8	6	4	5	7	7	5	58	6.5	10	4
NH_3 Nitrogen ppm		0.55	0.35	0.45	0.17	0.168	0.5	0.168	0.336	0.56	0.504	3.76	0.38	0.56	0.168
NO_2 Nitrogen ppm		0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.012	0.014	0.021	0.197	00.02	0.03	0.01
NO_3 Nitrogen ppm		0.6	0.4	0.8	0.6	0.40	0.384	0.368	0.32	0.368	0.288	4.53	0.45	0.8	0.288
C.O.D. ppm			25			168		16		16	24	97	19	25	16
Temperature °C	29°	30°	30°	30°	29.5°	26.5°	27°	27°	28°		26°			30°	26°
Time (0 to 2300)	13:10	13:35	14:10	14:30	13:35	15:35	13:30	13:15	14:40	11:10	11:20				
MPN Coliform Per/100 cc	11000	24000	360	4600	140	930	73	91	36	230	430	41890	3810	11000	36
Observations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)				

(1),(2),(3),(4),(5),(6),(7), (10),(11)	No trash, sludge, scum, bark or oil noted - area clear.
(8)	Water very rough at Station 19 area
(9)	Area about halfway between Stations 18-19 covered with green scum. Station 19 area clear

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

		STATION 20							STATION 21						
Date		8-10	8-15	8-20	9-5	9-6	Total	Avg.	8-10	8-15	8-20	9-5	9-6	Total	Avg.
D.O. ppm		5.2	4.8	5.0	5.4	5.2	25.6	5.1	6.3	6.8	7.6	6.6	6.2	33.5	6.7
Alk. ppm $CaCO_3$		50	50	52			152	50	46	44	50			140	46
pH		7.4	7.8	7.8					7.4	7.8	7.8			7.8	7.4
B.O.D. ppm		1.9	2.3	1.0	0.8	0.8	6.8	1.4	1.4	2.1	0.9	1.2	0.9	6.5	1.3
Total	- Total	143	149	132			424	141	168	361	538			1067	355
Solids	- Volatile	44	83	4			131	45	61	59	100			220	73
ppm	- Fixed	99	66	128			293	98	107	302	438			847	282
Suspended	- Total	23	28	45			96	32	12	64	8			84	28
Solids	- Volatile	5	0	1			6	2	9	60	2			71	23
ppm	- Fixed	18	28	44			90	30	3	4	6			13	4
Sulfates (SO_4 ppm)		40	41	29			110	36	39	47	42			128	43
Chlorides (Clppm)		10	13	27			50	16	14	66	257			337	112
Turbidity ($SiSO_2$ ppm)			12	22			34	17		15	10			25	13
Color K-S Readings #54 Filter				5			5	5			4			4	4
NH_3 Nitrogen ppm			0.4	0.3			0.7	0.35		0.4	0.35			0.75	0.37
NO_2 Nitrogen ppm			0.02	0.01			0.03	0.015			0.02	0.008		0.028	0.014
NO_3 Nitrogen ppm			0.04	0.3			0.7	0.35		0.16	0.1			0.26	0.13
C.O.D. ppm															
Temperature °C		29°	29.5°	30°			30°	29°	20°	30°	30°			30°	29°
Time (0 to 2300)		13:30	14:00	14:45					14:10	14:30	15:30				
MPN Coliforms Per/100 cc		4600	360	4600	36		9596	2400	4600	910	110	73		5693	1420
Observations		(1)	(2)	(3)	(4)	(5)			(1)	(2)	(3)	(4)	(5)		

(1)-(2) No comment
(3),(4) and (5) Water had brackish appearance

TABLE 23
RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
Dissolved Oxygen Data
August 6-September 6, 1951

Station No.	D.O. PPM	Temp. °C.	Time 0-2300	Date 1951	Station No.	D.O. PPM	Temp. °C.	Time 0-2300	Date 1951
1	6.3		12:00	8-17	41	0.2		11:17	8-16
2	7.4		12:08	8-17	42	4.9		11:20	8-16
3	5.9		12:15	8-17	43	6.5		11:25	8-16
4	6.3		12:25	8-17	44	7.4		11:30	8-16
5	6.2		12:32	8-17	45	6.6		11:35	8-16
6	6.4		12:40	8-17	46	7.8		11:40	8-16
7	7.1		12:45	8-17	47	8.8		11:45	8-16
8	6.6		12:50	8-17	48	[illegible].4		11:50	8-16
9	5.8		12:55	8-17	49	9.4		11:55	8-16
10	5.9		13:00	8-17	50	8.9		12:00	8-16
11	9.4		13:05	8-17	51	9.2		12:15	8-16
12	10.3		13:10	8-17	52	8.6		12:30	8-16
13	7.6		13:15	8-17	53	9.2		12:45	8-16
14	0	37	13:20	8-17	54	8.2		14:15	8-17
15	2.4	39	13:25	8-17	55	7.5		14:30	8-17
16	3.3	40	13:30	8-17	56		31	12:45	8-16
17	2.5	39	13:35	8-17	57		32.5	13:30	8-16
18	0	37	13:40	8-17	58		32	13:40	8-16
19	8.2	31	13:45	8-17	59		33	13:10	8-16
20	4.8	30	13:50	8-17	60			12:00	8-16
21	8.0		8:30	8-16	61		30	12:30	8-16
22	7.6		8:37	8-16	61A	7.0		14:45	8-17
23	7.6		8:45	8-16	62	6.0		9:05	8-24
24	6.9		8:55	8-16	63	5.4		9:15	8-24
25	7.4		9:05	8-16	64	4.6	28	9:25	8-24
26	7.4		9:15	8-16	65	2.7		9:35	8-24
27	6.9		9:25	8-16	66	4.3		9:45	8-24
28	8.3		9:35	8-16	67	6.4	27	9:55	8-24
29	8.1		9:45	8-16	68	4.2		10:05	8-24
30	8.7		9:55	8-16	69	3.4		10:15	8-24
31	8.4		10:05	8-16	70	3.4		10:25	8-24
32	6.9		10:15	8-16	71	3.8		10:35	8-24
33	6.3		10:25	8-16	72	5.6		10:45	8-24
34	6.3		10:35	8-16	73	3.7		11:05	8-24
35	6.9		10:45	8-16	74	5.3		11:15	8-24
36	6.5		10:52	8-16	75	8.2		11:25	8-24
37	6.3		11:00	8-16	76	5.8		11:35	8-24
38	0.3		11:05	8-16	77	3.8	28	11:45	8-24
39	0		11:09	8-16	78	4.2		11:55	8-24
40	0.2		11:13	8-16	79	6.1		12:05	8-24
					80	2.8	28	12:15	8-24
					81	3.9		12:25	8-24
					82	1.4		12:35	8-24
					83	5.1		12:45	8-24
					84	0		13:00	8-24

RESULTS OF LABORATORY ANALYSES
LOWER JAMES RIVER POLLUTION STUDY
Miscellaneous Samples
August 6-September 6, 1951

TABLE 24
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	Eppes Creek D.O Sta. 60 8-16	Between Eppes Creek & Packs Pt. D.O. Sta. 61 8-16	Packs Pt. D.O. Sta. 56 8-16	Baileys Creek D.O. Sta. 59 8-16	Between Bailey's Creek & Jordans Pt. D.O Sta. 57 8-16	Back of Jordans Pt. D.O. Sta. 58 8-24	Above Kimages Creek D.O. Sta. 64 8-24	Between Kimages Creek & Coggins Pt. D.O. Sta. 67 8-24	Coggins Pt. D.O. Sta. 70 8-24	Sub Channel Tar Bay D.O. Sta. 77	Sub Channel Tar Bay D.O. Sta. 80
D.O. ppm							4.6	6.4	3.4	3.8	2.4
Alk. ppm $CaCO_3$	46	46	47	107	83	66	51	53	50	70	56
pH	7.55	7.4	8.0	7.55	7.55	7.45	7.6	7.45	7.4	7.4	7.4
B.O.D. ppm	4.2	5.0	8.6	31	23	6.4	2.8	2.5	1.9	9.9	6.3
Total Solids ppm -Total	276	212	342	513	17[illegible]	205	173	115	119	347	193
Total Solids ppm -Volatile	99	88	112	200	26	61	42	86	51	51	53
Total Solids ppm -Fixed	177	124	230	313	15[illegible]	144	131	29	68	296	140
Suspended Solids ppm -Total	63	94	134	114	22	38	47	154	35	24	33
Suspended Solids ppm -Volatile	19	23	31	40	22	27	7	121	14	13	9
Suspended Solids ppm -Fixed	44	71	103	74	0	11	40	33	21	11	24
Sulfates (SO_4) ppm	54	68	82	74	36	61	40	37	42	48	42
Chlorides (Cl ppm)	13	14	14	56	38	20	12	12	14	20	13
Turbidity ($SiSO_2$ ppm)	45	45	63	50	19	20	26	16	10	22	16
Color-K-S Readings #54 Filter							13	13	13	20	15
NH_3 Nitrogen	0.6	0.55	0.3	0.8	0.3	0.8					
NO_2 Nitrogen	0.05	0.036	0.012	0.003	0.12	0.16					
NO_3 Nitrogen	0.1	0.06	0.02	0.3	0.2	0.06					
C.O.D. ppm											
Temperature °C		30	31	33	32.5	32	28	27		28	28
Time (0 to 2300)	12:00	12:30	12:45	13:10	13:30	13:40	9:05	9:45	10:05	11:50	12:20

CONDUCTIVITY DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

TABLE 25
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STATIONS	Line # 1 RESISTANCE-OHMS TIME(1:15-2:00 P.M.) 8-6-51						Line # 2 RESISTANCE-OHMS TIME (2:35-3:15 P.M.) 8-6-51				
DEPTH(Feet)	1	2	3	4	5	6	1	2	3	4	5
0	34,000	33,000	33,000	34,0000	35,500	34,000	42,000	41,000	41,000	41,000	40,000
1	34,000	33,000	33,000	34,000	35,500	34,000	41,000	40,000	41,000	41,000	40,000
2				34,000	35,500		41,000	40,000	41,000	41,000	40,000
3				34,000	35,500				41,000	41,000	40,000
4				34,000	35,000				41,000	41,000	
5				34,500	35,000					41,000	
6				35,000	35,000					41,000	
7					35,000					41,000	
8					35,000					41,000	

(See figure 2 for location of lines)

CONDUCTIVITY DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

STATIONS	Line # 3 RESISTANCE - OHMS TIME (3:20-3:55 P.M.) 8-6-51			Line # 4 RESISTANCE - OHMS TIME (3:55-4:05 P.M.)8-6-51			Line # 5 RESISTANCE - OHMS TIME (4:10 P.M.)8-6-51
DEPTH(feet)	1	2	3	1	2	3	1
0	40,500	41,000	40,000	40,000	40,000	39,500	40,000
1	40,500	41,000	40,000	40,000	40,000	39,000	40,000
2	40,500		40,000	40,000	40,000	39,000	40,000
3	40,500		40,000	40,000	40,000	39,000	40,000
4	40,500		40,000	40,000	39,500	39,000	
5							
6 etc.							
40							
41							
42							

(See figure 2 for location of lines)

CONDUCTIVITY DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

TABLE 27
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	Line # 6 RESISTANCE-OHMS TIME (1:00-1:50 P.M., 8-7-51)						Line #6 RESISTANCE-OHMS TIME(10-10:30A.M.8-8-51)			Line # 7 RESISTANCE-OHMS TIME(2:00-3:00 P.M. 8-7-51)					
STATIONS	2	1	3	4	5	6	4	5	6	1	2	3	4	5	6
DEPTH(Feet)															
0	12,800	12,800	12,200	12,100	10,700	7,450	10,900	7,000	8,600	12,400	11,900	10,800	11,400	10,600	4,000
1	12,200	12,400	12,400	11,400	10,500	7,500	10,900	7,200	8,700	12,000	11,900	11,300	11,400	10,600	3,400
2	13,000		12,400	10,900	10,800	7,400	10,900	7,200		12,400	12,000	11,200	11,400	10,600	
3	12,200		12,400	11,800	11,000		10,800	7,700		12,400	11,900	11,500	11,200	10,000	
4	13,000		12,200	11,500	11,100		10,900	7,800			11,500	12,400			
5	13,400		12,400	11,600	11,100		10,800	7,800			11,600	12,100	1'Under		
6	12,600		12,400	13,000	11,600		11,000	7,400				12,000	8-8-51		
7	13,300		12,300	12,400	11,800		10,800	9,000				12,800	9,200		
8	12,800		12,000	12,800	12,000		10,900	9,000				11,400			
9	13,300		11,600	12,200	12,200		10,800	9,300				11,900			
10	13,200		12,000	12,200	12,100		11,100	9,400				12,200			
11	13,000			12,400	12,000		10,700	9,400				12,200			
12	13,400			13,000	12,000		10,800	9,400				12,400			
13				12,750	12,100		10,600	9,000				12,300			
14				12,400	11,900		10,800					12,300			
15				12,100	11,900		10,700					12,400			
16				12,400	12,000		10,800					12,200			
17				12,100	12,100		10,600					12,200			
18				12,300	12,000		10,800					12,200			
19				12,900	12,800		10,800					12,000			
20				12,100	12,800		10,800					12,200			
21				12,200	12,800		10,800					12,200			
22				12,000	12,900		10,800					12,200			
23				12,200	12,700		10,900					12,200			
24				12,100			11,300					12,500			
25				12,000			11,000					12,800			
26				12,400			11,300					12,600			
27				11,900			10,800					12,600			
28							11,000					12,200			
29							11,000					12,800			
30							10,800					12,400			
31							10,800								
32							10,600								

[illegible] Figure [illegible] location of lines)

CONDUCTIVITY DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

	Line # 8 RESISTANCE - OHMS TIME (3:10-4:00 P.M.) 8-7-51					Line # 9 RESISTANCE - OHMS TIME(4:10-5:00 P.M.) 8-7-51				Line # 10 RESISTANCE - OHMS TIME(8:10-8:40PM)8-8-51	
STATIONS DEPTH(Feet)	1	2	3	4A	4	1	2	3	4	1	2
0	4,000	6,000	11,200	8,100	8,400	11,000	12,000 9,200	12,000	13,000	9,950	9,600
1	4,900	6,000	11,200	8,100	8,200	11,000	(8-8-51)	12,000	12,400	9,900	9,700
2	4,000	5,800	11,200	8,100		11,000	11,700	12,100	12,200	9,900	9,800
3	4,900	6,000	11,200			11,000		12,200	12,100	9,900	9,800
4			12,000			11,000	11,800			9,900	9,800
5						11,100					9,800
6						11,200	12,800				9,600
7						11,200					9,600
8						11,300	11,600				9,800
9						11,300					9,900
10						11,200	11,800				9,800
11						10,300					9,800
12						10,200	12,000				9,600
13						10,000					9,600
14						10,200	12,050				9,700
15						10,000					9,700
16						10,000	11,800				9,600
17						10,000					9,800
18						9,000	11,800				9,800
19						9,000					9,800
20						10,000	11,800				9,600
21						10,000					9,600
22						9,800	11,900				9,600
23						9,300					9,600
24						9,600	11,900				9,600
25						9,600					9,500
26						9,600	12,500				9,700
27						9,600					9,500
28						9,200	11,800				9,500
29						9,600					
30 etc.							12,000				
36											
39											

(See figure 2 for location of lines)

CONDUCTIVITY DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

TABLE 29
Page 50

	Line # 11 RESISTANCE - OHMS TIME (8:50-9:10 A.M.) 8-8-51			Line # 12 RESISTANCE - OHMS TIME (9:15-9:40 A.M.) 8-8-51						
STATIONS / DEPTH(Feet)	1	2	3	1	2	3	4	5	6	7
0	9,900	8,600	3,900	3,900	7,400	9,800	10,000	10,300	10,200	10,900
1	9,600	8,600			8,400	9,800	10,000	10,300	10,400	10,800
2	9,000	9,400				10,000	10,000	10,800	10,300	10,900
3		3,900				9,800	9,800			10,600
4						9,400	10,000			
5						9,600	10,000			
6							10,000			
7							10,000			
8							10,000			
9							9,900			
10							10,000			
11							9,900			
12							10,000			
13							9,900			
14							9,900			
15							10,000			
16							10,000			
17							10,000			
18							9,800			
19							9,900			
20							9,900			
21							10,000			
22							9,900			
23							10,000			
24							9,800			
25							10,000			
26							10,000			
27							9,600			
28							10,000			
29							9,700			

(See figure 2 for location of lines)

CONDUCTIVITY DATA
LOWER JAMES RIVER POLLUTION STUDY

TABLE 30
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Resistance - Ohms

STATIONS	10	11	12	13	14	15	16	16	17	18	19	20	21
DATE	8-21-51	8-20-51	8-21-51	8-21-51	8-21-51	8-21-51	8-20-51	8-21-51	8-20-51	8-20-51	8-20-51	8-20-51	8-20-51
TIME	10:30AM	6:10 PM	10:40AM	10:50AM	11:15AM	11:00PM	12:00N	11:10AM	12:45PM	1:30PM	2:10PM	2:45PM	3:30PM
DEPTH(Ft)													
0	9,800	8,800	9,200	9,000	4,200	8,400	7,400	7,800	8,200	8,300	8,500	7,000	2,115
2	9,600	8,700	9,200	9,000	4,600	8,400	7,500	7,800		8,300	8,700	7,200	2,500 1,900
4	9,600	8,700	9,200	9,000	5,100	8,500	7,500	7,800		8,400	8,600	7,300	2,200 2,000
6	9,700	8,700	9,200	9,000	5,400	8,600	7,400	7,800		8,400	8,400	7,400	1,750 1,775
8	9,800	8,400	9,000	9,000	6,000	8,600	7,400	7,700		8,400	8,400	7,500	2,000 1,800
10	10,000	8,400	9,000	9,000	6,900	8,500	7,400	7,600	8,200	8,400	8,400	7,600	1,600 1,650
12	10,000	8,400	9,000	9,000	6,900	8,500	7,400	7,500		8,400	8,300	7,600	1,800 1,725
14	10,000	8,400	9,000	9,000	6,900	8,500	7,400	7,300		8,300	8,300	7,700	1,550 1,525
16	9,800	8,400	9,000	9,000	8,000	8,500	7,400	7,400		8,400	8,300	7,700	1,700 1,525
18	9,500	8,400	9,000	8,800	7,900	8,400	7,400	7,400		8,200	8,500	7,700	1,700 1,525
20	9,400	8,400	9,000	8,800	7,800	8,400	7,400	7,300		8,200	8,400	7,800	1,725 1,750
22	9,400	8,400	9,000	9,000	7,400	8,400	7,400	7,400		8,200	8,300	7,800	1,525 1,750
24	8,800	8,400	9,000	9,000	7,200	8,400	7,200	7,400		8,400	8,300	7,700	1,550 1,750
26		8,400	9,100	8,900		8,400	7,500	7,400		8,400	8,300	7,700	1,550 1,550
28		8,400	9,000	8,800		8,400	7,600	7,500		8,400	8,400	7,800	1,750 1,525
30		8,400	9,300	8,800			7,600	7,200		8,400	8,300	7,800	1,750 1,550
32	80		V	V			7,600	V		V	V	7,000	1,750 V

(See figure 2 for location of lines)

TABLE 31
RESULTS OF LABORATORY ANALYSES
THE SOLVAY PROCESS DIVISION, HOPEWELL, VA.
24-HR COMPOSITE SAMPLES OF JAMES RIVER WATER INTAKE (1)

Date	8-15	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm spot samples (a)	-	4.1	3.8	4.1	3.4	4.5	5.5	4.4	4.8	3.7	38.3	4.3	5.5	3.4
Alk. (M.O.) ppm $CaCO_3$	52	52	49	54	52	56	60	58	57	53	543	54	60	49
pH	7.6	8.2	8.1	7.9	7.35	7.3	8.0	6.8	6.6	7.55			8.2	6.6
B.O.D. ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total - Total	204	191	180	184	206	235	212	208	196	206	2022	202	235	180
Solids - Volatile	-	56	-	-	-	-	-	-	-	-				
ppm - Fixed	-	135	-	-	-	-	-	-	-	-				
Suspended - Total	55	46	42	42	31	30	32	33	32	33	376	38	55	30
Solids - Volatile	-	13	-	-	-	-	-	-	-	-				
ppm - Fixed	-	33	-	-	-	-	-	-	-	-				
NH_3 Nitrogen ppm	-	0.28	0.1	-	Trace	0.8	-	0.1	1.2	-	2.48	0.41	1.2	Trace
NO_2 Nitrogen ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NO_3 Nitrogen ppm	-	2.0	0.1	-	1.0	1.5	-	0.3	0.2	-	5.10	0.85	2.0	0.2
C.O.D. ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Temperature °C)	-	29	29	29	26	25	25	27.5	27	26.5			29	25
Flow - M Gals. per day	197316	192552	195198	194148	191856	193164	191406	196626	199308	193758	1945332	194533	199308	191406

(1) 24 hour (8 A.M.) composite samples except: (a) D.O. analyses.

TABLE 32
RESULTS OF LABORATORY ANALYSES
THE SOLVAY PROCESS DIVISION, HOPEWELL, VA.
24-HR COMPOSITE SAMPLES OF POYTHRESS RUN EFFLUENT (1)

Date	8-15- (b)	8-20	8-21	8-22	8-27	8-28	8-29	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm) spot samples (a)	-	6.3	6.3	6.4	6.3	6.1	6.7	6.4	6.5	6.2	57.2	6.4	6.7	6.1
Alk. (M.O.) ppm $CaCO_3$	60	51	47	53	43	52	61	54	60	65	546	55	65	43
pH	8.1	7.9	7.7	7.5	7.1	7.3	7.7	7.0	7.6	7.75	-	-	8.1	7.0
B.O.D. ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total - Total	349	267	244	271	302	317	297	322	292	284	2945	295	349	244
Solids - Volatile	-	93	-	-	-	-	-	-	-	-				
ppm - Fixed	-	174	-	-	-	-	-	-	-	-				
Suspended - Total	129	45	44	50	52	41	40	36	33	36	506	51	129	33
Solids - Volatile	-	12	-	-	-	-	-	-	-	-				
ppm - Fixed	-	32	-	-	-	-	-	-	-	-				
NH_3 Nitrogen ppm	-	4.3	4.7	-	3.4	3.5	-	4.3	2.6	-	22.8	3.8	4.7	2.6
NO_2 Nitrogen ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NO_3 Nitrogen ppm	-	4.8	6.8	-	4.0	8.5	-	8.5	5.5	-	38.1	6.4	8.5	4.0
Temperature $^{\circ}C$)	-	33.5	33	33.5	31	29.5	30	32	32	31			33.5	29.5
Flow - M Gals. per Day	25632	23136	23040	23136	23136	23808	23424	24096	24096	24192	237696	23770	25632	23040

(1) 24 hour (8 A.M. to 8 A.M.) composite samples except: (a) D. O. analyses
(b) Aug. 15 = 7 hour composite - storm dislocated sampling equipment. Sample pipe plugged with silt.

TABLE 33
RESULTS OF LABORATORY ANALYSES
THE SOLVAY PROCESS DIVISION, HOPEWELL, VA.
24 HR COMPOSITE SAMPLES OF GRAVALLY RUN EFFLUENT (1)

Date	8-15	8-20	8-21	8-22	8-27	8-28b	8-29c	9-4	9-5	9-6	Total	Avg.	High	Low
D.O. ppm) spot samples (a)	-	6.0	5.9	5.9	6.1	6.3	6.1	6.2	6.1	5.9	54.5	6.1	6.3	5.9
Alk. (M.O.) ppm $CaCO_3$	56	73	64	65	0	2	29	63	67	64	483	48	73	0
pH	7.9	8.3	7.9	7.7	4.45	5.0	7.4	7.15	8.0	7.7			8.3	4.45
B.O.D.ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Solids ppm - Total	287	239	224	224	389	479	338	263	247	241	2951	295	479	224
Total Solids ppm - Volatile		76	- -	-	-	-	-	-	-	-				
Total Solids ppm - Fixed	-	163	-	-	-	-	-	-	-	-				
Suspended Solids ppm -Total	92	58	53	58	51	193	52	40	39	39	675	68	193	39
Suspended Solids ppm -Volatile	-	15	-	-	-	-	-	-	-	-				
Suspended Solids ppm - Fixed	-	32	-	-	-	-	-	-	-	-				
NH_3 Nitrogen ppm	-	3.2	5.2	-	2.8	4.6	-	5.2	2.8	-	23.8	4.0	5.2	2.8
NO_2 Nitrogen ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NO_2 Nitrogen ppm	-	3.4	2.4	-	12.5	7.5	-	1.4	2.2	-	29.4	4.9	12.5	1.4
C.O.D. ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Temperature °C)	-	37	37	37	34	33	34.5	36	36.5	35.5			37	33
Flow - M Gals. per Day	171684	169416	172158	171012	168720	169356	167982	172530	175212	169566	170736	170764	175212	167982

(1) 24 hour (8 A.M. to 8 A.M.) composite samples except: (a) D.O. analyses.
(b) Aug. 28 - Duration of composite questionable.
(c) Aug. 29 - 7 hour composite.

TABLE 34
RESULTS OF LABORATORY ANALYSES
CELANESE CORPORATION OF AMERICA
24 HOUR COMPOSITE SAMPLES OF PLANT WASTES

Date		8-20	8-21	8-22	8-27	8-28	8-29	9-5*	9-6	9-7	Total	Avg.	High	Low
D.O. ppm		3.8	4.8	5.7	3.7	2.2	5.1	4.2	2.5	4.9	36.9	4.1	5.7	2.2
Alk. ppm $CaCO_3$		96	74	74	80	56	114	78	78	77	727	81	114	56
pH		7.8	7.7	7.8	7.8	7.7	7.9	7.8	7.5	7.8	69.8	7.8	7.9	7.5
B.O.D. ppm		229	128	162	132	204	146	172	122	228	1523	169	229	122
Total	- Total	670	560	520	512	848	590	437	442	598	5177	575	848	437
Solids	- Volatile	375	325	340	320	470	340	282	260	404	3116	346	470	260
ppm	- Fixed	295	235	180	192	378	250	155	182	194	2061	229	378	155
Suspended	- Total	50	55	50	45	47	55	49	52	37	440	49	55	37
Solids	- Volatile	49	55	40	45	37	45	46	44	37	398	44	55	37
ppm	- Fixed	1	0	10	0	10	10	3	8	0	42	5	10	0
Sulfates (SO_4 ppm)		-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorides (Cl ppm)		134	125	122	67	282	117	55	79	139	1120	124	282	55
Turbidity (SiO_2 ppm)		-	-	-	-	-	-	-	-	-	-	-	-	-
Color K-S Reading No. 54 Filter		-	-	-	-	-	-	-	-	-	-	-	-	-
NH_3 Nitrogen ppm		-	-	-	-	-	-	-	-	-	-	-	-	-
NO_2 Nitrogen ppm		-	-	-	-	-	-	-	-	-	-	-	-	-
NO_3 Nitrogen ppm		-	-	-	-	-	-	-	-	-	-	-	-	-
C.O.D. ppm		640	318	396	279	438	279	400	280	520	3550	394	640	279
Temperature °C.		-	-	-	-	-	-	-	-	-	-	-	-	-
Time 0 to 2300		-	-	-	-	-	-	-	-	-	-	-	-	-
MPN Coliform per 100 cc.		-	-	-	-	-	-	-	-	-	-	-	-	-
Settleable Solids ml/L		0.5	0.35	0.35	0.25	0.4	1.0	1.0	0.4	0.9	5.15	.57	1.0	0.25
Total Flow M.G.D.		.650	.740	.610	.805	.765	.605	.65	.695	.625	6.145	.683	.805	.605

* - Plant did not operate on 9-3 and 9-4.

TABLE 35
RESULTS OF LABORATORY ANALYSES
CONTINENTAL CAN CO., INC.
24-HOUR COMPOSITE SAMPLES OF MAIN MILL EFFLUENT

te.	8-19	8-20	8-21	8-26	8-27	8-28	9-3	9-4	9-5	Total	Avg.	High	Low
O.	-	-	-	-	-	-	-	-	-	-	-	-	-
k. ppm $CaCO_3$	350	320	350	255	340	310	310	290	240	2765	307	350	240
[	9.80	9.60	9.60	9.35	9.50	10.00	9.70	9.40	9.60	86.55	9.61	10.00	9.35
.O.D. ppm	240	400	360	210	350	560	280	320	220	2940	326	560	210
.O.D. (ox. consumed)	604	693	792	400	590	670	490	530	550	5319	591	693	400
tal Solids ppm	1950	2136	2096	1216	1340	1480	1870	1466	1288	14842	1649	2136	1216
spended Solids ppm	592	696	524	194	236	292	284	212	362	3392	377	696	194
ttleable Solids ppm	490	558	398	134	126	222	204	124	318	2574	286	558	124
llons Raw Water ~~(Millions)~~ (Thousands)	10,343	10,500	10,593	10436	11000	11198	10725	10899	12280	97974	10886	12280	10343

TABLE 36
RESULTS OF LABORATORY ANALYSES
HERCULES POWDER COMPANY, VIRGINIA CELLULOSE PLANT
24-HOUR COMPOSITE SAMPLES OF COMBINED PLANT EFFLUENT

Date	8-19	8-20	8-21	8-22	8-26	8-27	8-28	8-29	9-3	9-4	9-5	9-6	Avg.	High	Low
D.O. ppm	-	-	-	-	-	-	-	-	-	-	-	-			
Alk. ppm $CaCO_3$	531	552	436	457	483	514	626	579	756	667	623	531	563	756	436
pH	10.9	10.8	11.1	11.25	11.2	11.1	11.4	11.2	11.6	11.5	11.5	11.45	11.25	11.6	10.8
B.O.D., ppm	552	510	470	432	480	425	407	435	508	437	380	478	460	552	380
Total Solids ppm - Total	2430	2443	2031	1919	2368	2191	2359	2394	2411	2366	2377	2360	2304	2443	1919
- Volatile	1426	1317	1118	991	1298	1106	1266	1442	1399	1278	1200	1337	1263	1442	991
- Fixed	1004	1126	913	928	1070	1084	1093	952	1014	1084	1177	1023	1040	1177	913
Suspended Solids ppm															
- Total	166	288	222	221	196	198	229	196	214	279	274	211	224	288	166
- Volatile	159	275	209	200	180	180	216	174	203	219	216	194	202	275	159
- Fixed	7	13	13	21	16	18	13	22	12	60	57	17	22	60	7
Sulfates (SO_4, ppm)	-	-	-	-	-	-	-	-	-	-	-	-			
Chlorides (Cl, ppm)	202	226	170	166	180	212	180	172	140	202	254	240	195	254	140
Turbidity ($SiSO_2$ ppm)	-	-	-	-	-	-	-	-	-	-	-	-			
Color K.S. Readings #54 Filter	-	-	-	-	-	-	-	-	-	-	-	-			
NH_3 Nitrogen, ppm	-	-	-	-	-	-	-	-	-	-	-	-			
NO_2 Nitrogen, ppm	-	-	-	-	-	-	-	-	-	-	-	-			
NO_3 Motrpgem. $\frac{11}{22}$,	-	-	-	-	-	-	-	-	-	-	-	-			
C.O.D. ppm	1540	1805	1388	1175	1549	1301	1444	1462	1408	1295	1232	1340	1412	1805	1175
Temperature °C.	-	-	-	-	-	-	-	-	-	-	-	-			
Time (0 to 2300)	24 H ur Continuous Sampling														
Settleable Solids cc?Liter	3.5	4.5	4.5	3.5	3.5	7.0	4.0	3.0	4.8	4.0	5.5	5.0	4.4	7.0	3.0
Estimated Flow Gal. x 10^6/Day	12.92	14.26	13.94	14.59	11.57	13.00	15.10	15.70	14.40	14.10	14.95	15.30	14.16	15.70	11.57

TABLE 37
RESULTS OF LABORATORY ANALYSES
HERCULES POWDER COMPANY, CELLULOSE PRODUCTS PLANT
24-HOUR COMPOSITE SAMPLING OF COMBINED PLANT EFFLUENT

Date		8-19	8-20	8-21	8-26	8-27	8-28	9-3	9-4	9-5	Avg.	High	Low
D.O., ppm		-	-	-	-	-	-	-	-	-			
Alk. ppm $CaCO_3$		480	-210*	528	818	542	1177	201	205	402	460	1177	-210
pH		11.6	3.8	11.8	12.4	11.9	12.2	10.3	10.6	11.5	10.65	12.4	3.8
B.O.D., ppm		580	727	630	820	550	445	377	377	380	543	820	377
Total Solids, ppm	- Total	5237	4863	5293	4865	4201	5657	3657	3980	3523	4586	5657	3523
	- Volatile	1811	590	1192	858	536	769	1773	904	570	1000	1773	536
	- Fixed	3426	4273	4101	4007	3665	4888	1884	3076	2953	3585	4888	1884
Suspended Solids, ppm	- Total	66	62	188	149	81	195	80	97	157	119	195	62
	- Volatile	49	56	101	71	49	83	57	70	68	67	101	49
	- Fixed	17	6	87	78	32	112	23	27	89	52	112	6
Sulfates (SO_4, ppm)		-	-	-	-	-	-	-	-	-			
Chlorides (Cl, ppm)		2025	2370	2225	1730	1840	2360	1810	1920	1530	1979	2370	1530
Turbidity ($SiSO_2$, ppm)		-	-	-	-	-	-	-	-	-			
Color K-S Readings #54 Filter		-	-	-	-	-	-	-	-	-			
NH_3 Nitrogen, ppm		-	-	-	-	-	-	-	-	-			
NO_2 Nitrogen, ppm		-	-	-	-	-	-	-	-	-			
NO_3 Nitrogen, ppm		-	-	-	-	-	-	-	-	-			
C.O.D., ppm		889	1289	1124	1262	946	1285	852	855	752	1028	1289	752
Temperature °C.		-	-	-	-	-	-	-	-	-			
Time (o to 2300)		24 Hour Continuous Sampling											
Settleable Solids cc/Liter		1.7	0.6	32.0	8.0	2.0	6.5	2.5	2.0	19.0	8.3	32.0	0.6
Estimated Flow Gal. x 10^6/Day		2.20	2.18	2.60	2.03	2.36	2.21	2.22	2.24	2.12	2.24	2.60	2.03

*Acidity to phenolphthalein.

TABLE 38
DAILY AVERAGE STREAM FLOWS, CFS
LOWER JAMES RIVER POLLUTION STUDY
Aug. 6-Sept. 6, 1951

Date	James River Near Richmond	James River and Kanawha Canal near Richmond	Falling Creek near Drewrys Bluff	Appomattox River near Petersburg	Chickahominy River near Providence Forge
Aug. 1	2350	957			
2	2250	957			
3	1980	936			
4	1900	936			
5	1950	915			
6	1390	915	3.3	284	34
7	2380	957	5.3	318	46
8	1820	936	5.8	357	62
9	1920	936	5.6	385	70
10	1980	936	5.6	462	60
11	2050	936	5.1	339	119
12	2500	957	5.6	840	124
13	2250	936	16	784	200
14	1640	906(1)	13	752	182
15	1480	900(1)	7.6	440	178
16	1320	900(1)	6.3	479	215
17	1450	900(1)	5.1	335	205
18	1570	900(1)	4.2	276	124
19	1730	900(1)	3.5	615	56
20	1300	900(1)	3.3	462	41
21	880	900(1)	2.8	335	35
22	901	900(1)	2.2	268	31
23	1050	900(1)	2.1	235	27
24	880	873	2.0	215	26
25	712	852	1.8	206	24
26	712	852	1.7	197	22
27	670	852	1.7	191	22
28	712	852	5.6	263	34
29	838	873	7.9	457	56
30	1200	894	6.0	544	60
31	1200	894	4.7	435	50
Sept. 1	1030	873	3.8	326	33
2	922	873	3.3	260	28
3	1240	894	3.6	1010	28
4	1880	936	5.1	1430	42
5	1340	894	4.5	692	53
6	1320	894	4.2	502	53

(1) Gauge not working; flow is estimated

[illegible]

TIDAL CURRENT DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

Date	STATION 10										STATION 11									
	Slack; Flood Begins		Maximum Flood		Velocity of Max. Flood	Slack; Ebb Begins		Maximum Ebb		Velocity of Max. Ebb	Slack; Flood Begins		Maximum Flood		Velocity of Max. Flood	Slack; Ebb Begins		Maximum Ebb		Velocity of Max. Ebb
	h	m	h	m	kn	h	m	h	m	kn	h	m	h	m	kn	h	m	h	m	kn
Aug.																				
6	12	21	14	48	0.8	17	21	9	00	1.2	12	16	14	43	0.6	17	16	21	04	1.1
7	13	02	15	33	0.8	18	14	9	36	1.2	12	57	15	28	0.6	18	09	21	52	1.0
8	13	50	16	24	0.9	6	35	10	19	1.2	13	45	16	19	0.7	19	09	10	14	1.0
9	14	46	17	25	0.9	20	22	11	10	1.2	14	41	17	20	0.7	20	17	11	05	1.0
10	15	47	18	29	0.9	8	03	12	10	1.3	15	42	18	24	0.7	21	33	12	05	1.1
15	8	34	10	58	0.9	13	31	17	27	1.8	20	45	10	53	0.7	13	26	17	22	1.5
16	9	22	11	51	1.0	14	29	18	19	1.9	21	38	11	46	0.8	14	24	18	14	1.6
17	10	07	12	42	1.0	15	22	19	09	1.9	22	28	12	37	0.9	15	17	19	04	1.6
20	12	26	15	06	1.0	17	56	9	13	1.4	12	21	15	01	0.8	17	51	21	32	1.2
21	13	17	15	55	1.0	18	48	9	58	1.3	13	12	15	50	0.8	18	43	22	25	1.1
22	14	08	16	46	0.8	6	55	10	47	1.2	14	03	16	41	0.6	19	40	10	42	1.1
24	16	02	18	41	0.7	8	09	12	36	1.1	15	57	18	36	0.6	21	49	12	31	1.0
27	7	10	8	57	0.3	10	59	15	28	1.1	18	46	8	52	0.2	10	54	15	23	1.0
28	7	53	9	48	0.4	11	59	16	17	1.1	19	34	9	43	0.3	11	54	16	12	1.0
29	8	30	10	34	0.4	12	49	17	01	1.2	20	18	10	29	0.3	12	44	16	56	1.1
Sept.																				
4	11	51	14	30	1.0	17	20	8	30	1.3	11	46	14	25	0.9	17	15	20	53	1.1
5	12	34	15	17	1.0	18	13	9	08	1.4	12	29	15	12	0.9	18	08	21	41	1.2
6	13	22	16	09	1.0	19	12	9	53	1.4	13	17	16	04	0.9	19	07	22	36	1.2

The hours of the day are numbered consecutively from 0^h (midnight) to 23^h (11:00 p.m.). 12^h is noon. All hours greater than 12 are in the afternoon (p.m.). kn means knots.

TABLE 40
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TIDAL CURRENT DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

	STATION 12								STATION 13							
Date	Slack; Flood Begins	Maximum	Flood	Velocity of Max. Flood	Slack; Ebb Begins	Maximum	Ebb	Velocity of Max. Ebb	Slack; Flood Begins	Maximum	Flood	Velocity of Max. Flood	Slack; Ebb Begins	Maximum	Ebb	Velocity of Max. Ebb
	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn
Aug.																
6	12 06	14	33	0.8	17 06	8	45	1.3	12 02	14	29	0.7	17 02	8	41	1.2
7	12 47	15	18	0.8	17 59	9	21	1.3	12 44	15	14	0.7	17 55	9	17	1.2
8	13 35	16	09	0.9	6 20	10	04	1.3	13 31	16	05	0.8	6 16	10	00	1.2
9	14 31	17	10	0.9	20 07	10	55	1.3	14 27	17	06	0.8	20 03	10	51	1.2
10	15 32	18	14	0.9	7 48	11	55	1.4	15 28	18	10	0.8	7 44	11	51	1.3
15	8 19	10	43	0.9	13 16	17	12	1.9	8 15	10	39	0.8	13 12	17	08	1.7
16	9 07	11	36	1.0	14 14	18	04	2.0	9 03	11	32	0.9	14 10	18	00	1.8
17	9 52	12	27	1.1	15 07	18	54	2.0	9 48	12	23	1.0	15 03	18	50	1.8
20	12 11	14	51	1.0	17 41	8	58	1.5	12 07	14	47	0.9	17 37	8	54	1.4
21	13 02	15	40	1.0	18 33	9	43	1.4	12 58	15	36	0.9	18 29	9	39	1.3
22	13 53	16	31	0.8	6 40	10	32	1.3	13 49	16	27	0.7	6 36	10	28	1.2
24	15 47	18	26	0.7	7 54	12	21	1.2	15 43	18	22	0.6	7 50	12	17	1.1
27	6 55	8	42	0.3	10 44	15	13	1.2	6 51	8	38	0.3	10 40	15	09	1.1
28	7 38	9	33	0.4	11 44	16	02	1.2	7 34	9	29	0.4	11 40	15	58	1.1
29	8 15	10	19	0.4	12 34	16	46	1.3	8 11	10	15	0.4	12 30	16	42	1.2
Sept.																
4	11 36	14	35	1.1	17 05	8	15	1.4	11 32	14	31	1.0	17 01	8	11	1.3
5	12 19	15	02	1.1	17 58	8	58	1.5	12 15	14	58	1.0	17 54	8	54	1.4
6	13 07	15	54	1.1	18 57	9	38	1.5	13 03	15	50	1.0	18 53	9	34	1.4

The hours of the day are numbered consecutively from 0^h (midnight) to 23^h (11:00 p.m.). 12^h is noon. All hours greater than 12 are in the afternoon (p.m.). kn means knots.

TIDAL CURRENT DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

	STATIONS 14 & 15								STATION 16							
Date	Slack; Flood Begins	Maxi-mum	Flood	Veloc-ity of Max. Flood	Slack; Ebb Begins	Maxi-mum	Ebb	Veloc-ity of Max. Ebb	Slack; Flood Begins	Maxi-mum	Flood	Veloc-ity of Max. Flood	Slack; Ebb Begins	Maxi-mum	Ebb	Veloc-ity of Max. Ebb
	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn
Aug.																
6	11 58	14	25	0.6	16 58	8	37	1.0	11 51	14	18	0.5	16 51	8	30	0.8
7	12 40	15	10	0.6	17 51	9	13	1.0	12 33	15	03	0.5	17 44	9	06	0.8
8	13 27	16	01	0.7	6 12	9	56	1.0	13 20	15	54	0.5	18 44	9	49	0.8
9	14 23	17	02	0.7	19 59	10	47	1.0	14 16	16	55	0.5	19 52	10	40	0.8
10	15 24	18	06	0.7	7 40	11	47	1.1	15 17	17	59	0.5	21 08	11	40	0.8
15	8 11	10	35	0.7	13 08	17	04	1.5	20 20	10	28	0.5	13 01	16	57	1.1
16	8 59	11	28	0.8	14 06	17	56	1.6	21 13	11	21	0.6	13 59	17	49	1.2
17	9 44	12	19	0.9	14 59	18	46	1.6	9 37	12	12	0.7	14 52	18	39	1.2
20	12 03	14	43	0.8	17 33	8	51	1.2	11 56	14	36	0.6	17 26	8	44	0.9
21	12 54	15	32	0.8	18 25	9	35	1.1	12 47	15	25	0.6	18 18	9	28	0.8
22	13 45	16	23	0.6	6 32	10	24	1.0	13 38	16	16	0.5	19 15	10	17	0.8
24	15 39	18	18	0.6	7 46	12	13	1.0	15 32	18	11	0.4	7 39	12	06	0.7
27	6 47	8	34	0.2	10 36	15	05	1.0	18 21	8	27	0.2	10 29	14	58	0.7
28	7 30	9	25	0.3	11 36	15	54	1.0	19 09	9	18	0.2	11 29	15	47	0.7
29	8 07	10	11	0.3	12 26	16	38	1.0	19 53	10	04	0.2	12 19	16	31	0.8
Sept.																
4	11 28	14	27	0.9	16 57	8	07	1.1	11 21	14	20	0.7	16 50	8	00	0.8
5	12 11	14	54	0.9	17 50	8	50	1.2	12 04	14	47	0.7	17 43	8	43	0.9
6	12 59	15	46	0.9	18 47	9	30	1.2	12 52	15	39	0.7	18 40	9	23	0.9

The hours of the day are numbered consecutively from 0^h (midnight) to 23^h (11:00 p.m.). 12^h is noon. All hours greater than 12 are in the afternoon (p.m.). kn means knots.

TIDAL CURRENT DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

Date	Station 17: Slack; Flood Begins	Station 17: Maximum	Station 17: Flood	Station 17: Velocity of Max. Flood	Station 17: Slack; Ebb Begins	Station 17: Maximum	Station 17: Ebb	Station 17: Velocity of Max. Ebb	Station 18: Slack; Flood Begins	Station 18: Maximum	Station 18: Flood	Station 18: Velocity of Max. Flood	Station 18: Slack; Ebb Begins	Station 18: Maximum	Station 18: Ebb	Station 18: Velocity of Max. Ebb
	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn
Aug.																
6	11 42	14	09	0.6	16 42	8	21	1.0	11 27	13	54	0.8	16 27	20	15	1.2
7	12 24	14	54	0.6	17 35	8	57	1.0	12 09	14	39	0.8	17 20	8	42	1.2
8	13 11	15	45	0.7	18 35	9	40	1.0	12 56	15	30	0.9	18 20	9	25	1.2
9	14 07	16	46	0.7	19 43	10	31	1.0	13 52	16	31	0.9	19 28	10	16	1.2
10	15 08	17	50	0.7	20 59	11	31	1.1	14 53	17	35	0.9	20 44	11	16	1.3
15	20 11	10	19	0.7	12 52	16	48	1.4	19 56	10	04	0.9	12 37	16	33	1.8
16	21 04	11	12	0.8	13 50	17	40	1.5	20 49	10	57	1.0	13 35	17	25	1.9
17	9 28	12	03	0.8	14 43	18	30	1.5	9 13	11	48	1.0	14 28	18	15	1.9
20	11 47	14	27	0.8	17 17	20	58	1.1	11 32	14	12	1.0	17 02	20	43	1.5
22	13 29	16	07	0.6	19 06	10	08	1.0	13 14	15	52	0.8	18 51	9	53	1.2
24	15 23	18	02	0.5	7 30	11	57	0.9	15 08	17	47	0.7	7 15	11	42	1.1
27	18 12	8	16	0.2	10 20	14	49	0.9	17 57	8	01	0.3	10 05	14	34	1.1
28	19 00	9	09	0.3	11 20	15	38	0.9	18 45	8	54	0.4	11 05	15	23	1.1
29	19 44	9	55	0.3	12 10	16	22	1.0	19 29	9	40	0.4	11 55	16	07	1.2
Sept.																
4	11 12	14	11	0.8	16 41	20	19	1.1	10 57	13	56	1.0	16 26	20	04	1.3
5	11 55	14	38	0.8	17 34	8	34	1.1	11 40	14	23	1.0	17 19	8	19	1.4
6	12 43	15	30	0.8	18 31	9	34	1.1	12 28	15	15	1.0	18 16	9	19	1.4

The hours of the day are numbered consecutively from 0^h (midnight) to 23^h (11:00 P.M.). 12^h is noon. All hours greater than 12 are in the afternoon (p.m.). kn meansknots.

TIDAL CURRENT DATA
LOWER JAMES RIVER POLLUTION STUDY
August 6-September 6, 1951

Date	STATION 19 Slack; Flood Begins	Maximum	Flood	Velocity of Max. Flood	Slack; Ebb Begins	Maximum	Ebb	Velocity of Max. Ebb	STATION 20 Slack; Flood Begins	Maximum	Flood	Velocity of Max. Flood	Slack; Ebb Begins	Maximum	Ebb	Velocity of Max. Ebb
	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn	h m	h	m	kn
Aug.																
6	11 20	13	47	0.8	16 20	20	08	1.4	11 11	13	36	0.9	16 09	19	57	1.5
7	12 02	14	32	0.8	17 13	8	35	1.4	11 51	14	21	0.9	17 02	8	24	1.5
8	12 49	15	23	0.9	18 13	9	18	1.4	12 38	15	12	1.0	18 02	9	07	1.5
9	13 45	16	24	0.9	19 21	10	09	1.4	13 34	16	13	1.0	19 10	9	58	1.5
10	14 46	17	28	0.9	20 37	11	09	1.5	14 35	17	17	1.0	20 26	10	58	1.6
15	19 49	9	57	0.9	12 30	16	26	2.0	19 38	9	46	1.0	12 19	16	15	2.1
16	20 42	10	50	1.1	13 28	17	18	2.1	20 31	10	39	1.1	13 17	17	07	2.3
17	9 06	11	41	1.2	14 21	18	08	2.1	8 55	11	30	1.2	14 10	17	57	2.3
20	11 25	14	07	1.1	16 55	20	36	1.6	11 14	13	56	1.1	16 44	20	25	1.7
21	12 16	14	54	1.1	17 47	8	57	1.5	12 05	14	43	1.1	17 36	8	46	1.6
22	13 07	15	45	0.8	18 44	9	46	1.4	12 56	15	34	0.9	18 33	9	35	1.5
24	15 01	17	40	0.7	7 08	11	35	1.3	14 50	17	29	0.8	20 42	11	24	1.4
27	17 50	20	37	0.8	9 58	14	27	1.3	17 39	20	26	0.9	9 47	14	16	1.4
28	18 38	21	25	0.9	10 58	15	16	1.3	18 27	21	14	1.0	10 47	15	05	1.4
29	19 22	9	33	0.4	11 48	16	00	1.4	19 11	9	22	0.5	11 37	15	49	1.5
Sept.																
4	10 50	13	49	1.2	16 19	19	57	1.5	10 39	13	38	1.2	16 08	19	46	1.6
5	11 33	14	16	1.2	17 12	8	12	1.6	11 22	14	05	1.2	17 01	8	01	1.7
6	12 21	15	08	1.2	18 09	9	12	1.6	12 10	14	57	1.2	17 58	9	01	1.7

The hours of the day are numbered consecutively from 0^h (midnight) to 23^h (11:00 p.m.). 12^h is noon. All hours greater than 12 are in the afternoon (p.m.). kn means knots.