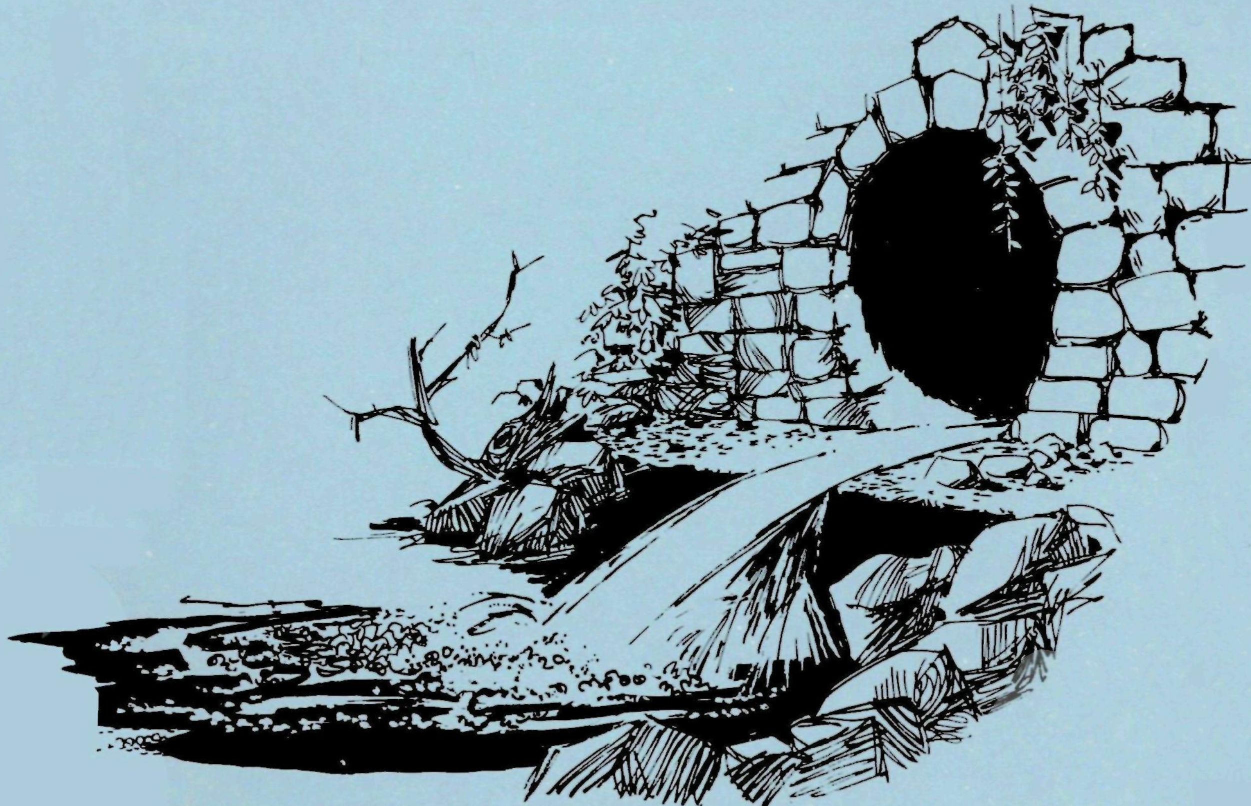
CLEAN WATER WATER POLLUTION CONTROL RESEARCH SERIES • 11023 FDD 07/71

# Demonstration of Rotary Screening For Combined Sewer Overflows



ENVIRONMENTAL PROTECTION AGENCY • RESEARCH AND MONITORING

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# DEMONSTRATION OF ROTARY SCREENING

# FOR

# COMBINED SEWER OVERFLOWS

For

ENVIRONMENTAL PROTECTION AGENCY

By


CITY OF PORTLAND, OREGON

DEPARTMENT OF PUBLIC WORKS

BUREAU OF SANITARY ENGINEERING



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## ABSTRACT


The objective of this demonstration was to determine screen durability, solids removal, COD removal, and hydraulic efficiency of rotary fine screening of storm-caused combined sewer overflows.

2300 gpm were evenly distributed to a 60 inch diameter rotating (55 rpm) screen cage holding 18 $ft^2$ of 165 mesh stainless steel screens (105 micron opening, 47.1 percent open area). During a screening cycle a concentrate sensor stopped the sewage pumps, ending the screening phase and initiating a 30 second cleaning phase during which the screens were automatically washed. At the end of the cleaning phase the pumps restarted automatically and a new cycle began.

Performance on storm-caused combined sewage flow averaged 54.8 percent removal of settleable solids, 26.6 percent removal of suspended solids, and 15.5 percent removal of COD. Duration of the screening phases averaged 14.6 minutes with average hydraulic efficiencies dropping from 0.880 to 0.668.

The ultimate screen life varied from a minimum of 190.5 hours to a maximum of 516 hours with an average of 346. Screens required an average of 3.5 repairs during this life. (Schmidt - Portland).

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# SECTION 1

## CONCLUSIONS

1. Effective screening of storm caused combined sewage overflow is reduced substantially in the presence of oil and grease. Frequent backwashing is required to return the screens to their original capacity.

2. Paint has a detrimental effect on hydraulic efficiency and only after hand application of concentrated cleaner, Zep 9658, could the screens be returned to normal efficiency.

3. Screen failures were attributable to two causes, physical breakdown and puncture.

4. At low velocity an average screen was repaired 3.5 times before ultimate failure. At high velocity an average screen was repaired 2.3 times before ultimate failure.

5. Alkaline, acidic, and alcoholic agents did not adequately clean the screens. Chloroform, solvent parts cleaner, soluble pine oil, Zif, Formula 409, and Vestal Eight offered limited effectiveness. Zep 9658 cleaned the screens effectively but it should be noted that water quality implications were not determined.

6. Appreciable quantities of frothy floating oil were noted in the relatively quiescent baffled trough which served as an effluent channel.

# SECTION 2

## RECOMMENDATIONS

1. It is recommended a study be made to determine hydraulic efficiency of the screens at pre-determined grease loadings. Such a study would facilitate predicting hydraulic performance of screening equipment when grease loading of the sewer is known.

2. It is recommended a study be made for finding an economical screen cleaning agent, one which would be environmentally acceptable when discharged into a receiving water.

3. It is recommended a study be made to find a practicable method to skim the oil from the screened effluent in the effluent channel where appreciable quantities of frothy floating oil were observed passing over the weir into the receiving water.

# SECTION 3

# INTRODUCTION

## COMBINED SEWAGE STORMWATER OVERFLOW

The majority of the existing sewers in the City of Portland, Oregon, carry combined storm and sanitary flows. Only three times average dry weather flow reaches the sewage treatment plant. The storm caused flow, above three times average flow, bypasses to the receiving streams thereby causing pollution of the water course. To correct this condition, separate storm and sanitary sewers would be required.

A method proposed to reduce the cost of separate sewers is the installation of high-rate, fine mesh screening units on outfall sewers to intercept and provide primary treatment of the storm overflow. The feasibility of this method has been researched at this location prior to this study. It was the objective of this test period to determine ultimate screen life, solids removal efficiency, C.O.D. removal efficiency and hydraulic efficiency of the SWECO screening equipment at the rate of 3.3 MGD during storm flow conditions.

For storm water testing of the screenings unit, it was assumed that a 50 percent increase of the recorded average daily flow at the Sullivan Sewage Pumping Station, would be considered storm caused flow.

Monthly rainfall records for the period of operation are shown in figure No. 5.

SECTION 4

DEMONSTRATION PROCEDURE

## SITE DESCRIPTION

The screening facility is located adjacent to the Sullivan Sewage Pumping Station in Portland, Oregon. The Sullivan Station serves a drainage basin of approximately 25,000 acres of Portland's metropolitan area from which it pumps up to 53 (MGD) million gallons a day. This area is mainly residential with approximately 30,000 single-family residences within its boundaries. The usual services are available within this area to support the population. Paint and automobile related industries are well represented in this area as indicated by their waste products frequently visible in the screened effluent channel. Since these are combined sewers, the usual undesirable amounts of oils and fats are present in varying amounts. During prolonged rainy periods, these amounts are, understandably, less concentrated. The 72-inch interceptor sewer has a capacity upwards of 59 MGD. The Sullivan Pumping Station is adequately sized to handle the flow without by-passing.

The flow to the screening facility was pumped from the Sullivan Pump Station by-pass channel at all levels of flow into the station.

## SCREENING PLANT LAYOUT

Figure 1 illustrates the layout of the screening facility adjacent to the Sullivan Sewage Pumping Station. Combined sewage flows to the Sullivan Station through a 72-inch horseshoe interceptor sewer. The flow enters the by-pass chamber through a coarse bar screen before reaching the screening facility pumps. The two vertical turbine pumps are capable of lifting combined sewage flow at the rate of 5.6 MGD.

In a typical installation on an outfall sewer, the flow passing through the screens would pass to a receiving stream after disinfection. The retained flow would be returned to an interceptor sewer. In this demonstration installation, both flows are returned to the Sullivan Pumping Station.

## DESCRIPTION AND OPERATION OF SCREENING EQUIPMENT

Figures 3 and 4 show sections of the SWECO screening unit. This unit stands 69 inches high with an outside diameter of 84 inches. The flow enters near the bottom of the unit and passes up through a pipe in the center of the unit onto a horizontal distribution dome. This flighted dome spreads and directs the flow downward against the inner top surface of the screens. The manufacturer reports an impingement velocity of approximately 15 feet per second at the screen. This flow action together with the centrifugal force resulting from the rotation of the screen cage and the characteristics of the influent determine the percentage of the flow through the screen and that concentrate flow retained inside the screen. The unit is equipped with a cleaning device which activates when the concentrate flow reaches a predetermined level. Hot water (170 degrees F) from a commercial water heater and tar and asphalt remover, Zep 9658, were used to clean the screens. The cleaner was injected into the hotwater piping with a positive displacement pump at dilutions varying with the consistency of the sewage. During the cleaning phase, the pump stops and the screen cage continues to revolve at 55 rpm while spray nozzles, located outside the screens, blast solids and grease back into the concentrate bowl, then the inside nozzles operate with each set alternating twice during the 30 second cleaning phase. This cleaning returns the screens to their initial hydraulic capacity except when materials like paints and heavy asphalts are present. When such materials are present, the screens must be cleaned manually with concentrated cleaner. The materials which cannot pass through the 105 micron screens are contained and drop down inside of the screens to a concentrate bowl located below the screen cage and are discharged by gravity.

The screened effluent is collected in a concentric annular chamber box at the bottom of the unit. The screen cage drive is located at the top of the screening unit and is driven at 55 rpm by a 5 HP induction motor.

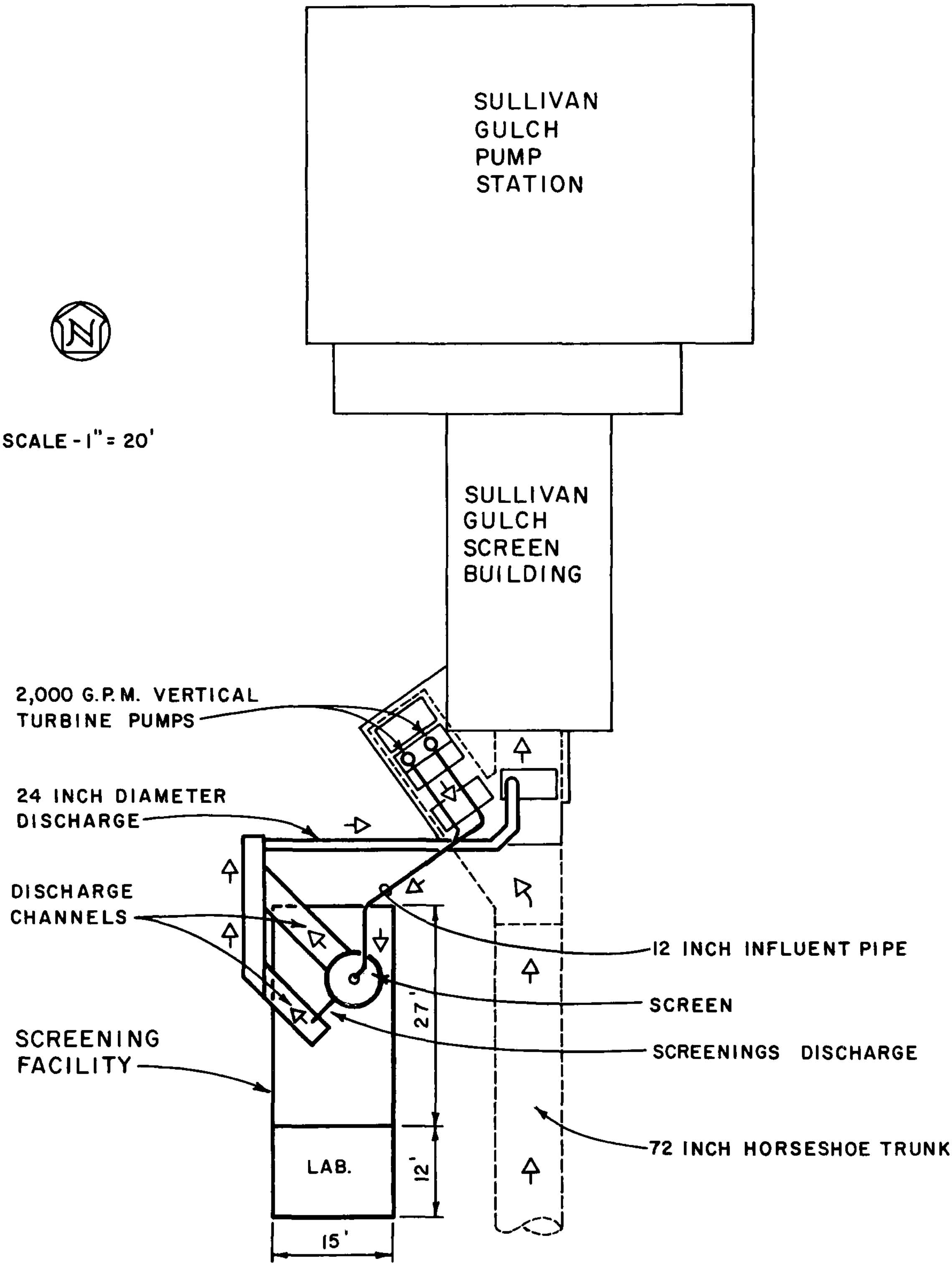



FIGURE I
GENERAL LAYOUT
SULLIVAN GULCH PUMP STATION
AND SCREENING FACILITY
PORTLAND, OREGON

# SAMPLING PROGRAM

Three grab samples of equal volume were taken during a one hour time period at twenty minute intervals to make up a one hour composite sample. The influent samples were taken from a one inch line attached to the influent supply pipe. The effluent samples were taken at the sampling point provided for on the screening unit. Table 1 is a summary of the sampling program.

A schematic diagram of the screening facility, the process streams and the observations made on each stream are shown on figure 2.

| OBSERVATIONS | PROCESS STREAM | SAMPLE FREQUENCY [1] | ANALYTICAL METHOD |
|---|---|---|---|
| SETTLEABLE SOLIDS | Influent and screened effluent | twice/day | Appendix page 83 |
| SUSPENDED SOLIDS | Influent and screened effluent | twice/day | Wyckoff, "Rapid Solids Determination using Glass Fiber Filters", Water and Sewage Works, June 1964. |
| COD | Influent and screened effluent | twice/day | Jeris, "A Rapid COD Test" Water and Wastes Engineering, May 1967. |
| FLOW RATE | Screened effluent and solids concentrate | continuously | recorder |
| BACKWASH FREQUENCY | - - - | continuously | recorder |
| SCREEN LIFE | - - - | - - - | Visual observation and log |
| BOD | Influent and screened effluent | once/week | Standard Methods, 12th Ed. |
| TOTAL SOLIDS | Influent, effluent, concentrate | once/week | " " " " |
| VOLATILE SOLIDS | Influent, effluent, concentrate | once/week | " " " " |
| CHLORINE REQUIREMENT | Influent, effluent | twice/day | Appendix page 83 |
| GREASE | Influent, effluent, concentrate | once/week | Appendix page 83 |

1- A sample is a one-hour composite consisting of three grab samples

TABLE I
DETAILED SAMPLING PROGRAM

# SECTION 5

## MODE OF OPERATION

During the testing program the machine was in operation under test conditions for a total of 914 hours. The first 76 hours the screen cage was rotated at 65 rpm. The 3 MGD flow was fed to the unit at high velocity (the velocity was not determined). The high velocity was accomplished by placing an extension piece on the inlet pipe and tightening down on a movable deflection plate thereby decreasing the flow area.

It was discovered that general screen life was not acceptable under these operating conditions; therefore, the screen cage was reduced to 55 rpm, the extension piece and deflection plate were removed and the flow reduced to 2.5 MGD. These low velocity conditions were maintained for a total of 188 hours. During the remaining 650 hours, the machine was operated at 3 MGD and the screen was rotated at 55 rpm without the extension piece and high velocity plate attached.

It should be understood that process stream flows are approximations only and may range as follows: 3 MGD (high velocity) varied between 3.1 MGD and 3.8 MGD, 3 MGD (low velocity) varied between 3.2 MGD and 3.6 MGD, 2.5 MGD (low velocity) varied between 2.5 MGD and 3.3 MGD. Actual flows are dependent on the length of the screening cycle.

During the testing program, the screens were inspected about once every two hours for failures. This was done by shutting the machine off and observing the screens through the window or the opening provided in the top of the machine while turning the screen cage by hand. Shining a light on the screens made any holes or rips quite visible. If a screen developed a large rip (4" or larger) it could usually be detected by the change it caused in the flow pattern on the window while the machine was running.

Screens were patched with epoxy glue; and after mastering the repair technique, the screens can be back in operation within an hour after they have been removed.

During the 914 hours of operation, the main bearing required lubrication three times. This was accomplished by lifting the hinged motor cover to expose the grease fitting and could be done in five minutes.

## SECTION 6

## DISCUSSION OF RESULTS

The results of the EPA Research and Development Project ("Rotary Vibratory Fine Screening of Combined Sewer Overflows", Program 11023 FDD) by Cornell, Howland, Hayes and Merryfield, indicated that screen life was quite short and that testing under this contract should include screen durability tests under rain caused combined sewer overflows.

Preliminary to the final testing program, the screen rotation was set at 65 RPM and the sewage inflow pipe below the distribution pan, was extended for the purpose of increasing flow velocity. It was hoped that this increased velocity would increase hydraulic performance.

The combination of the 65 RPM screen speed and the high velocity sewage flow proved to be disastrous to general screen life.

The screen velocity was reduced to 55 RPM and the extension fitting on the inflow pipe was removed. The flow was also reduced to approximately 2.5 MGD. After considerable testing it became apparent that the high velocity of the screen and the increased velocity through the extension fitting were primarily responsible for the short screen life and that the flow could again be increased to 3 MGD without detriment.

Final testing of the screening unit was conducted at the lower velocity inflow at 3 MGD with a screen speed of 55 rpm.

The results of the screen life tests are shown on Table No. 3.

| OPERATING CONDITIONS AND NUMBER OF OBSERVATIONS | HYDRAULIC EFFICIENCY [1] AT START OF SCREENING PHASE | | | HYDRAULIC EFFICIENCY AT END OF SCREENING PHASE | | | SCREENING PHASE LENGTH IN MINUTES | | |
|---|---|---|---|---|---|---|---|---|---|
| | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. |
| 3 MGD DRY<br>20 OBSERVATIONS<br>HIGH VELOCITY [2] | 0.848 | 0.892 | 0.805 | 0.768 | 0.811 | 0.733 | 8.0 | 2.8 | 25.0 |
| 2.5 MGD DRY<br>31 OBSERVATIONS<br>LOW VELOCITY [2] | 0.833 | 0.873 | 0.764 | 0.659 | 0.773 | 0.570 | 9.6 | 4.5 | 25.0 |
| 2.5 MGD RAIN<br>6 OBSERVATIONS<br>LOW VELOCITY | 0.822 | 0.843 | 0.804 | 0.670 | 0.688 | 0.617 | 9.6 | 5.0 | 20.0 |
| 3 MGD DRY<br>20 OBSERVATIONS<br>LOW VELOCITY | 0.878 | 0.915 | 0.840 | 0.750 | 0.900 | 0.656 | 11.2 | 4.0 | 40.0 |
| 3 MGD RAIN<br>26 OBSERVATIONS<br>LOW VELOCITY | 0.880 | 0.920 | 0.837 | 0.768 | 0.894 | 0.650 | 14.6 | 4.0 | 56.0 |

1- SEE GLOSSARY

TABLE 2
HYDRAULIC EFFICIENCY

2- SEE GLOSSARY

| FLOW AND OPERATING CONDITIONS | INITIAL SCREEN LIFE (HRS.) | | | NUMBER OF REPAIRS | | | ULTIMATE SCREEN LIFE (HRS.) [1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ave. | Min. | Max. | Ave. | Min. | Max. | Ave. | Min. | Max. |
| 3.1 - 3.8 MGD FLOW<br>HIGH VELOCITY 65 RPM<br>18 SCREENS TESTED | 20.5 | 1.8 | 35.5 | 2.3 | 0 | 7 | 34.3 | 16.5 | 95.3 |
| 2.5 - 3.6 MGD FLOW<br>LOW VELOCITY 55 RPM<br>17 SCREENS TESTED | 233.2 | 32 | 336.8 | 3.5 | 0 | 10 | 346. | 190.5 | 516. |

1- The ultimate screen life as reported above is actual running hours of the screens, and the life of an individual screen ended only when it could no longer be successfully repaired. See Appendix .

**TABLE 3**
**SCREEN LIFE**

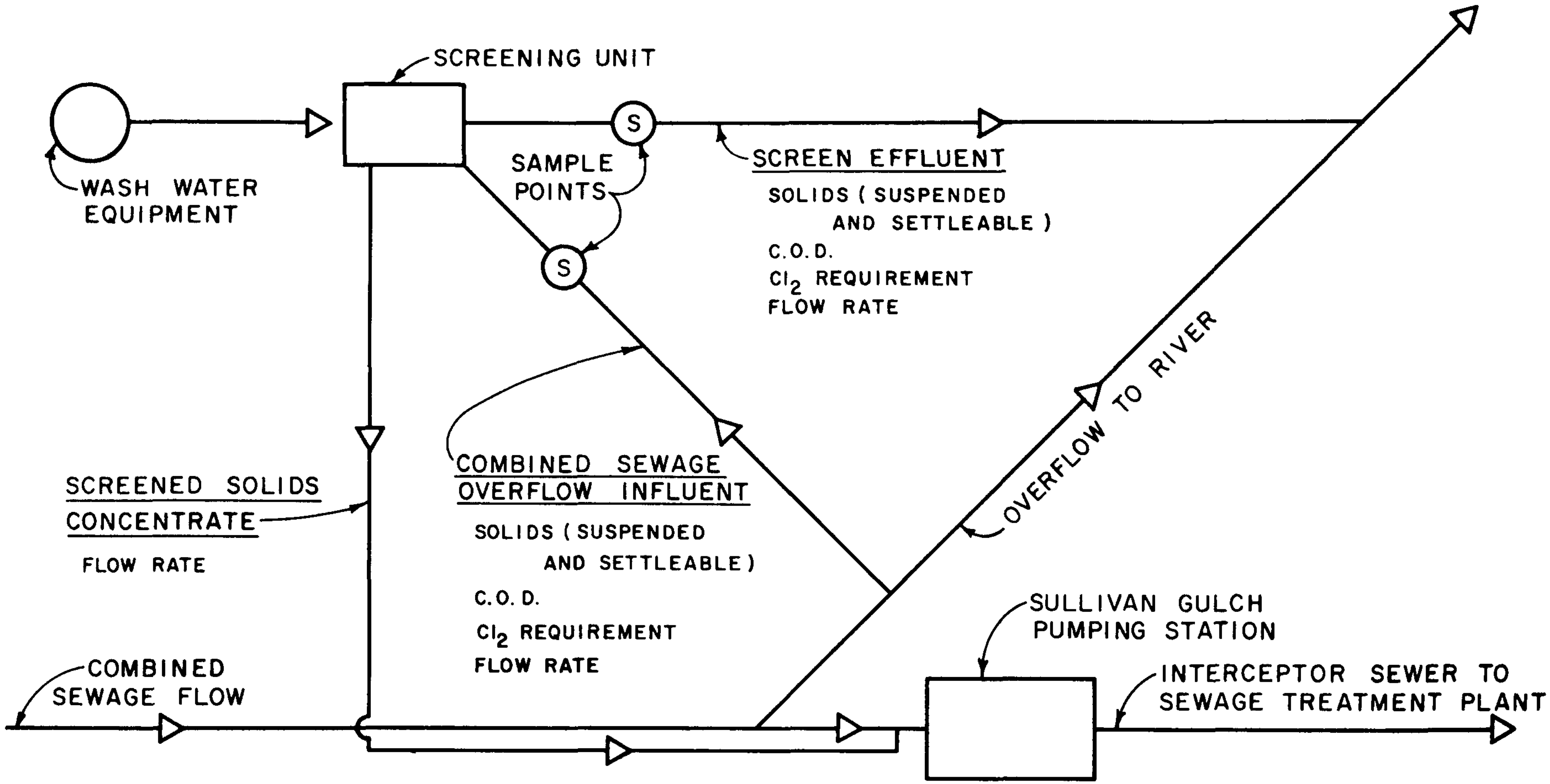



FIGURE 2
TYPICAL
COMBINED SEWAGE OVERFLOW SCREENING
SAMPLING DIAGRAM

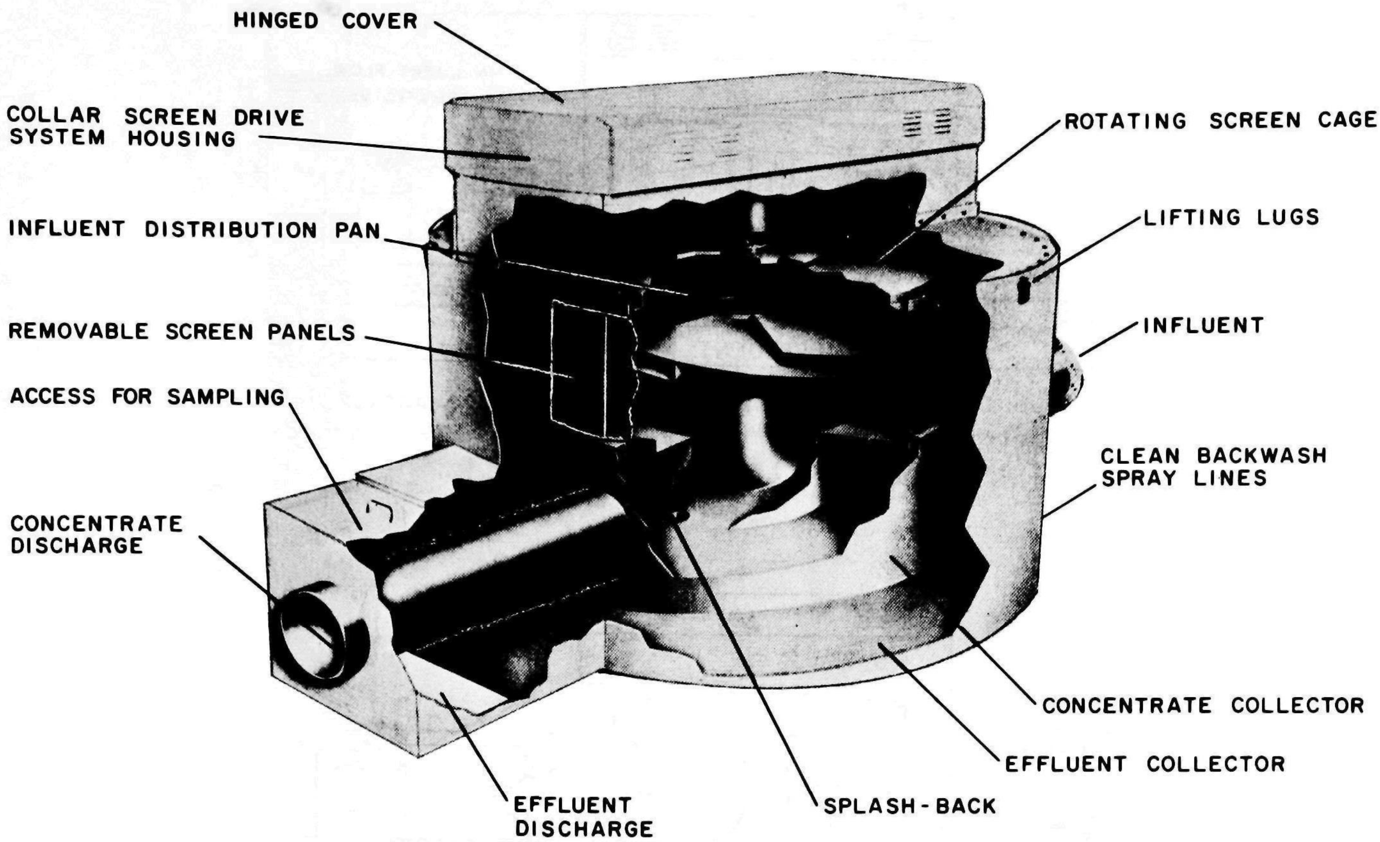
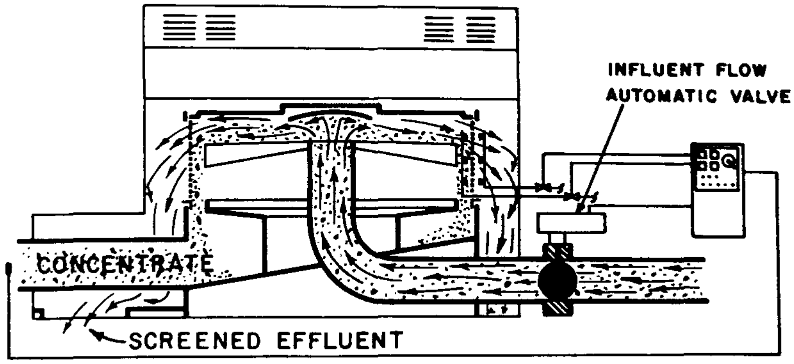
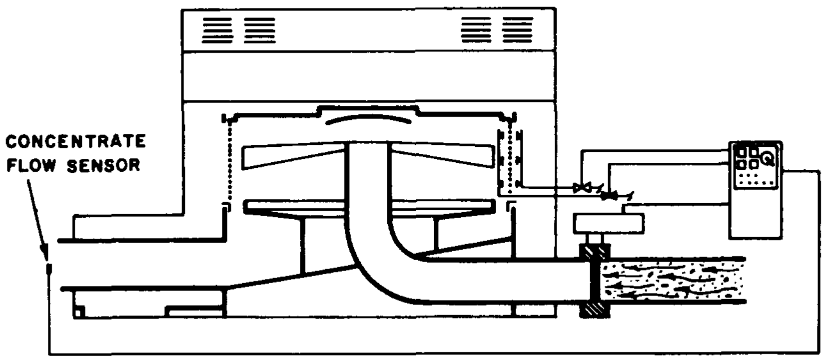



FIGURE 3
**SWECO WASTEWATER CONCENTRATOR**

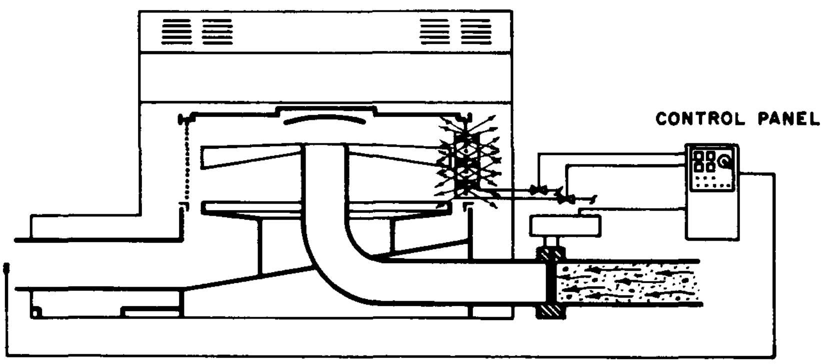
This unit stands 69 inches high with an outside diameter of 84 inches. The flow enters near the bottom of the unit and passes up through a pipe in the center of the unit onto a horizontal distribution dome. This flighted dome spreads and directs the flow downward against the inner top surface of the screens. The manufacturer reports an impingement velocity of approximately 15 feet per second at the screen. This flow action together with the centrifugal force resulting from the rotation of the screen cage and the characteristics of the influent determine the percentage of the flow through the screen and that concentrate flow retained inside the screen.




Influent flow valve open: flow continues until the pre-determined maximum concentrate level is reached. (Monitored by Sensor)




Influent flow valve closes: Concentrate flow has reached pre-determined maximum level. Cleaning phase is then initiated.




Cleaning phase: The screen cage continues to revolve during the 30-second cleaning phase. First the outside nozzles spray, then the inside, with each set operating twice during the phase. Following the cleaning, the influent flow valve automatically opens and the screening cycle is repeated.

**FIGURE 4**
**SCREENING CYCLE**

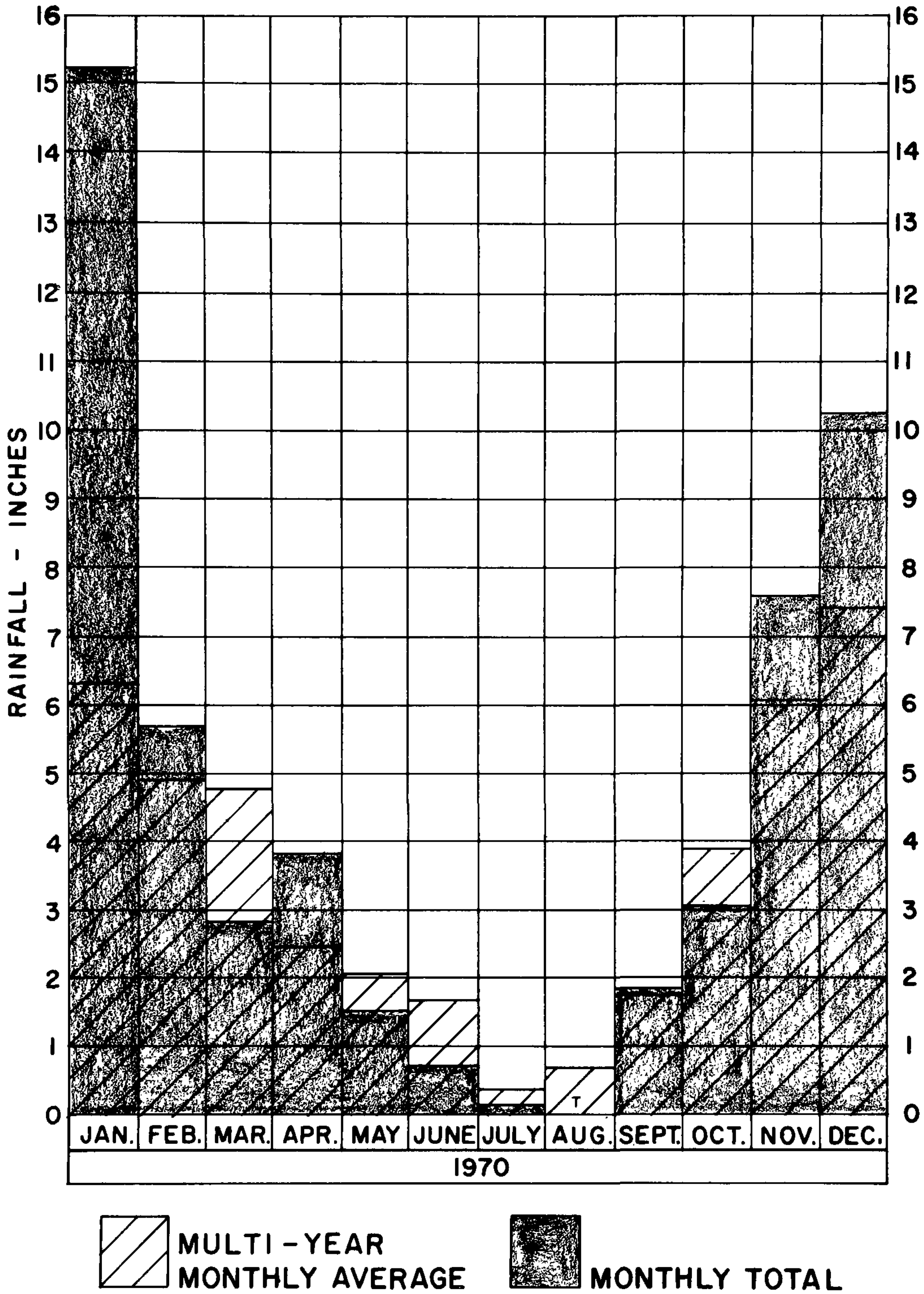



FIGURE 5
RAINFALL
PORTLAND, OREGON

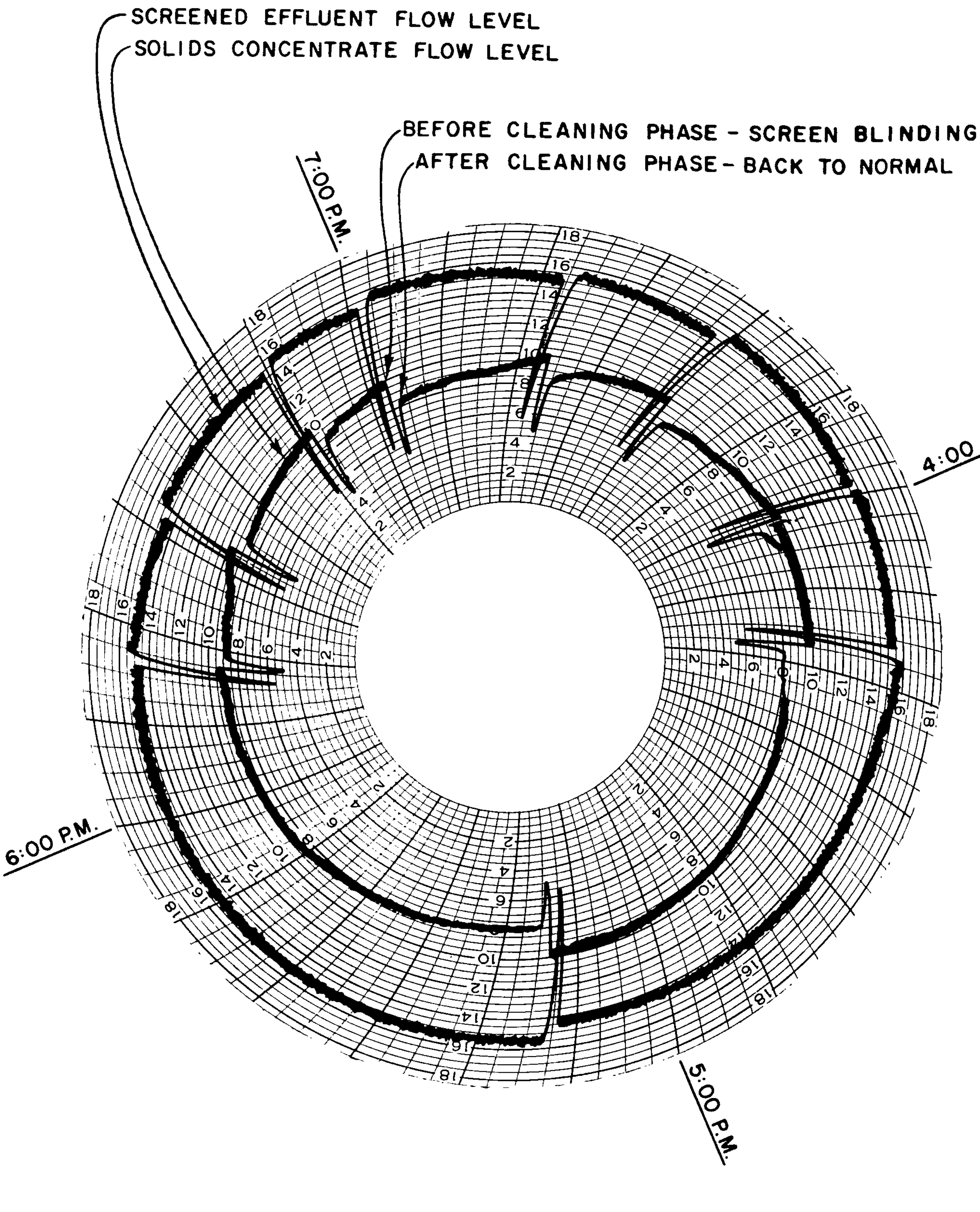



FIGURE 6
INDICATION OF
LOW SOLIDS AND LOW GREASE LOADINGS
OVER FOUR-HOUR PERIOD

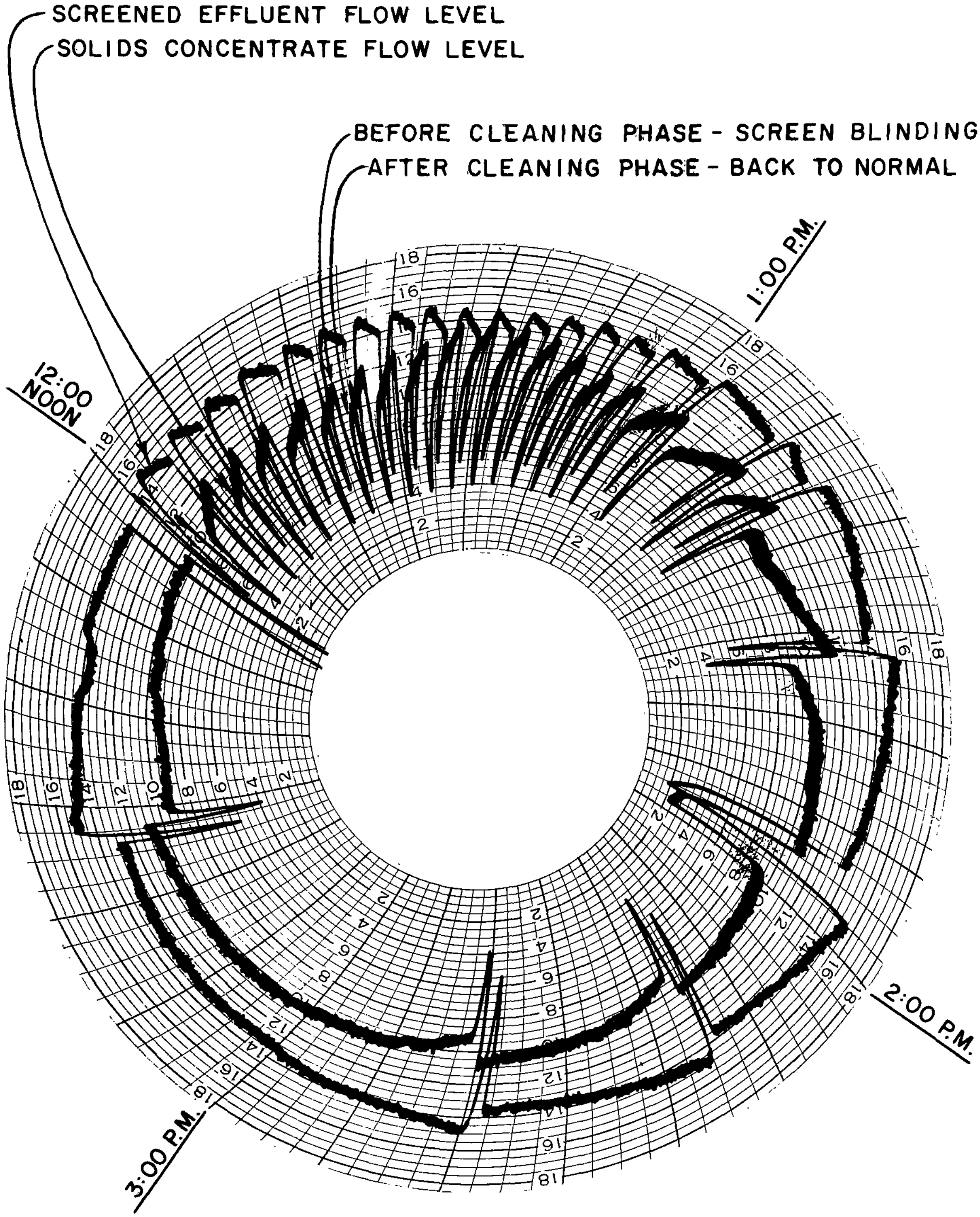



FIGURE 7
INDICATION OF
SEWAGE CHARACTERISTIC CHANGES
OVER FOUR-HOUR PERIOD

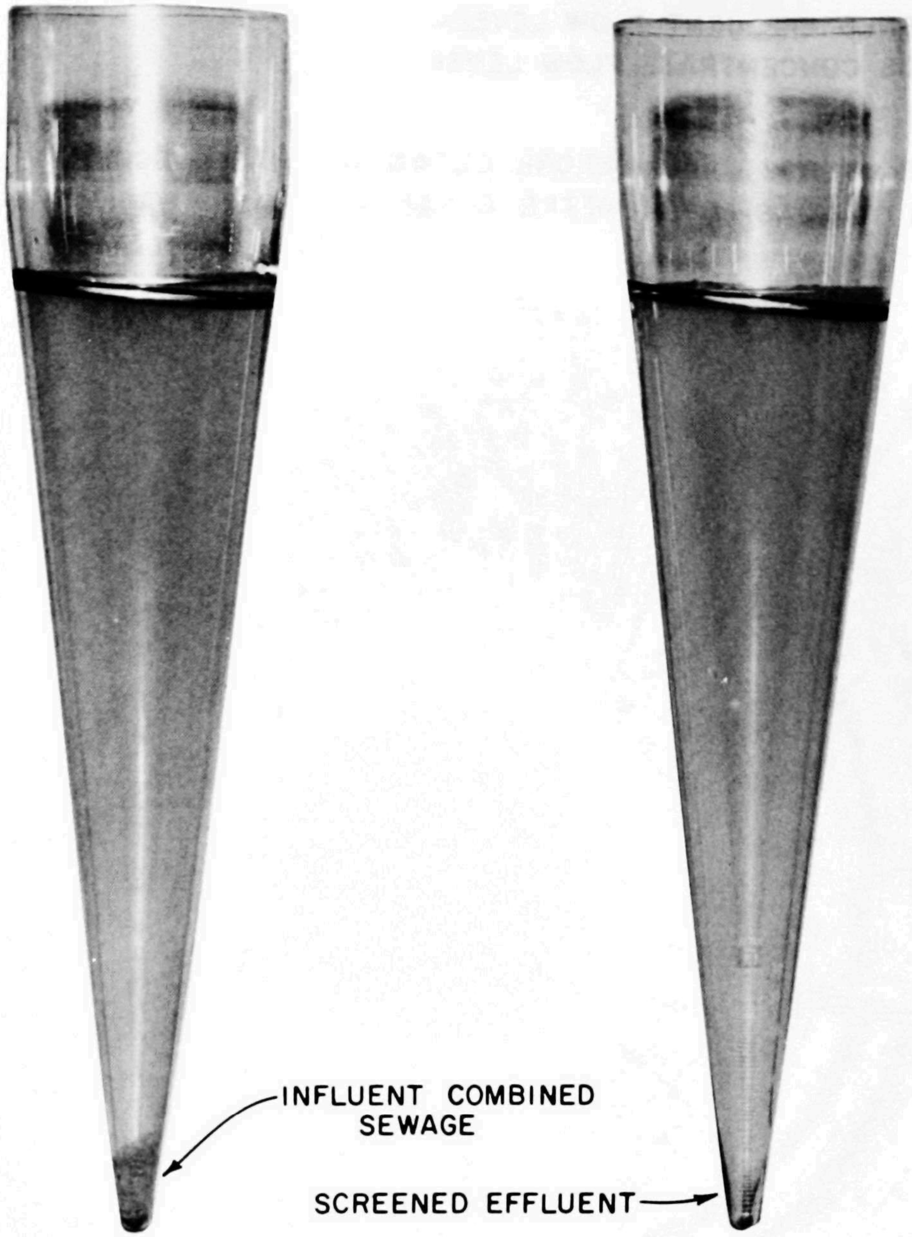



FIGURE 8
IMHOFF CONE COMPARISON
OF
SCREENED AND UNSCREENED FLOWS

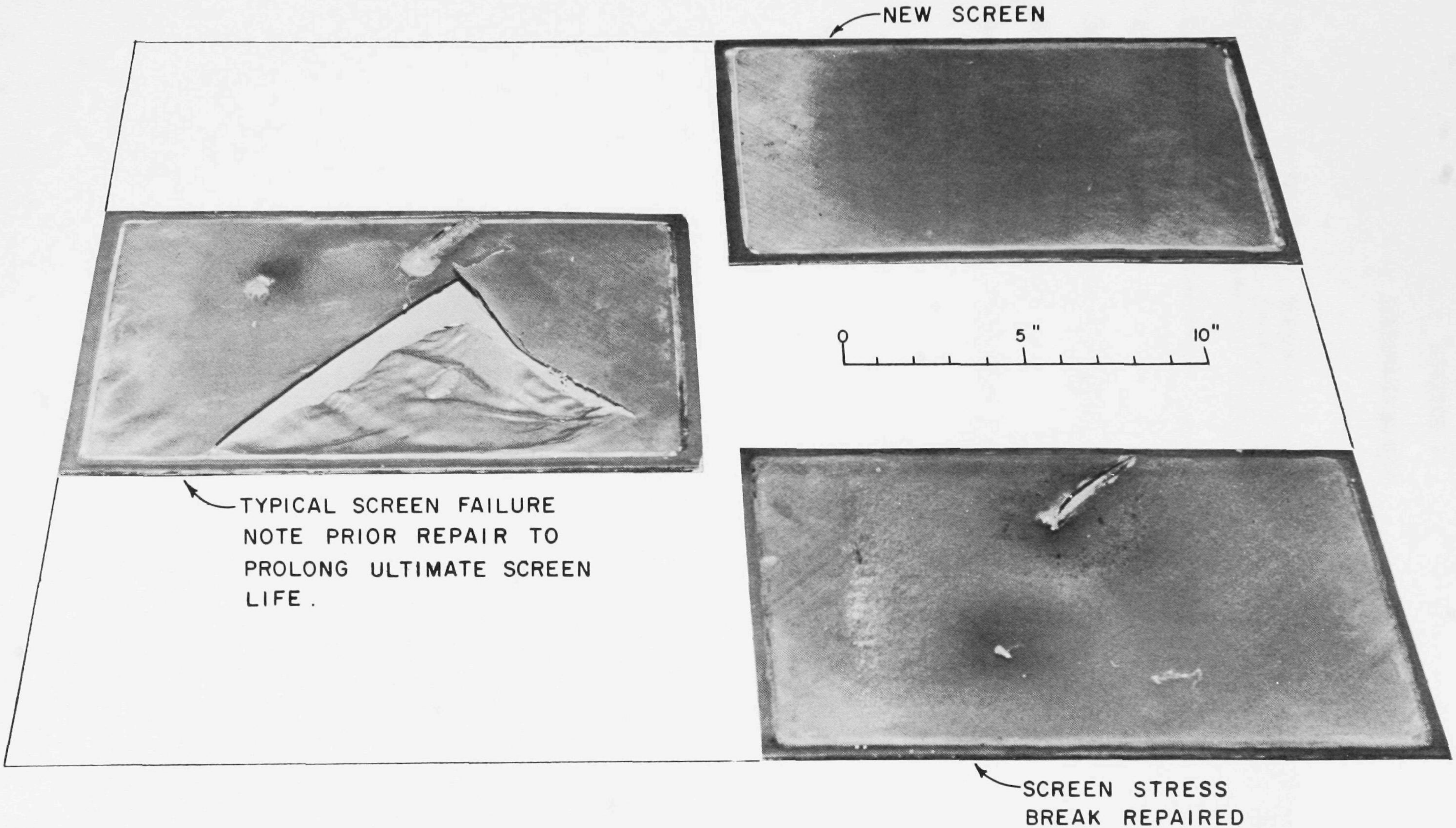



FIGURE 9
TYPICAL SCREENS

## SECTION 7

## ACKNOWLEDGMENTS

The City of Portland, Oregon acknowledges SWECO, INC. of Los Angeles, California, for their cooperation and assistance in conducting this study for the Environmental Protection Agency.

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T A B L E S

REMOVAL RATES RAIN CAUSED FLOW

26 OBSERVATIONS

3 MGD

| CHARACTERISTIC | INFLUENT | | | EFFLUENT | | | PERCENT REMOVAL [1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. |
| SETTLEABLE SOLIDS mg/L | 59.5 | 22 | 180 | 28.2 | 2 | 120 | 54 8 | 16.1 | 92.5 |
| SUSPENDED SOLIDS mg/L | 111.8 | 54 | 246 | 81.6 | 36 | 192 | 26.6 | 6.1 | 56.4 |
| C O D mg/L | 180.5 | 79 | 303 | 152.2 | 60 | 281 | 15.5 | 5.9 | 31 |

1- 26 OBSERVATIONS (SEE APPENDIX)

TABLE 4

REMOVAL RATES DRY-WEATHER FLOW

20 OBSERVATIONS

3 MGD

| CHARACTERISTIC | INFLUENT | | | EFFLUENT | | | PERCENT REMOVAL[1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. |
| SETTLEABLE SOLIDS mg/L | 46.4 | 28 | 92 | 17.1 | 6 | 44 | 62.7 | 12 | 85.7 |
| SUSPENDED SOLIDS mg/L | 85.3 | 54 | 128 | 57.6 | 38 | 82 | 31.9 | 10.7 | 45.7 |
| C O D mg/L | 217 | 67 | 303 | 188.8 | 57 | 272 | 13.5 | 5.3 | 27.8 |

1- 20 OBSERVATIONS (SEE APPENDIX)

TABLE 5

REMOVAL RATES RAIN CAUSED FLOW

6 OBSERVATIONS

2.5 MGD

| CHARACTERISTIC | INFLUENT | | | EFFLUENT | | | PERCENT REMOVAL [1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. |
| SETTLEABLE SOLIDS mg/L | 65 | 38 | 176 | 26.3 | 0 | 82 | 64.2 | 35 | 100 |
| SUSPENDED SOLIDS mg/L | 111 | 70 | 224 | 77.7 | 52 | 136 | 28.0 | 20 | 39.3 |
| C O D mg/L | 273.5 | 248 | 299 | 207.5 | 182 | 233 | 224.1 | 22.1 | 26.6 |

1- 6 OBSERVATIONS (SEE APPENDIX)

TABLE 6

REMOVAL RATES DRY-WEATHER FLOW

31 OBSERVATIONS

2.5 MGD

| CHARACTERISTIC | INFLUENT | | | EFFLUENT | | | PERCENT REMOVAL [1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. |
| SETTLEABLE SOLIDS mg/L | 68.8 | 30 | 182 | 21.9 | 6 | 66 | 68.8 | 39.4 | 93.3 |
| SUSPENDED SOLIDS mg/L | 113.8 | 62 | 246 | 71.6 | 38 | 134 | 35.9 | 20 | 53.6 |
| C O D mg/L | 284.4 | 160 | 405 | 244.3 | 123 | 347 | 14.7 | 7.1 | 23.1 |

1- 31 OBSERVATIONS (SEE APPENDIX)

TABLE 7

REMOVAL RATES DRY-WEATHER FLOW

20 OBSERVATIONS

3 MGD high velocity

| CHARACTERISTIC | INFLUENT | | | EFFLUENT | | | PERCENT REMOVAL[1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. | MEAN | MIN. | MAX. |
| SETTLEABLE SOLIDS mg/L | 74.8 | 46 | 134 | 32.3 | 8 | 64 | 57.5 | 33.3 | 82.6 |
| SUSPENDED SOLIDS mg/L | 124.1 | 86 | 186 | 88 | 60 | 122 | 28.7 | 16.1 | 38.1 |
| C O D mg/L | 350 | 24 | 532 | 305 | 206 | 502 | 12.9 | 5.6 | 24.7 |

1- 20 OBSERVATIONS (SEE APPENDIX)

TABLE 8

# SECTION 8

## GLOSSARY

AVERAGE DAILY DRY WEATHER FLOW - The flow from a complete sewer system, or a defined portion thereof, measured in total gallons throughout a 24-hour period (expressed in millions of gallons per day).

BAR SCREEN - A screen composed of parallel bars, either vertical or inclined, placed in a waterway to catch debris, and from which the screenings may be raked. (Also called a rack).

$BOD_5$ - Five-day Biochemical Oxygen Demand is that amount of oxygen utilized in aerobic decomposition of a waste material during a five-day incubation at constant temperature.

CLEANING PHASE - That part of the screening cycle during which the sewage pumps are off and the screens are being automatically washed.

COD - Chemical oxygen demand is a measure of the oxygen necessary to stabilize most of the oxidizable compounds in a waste.

COMBINED SEWER SYSTEM - A system of sewers receiving both surface runoff and sewage.

COMPOSITE SAMPLE - Integrated sample collected by taking a portion at regular time intervals, with sample size varying with flow; or taking uniform portions on a time schedule varying with the total flow.

CONCENTRATE - That portion of the flow (solids and liquid) which does not pass through the screens.

DISSOLVED OXYGEN - Usually designated as D.O. The oxygen dissolved in sewage or other liquid usually expressed in milligrams per liter or per cent of saturation.

DISSOLVED SOLIDS - Solids which are present in solution.

EFFICIENCY - The ratio of the actual performance of a device to the theoretically perfect performance sometimes expressed as a percentage.

EFFLUENT - Liquid flowing out of a basin or treatment plant.

EFFLUENT WEIR - A weir at the outflow end of a sedimentation basin or other hydraulic structure.

GENERAL SCREEN LIFE - Collective term used in referring to any or all of ultimate, initial, or service screen lives.

GREASE - In sewage, grease includes fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and other nonfatty materials. Substances soluble in n-hexane.

GRIT - The heavy mineral matter in water or sewage, such as sand, gravel, cinders, etc.

HIGH VELOCITY - The impingement velocity upon the screens when the screen cage is rotating at 65 RPM, the extension piece coupled to the influent line and the deflection plate is closed down over the end of the extension.

HYDRAULIC EFFICIENCY - The ratio of screened effluent flow to influent flow.

INFLUENT - Liquid flowing into a basin or treatment plant.

INITIAL SCREEN LIFE - The number of working hours on a screen until it sustains its first damage, repairable or not.

LOW VELOCITY - The impingement velocity upon the screens when the screen cage is rotating at 55 RPM, the deflection plate is raised and there are no alterations to the influent line.

mg/L - Milligrams per liter.

MGD - Million gallons per day.

OUTFALL SEWER - The outlet or structure through which sewage is finally discharged.

PER CENT CONCENTRATE - (100) (Concentrate Flow) / (Influent flow)

PRIMARY TREATMENT - The removal of settleable organic and inorganic solids by the process of sedimentation.

SCREENING CYCLE - The sequential events between sewage pump start-up and the conclusion of the cleaning phase.

SCREENING PHASE - That part of the screening cycle during which sewage is being pumped to the screens.

SEDIMENTATION - The process of subsidence and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point where it can transport the suspended material.

SERVICE SCREEN LIFE - The number of working hours on a screen between repairs.

SETTLEABLE SOLIDS - That matter in sewage which will not stay in suspension during the settling period.

SEWAGE TREATMENT PLANT - Man-made structures which subject sewage to treatment by physical, chemical, or biological processes for the purpose of removing or altering its objectionable constituents, and rendering it less offensive or dangerous.

STORM SEWER - A sewer which carries storm water and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes. (Also called a Storm Drain).

SEPARATE SYSTEM - A sewer system comprised exclusively of sanitary sewers which carry only sewage and to which storm water, surface water, and ground water are not intentionally admitted; also referred to as "sanitary system" or separate sanitary system.

SUSPENDED SOLIDS - Non-filterable residue (expressed in parts per million, ppm, or milligrams per liter, mg/L).

TOTAL SOLIDS - The solids in water, sewage, or other liquids.

ULTIMATE SCREEN LIFE - The number of working hours on a screen until it sustains irreparable damage.

VOLATILE SOLIDS - The quantity of solids in water, sewage or other liquid lost on ignition of the total solids.

SECTION 9

APPENDICES

## SCREEN CLEANING AGENTS

Early in the program it was found that sodium hypochlorite did not clean the screens adequately and a minor research project ensued. Several screens were taken to the laboratory where they were wetted and various solutions applied to them to determine the best cleaning agent. Concentrated sodium hydroxide, potassium hydroxide, 14% sodium hypochlorite, acetone and chloroform were tried and only chloroform appeared to have an affect on the screen residue. A solvent parts cleaner was tried under actual working conditions; it successfully cleaned the screens but the high water temperature combined with its volatile nature made it unacceptable. A soluble pine oil, Zif, Formula 409, Vestal Eight and a few other similar type cleaners offered limited effectiveness.

A cleaner called Zep 9658 (designed for asphalt and tar removal) was tried and was found to do a very good job cleaning the screens. This may not be the ultimate cleaner as no evaluation of its economic or environmental implications was attempted, but it performed satisfactorily at this installation and no effort was exerted to find a better cleaner.

SCREEN VELOCITY (55 RPM)

| RUN NO. | | 1 | 2 | 3 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 | 1300<br>1400 | 1300<br>1400 | 0900<br>1000 | 1300<br>1400 | 2000<br>2100 | 0900<br>1000 |
| WEATHER | | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| SULLIVAN FLOW-MGD | | 24 | 24 | 21 | 30 | 22 | 27 | 30 | 20 | 25 | 22 | 20 |
| PROCESS STREAM FLOW-MGD | | 2.8 | 2.8 | 2.5 | 3.0 | 2.8 | 2.9 | 2.9 | 2.8 | 3.1 | 3.0 | 2.9 |
| HYDRAULIC EFFICIENCY | START<br>STOP | 0.754<br>0.659 | 0.764<br>0.598 | 0.820<br>0.570 | 0.808<br>0.664 | 0.799<br>0.659 | 0.811<br>0.665 | 0.834<br>0.873 | 0.842<br>0.623 | 0.834<br>0.653 | 0.860<br>0.642 | 0.834<br>0.666 |
| SCREENING PHASE (MINUTES) | | 7.5 | 6.1 | 9.5 | 4.5 | 9.5 | 6.1 | 6.0 | 11.5 | 8.0 | 6.1 | 25.0 |
| INFLUENT | SETT. SOLIDS mg/L | 60 | 48 | 56 | 50 | 112 | 42 | 64 | 58 | 94 | 50 | 64 |
| INFLUENT | SUSP. SOLIDS mg/L | 88 | 90 | 120 | 84 | 164 | 80 | 132 | 106 | 126 | 116 | 112 |
| INFLUENT | C O D mg/L | | | | 252 | 405 | 272 | 396 | 347 | 260 | | 314 |
| INFLUENT | $CL_2$ REQUIREMENT mg/L | | | | | | | | 14.6 | | | |
| EFFLUENT | SETT. SOLIDS mg/L | 18 | 10 | 28 | 16 | 16 | 24 | 30 | 8 | 34 | 22 | 24 |
| EFFLUENT | SUSP. SOLIDS mg/L | 46 | 54 | 88 | 54 | 76 | 64 | 102 | 68 | 76 | 88 | 84 |
| EFFLUENT | C O D mg/L | | | | 211 | 347 | 239 | 368 | 289 | 210 | | 272 |
| EFFLUENT | $CL_2$ REQUIREMENT mg/L | | | | | | | | 15.0 | | | |
| % REMOVAL SETT. SOLIDS | | 70 | 79.2 | 50 | 68 | 85.7 | 42.8 | 53.1 | 86.2 | 63.8 | 56.0 | 62.5 |
| % REMOVAL SUSP. SOLIDS | | 47.7 | 40.0 | 26.7 | 35.7 | 53.6 | 20.0 | 23.9 | 35.8 | 39.7 | 24.1 | 25.0 |
| % REMOVAL C O D | | | | | 16.3 | 14.3 | 12.1 | 7.1 | 16.7 | 19.2 | | 13.4 |

SCREEN VELOCITY (55 RPM)

| | | 16 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RUN NO. | | 16 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| TIME | | 1300<br>1400 | 1300<br>1400 | 1700<br>1800 | 0800<br>0900 | 1300<br>1400 | 1700<br>1800 | 2000<br>2100 | 0900<br>1000 | 1300<br>1400 | 1700<br>1800 | 2000<br>2100 |
| WEATHER | | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| SULLIVAN FLOW-MGD | | 30 | 30 | 32 | 22 | 30 | 28 | 24 | 24 | 24 | 23 | 26 |
| PROCESS STREAM FLOW-MGD | | 3.1 | 3.0 | 3.3 | 3.0 | 3.0 | 3.0 | 2.8 | 2.7 | 2.8 | | 2.7 |
| HYDRAULIC EFFICIENCY | START<br>STOP | 0.814<br>0.659 | 0.908<br>0.647 | 0.850<br>0.745 | 0.798<br>0.685 | 0.825<br>0.653 | 0.817<br>0.643 | 0.862<br>0.600 | 0.849<br>0.649 | 0.862<br>0.637 | | 0.866<br>0.623 |
| SCREENING PHASE (MINUTES) | | 8.0 | 5.0 | 9.5 | 7.0 | 14.0 | 14.0 | 15.0 | 20.0 | 8.0 | 8.0 | 8.0 |
| INFLUENT | SETT SOLIDS mg/L | 56 | 82 | 114 | 182 | 60 | 66 | 32 | 34 | 50 | 30 | 32 |
| | SUSP SOLIDS mg/L | 80 | 124 | 160 | 246 | 92 | 140 | 64 | 82 | 80 | 78 | 62 |
| | C O D mg/L | 194 | | | | | | | | | 272 | |
| | $CL_2$ REQUIREMENT mg/L | | | | | | | | | 12.2 | 15.6 | |
| EFFLUENT | SETT. SOLIDS mg/L | 20 | 22 | 44 | 34 | 30 | 40 | 4 | 8 | 22 | 8 | 8 |
| | SUSP. SOLIDS mg/L | 54 | 70 | 94 | 114 | 48 | 108 | 38 | 58 | 54 | 62 | 48 |
| | C O D mg/L | 156 | | | | | | | | 223 | | |
| | $CL_2$ REQUIREMENT mg/L | | | | | | | | 11.8 | 13.0 | | |
| % REMOVAL SETT. SOLIDS | | 64.3 | 73.2 | 61.4 | 81.3 | 50.0 | 39.4 | 87.5 | 76.5 | 56 | 73.3 | 75.0 |
| % REMOVAL SUSP. SOLIDS | | 32.5 | 43.5 | 41.2 | 53.6 | 47.8 | 22.8 | 40.6 | 29.3 | 32.5 | 20.5 | 22.6 |
| % REMOVAL C O D | | 19.6 | | | | | | | | 18.0 | | |

SCREEN VELOCITY (55 RPM)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RUN NO. | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 39 | 40 | | |
| TIME | 0800<br>0900 | 1300<br>1400 | 1700<br>1800 | 2000<br>2100 | 0800<br>0900 | 1700<br>1800 | 2000<br>2100 | 1300<br>1400 | 1700<br>1800 | | |
| WEATHER | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | | |
| SULLIVAN FLOW-MGD | 20 | 26 | 21 | 20 | 20 | 21 | 25 | 21 | 20 | | |
| PROCESS STREAM FLOW-MGD | 2.7 | 3.0 | 3.1 | 2.8 | 2.8 | 3.0 | 3.0 | 3.1 | 2.9 | | |
| HYDRAULIC EFFICIENCY START<br>STOP | 0.863<br>0.642 | 0.860<br>0.679 | 0.852<br>0.679 | 0.853<br>0.604 | 0.853<br>0.693 | 0.834<br>0.686 | 0.873<br>0.700 | 0.843<br>0.698 | 0.834<br>0.666 | | |
| SCREENING PHASE (MINUTES) | 14.5 | 6.1 | 13.7 | 7.0 | 11.5 | 5.5 | 5.5 | 5.5 | 12.0 | | |
| INFLUENT SETT. SOLIDS mg/L | 120 | 56 | 46 | 54 | 38 | 70 | 64 | 82 | 112 | | |
| INFLUENT SUSP. SOLIDS mg/L | 144 | 100 | 90 | 114 | 68 | 126 | 112 | 122 | 184 | | |
| INFLUENT C O D mg/L | 160 | 309 | | | 157 | | | 360 | | | |
| INFLUENT $CL_2$ REQUIREMENT mg/L | 12.3 | 12.0 | | | 12.3 | | | 12.7 | | | |
| EFFLUENT SETT. SOLIDS mg/L | 8 | 8 | 6 | 16 | 8 | 26 | 10 | 32 | 52 | | |
| EFFLUENT SUSP. SOLIDS mg/L | 40 | 58 | 54 | 78 | 48 | 88 | 60 | 78 | 134 | | |
| EFFLUENT C O D mg/L | 123 | 264 | | | 144 | | | 330 | | | |
| EFFLUENT $CL_2$ REQUIREMENT mg/L | 10.4 | 12.0 | | | 11.3 | | | 12.0 | | | |
| % REMOVAL SETT. SOLIDS | 93.3 | 85.7 | 87 | 70.4 | 78.9 | 62.8 | 84.4 | 61.0 | 53.6 | | |
| % REMOVAL SUSP. SOLIDS | 72.2 | 42 | 40.0 | 31.6 | 29.4 | 30.2 | 46.4 | 36.1 | 27.2 | | |
| % REMOVAL C O D | 23.1 | 14.6 | | | 8.3 | | | 8.3 | | | |

SCREEN VELOCITY (55 RPM)

| RUN NO. | | 104 | 105 | 129 | 160 | 162 | 169 | 170 | 171 | 173 | 174 | 175 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 | 0100<br>0200 | 1300<br>1400 | 1700<br>1800 | 2000<br>2100 | 0100<br>0200 | 0900<br>1000 | 1300<br>1400 | 1630<br>1730 |
| WEATHER | | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| SULLIVAN FLOW-MGD | | 25 | 20 | 22 | 21 | 31 | 23 | 22 | 20 | 25 | 30 | 21 |
| PROCESS STREAM FLOW-MGD | | 3.5 | 3.3 | 3.5 | 3.3 | 3.4 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| HYDRAULIC EFFICIENCY | START<br>STOP | 0.860<br>0.694 | 0.840<br>0.660 | 0.890<br>0.726 | 0.884<br>0.826 | 0.850<br>0.872 | 0.901<br>0.880 | 0.886<br>0.729 | 0.901<br>0.753 | 0.839<br>0.794 | 0.870<br>0.760 | 0.882<br>0.660 |
| SCREENING PHASE (MINUTES) | | 15.0 | 10.6 | 5.5 | 20.0 | 4.0 | 10.0 | 3.5 | 8.0 | 5.0 | 4.0 | 12.0 |
| INFLUENT | SETT. SOLIDS mg/L | 40 | 50 | 36 | 86 | 34 | 40 | 44 | 28 | 52 | 42 | 42 |
| INFLUENT | SUSP. SOLIDS mg/L | 86 | 106 | 78 | 128 | 74 | 84 | 84 | 68 | 98 | 98 | 94 |
| INFLUENT | C O D mg/L | 288 | 280 | 266 | 127 | 245 | 249 | 245 | 162 | 252 | 298 | 303 |
| INFLUENT | $CL_2$ REQUIREMENT mg/L | 13.3 | 12.7 | 13.0 | 10.0 | 11.3 | 6.9 | 8.7 | 8.7 | 10.0 | 9.7 | 9.4 |
| EFFLUENT | SETT. SOLIDS mg/L | 16 | 20 | 12 | 28 | 10 | 14 | 12 | 16 | 18 | 8 | 12 |
| EFFLUENT | SUSP. SOLIDS mg/L | 64 | 82 | 52 | 76 | 52 | 56 | 54 | 48 | 68 | 66 | 66 |
| EFFLUENT | C O D mg/L | 228 | 232 | 223 | 100 | 232 | 205 | 205 | 148 | 222 | 267 | 272 |
| EFFLUENT | $CL_2$ REQUIREMENT mg/L | 12.0 | 12.7 | 12 | 11.1 | 13.1 | 7.6 | 8.0 | 9.0 | 8.4 | 8.4 | 9.0 |
| % REMOVAL SETT. SOLIDS | | 60 | 60.0 | 66.7 | 67.4 | 70.6 | 65 | 72.7 | 42.8 | 65.4 | 81 | 71.4 |
| % REMOVAL SUSP. SOLIDS | | 25.5 | 22.6 | 33.3 | 40.6 | 29.7 | 33.3 | 35.7 | 29.4 | 30.6 | 32.6 | 29.8 |
| % REMOVAL C O D | | 20.8 | 17.1 | 16.2 | 21.2 | 5.3 | 17.7 | 16.3 | 8.6 | 11.9 | 10.4 | 10.2 |

## SCREEN VELOCITY (55 RPM)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RUN NO. | | 176 | 181 | 196 | 199 | 205 | 206 | 210 | 211 | 215 | | |
| TIME | | 2000<br>2100 | 0100<br>0200 | 0100<br>0200 | 1300<br>1400 | 2000<br>2100 | 0100<br>0200 | 1700<br>1800 | 2000<br>2100 | 1300<br>1400 | | |
| WEATHER | | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | | |
| SULLIVAN FLOW-MGD | | 20 | 21 | 12 | 20 | 19 | 12 | 20 | 19 | 30 | | |
| PROCESS STREAM FLOW-MGD | | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.4 | 3.4 | 3.3 | 3.2 | | |
| HYDRAULIC EFFICIENCY | START<br>STOP | 0.853<br>0.656 | 0.915<br>0.900 | 0.900<br>0.866 | 0.876<br>0.746 | 0.874<br>0.660 | 0.902<br>0.757 | 0.886<br>0.744 | 0.882<br>0.706 | 0.862<br>0.732 | | |
| SCREENING PHASE (MINUTES) | | 10.0 | 20.0 | 25.0 | 7.5 | 15.0 | 10.0 | 23.0 | 10.0 | 5.0 | | |
| INFLUENT | SETT. SOLIDS mg/L | 52 | 32 | 50 | 42 | 32 | 92 | 40 | 52 | 42 | | |
| | SUSP. SOLIDS mg/L | 94 | 56 | 76 | 74 | 64 | 120 | 78 | 76 | 70 | | |
| | C O D mg/L | 232 | 79 | 67 | 243 | 170 | 152 | 234 | 217 | 232 | | |
| | $CL_2$ REQUIREMENT mg/L | 7.6 | 12.9 | 12.4 | 12.4 | 11.1 | 6.6 | 38.3 | 9.6 | 9.7 | | |
| EFFLUENT | SETT. SOLIDS mg/L | 14 | 26 | 44 | 6 | 8 | 34 | 14 | 20 | 10 | | |
| | SUSP. SOLIDS mg/L | 58 | 50 | 64 | 54 | 38 | 68 | 52 | 46 | 38 | | |
| | C O D mg/L | 219 | 57 | 60 | 234 | 133 | 135 | 213 | 184 | 208 | | |
| | $CL_2$ REQUIREMENT mg/L | 8.7 | 16.2 | 13.1 | 11.0 | 8.3 | 9.0 | 34.8 | 11.3 | 9.3 | | |
| % REMOVAL SETT. SOLIDS | | 73.1 | 18.8 | 12.0 | 85.7 | 75 | 63.0 | 65 | 61.5 | 76.2 | | |
| % REMOVAL SUSP. SOLIDS | | 38.3 | 10.7 | 15.8 | 27.0 | 40.6 | 43.3 | 33.3 | 39.5 | 45.7 | | |
| % REMOVAL C O D | | 5.6 | 27.8 | 10.4 | 3.7 | 21.8 | 11.2 | 9 | 15.2 | 10.3 | | |

SCREEN VELOCITY (55 RPM)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RUN NO. | 9 | 14 | 15 | 17 | 18 | 38 | | | | | |
| TIME | 0900<br>1000 | 1700<br>1800 | 2000<br>2100 | 1700<br>1800 | 2000<br>2100 | 0800<br>0900 | | | | | |
| WEATHER | Rain | Rain | Rain | Rain | Rain | Rain | | | | | |
| SULLIVAN FLOW-MGD | 30 | 32 | 30 | 33 | 32 | 30 | | | | | |
| PROCESS STREAM FLOW-MGD | 3.1 | 3.1 | 2.6 | 3.0 | 2.8 | 3.1 | | | | | |
| HYDRAULIC EFFICIENCY START | 0.824 | 0.840 | 0.843 | 0.808 | 0.804 | 0.814 | | | | | |
| HYDRAULIC EFFICIENCY STOP | 0.688 | 0.681 | 0.617 | 0.647 | 0.634 | 0.751 | | | | | |
| SCREENING PHASE (MINUTES) | 8.0 | 9.5 | 5.0 | 7.0 | 8.0 | 20.0 | | | | | |
| INFLUENT SETT. SOLIDS mg/L | 54 | 38 | 40 | 38 | 44 | 176 | | | | | |
| INFLUENT SUSP. SOLIDS mg/L | 104 | 90 | 100 | 70 | 78 | 224 | | | | | |
| INFLUENT C O D mg/L | 248 | | | | | 299 | | | | | |
| INFLUENT $CL_2$ REQUIREMENT mg/L | | | | | | 13 | | | | | |
| EFFLUENT SETT. SOLIDS mg/L | 30 | 0 | 26 | 6 | 14 | 82 | | | | | |
| EFFLUENT SUSP. SOLIDS mg/L | 82 | 62 | 80 | 54 | 52 | 136 | | | | | |
| EFFLUENT C O D mg/L | 182 | | | | | 233 | | | | | |
| EFFLUENT $CL_2$ REQUIREMENT mg/L | | | | | | 14.3 | | | | | |
| % REMOVAL SETT. SOLIDS | 44.4 | 100 | 35.0 | 84.2 | 68.2 | 53.4 | | | | | |
| % REMOVAL SUSP. SOLIDS | 21.2 | 31.1 | 20.0 | 22.8 | 33.3 | 39.3 | | | | | |
| % REMOVAL C O D | 26.6 | | | | | 22.1 | | | | | |

SCREEN VELOCITY (55 RPM)

| | RUN NO | 124 | 125 | 130 | 131 | 162 | 168 | 177 | 178 | 179 | 180 | 183 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TIME | 0900<br>1000 | 1900<br>2000 | 1700<br>1800 | 2000<br>2100 | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 | 1300<br>1400 | 1630<br>1730 | 2000<br>2100 | 0900<br>1000 |
| | WEATHER | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain |
| | SULLIVAN FLOW-MGD | 55 | 55 | 55 | 45 | 45 | 33 | 48 | 58 | 44 | 58 | 38 |
| | PROCESS STREAM FLOW-MGD | 3.3 | 3.2 | 3.3 | 3.6 | 3.3 | 3.3 | 3.3 | 3.3 | 3.4 | 3.3 | 3.3 |
| | HYDRAULIC EFFICIENCY START<br>STOP | 0.870<br>0.650 | 0.910<br>0.800 | 0.878<br>0.732 | 0.907<br>0.838 | 0.862<br>0.748 | 0.860<br>0.746 | 0.859<br>0.726 | 0.875<br>0.837 | 0.904<br>0.787 | 0.900<br>0.724 | 0.884<br>0.837 |
| | SCREENING PHASE (MINUTES) | 40.0 | 10.5 | 16.5 | 12.0 | 10.5 | 4.5 | 10.0 | 15.0 | 10.0 | 20.0 | 0.5 |
| INFLUENT | SETT SOLIDS mg/L | 66 | 28 | 54 | 56 | 52 | 56 | 130 | 42 | 50 | 58 | 42 |
| INFLUENT | SUSP SOLIDS mg/L | 114 | 58 | 94 | 92 | 92 | 122 | 224 | 98 | 120 | 128 | 70 |
| INFLUENT | C O D mg/L | 228 | 172 | 211 | 116 | 162 | 303 | 237 | 158 | 169 | 193 | 206 |
| INFLUENT | $CL_2$ REQUIREMENT mg/L | 12.7 | 11.6 | 10.3 | 8.1 | 12.1 | 11.1 | 10.4 | 14.1 | 13.8 | 11.1 | 12.9 |
| EFFLUENT | SETT. SOLIDS mg/L | 42 | 12 | 20 | 28 | 26 | 20 | 60 | 22 | 20 | 22 | 14 |
| EFFLUENT | SUSP. SOLIDS mg/L | 88 | 46 | 66 | 68 | 68 | 88 | 162 | 66 | 86 | 98 | 44 |
| EFFLUENT | C O D mg/L | 176 | 120 | 159 | 99 | 144 | 281 | 175 | 109 | 151 | 175 | 179 |
| EFFLUENT | $CL_2$ REQUIREMENT mg/L | 13.1 | 14.0 | 10.8 | 7.1 | 11.1 | 12.4 | 10.0 | 14.1 | 13.1 | 11.1 | 11.7 |
| | % REMOVAL SETT. SOLIDS | 36.4 | 57.1 | 63.0 | 50 | 50 | 64.3 | 53.8 | 47.6 | 60 | 62.1 | 66.7 |
| | % REMOVAL SUSP. SOLIDS | 22.8 | 20.7 | 29.8 | 26.1 | 26.1 | 27.9 | 27.7 | 32.6 | 28.3 | 23.7 | 37.1 |
| | % REMOVAL C O D | 22.8 | 30.2 | 24.6 | 14.6 | 11.1 | 7.3 | 26.2 | 31.0 | 10.6 | 9.3 | 13.1 |

SCREEN VELOCITY (55 RPM)

| RUN NO. | 184 | 185 | 186 | 190 | 191 | 192 | 193 | 194 | 195 | 198 | 202 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | 1300<br>1400 | 0100<br>0200 | 1000<br>1100 | 2000<br>2100 | 0100<br>0200 | 0900<br>1000 | 1300<br>1400 | 1700<br>1800 | 2000<br>2100 | 0900<br>1000 | 0900<br>1000 |
| WEATHER | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain | Rain |
| SULLIVAN FLOW-MGD | 38 | 54 | 38 | 36 | 48 | 30 | 50 | 44 | 40 | 33 | 34 |
| PROCESS STREAM FLOW-MGD | 3.3 | 3.3 | 3.3 | 3.5 | 3.3 | 3.3 | 3.3 | 3.3 | 3.5 | 3.3 | 3.3 |
| HYDRAULIC EFFICIENCY START | 0.857 | 0.866 | 0.837 | 0.899 | 0.878 | 0.850 | 0.884 | 0.901 | 0.904 | 0.875 | 0.868 |
| HYDRAULIC EFFICIENCY STOP | 0.755 | 0.804 | 0.750 | 0.742 | 0.797 | 0.731 | 0.739 | 0.696 | 0.810 | 0.790 | 0.794 |
| SCREENING PHASE (MINUTES) | 14.0 | 12.0 | 4.0 | 16.5 | 5.5 | 6.5 | 8.0 | 56.0 | 35.0 | 15.0 | 5.0 |
| INFLUENT SETT. SOLIDS mg/L | 180 | 22 | 80 | 56 | 62 | 32 | 50 | 82 | 38 | 34 | 40. |
| INFLUENT SUSP. SOLIDS mg/L | 246 | 54 | 124 | 134 | 98 | 84 | 88 | 148 | 84 | 84 | 98 |
| INFLUENT C O D mg/L | 180 | 79 | 80 | 122 | 191 | 187 | 172 | 155 | 140 | 148 | 215 |
| INFLUENT $CL_2$ REQUIREMENT mg/L | 14.8 | 10.4 | 9.4 | 10.7 | 9.7 | 9.7 | 13.1 | 9.7 | 13.5 | 17.6 | 11.1 |
| EFFLUENT SETT. SOLIDS mg/L | 120 | 2 | 6 | 14 | 52 | 12 | 36 | 36 | 16 | 12 | 18 |
| EFFLUENT SUSP. SOLIDS mg/L | 192 | 36 | 54 | 94 | 92 | 62 | 70 | 100 | 62 | 68 | 72 |
| EFFLUENT C O D mg/L | 162 | 70 | 226 | 109 | 148 | 176 | 121 | 129 | 114 | 138 | 178 |
| EFFLUENT $CL_2$ REQUIREMENT mg/L | 12.9 | 9.6 | 9.4 | 11.1 | 10.4 | 9.4 | 11.4 | 10.4 | 14.5 | 11.7 | 10.0 |
| % REMOVAL SETT. SOLIDS | 33.3 | 90.9 | 92.5 | 75 | 16.1 | 62.5 | 28.0 | 56.1 | 57.9 | 64.7 | 55 |
| % REMOVAL SUSP. SOLIDS | 22.0 | 33.3 | 56.4 | 29.8 | 6.1 | 26.2 | 20.4 | 32.4 | 26.2 | 19 | 26.5 |
| % REMOVAL C O D | 10.0 | 11.4 | 8.9 | 10.8 | 22.5 | 5.9 | 29.6 | 16.8 | 18.6 | 6.8 | 17.2 |

SCREEN VELOCITY (55 RPM)

| RUN NO. | | 203 | 204 | 208 | 209 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | | 1300<br>1400 | 1700<br>1800 | 0900<br>1000 | 1300<br>1400 | | | | | | | |
| WEATHER | | Rain | Rain | Rain | Rain | | | | | | | |
| SULLIVAN FLOW-MGD | | 33 | 28 | 58 | 30 | | | | | | | |
| PROCESS STREAM FLOW-MGD | | 3.2 | 3.3 | 3.3 | 3.3 | | | | | | | |
| HYDRAULIC EFFICIENCY | START<br>STOP | 0.844<br>0.686 | 0.878<br>0.703 | 0.917<br>0.894 | 0.900<br>0.836 | | | | | | | |
| SCREENING PHASE (MINUTES) | | 4.2 | 20.0 | 15.0 | 8.0 | | | | | | | |
| INFLUENT | SETT. SOLIDS mg/L | 64 | 96 | 42 | 34 | | | | | | | |
| INFLUENT | SUSP. SOLIDS mg/L | 116 | 198 | 72 | 68 | | | | | | | |
| INFLUENT | C O D mg/L | 239 | 248 | 70 | 136 | | | | | | | |
| INFLUENT | $CL_2$ REQUIREMENT mg/L | 10.4 | 14.2 | 12.1 | 12.1 | | | | | | | |
| EFFLUENT | SETT. SOLIDS mg/L | 36 | 38 | 34 | 14 | | | | | | | |
| EFFLUENT | SUSP. SOLIDS mg/L | 88 | 138 | 64 | 50 | | | | | | | |
| EFFLUENT | C O D mg/L | 208 | 226 | 60 | 125 | | | | | | | |
| EFFLUENT | $CL_2$ REQUIREMENT mg/L | 8.7 | 9.7 | 12.1 | 12.1 | | | | | | | |
| % REMOVAL SETT. SOLIDS | | 43.8 | 60.4 | 19 | 58.8 | | | | | | | |
| % REMOVAL SUSP. SOLIDS | | 24.1 | 29.6 | 11.1 | 26.5 | | | | | | | |
| % REMOVAL C O D | | 13 | 8.9 | 14.3 | 8.1 | | | | | | | |

## SCREEN VELOCITY (65 RPM)

| RUN NO | | 1-1 | 1-2 | 1-3 | 1-4 | 1-5 | 1-6 | 1-7 | 1-8 | 1-11 | 1-12 | 1-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 | 1300<br>1400 | 0900<br>100 | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 |
| WEATHER | | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry |
| SULLIVAN FLOW-MGD | | | 30 | 25 | 25 | 24 | 24 | 30 | 20 | 32 | 25 | 21 |
| PROCESS STREAM FLOW-MGD | | 3.8 | 3.4 | 3.5 | 3.5 | 3.3 | 3.6 | 3.3 | 3.3 | 3.6 | 3.6 | 3.3 |
| HYDRAULIC EFFICIENCY | START<br>STOP | 0.848<br>0.785 | 0.832<br>0.774 | 0.846<br>0.780 | 0.855<br>0.786 | 0.858<br>0.793 | 0.806<br>0.782 | 0.866<br>0.799 | 0.892<br>0.740 | 0.836<br>0.761 | 0.856<br>0.761 | 0.865<br>0.740 |
| SCREENING PHASE (MINUTES) | | 6.0 | 3.7 | 12.8 | 5.5 | 4.5 | 2.8 | 14.5 | 25.0 | 3.3 | 4.5 | 13.0 |
| INFLUENT | SETT. SOLIDS mg/L | | 76 | 46 | 75 | 54 | 48 | 108 | 90 | 52 | 118 | 50 |
| | SUSP. SOLIDS mg/L | 125 | 148 | 105 | 149 | 112 | 98 | 162 | 154 | 86 | 162 | 116 |
| | C O D mg/L | 246 | 310 | 356 | 301 | 339 | 267 | 281 | 532 | 303 | 377 | 476 |
| | $CL_2$ REQUIREMENT mg/L | | | | | | | | | | | |
| EFFLUENT | SETT. SOLIDS mg/L | | 26 | 8 | 29 | 36 | 16 | 58 | 48 | 24 | 64 | 22 |
| | SUSP. SOLIDS mg/L | 99 | 110 | 72 | 119 | 94 | 68 | 114 | 122 | 60 | 116 | 88 |
| | C O D mg/L | 224 | 265 | 322 | 275 | 318 | 234 | 250 | 502 | 269 | 328 | 410 |
| | $CL_2$ REQUIREMENT mg/L | | | | | | | | | | | |
| % REMOVAL SETT. SOLIDS | | | 65.8 | 82.6 | 61.3 | 33.3 | 66.6 | 46.3 | 46.6 | 53.8 | 45.8 | 56 |
| % REMOVAL SUSP. SOLIDS | | 20.8 | 25.7 | 31.4 | 20.1 | 16.1 | 30.6 | 29.6 | 20.8 | 30.2 | 28.4 | 24.1 |
| % REMOVAL C O D | | 8.9 | 14.5 | 9.6 | 8.6 | 6.2 | 12.4 | 11.0 | 5.6 | 11.2 | 13.0 | 13.9 |

SCREEN VELOCITY (65 RPM)

| | | RUN NO. | 1-14 | 1-15 | 1-16 | 1-17 | 1-18 | 1-19 | 2-2 | 2-3 | 2-4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | | | 1300<br>1400 | 0900<br>1000 | 1300<br>1400 | 0900<br>1000 | 1300<br>1400 | 2100<br>2200 | 1700<br>1800 | 1700<br>1800 | 2100<br>2200 | | |
| WEATHER | | | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | Dry | | |
| SULLIVAN FLOW-MGD | | | 22 | 30 | 30 | 22 | 30 | 30 | 21 | 25 | 20 | | |
| PROCESS STREAM FLOW-MGD | | | 3.3 | 3.4 | 3.4 | 3.5 | 3.3 | 3.6 | 3.3 | 3.3 | 3.1 | | |
| HYDRAULIC EFFICIENCY | START | | 0.850 | 0.841 | 0.841 | 0.832 | 0.858 | 0.838 | 0.884 | 0.858 | 0.805 | | |
| | STOP | | 0.758 | 0.760 | 0.733 | 0.811 | 0.768 | 0.745 | 0.791 | 0.756 | 0.754 | | |
| SCREENING PHASE (MINUTES) | | | 5.0 | 10 | 8.1 | 11.5 | 7.0 | 4.5 | 11.5 | 3.5 | 3.5 | | |
| INFLUENT | SETT. SOLIDS | mg/L | 70 | 72 | 134 | 60 | 54 | 92 | 92 | 54 | 68 | | |
| | SUSP. SOLIDS | mg/L | 118 | 96 | 186 | 106 | 100 | 138 | 122 | 94 | 96 | | |
| | C O D | mg/L | 348 | 336 | 352 | 422 | 341 | 302 | 246 | 504 | 254 | | |
| | $CL_2$ REQUIREMENT | mg/L | | | | | | | | | | | |
| EFFLUENT | SETT. SOLIDS | mg/L | 30 | 38 | 60 | 18 | 28 | 38 | 28 | 16 | 28 | | |
| | SUSP. SOLIDS | mg/L | 84 | 66 | 116 | 72 | 78 | 90 | 76 | 60 | 62 | | |
| | C O D | mg/L | 302 | 253 | 291 | 327 | 315 | 263 | 211 | 448 | 206 | | |
| | $CL_2$ REQUIREMENT | mg/L | | | | | | | | | | | |
| % REMOVAL SETT. SOLIDS | | | 57.1 | 47.2 | 55.2 | 70 | 48 | 58.7 | 69.6 | 70.4 | 58.8 | | |
| % REMOVAL SUSP. SOLIDS | | | 28.8 | 31.2 | 37.6 | 32.1 | 22.0 | 34.8 | 37.7 | 36.2 | 35.4 | | |
| % REMOVAL C O D | | | 13.2 | 24.7 | 17.3 | 22.5 | 7.6 | 12.9 | 14.2 | 11.1 | 18.8 | | |

## SUPPLEMENTAL DATA

| | 1970 DATE | 7-27 | 8-3 | 8-10 | 9-21 | 9-28 | 10-6 | 10-13 | 10-20 | 11-19 | 11-24 | 11-30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INFLUENT | 5 Day BOD mg/L | 145 | 175 | 180 | 145 | 130 | 110 | | 100 | 90 | 90 | 85 |
| | Hexane Solubles mg/L | 43 | 32 | 16 | 18 | 12.8 | 23 | 32 | 23 | 64 | 37.6 | |
| | Total Solids mg/L | 570 | 435 | 343 | 437 | 373 | 331 | 356 | 245 | 273 | 382 | 294 |
| EFFLUENT | 5 Day BOD mg/L | 165 | 180 | 30 | 145 | 115 | 120 | | 85 | 105 | 75 | 70 |
| | Hexane Solubles mg/L | 29 | 35 | 8 | 11 | 10.4 | 16 | 24 | 30 | 36.4 | 32.4 | 24 |
| | Total Solids mg/L | 444 | 383 | 315 | 377 | 274 | 310 | 325 | 224 | 275 | 358 | 274 |
| CONCENTRATE | 5 Day BOD mg/L | 190 | 250 | 105 | 185 | 205 | 195 | | | 115 | 120 | 110 |
| | Hexane Solubles mg/L | 47 | 43 | 18 | 13 | 16 | 28 | 32 | | 34.4 | 42.8 | 28 |
| | Total Solids mg/L | 728 | 607 | 482 | 489 | 508 | 533 | 470 | | 326 | 480 | 409 |

# DETAILED METHOD OF ANALYSIS

## SETTLEABLE SOLIDS

1. Determine suspended solids on a well-mixed sample.

2. Pour approximately three quarts of well mixed sample into a wide-mouthed plastic gallon jug. Depth should be at least 20 cm, diameter at least 9 cm.

3. Affix a glass siphon tube to a sturdy holder with the end of the tube in the middle of the jug and allow to remain quiescent for one hour. After one hour siphon off 250 ml being careful not to disturb the material.

4. Determine suspended solids on the 250 ml portion. Express result as mg/L non-settleable matter.

5. Calculation:
   mg/L sett. matter = mg/L susp. matter - mg/L non-sett. matter

## CHLORINE REQUIREMENT

A rapid method of determining the amount of chlorine which must be applied to produce a measurable chlorine residual will be used. Contact time is arbitrarily set at fifteen minutes. Standardized dilute sodium hypochlorite (Clorox) is added to the sample in sufficient quantity to produce a measurable residual after the contact period. The residual chlorine level is titrated with standard sodium thiosulfate/starch-iodide, and the chlorine requirement is calculated as the difference between the amount applied and the residual.

## GREASE

Filterable n-hexane soluble substance will be determined by mixing 250 ml of sample and 250 ml of n-hexane in a liter separatory funnel, filtering the hexane phase through Whatman's #40 and weighing the residue upon evaporation of the filtrate at 85°C.

| SCREEN NUMBER | INITIAL SCREEN LIFE-HRS. | NUMBER OF REPAIRS | ULTIMATE SCREEN LIFE-HRS. |
|---|---|---|---|
| 101 | Non-Reparable | -- | 19. |
| 102 | Non-Reparable | -- | 32.25 |
| 103 | Non-Reparable | -- | 36. |
| 104 | 23.5 | 7 | 40. |
| 105 | Non-Reparable | -- | 19.5 |
| 106 | 25.25 | 6 | 95.25 |
| 107 | 35.5 | 6 | 65.5 |
| 108 | Non-Reparable | -- | 16.5 |
| 109 | Non-Reparable | -- | 18.5 |
| 111 | 15.5 | 2 | 19.5 |
| 112 | 16. | 1 | 23. |
| 113 | 1.75 | 5 | 31.25 |
| 114 | 28. | 1 | 30. |
| 115 | 15.25 | 3 | 30.25 |
| 117 | 22. | 3 | 30.75 |
| 118 | 12.5 | 5 | 32.75 |
| 120 | 23.75 | 2 | 44.25 |
| 122 | 26.5 | 1 | 33.5 |

SCREEN LIFE 3.1 - 3.8 MGD - HIGH VELOCITY 65 RPM

| SCREEN NUMBER | INITIAL SCREEN LIFE-HRS. | NUMBER OF REPAIRS | ULTIMATE SCREEN LIFE-HRS. |
|---|---|---|---|
| 152 | 49.25 | 3 | 395.75 |
| 153 | 336.75 | 2 | 516. |
| 154 | 226.5 | 10 | 428.25 |
| 155 | 228.75 | 5 | 397.25 |
| 156 | 216. | 3 | 320.5 |
| 157 | Non-Reparable | -- | 239.25 |
| 158 | 32. | 7 | 325.75 |
| 159 | 118. | 1 | 190.5 |
| 160 | 299. | 4 | 364. |
| 161 | 216 | 4 | 324. |
| 162 | 232.25 | 3 | 355. |
| 163 | 283.25 | 3 | 306.5 |
| 164 | 288.5 | 2 | 315.25 |
| 165 | 316.75 | 1 | 321.75 |
| 166 | 312.5 | 4 | 385.5 |
| 167 | 293. | 4 | 385.25 |
| 168 | 283.25 | 3 | 345.25 |

SCREEN LIFE - 2.5-3.6 MGD - LOW VELOCITY 55 RPM

| 1 Accession Number | 2 Subject Field & Group | |
|---|---|---|
| | Ø 5 D | **SELECTED WATER RESOURCES ABSTRACTS** INPUT TRANSACTION FORM |

5 *Organization*

Bureau of Sanitary Engineering, City of Portland, Oregon

6 *Title*

DEMONSTRATION OF ROTARY SCREENING FOR COMBINED SEWER OVERFLOWS,

10 *Author(s)*

Neketin, Tim H.

Dennis, Harry K., Jr.

16 *Project Designation*

EPA Contract No. 14-12-128 Modification No. 7

21 *Note*

22 *Citation*

23 *Descriptors (Starred First)*

storm runoff, water pollution control

25 *Identifiers (Starred First)*

combined sewage treatment *, high-rate screening, solids removal efficiency, C.O.D. removal efficiency

27 *Abstract*

The objective of this demonstration was to determine screen durability, solids removal, COD removal, and hydraulic efficiency of rotary fine screening of storm-caused combined sewer overflows.

2300 gpm were evenly distributed to a 60 inch diameter rotating (55 rpm) screen cage holding 18 $ft^2$ of 165 mesh stainless steel screens (105 micron opening, 47.1 percent open area). During a screening cycle a concentrate sensor stopped the sewage pumps, ending the screening phase and initiating a 30 second cleaning phase during which the screens were automatically washed. At the end of the cleaning phase the pumps restarted automatically and a new cycle began.

Performance on storm-caused combined sewage flow averaged 54.8 percent removal of settleable solids, 26.6 percent removal of suspended solids, and 15.5 percent removal of COD. Duration of the screening phases averaged 14.6 minutes with average hydraulic efficiencies dropping from 0.880 to 0.668.

The ultimate screen life varied from a minimum of 190.5 hours to a maximum of 516 hours with an average of 346. Screens required an average of 3.5 repairs during this life. (Schmidt - Portland)

| Abstractor | Institution |
|---|---|
| | |

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Continued from inside front cover....

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|---|---|---|
| 11022 --- | 08/67 | Phase I - Feasibility of a Periodic Flushing System for Combined Sewer Cleaning |
| 11023 --- | 09/67 | Demonstrate Feasibility of the Use of Ultrasonic Filtration in Treating the Overflows from Combined and/or Storm Sewers |
| 11020 --- | 12/67 | Problems of Combined Sewer Facilities and Overflows, 1967 (WP-20-11) |
| 11023 --- | 05/68 | Feasibility of a Stabilization-Retention Basin in Lake Erie at Cleveland, Ohio |
| 11031 --- | 08/68 | The Beneficial Use of Storm Water |
| 11030 DNS | 01/69 | Water Pollution Aspects of Urban Runoff, (WP-20-15) |
| 11020 DIH | 06/69 | Improved Sealants for Infiltration Control, (WP-20-18) |
| 11020 DES | 06/69 | Selected Urban Storm Water Runoff Abstracts, (WP-20-21) |
| 11020 --- | 06/69 | Sewer Infiltration Reduction by Zone Pumping, (DAST-9) |
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| 11020 DIG | 08/69 | Polymers for Sewer Flow Control, (WP-20-22) |
| 11023 DPI | 08/69 | Rapid-Flow Filter for Sewer Overflows |
| 11020 DGZ | 10/69 | Design of a Combined Sewer Fluidic Regulator, (DAST-13) |
| 11020 EKO | 10/69 | Combined Sewer Separation Using Pressure Sewers, (ORD-4) |
| 11020 --- | 10/69 | Crazed Resin Filtration of Combined Sewer Overflows, (DAST-4) |
| 11024 FKN | 11/69 | Stream Pollution and Abatement from Combined Sewer Overflows - Bucyrus, Ohio, (DAST-32) |
| 11020 DWF | 12/69 | Control of Pollution by Underwater Storage |
| 11000 --- | 01/70 | Storm and Combined Sewer Demonstration Projects - January 1970 |
| 11020 FKI | 01/70 | Dissolved Air Flotation Treatment of Combined Sewer Overflows, (WP-20-17) |
| 11024 DOK | 02/70 | Proposed Combined Sewer Control by Electrode Potential |
| 11023 FDD | 03/70 | Rotary Vibratory Fine Screening of Combined Sewer Overflows, (DAST-5) |
| 11024 DMS | 05/70 | Engineering Investigation of Sewer Overflow Problem - Roanoke, Virginia |
| 11023 EVO | 06/70 | Microstraining and Disinfection of Combined Sewer Overflows |
| 11024 --- | 06/70 | Combined Sewer Overflow Abatement Technology |
| 11034 FKL | 07/70 | Storm Water Pollution from Urban Land Activity |
| 11022 DMU | 07/70 | Combined Sewer Regulator Overflow Facilities |
| 11024 EJC | 07/70 | Selected Urban Storm Water Abstracts, July 1968 - June 1970 |
| 11020 --- | 08/70 | Combined Sewer Overflow Seminar Papers |
| 11022 DMU | 08/70 | Combined Sewer Regulation and Management - A Manual of Practice |
| 11023 --- | 08/70 | Retention Basin Control of Combined Sewer Overflows |
| 11023 FIX | 08/70 | Conceptual Engineering Report - Kingman Lake Project |
| 11024 EXF | 08/70 | Combined Sewer Overflow Abatement Alternatives - Washington, D.C. |