AUTOMATED WATER MONITOR SYSTEM FIELD DEMONSTRATION TEST REPORT

VOLUME II
TECHNICAL SUMMARY

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VOLUME II

TECHNICAL SUMMARY

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ABSTRACT

The Santa Clara Valley Water District (SCVWD) owns and operates a water reclamation facility located in the Palo Alto Baylands area in Northern California. The purpose of the facility is to evaluate the technical and cost feasibility of producing high quality reclaimed water in Santa Clara County. The SCVWD requested NASA to move their Water Monitor System to the reclamation facility to provide the district with data to help them evaluate the individual treatment processes and the entire treatment train. The field demonstration test period at the SCVWD Water Reclamation Facility began in July 1977 and ended in February 1981. This technical summary is divided into two major parts. The first part covers the results of the data gathered by the WMS and the SCVWD from January 1978 to September 1979. The second portion of the Technical Summary covers the results of the data gathered from July 1980 through February 1981.

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ACRONYMS

A/D	Analog to Digital Converter
ADAM	Air Data Acquisition and Monitoring
AER	Aeration
ATP	Adenosine Triphosphate
b	Constant
BOD	Biochemical Oxygen Demand
BV	Biosensor Valve
C	Concentration
$CaCO_3$	Calcium Carbonate
C_2CL_4	Tetrachloroethylene
CHLOR	Chlorination
CLAR	Clarification
CH_2Cl_2	Methylene Chloride
$C_2H_2Cl_2$	1,2 - Dichloroethylene
$CHCl_3$	Chloroform
CH_3CCl_3	1,1,1, - Trichloroethane
$CHBrCl_2$	Bromodichloromethane
C_2HCl_3	Trichloroethylene
$CHBr_2Cl$	Dibromochloromethane
$CHBr_3$	Bromoform
CLSS	Closed-Loop Stripping System
CO	Carbon Monoxide

ACRONYMS (Continued)

COD	Chemical Oxygen Demand
°C	Degrees Celsius
CRT	Cathode Ray Tube
CV	Coliform Valve
DAS	Data Acquisition System
DI	Deionized Water
DO	Dissolved Oxygen
DOY	Day of Year
DSLTB	Double Strength Lauryl Tryptose Broth
ECD	Electron Capture Detector
EDTA	Ethylene Diamine Tetra Acetic Acid
EVE	Environmental Verification and Evaluation
°F	Degrees Fahrenheit
FID	Flame Ionization Detector
FILT	Filtration
floc	Flocculant
F/M	Food to Biomass Ratio
FTU	Formazin Turbidity Units
GAC	Granular Activated Carbon
GC	Gas Chromatograph
GLI	Great Lakes Instruments
gm, gms	Grams
gph	Gallons Per Hour

gpm	Gallons Per Minute
HCl	Hydrochloric Acid
HNO_3	Nitric Acid
H_2O, HOH	Water
H_2O_2	Hydrogen Peroxide
H_2	Hydrogen Gas
H^+	Hydrogen Ion
I	Input, Influent
IR	Infrared
JTU	Jackson Turbidity Unit
K	Constant
KH_2PO_4	Potassium Phosphate
LB/DAY	Pounds Per Day
LED	Light Emitting Diode
LIT, L, l	Liter
LTB	Lauryl Tryptose Broth
M	Molar Concentration
m	Constant, Meter
MCL	Maximum Concentration Limit
m^3/s	Cubic Meters Per Second (22.8 mgd)
mc/ml	Millions of Cells per Milliliter
mgal	Millions of Gallons
mgd	Millions of Gallons Per Day

mg/l	Milligrams Per Liter
ml	Milliliters
ml/min	Milliliters Per Minute
MPN	Most Probable Number
mv	Millivolt
N	Normal Concentration
n	Number of Samples
N_2	Nitrogen
NaOH	Sodium Hydroxide
NASA	National Aeronautics and Space Administration
NEDA	N-1 Napthyl-Ethylenediamine Hydrochloride
NH_3	Ammonia
NTU	Nephelometric Turbidity Units
O	Output
O/I	Effluent (Output)/Influent (Input)
O&M	Operations and Maintenance
OZON	Ozonation
PMT	Photomultiplier Tube
POX	Purgeable Organic Halogens
ppb	Parts Per Billion
ppm	Parts Per Million
psi	Pounds Per Square Inch
psig	Pounds per Square Inch Gage

ACRONYMS (Continued)

PVC	Polyvinyl Chloride
Q	Plant Flow, mgd
Q_W	Wasted Sludge, mgd
Q_R	Returned Sludge, mgd
r	Correlation Coefficient
RDOS	Real-Time Disk Operating System
RO	Reverse Osmosis
RPM	Revolutions Per Minute
RTD	Resistance Thermal Detector
S_a	Aerator Substrate, mg/l TOC
SCVWD-WRF/PA	Santa Clara Valley Water District-Water Reclamation Facility at Palo Alto
sec	Seconds
S_i	Primary Effluent Substrate, mg/l TOC
SiO_2	Silicon Dioxide
sorption	Adsorption or Absorption
TC	Total Carbon
TEC	Techtronics
THC	Total Halocarbons
TOC	Total Organic Carbon
TOX	Total Organic Halogens
T_s	Total Biomass in Aerator/Clarifier, mg
UV	Ultraviolet
V_a	Aerator Volume, mgal

ACRONYMS (Continued)

VAC	Volts Alternating Current
V_c	Clarifier Volume, mgal
VDC	Volts Direct Current
V_e	Chlorine Contact Volume, mgal
WMS	Water Monitor System
x	Independent Variable
X_a	Biomass In Aerator, mc/ml
X_c	Biomass in Clarifier Effluent, mc/ml
X_e	Biomass in Effluent From Chlorine Contact Tank, mc/ml
Y	Mass Yield of Biomass per Unit Substrate Consumed, mg/mg
y	Dependent Variable
μ	Microns, Micro
#	Number
%	Percent
σ	Standard Deviation
σ_E	Standard Error of Estimate
Z	The Number of Standard Deviations from the Mean

SECTION 1.0

INTRODUCTION

SCVWD-WRF/PA BACKGROUND

The Santa Clara Valley Water District, in cooperation with the Cities of Palo Alto, Los Altos, and Mountain View, embarked upon a developmental program of water reclamation and injection of the reclaimed water into underground aquifers in the South San Francisco bayfront area. The purposes of this program were to demonstrate the technical and economic feasibility of certain reclamation processes, and to attempt to provide a freshwater barrier to the intrusion of saltwater into a shallow aquifer. The wastewater supply to this system is the effluent from the Palo Alto Regional Water Quality Control Plant.

The Water Reclamation Plant provides tertiary treatment to the secondary effluent from the Palo Alto city plant, and in addition to its basic function of providing a supply for groundwater recharge, the reclamation plant can produce water of lesser quality for use in golf course irrigation or as a supplemental supply for the Palo Alto city plant's Reclaimed Water System for in-plant use.

The project took advantage of unused existing facilities at the Palo Alto plant in the construction of certain process units. An old clarifier was converted to a combined flocculator/clarifier, an unused sludge digestion tank has been used for reclaimed water storage, and an old vacuator structure has been adapted to house filters.

WMS BACKGROUND

As an outgrowth of its involvement in water reclamation and water quality monitoring for both spacecraft and domestic applications, NASA has conducted a project to develop and test an automated WMS (Water Monitor System). The objective of this project was to develop a system whereby water quality monitoring could be performed as it would be done in a spacecraft, on-line and in real-time. The design goal was to establish the capability to determine conformance to future high effluent quality standards, and thereby increase the potential for reclamation and reuse of wastewater. The resulting system includes both commercially available and NASA-developed sensors, an automated sample collection and distribution system, and a computerized data acquisition and reporting system. The project completed assembly and checkout of the WMS under separate contract (Reference 15). The project then entered into the field demonstration test phase which ended on February 28, 1981.

TEST PROGRAM

This report is a summary of test data recorded during the test period, January 1978 through February 1981. Data were recorded on the operation of the reclamation facility and its individual processes and on the operation of the WMS. These data included reliability and availability statistics, downtime and maintenance, and operations costs. The test program was divided into two major parts. The first part of the test program and of this report covers the results of the data gathered by the WMS and the SCVWD from January 1978 to September 1979. The second portion of the test period and of this report covers the results of the data gathered from July 1980 through February 1981.

SECTION 2

PART I FIELD DEMONSTRATION TEST RESULTS

This section will cover the results from the data collected by the WMS and the Santa Clara Valley Water District.

TEST OBJECTIVES/ACCOMPLISHMENTS

The primary goal of this phase of the field demonstration program was to determine the benefits and costs of continuous monitoring as a basis for maintaining high effluent quality in a wastewater treatment application. In support of this goal, key test objectives were identified. The accomplishments, thus far, in satisfying these objectives are highlighted below.

1. Characterize treatment process performance and define the key parameters for maintaining an optimum effluent quality.

   Accomplishments: The performance of each of the unit processes in the reclamation facility has been measured in terms of the WMS parameters over a wide range of operating conditions. These data, along with an interpretation of their meaning, are presented later in this section.

2. Define how the WMS concept of continuous automated monitoring might be applied in the reclamation facility.

   Accomplishments: Several opportunities for process control have been identified. These are discussed at the end of this section. The potential economic impact of certain unusual control concepts is also presented. Additional work will be required before these concepts are proven feasible. The task of developing process control algorithms for normal process functions is currently in progress.

3. Demonstrate the performance of the NASA-developed sensors.

   Accomplishments:

   A. Chemiluminescence Biosensor

      The capability for measuring viable as well as total bacteria was incorporated into the sensor. The sensor proved to be the most reliable method of measuring the performance of various processes for biological solids removal. (Dependence on the biosensor for solids removal data has steadily increased with experience. The other major source of this information, turbidity, has proven to be of questionable value due to unexplained increases across the filtering process, possibly due to sensor susceptibility to entrained gases or to particle size.) However, efforts to correlate the biosensor to coliform, the current standard for effluent biological quality, were unsuccessful. This result might be expected considering that coliform represents less than 1 percent of the total bacterial population. A more comprehensive survey to relate the biosensor to other biological measures, including virus, might be fruitful but is beyond the scope of our current efforts. It was intended to test another potential biosensor application, biological control of the activated sludge process; however, resource constraints prevented the necessary planning. The operation of the bioluminescence (ATP) sensor was terminated when it was found that chemiluminescence, with the addition of the viable bacteria capability, provided similar information. Low operating cost and simplicity strongly favor chemiluminescence.

B. Hydrogen Sensing Coliform Detector

An extensive test program was performed to compare sensor performance against the standard method, MPN test. A random interference was found when testing water at very low concentrations, after disinfection. The interferring bacterium was isolated and was shown to imitate, by chemical means, the hydrogen gas production of the coliform. A change in the sensor configuration eliminated the interference problem.

C. Trace Organics Sensor

The gas chromatograph was calibrated for nine compounds which include the trihalomethanes - chloroform, bromodichloromethane, dibromochloromethane, and bromoform. The calibration results, as well as split samples with the Ames Research Center and Stanford University, have shown good accuracy down to at least a level of 5 ppb. Procedures have been developed to resolve recent problems with excessive column bleed. As discussed later in this section, the instrument has been useful in several instances but particularly in characterizing the solvent dumping practices of local industry.

4. Characterize the performance of each element within the WMS in terms of availability.

Accomplishments: This section presents an evaluation of each of the WMS elements and reflects the reliability problems encountered with many of the commercial sensors.

CONCLUSIONS

Continuous monitoring of various biological and physical/chemical treatment processes has identified certain key parameters which influence effluent quality. Work was conducted in order to expand and apply this knowledge by developing control algorithms where the monitoring system would be utilized for direct process control and housekeeping functions. The information collected shows that an automated monitoring system could support the following plant control functions, thereby maintaining effluent quality while preventing wasteful expenditures for consumables and energy.

1. Efficient solids removal in the flocculation process by optimum control of the feed rate of lime and flocculant aids, sludge return rate, and sludge wasting rate based on influent conditions.

2. Minimum aeration conditions (0, 1, or 2 aerators) for effective trace volatile organics removal to support desirable biological growth in the granular activated carbon (GAC) and to comply with effluent discharge restrictions for dissolved oxygen.

3. Filter backwash frequency based on head loss and effluent discharge restrictions on dissolved oxygen.

4. Activated carbon maintenance scheduling to provide acceptable performance at lowest maintenance cost.

5. Effluent neutralization by recarbonation dosage control to comply with the effluent restriction on pH.

6. Disinfection (chlorination and ozonation) based on flow and dosage requirement.

7. Selection of plant flow and process stream configuration based on desired effluent quality and existing influent conditions.

Of the 24 parameters measured by the WMS, a few provided the bulk of the useful information in that they reflected change in water quality produced in the reclamation processes. These were:

Total Organic Carbon
Total Halocarbons
Dissolved Oxygen
Biomass
Turbidity
Total Residual Chlorine
pH
Ammonia
Nitrate/Nitrite

Thus, these are the available parameters which, potentially, can support process control. The other inorganic parameters were essentially unchanged in the treatment process since ion exchange of reverse osmosis is not among the reclamation processes at this site. On the other hand, the capability for measuring phosphorus and heavy metals, which are removed in lime clarification, was not available in the WMS. Thus, the contingent of sensors on-hand was not tailored to all specific needs of this particular facility but the data provided are judged to be adequate for the purpose, even though not comprehensive.

Sample Collection and Distribution

The system provided itself to be extremely successful in doing what it was designed for: to continuously deliver both a filtered and unfiltered sample to the sensors. The system demonstrated its ability to filter samples ranging from tap water to primary effluent with a minimum amount of maintenance. The 50 micron stainless steel filters showed that they removed the large particles from the stream without affecting the parameters measured with filtered sample. It was found that the biggest hazard for the filters was grease from the sample. This was not only a problem during operation, but also during cleanup. After extensive testing, an effective method of cleaning the grease from the filters was developed. The system demonstrated that the concept of multipoint sampling is very feasible.

Sensors

Commercial Sensors

The performance of the commercial sensors varied greatly. On one extreme, the Sigrist Photometer performed throughout the test period with hardly a single malfunction and a minimum of required maintenance. On the other hand, the chloride analyzer was out of service 65% of the test period, either for repair at the manufacturer's or for troubleshooting at the WMS. The remainder of the commercial sensors fell somewhere between these two extremes. The major problem cited with these sensors as a group was reliability. Mechanical and electronic failures were a continuing problem. However, in defense of these sensors it must be noted that several of the sensors were not designed for the type of continuous 24-hours a day, seven days a week usage. Additionally, all these sensors are at least 42 months old, and several are over 50 months old. It is reasonable to expect that during that period of time the various manufacturers have made significant changes and improvements to their sensors. The feasibility of computer controlled auto standardization was successfully demonstrated. In any type of sensor operation, this would result in a significant decrease in the amount of manpower required to maintain and operate the system.

Chemiluminescence Biosensor

The state of the art for an automated chemiluminescence biosensor has come a long way during the test period. The mechanical and electronic reliability of the sensor has been extremely good, especially for a prototype.

Coliform Detector

The coliform detector demonstrated itself to be quite reliable, both mechanically and electronically. The only significant electronic failures were the three electrodes, three thermistors, and two temperature control boards that failed. However, all these components were at least 3 years old at the time they failed. Both the reproducibility and validity of the detector adequately demonstrated using seeded samples.

Gas Chromatograph

The gas chromatograph has proven to be a realiable instrument for monitoring volatile halogenated organics. The instrument has operated without any major problems since its installation over 1-1/2 years ago. The method was shown to be accurate down to 5 parts per billion. It appears that this level is the sensitivity limit with this method; however, this sensitivity should be sufficient for monitoring potable water.

The chromatography for the nine monitored compounds is adequate. The chromatography for methylene chloride and 1,2-dichloroethylene could be improved and would probably yield somewhat more accurate results. In addition, several as yet unidentified compound peaks can be found in the chromatograms. Identification of these peaks will provide additional information in the characterization of the water quality.

Deionized Water System

The system functioned quite reliably throughout the test period. The only significant mechanical failures were those involving the pump impeller. These were typically due to operator error. Bacteria contamination of the storage reservoirs was periodically a problem. The system's capability to provide a continuous supply of reagent grade deionized water made the sensor system possible.

Other Sensors

Attempts to develop a total nitrogen sensor were unsuccessful. The following describes the test system and problems encountered. The IBC/Berkeley Nitrogen Analyzer receives the noncondensable combustion gases from the TOD analyzer and determines the concentration of nitric oxide by measurement of the potential between two electrodes. During the combustion at 850°C, nitrogen compounds in the sample are converted to nitric oxide; thus, a total nitrogen reading is provided by the instrument in the range of 10 to 10000 ppm nitrogen. Testing results showed inconsistent performance for this measurement. It was discovered that measurement sensitivity was considerably greater for nitrogen in the form of nitrates than that in the form of ammonia (about 5 to 1). It was concluded that a large portion of the ammonia nitrogen was being reduced to nitrogen gas (N_2) rather than to nitric oxide (NO). A sensor utilizing chemiluminescence for detection was tried with similar results. Thus, a mixture of nitrogen compounds in a sample must be converted to a single form in order for this technique to be accurate.

WMS PERFORMANCE EVALUATION

Sample Collection and Distribution System

Figure 21 shows the location of the six sampling points used during the test period, which included water of a quality ranging from primary to tertiary treated wastewater. The system worked very well throughout the test period. Fifty micron woven stainless steel filters were used for filtration purposes for 80% of the test period. The remaining 20% of the time, thirty micron woven stainless steel filters were used. Due to the high flow rate of sample across the filter surface and the backflushing action, the system had no difficulty removing particles and debris from the sample stream. This was true even for the primary effluent sample from the Palo Alto waste treatment plant. However, what did present a problem was the grease contained in the primary and secondary effluent sample stream. Within about 4 days, the buildup of grease would be enough to reduce the filtered sample flow below the required 2000 ml/min. flow rate to the trailer. Additionally, when the filters were removed for cleaning, the grease was extremely difficult to remove. In order to prevent a loss of sample flow, a schedule was established where the filters were changed three times a week; on Monday, Wednesday, and Friday. This schedule proved to be extremely effective in preventing any significant drop in filtered sample flow rate. Various solvents, acids, and detergents were tested for their ability to clean the filter screens so they could be reused. Finally, a procedure was developed which thoroughly cleaned the filters. As soon as the filter screens were removed from the filter housing they were rinsed with tap water. Next, the filter screens were soaked in a solution of enzyme detergent and water overnight. The filter screens were then placed in a solution of Isoterge detergent and soaked overnight. The filter screens have been reused numerous times using this cleaning procedure.

Overall, the sample collection system performed well with only a minimal number of failures. During the test period four pump boots failed. Two of these were due to loss of sample flow over a long period of time (2 days). One boot failed due to a bad universal joint in the Monyo pump. The last boot failed due to overpressurization when two sample lines in the trailer became clogged. Also during the test period each pump had to have its bearings replaced. The Red Valves which are used on the sample collection system worked quite well. Five of the valve liners had to be replaced during the test period. Each of these five developed a small leak after almost a year of operation. Six of the Red Valves had tygon tubing used as a pneumatic line. This proved to be a mistake as the tygon softened with age. This resulted in three of the lines rupturing. All the lines were replaced with 1/4" polyethylene tubing. During the test period one of the Bimba air actuators used for the backflush system failed. Additionally, the gears on one of the backflush timers had to be replaced due to excessive wear. The only parts of the system which had repeated failures were the pressure gauges. The original gauges had a life expectancy of 4 months due to pressure surges from the backflush system. Snubbers were installed on all the gauges. However, this did not solve the problem. Finally, the gauges were replaced with liquid filled gauges manufactered by U.S. Gauge.

Total Organic Carbon (TOC)/Total Oxygen Demand (TOD)

The Astro Ecology TOC/TOD Analyzer was modified to allow for computer controlled automatic calibration. This system consisted of two teflon air actuated slider valves, two pilot valves and two micro switches. The slider valves were used to switch from sample to either zero or span standards. The micro switches were used to send the valves' status back to the computer.

The TOC analyzer worked quite reliably. However, several problems did show up during the test period. First, due to the high temperature (850°C) of the reactor, corrosion from the acid reagent caused the reactor to eventually fail. It appears that the life expectancy of the reactor is between 18 to 24 months. Another problem area was that the sample pumps were poorly located. If a pump tube failed it could result in water filling the furnace compartment. Since the construction of the WMS TOC Analyzer, the manufacturer has corrected both these problems. Due to the fact that the infrared analyzer was located in an adjoining rack, the line from the reactor to analyzer was longer than normal. As a result, condensation took place in the line. To prevent this, a 40 micron prefilter was installed in the line. Additionally, a trap was installed at the low point of the line. This prevented small amounts of moisture from accumulating and reducing the sample gas flow to the infrared analyzer. Also, a manual three-way valve was installed in the line to the 50 cc sample pump. This allowed grab samples to be easily tested. To verify the accuracy of the analyzer, numerous split samples were run in the SCVWD lab. The results of the comparisons showed good correlation of data. Comparisons were made with both TOC and TOD standards with less than 5% error. One of the difficulties with sampling of both primary effluent and Reclamation Plant effluent is that the analyzers must be scaled to read the high primary values. As a result the analyzer is not as exact as it would be on the lower scale. This was especially a problem for the TOC analyzer. The TOC values for primary effluent were often over 100 ppm, while they were as low as 1.0 ppm for the Reclamation Plant effluent.

The TOD analyzer used the same reactor as the TOC analyzer. The sample gas was routed from the reactor to the TOC infrared analyzer, then to the TOD analyzer, and lastly to the vent. A problem with the electronics overheating was discovered with the TOD analyzer. This was due to the location of the fiberglass box, which contained the electronics, within the same rack as the reactor. An attempt was made to relocate the electronics in another rack; however, it was found that the increased resistance from the longer wires was too high. The electronics were remounted in the old location. The door to the electronics was left open to allow cool air to enter. This stabilized the temperature and the data output. The most serious problem with the TOD analyzer was that the analyzer was designed for a range of 0-1000 ppm and the water sampled was generally in the range of 10 ppm. As a result, the accuracy of the measurements varied. This was not so much a design problem with the analyzer as it was a problem of trying to apply an instrument intended for industrial effluent to reclaimed wastewater.

Hardness Analyzer

The analyzer provided good, reliable data with few exceptions. The only problems encountered were when samples of primary effluent or secondary effluent were being analyzed. There is an apparent interference in the primary effluent which causes the analyzer to consistently read erroneously low values (less than 50 mg/L). The problem with the secondary effluent was apparent only 5% of the time. The analyzer would, on these occasions, show an erroneously high value. The interference would cause a jump in the reading of 200 to 500 ppm. The exact nature of the interference has yet to be determined. One possibility that is being studied is that the high residual chlorine level of the secondary effluent may be affecting the data. However, as stated earlier, the sensor operated very reliably 95% of the time. The other minor problems encountered during the test period included periodic rupturing of the analyzer's pump tubing. This problem was practically eliminated by replacing all the pump tubing every 2 months. Another problem was leaking "O" rings in the electrode holder. In the beginning of the test the "O" rings had to be replaced with a thin rubber gasket. This replacement gasket solved the problem.

Nitrate Analyzer

The analyzer was only run during the first month of the Phase I test period. During that month it was found that the levels were consistently less than 1 ppm. It was decided by NASA and SCVWD that at that level the nitrate was not a concern and that it would not be necessary to continue to run the analyzer. During that brief period of operation the following observations were made. The analyzer is fairly labor intensive due to the wet chemistry method of analysis used. Two gallons of reagent must be mixed each week. Additionally, due to the large number of pumps and drains used in the system, the analyzer needed to be frequently monitored for leaks. While on-line the analyzer did provide accurate and reliable data.

pH Analyzer

The Great Lakes Instrument Model 70 pH Analyzer generally provided good, reliable data. The sensor required calibration on an average of once a week during the test period. There was no serious fouling of the probe as a result of sampling primary or secondary effluent. The probe was removed once a month and checked for accumulations on the electrode. The electrode tip was cleaned in a 0.1 N acid solution if a significant accumulation was found. When calibrated, a pH standard of 7 was first used, then a pH standard of 10 was used to check the slope. One problem, which hampered operation of the sensor, was that air bubbles would come out of the sample and become trapped in the flow cell. When enough air bubbles would accumulate in the flow cell, the electrode would lose the necessary contact with the sample. This would result in the analyzer reading approximately .5 pH unit lower than the sample actual value. To resolve this problem a hole was drilled into the top of the flow cell to vent off the trapped air. This modification worked quite well. Throughout the test period the analyzer was supplied with 50 micron filtered sample. Shortly after the end of the test period the analyzer began to generate slightly erratic data. The epoxy used to build the probe began to pull away from the electrode body. At this point the probe was replaced with a new probe. With the new probe installed, the results were as stable as ever. Based on this information, the life of the pH probe is estimated to be 3 years.

Total Residual Chlorine Analyzer

The analyzer was generally very reliable and provided good, accurate data throughout the test period. The analyzer was modified with the WMS auto standardization system. The analyzer required a minimum amount of routine maintenance during the test period. The analyzer encountered some problems with clogging due to particles clumping together in the small diameter tubing (1/32") leading in an' out of the flow head. It was found that this was not a significant problem as long as the analyzer was operated continuously. However, if the analyzer was shut down for any period of time over 3 hours, the chances of clogging were greatly increased. Therefore, it is recommended that if possible, avoid prolonged shutdowns of the analyzer. If the analyzer should run out of reagent, it is recommended that the data switch be turned off and the analyzer run with deionized water in place of the reagent. On several occasions the pump tubes for the analyzer would fail within the pump. To prevent this problem it is recommended that the pump tubes be replaced every 2 weeks. Throughout the first half of the test period the analyzer's results were compared once a week with the SCVWD lab results on a split sample. The results were consistently within .1 ppm of each other. Periodically, every 2 months, the electrodes were removed from the analyzer and polished with Orion Rese-rch polishing strips. This prevented an accumulation of debris. It is recommer .d that the two electrodes be replaced every 6 months. The schedule . auto calibration once a day appears to be fine. Both the zero and span drift in a 24-hour period are approximately .1% full scale.

Sodium Analyzer

The Beckman Sodium Analyzer provided good data reliably throughout the majority of the test period. The only time that it did not perform was a two month period when it was out of service while awaiting arrival of a replacement sodium electrode. The major drawback to the analyzer is the high number of manhours required for routine maintenance. The analyzer is equipped with the WMS auto standardization system, and is calibrated once each day. One reason for the high number of manhours is that both gallon containers of standard (zero and span) must be refilled each day. Another reason is that the flow system must be disassembled and cleaned once each week. This is due to the fact that the anhydrous ammonia causes the particles in the sample to clump and settle in the flow system. The anhydrous ammonia is necessary to adjust the pH level of the sample prior to introducing it to the electrode. When cleaning the electrode and flow system, it is suggested that a dilute solution of HCL be used. Split sample comparisons with SCVWD lab were routinely made during the first part of the test period. The results showed an excellent correlation within 20 ppm. Tests were run to see if the analyzer could be operated without the anhydrous ammonia in order to reduce the amount of required maintenance. The results of the tests indicate that without the ammonia pretreatment the values are approximately 50% lower tha the actual value. One problem which was encountered was the unavailability of a replacement sodium electrode from Beckman. The original electrode was broken during a routine cleaning operation. When Beckman was contacted to order a new electrode there were none available off the shelf. A shorting problem had been found in the cable from the electrode to the analyzer. It took 2 months before the problem was fully resolved and the electrode delivered.

Temperature Analyzer

The two Action Pac Resistance Thermal Detectors worked without any problem during the test period. One of the electronic boards had to be replaced when it shorted out due to a major water spill. The two units were then relocated to prevent a recurrence of the problem. The probes were periodically checked with a thermometer to verify their readings. They showed essentially no drift during the entire test period.

Turbidity Analyzer

The Sigrist Photometer Turbidimeter Model UP52-TJ worked extremely well throughout the test period. The analyzer provided excellent data with a bare minimum of routine or unscheduled maintenance. The only component which failed during the entire test period was the replaceable light source. The only routine maintenance required by the instrument was a once a week cleaning of the mirror in the flow cell and a calibration. The TJ25 flow cell was used throughout the test period. The 0-100 mg/l SiO_2 standard was compatible with primary effluent and reclamation facility effluent. Some problems were encountered with the sample line running from the trailer wall to the analyzer. On several occasions the line would become clogged with debris. To resolve this problem the line was modified to remove all elbows and increase the diameter of the tubing. Since this modification was made there have been no more stoppages. A problem was also encountered with the drain line becoming clogged, resulting in an overflow of sample. This problem was resolved by removing the elbow in the drain line and doubling the diameter of the line.

Ammonia Analyzer

A serious problem with precipitates greatly hampered operation of the sensor during the first part of the test period. The precipitate was brownish in color and would appear in the color analysis tube for the sample. The precipitate would build up to such a point that the data generated by the analyzerwere invalid only a few hours after calibration. Extensive testing was done to find a method of preventing the precipitate from forming. Finally, it was found that by deleting the sodium nitroferricyanide reagent, the problem could be resolved. The manufacturer stated that for levels above 1.0 ppm of ammonia, the sodium nitroferricyanide was not required. The stability of the analyzer improved greatly after making this change. The analyzer was calibrated for a range of 0-40 ppm. This range was satisfactory for the primary effluent as well as the reclamation plant effluent. Another problem area was the pump seals used in the analyzer's sample pump, reagent pump, and drain pump. These seals would last an average of two months before they would have to be removed and replaced. Once they were removed they could be reused after cleaning and soaking in tap water for 48 hours. The metricone had to be removed once during the test period. This was necessary to polish out several small grooves in the teflon metricone. The gear drive train for the metricone had to be replaced once during the test period. All the plastic fittings had to be resealed during the beginning of the test period. This was due to the fact that the adhesive used by the manufacturer was dissolved by the analyzer's reagents.

The analyzer was equipped with the WMS auto standardization system and was automatically calibrated once each day. The span standard solution needed to be replenished once a week, as did each of the two reagents. Because of this, the analyzer was quite labor intensive. Samples were repeatedly split with the SCVWD lab. The analyzer's results were consistently within .5 ppm of the standard method results. It was found that the overhead lights in the WMS trailer had a noticeable effect on the readings. Because of this it was decided that the interior trailer lights would be left on at all times to provide a consistent background light level.

Chloride Analyzer

Operation of the analyzer proved to be difficult throughout the test period. It appeared at the beginning of the test that the sensor was working reliably; however, the sensor soon began to show signs of severe drift problems. Extensive calibration tests failed to resolve the problem. The probe and associated electronics were shipped back to the manufacturer for repair. It was determined by the manufacturer that the probe needed to be replaced; a replacement probe was received. Initial calibration tests indicated that the new probe was stable and accurate. The instrument was remounted in the trailer; however, problems quickly appeared. The WMS values were consistently lower than the SCVWD lab results for a split sample. While efforts were underway to resolve that problem, the analyzer began to exhibit a new problem. The analyzer would calibrate quite well, but when a real sample was introduced, the sensor would start to drift upward. The start of the drifting would occur after approximately 4 hours in the sample stream. The readings would continue to drift upward until going off scale high. This would normally take about 3 days of the probe being in contact with the sample. If the probe was then placed in a standard solution, the readings would accurately indicate the value of the standard after a 2 hour period. A five times normal solution of sodium nitrate was tested as an ionic strength adjuster. It had no appreciable effect on the readings. At this point the probe and electronics were returned to the manufacturer for repair. It was determined that the probe was being poisoned by some unknown interference in the sample.

Conductivity Analyzer

The Beckman analyzer performed throughout the test period without any significant problems. The values were frequently checked with SCVWD lab results for a split sample. The results showed excellent correlation (r = .99). Periodically the flow cell was removed from the flow system and checked for buildup on the cell walls.

Dissolved Oxygen Analyzer

The Delta Scientific D.O. analyzer performed quite well during the first half of the test period. However, the analyzer then began generating erratic data. The cause of the problem was not locatable. The probe and associated electronics were returned to the manufacturer for repair. The manufacturer found the probe had failed and had to be replaced. During its operational phase the analyzer was calibrated once a week. This was done using a zero standard and a span standard of known concentration. One problem encountered with the analyzer was that the sample line from the trailer wall to the probe would become blocked with debris. In order to resolve this problem, the line was replumbed to remove all the elbows and increase the diameter of the tubing. This left only one problem area, the flow control valve. It was found that this valve had to be watched closely to verify the flow rate to the probe. If the samples monitored included primary effluent or secondary effluent, it was necessary to check the flow cell weekly for a buildup of particulate matter.

The Honeywell Model 551011-00-01 dissolved oxygen sensor worked reliably throughout the majority of the test period. Some electronic problems developed with the sensor toward the end of the test period. As with the Delta Scientific D.O. sensor, it was necessary to replumb the sample line from the trailer wall to the sensor. This was done to prevent the sample line from clogging with debris. The analyzer was checked with a Hach wet chemistry D.O. kit on a weekly basis. Once each month the zero value was checked using a zero standard. The sensor experienced some contamination on the bottom of the flow cell and the probe. This especially became a problem when analyzing primary or secondary effluent. As a result, it was necessary to check the flow cell once a week for debris.

Chemiluminescence Biosensor

The chemiluminescence biosensor currently processes and measures total and viable bacteria once each 1-hour period. Typical values measured in the various wastewater effluents monitored by the WMS are illustrated in Figure 1. The sensor is routinely calibrated using a Coulter electronic particle counter and the firefly luciferase - ATP assay for total and viable bacteria, respectively.

To measure viable bacteria with an automated luminol chemiluminescence system, the laboratory single sample injection method developed at Goddard Space Flight Center had to be converted to a flowing system where reagents

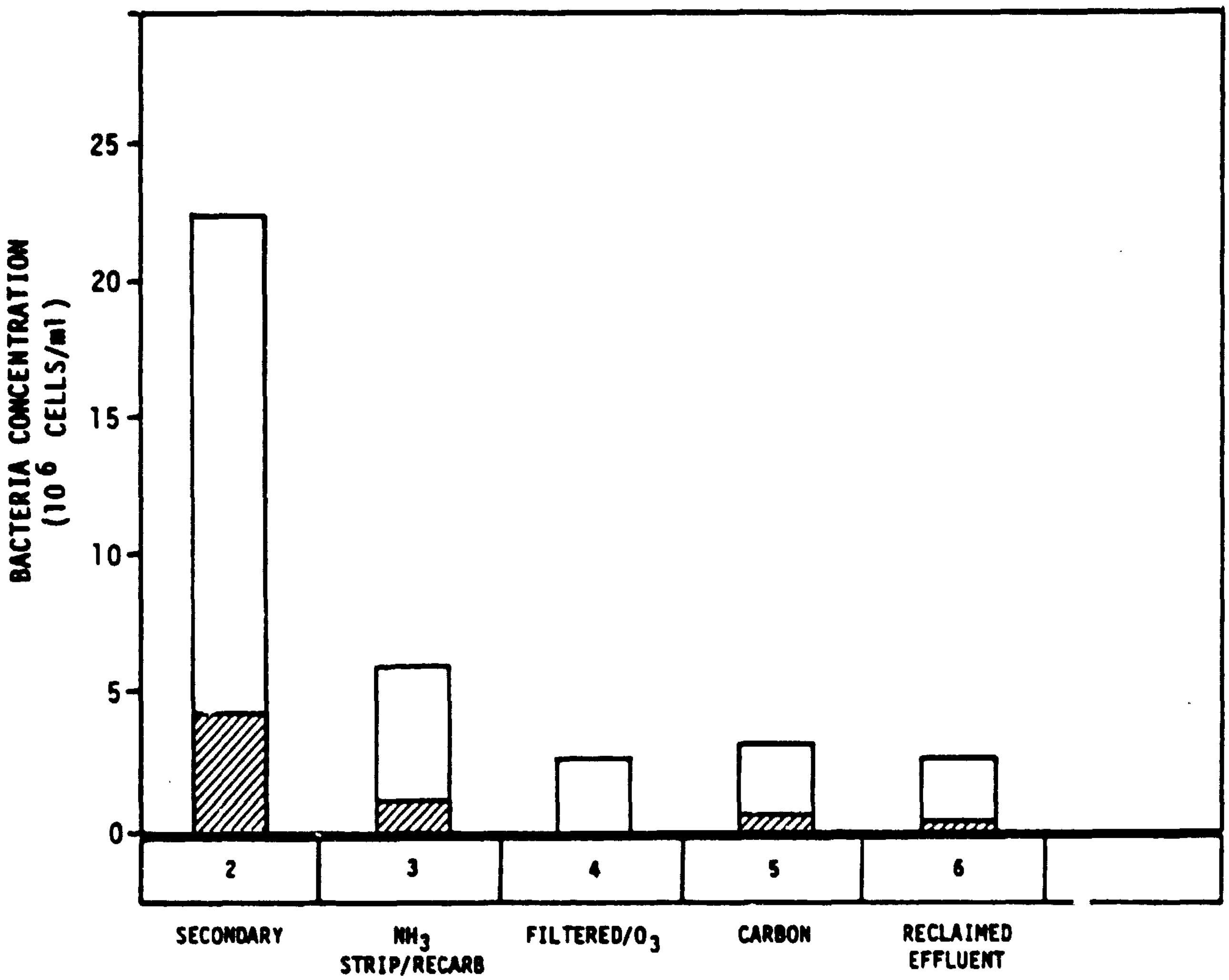

Figure 1 Total and Viable Bacteria Levels in Various Waste Water Effluents

and samples could be processed with peristaltic pumps. The major problem concerned handling the carbon monoxide-treated sample. It was known that light reverses the binding of the carbon monoxide with the iron porphyrins of viable bacteria. The carbon monoxide pretreatment had to be performed in the dark and the sample had to be protected from light until after the subsequent analysis. This was achieved by locating the carbon monoxide bubble chamber in a dark box and by using black tubing for transferring the sample from the chamber to the reaction coil.

In addition to the carbon monoxide required for the determination of viable bacteria, air had to be bubbled through the sample for accurate determination of total bacteria. Without the air treatment, total bacteria counts were artifically high, a fact still unexplained.

The biosensor schedule originally required 2 hours for a measurement of both total and viable bacteria. The schedule was later shortened to 1 hour after tests confirmed that sample flush, air/carbon monoxide treatments, and analysis times were sufficient for accurate quantitation.

A standard calibration method had to be developed to insure the accuracy and repeatability of the sensor. Calibrations were established using the Coulter electronic particle counter and the firefly luciferase - ATP assay for total and viable bacteria, respectively. The biosensor calibrations for total bacteria illustrated in Figure 4, Volume I, were reproducible for samples of cultured coliform bacteria or effluent samples. The calibration curve established by these points was $y = 2.15 (X - (-9.714))$ where y equals 10^6 cells/ml and X equals biosensor response in volts.[1] The correlation coefficient was equal to 0.96. The viable bacteria correlation curve illustrated in Figure 5, Volume I, shows much more scatter when cultured bacteria and effluent samples are compared. This may be due not so much to variations in biosensor response but due to variations in the ATP levels within the organisms grown in different environments and subject to various degrees of stress.

The standard curve generated from the measurement of total bacteria is used for the calibration of the sensor. The stability and repeatability of these measurements make it the method of choice. Extensive research in the laboratory supports the extension of the method to calculate viable bacteria with relative confidence.

The sensor has a lower sensitivity limit of 10^5 cells/ml, which is adequate for most municipal wastewater applications. The range of the biosensor is adjustable from a minimum of 2 logs (10^5-10^7 range) upwards to infinity. Thus, the sensor can be readily adapted to measure concentrated solutions such as activated sludge (10^9 cells/ml).

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[1] The previously established calibration curve of $y = 1.66 (X - (-10.32))$ has been left in the computer for the sake of subsequent comparison.

Correlation of the viable bacteria results of the biosensor presents special problems. Various values for viable bacteria can be obtained depending on the type of method employed. Each method measures a particular parameter associated with viability. The ATP method and luminol - CO method are measures of metabolism while the standard plate count method is a measure of the ability of a cell to reproduce and form colonies in an artificial environment. For this reason the luminol method cannot be expected to produce the same results as the plate counts. The ATP results have shown correlation with the luminol data; however, it is known that ATP levels within bacteria can fluctuate, depending on environmental conditions and growth phase. Due to this reason, the ATP method can be used for "ball park" comparison and some deviations should be expected. Other methods for monitoring viable bacteria should be examined to further support and verify the biosensor results.

Coliform Detector

The major accomplishments concerning the coliform sensor are as follows:

1. An improved cleanup procedure was developed to better protect against cross contamination. The major improvement involved substituting 0.1 N nitric acid for sodium hypochlorite reagent. In conjunction with this change, larger volumes and longer residence times of the bactericide were used.

2. A new sensor configuration was devised to allow auto inoculation of a grab sample. The benefits gained from this action include better reproducibility, ease of inoculation, and progressing toward the point of on-line operation. Figure 9, Volume I shows the improved valve configuration along with a series of valve steps to facilitate computer controlled inoculation.

3. A series of calibration curves were developed. The information gathered was used to compare the sensor to a NASA Ames coliform sensor, establish sensitivity and reproducibility limits, and to demonstrate the degree of agreement between the sensor values and MPN values.

   In order to calibrate the sensor, seeded samples were run and the reaction times were plotted against the MPN values obtained on the sample. The samples consisted of serial dilutions of unchlorinated secondary effluent using chlorinated secondary effluent (which had been dechlorinated) as diluent. The dechlorinated water was used as diluent in order to approximate the chemical composition of real world samples. Figures 10 and 11, Volume I show the fecal and total calibration curves which were obtained in the manner mentioned above. Linear regression analyses were run and gave the slope, y intercept, and r values for each calibration. For the fecal coliform calibration, the values were -1.26, 10.45 hrs., and 0.95, respectively. For the total calibration curve the values were -0.9, 9.04 hrs., and 0.95, respectively. By using the equation $y = mx+b$, the unknown (the original number of coliform bacteria in the sample) may be calculated. Whereas, y equals the original coliform concentration, m equals the slope, and b equals the y intercept. The reaction time is designated as the amount of time required to register a 200 m.v. drop from the electrode output.

The comparison between the WMS sensor and the impedance sensor showed that the instruments performed similarly. The r values for the WMS and impedance sensor were 0.95 and 0.98, respectively, for the fecal coliform calibration curve. For the total calibration curve, the r values were 0.95 and 0.96, respectively.

4. In the course of operating the coliform sensor, several cultures of bacteria (coliforms and non-coliforms) were obtained. It was discovered that one strain of non-coliform bacteria mimicked the m.v. response of coliform bacteria. This was a revelation in that previous experience had shown that non-coliform bacteria were incapable of driving the electrodes to the maximum negative point (-500 m.v.). This particular culture, however, gave negative responses equal to those of coliforms.

5. After it became apparent that the m.v. readings were influenced by end products of metabolism other than hydrogen, a new cell configuration was devised which allowed only evolved gas to reach the electrode. This process involves venting gas from the growth cell to another cell containing saline and the measuring electrode. The line from the growth cell is submerged in the saline of the measuring cell so the electrode will sense the dissolved gas. Preliminary work with the above configuration indicates that coliforms may be distinguished from non-coliforms in this manner. More experimentation was needed, however, to verify this system. (This additional work was conducted in Phase II of the test period and is reported in the Phase II section).

6. It has been determined that the lower limit of detection for the coliform sensor should be 2.2 coliforms per 100 ml. In order to achieve this level of sensitivity, it was deemed necessary to increase the sample size in order to increase the amount of coliforms inoculated.

Gas Chromatograph

The automated gas chromatograph separates and quantifies a total of nine volatile halogenerated hydrocarbons from wastewater samples within 50 minutes. Figure 2 is a typical electron capture detector (ECD) chromatograph from a secondary effluent sample using the current analytical column and temperature program. The calibration factors are based on calibrations using standards prepared in glacial acetic acid and diluted in distilled water prior to use. The data have been compared with NASA Ames Research Center and Stanford University Department of Civil Engineering for verification and found to be accurate to the 5 ppb level.

Preliminary testing involved the use of a flame ionization detector (FID) and ECD. Various methods were tested to determine the optimum means for monitoring the volatile organics. The FID proved to be inadequate for measuring the low concentrations of organics due to the sensitivity limit of the detector.

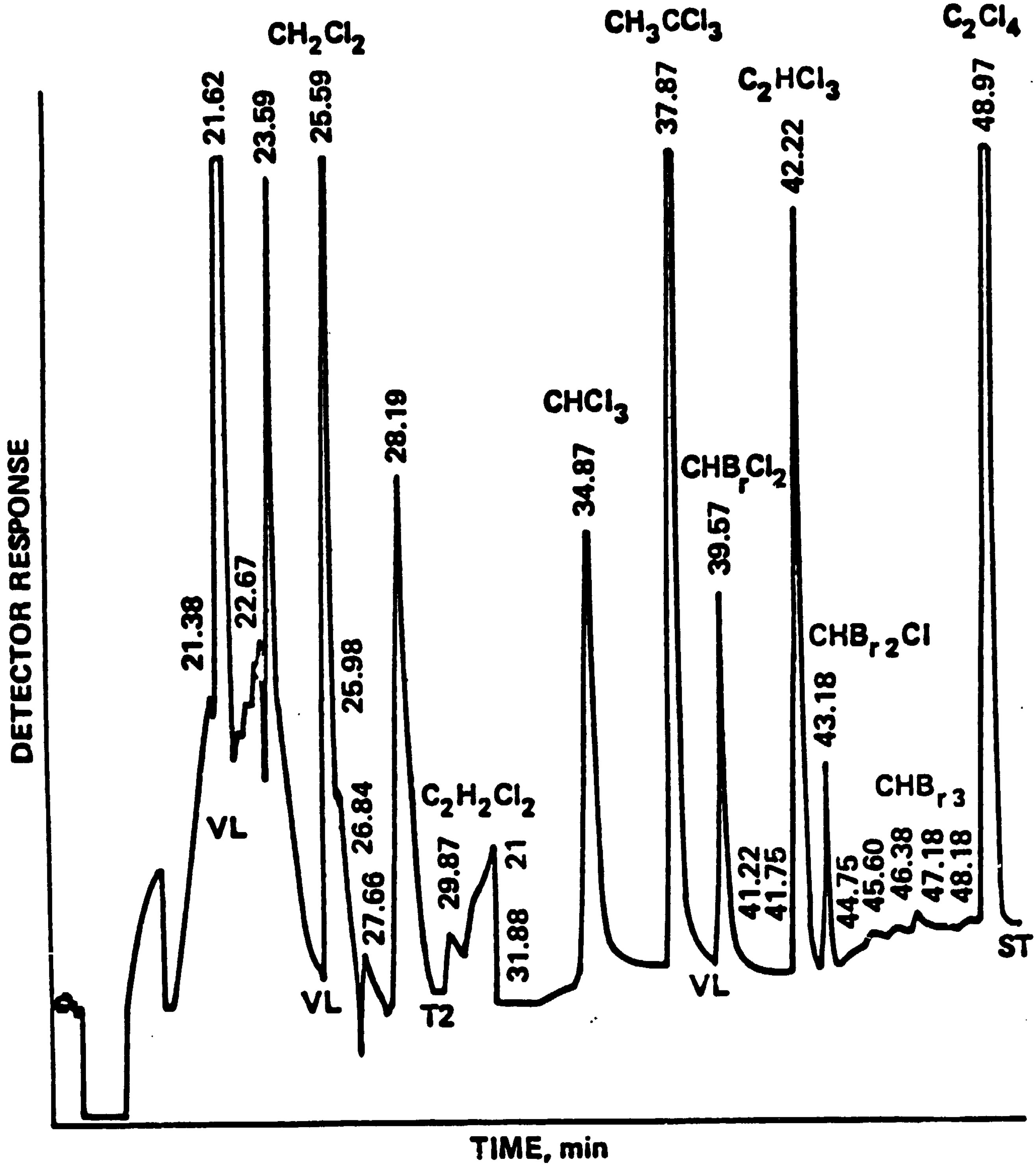

Figure 2 Typical Gas Chromatogram

Table 1 contains a list of the analytical columns and detectors tested and the reasons for their unacceptability. The principal criteria for column and detector selection were good separation of all the compounds of interest with sensitivity below 10 ppb and an analysis time less than 1 hour. The SP-1000 column used with the ECD met these criteria. While the SP-1000 column will not separate carbon tetrachloride from 1,1,1-trichloroethane, Stanford University has indicated that carbon tetrachloride levels are usually very low, <1 ppb. The 50-minute analysis time is sufficient to permit both analysis and data processing within the 1-hour period at sensitivity limit of 5 ppb.

The calibration method currently used was selected from several tested and is shown in Table 2. The calibration methods were similar, with the primary difference being the solvents used for the standards. Table 2 shows the repeatability of the methods as reflected by the standard deviation. Glacial acetic acid proved to be the best solvent with a repeatability of $\pm$ 5% and a shelf life of at least 14 days. Figures 3 through 11 illustrate the calibration curves generated with the nine standards.

Data have been continually compared with Stanford University and Ames Research Center for verification of accuracy of the results. The most recent comparison with Stanford University is shown in Table 3. Split samples were taken and simultaneously analyzed. The results indicate good correlation for those compounds observed at concentrations greater than 5 ppb, the sensitivity limit of the method. Previous comparisons have shown similar results.

Deionized Water System

The deionized water system performed very reliably throughout the test period. The system continuously provided the required quality of water. Due to poor quality of tap water fed to the system, the various filter cartridges did not last as long as originally anticipated. However, this was not the fault of the system. As expected, the average life of the Reverse Osmosis cartridge was found to be 1 year. The only significant mechanical failures were those associated with the pump impellers. On four different occasions the impeller had to be replaced. These failures were generally due to operator errors. The best pressure setting for the system was found to be 14 psig. Bacteria growth in the storage tanks was a recurring problem. Plate counts were routinely taken to verify the bacteria level in the tanks. When the level rose above 10 cells/100 ml, the tanks were sanitized with sodium hypochlorite and then flushed. A problem was encountered with carbon fibers escaping the carbon filter and clogging the ion exchange filters. This proved to be a generic problem which was corrected by the manufacturer. The conductivity of the tap water and the RO filtered water was routinely checked to verify that the RO cartridge was removing 90% of the conductivity. Also, routinely the deionized water was checked on the gas chromatograph to verify that the carbon filter was removing the halogenated hydrocarbons. This proved to be a very useful test for this purpose.

Data Acquisition and Report Generation System

Several types of peripheral and computer equipment have been integrated to provide the real-time data acquisition and control capabilities of the WMS.

TABLE 1 COMPARISON OF GC ANALYTICAL COLUMNS

COLUMN	DETECTOR	COMMENT
10' x 1/8" 10% SP-2250 (OV-17)	FID	Did not separate chloroform and 1,1,1-trichloroethane. Excessive column bleed.
10' x 1/8" 15% Carbowax 1540 80-100 WAW	FID	Excessive column bleed.
100' x 0.020" K-20M on Carbopak-C	FID	Excessive column bleed.
10' x 1/8" 10% SP-2250 (OV-17)	ECD	Did not separate chloroform and 1,1,1-trichloroethane.
10' x 1/8" 20% OV-101, 1% Carbowax 1500 100-120 WAW and 20' x 1/8" 20% FFAP on 60/80 chrom WAW	ECD	Separates all compounds; however, analysis requires 75 minutes to complete
11½' x 1/8" 0.2% SP-1000 on 80/100 Carbopak C	ECD	Does not separate carbon tetrachloride from 1,1,1-trichloroethane.

TABLE 2 REPRODUCIBILITY OF GC CALIBRATION MIXTURES MADE WITH VARIOUS SOLVENTS*

SOLVENT	AVERAGE STD. DEV. (%)	STORAGE TIME
WATER	9.8	8 HRS.
METHANOL	24.4	8 HRS.
	21.5	4 DAYS
GLACIAL ACETIC ACID	7.3	8 HRS.
	7.5	7 DAYS
	7.3	14 DAYS

* Reproducibility based on tetrachloroethylene, chloroform, trichloroethylene, and bromoform in silanized glassware.

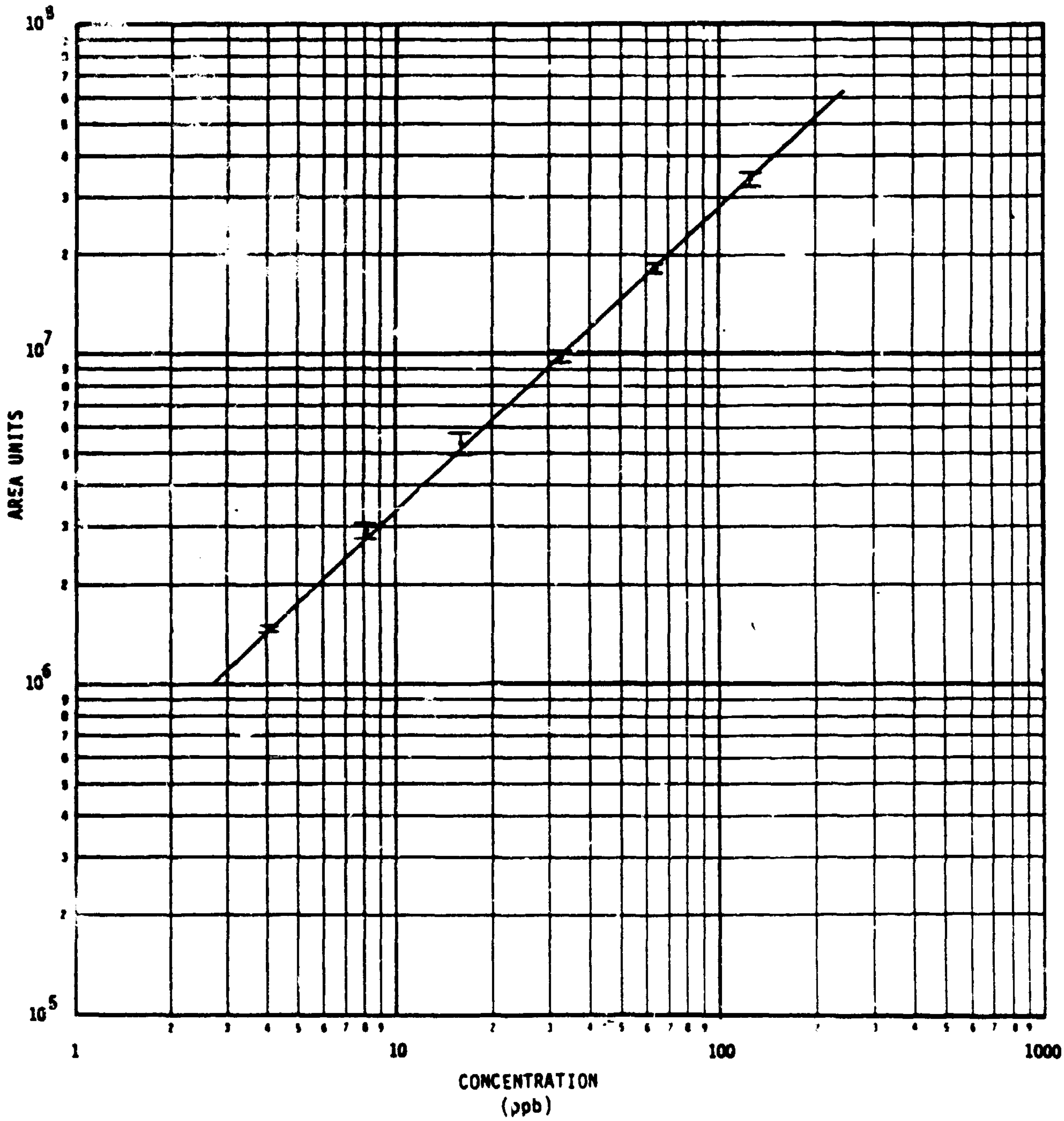

Figure 3 Calibration Curve for Tetrachloroethylene - #1

$$C = e^{1.115\,\mathrm{Ln}A - 14.45}$$

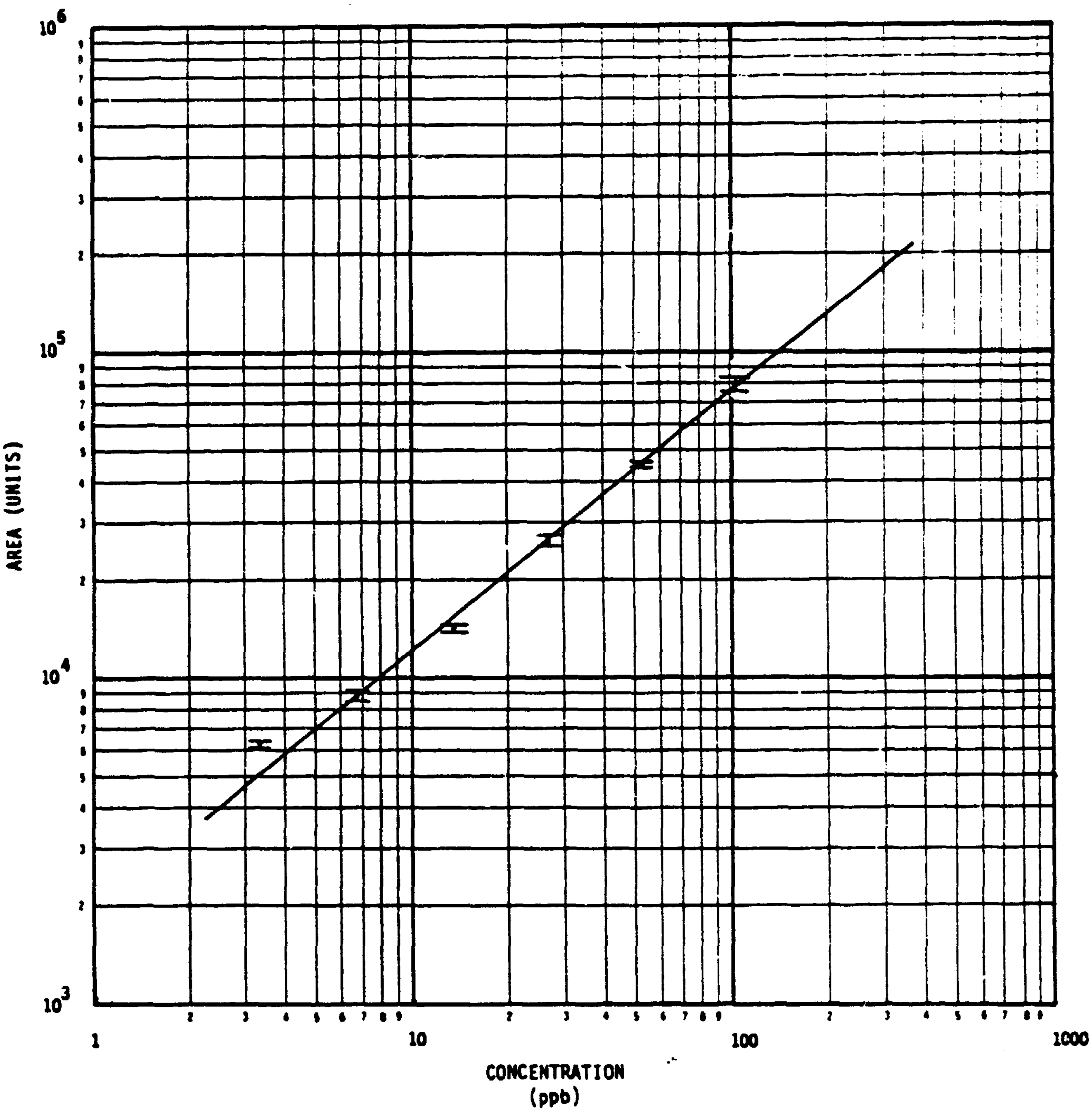

Figure 4 Calibration Curve for Methylene Chloride - #2

$$C = e^{1.244\ \mathrm{Ln}A - 9.370}$$

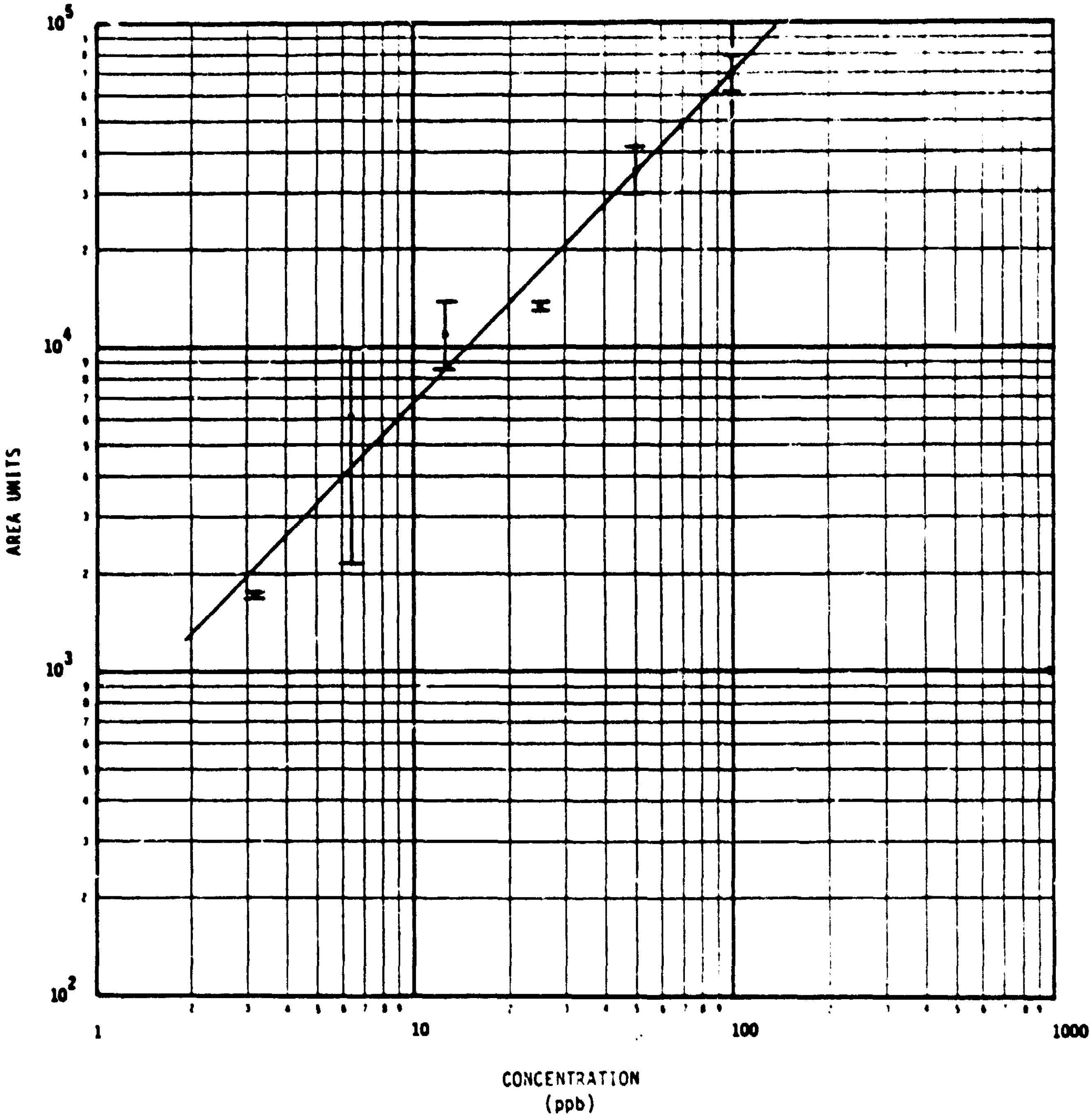

Figure 5 Calibration Curve 1, 2 - Dicloroethylene - #4

$C = e^{0.9731 \ln A - 6.297}$

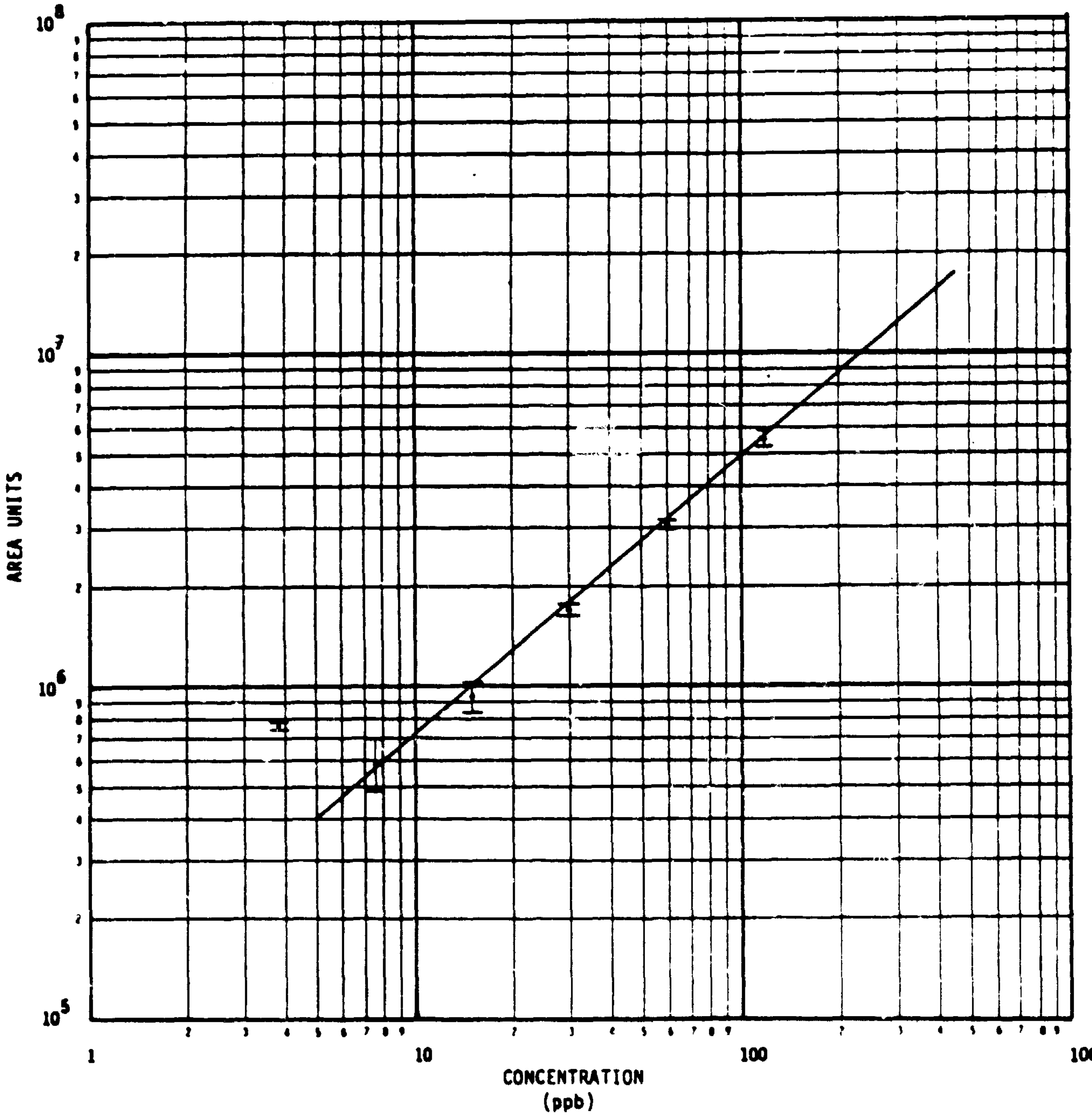

Figure 6 Calibration Curve for Chloroform - #5

$C = e^{1.209 \ln A - 13.96}$

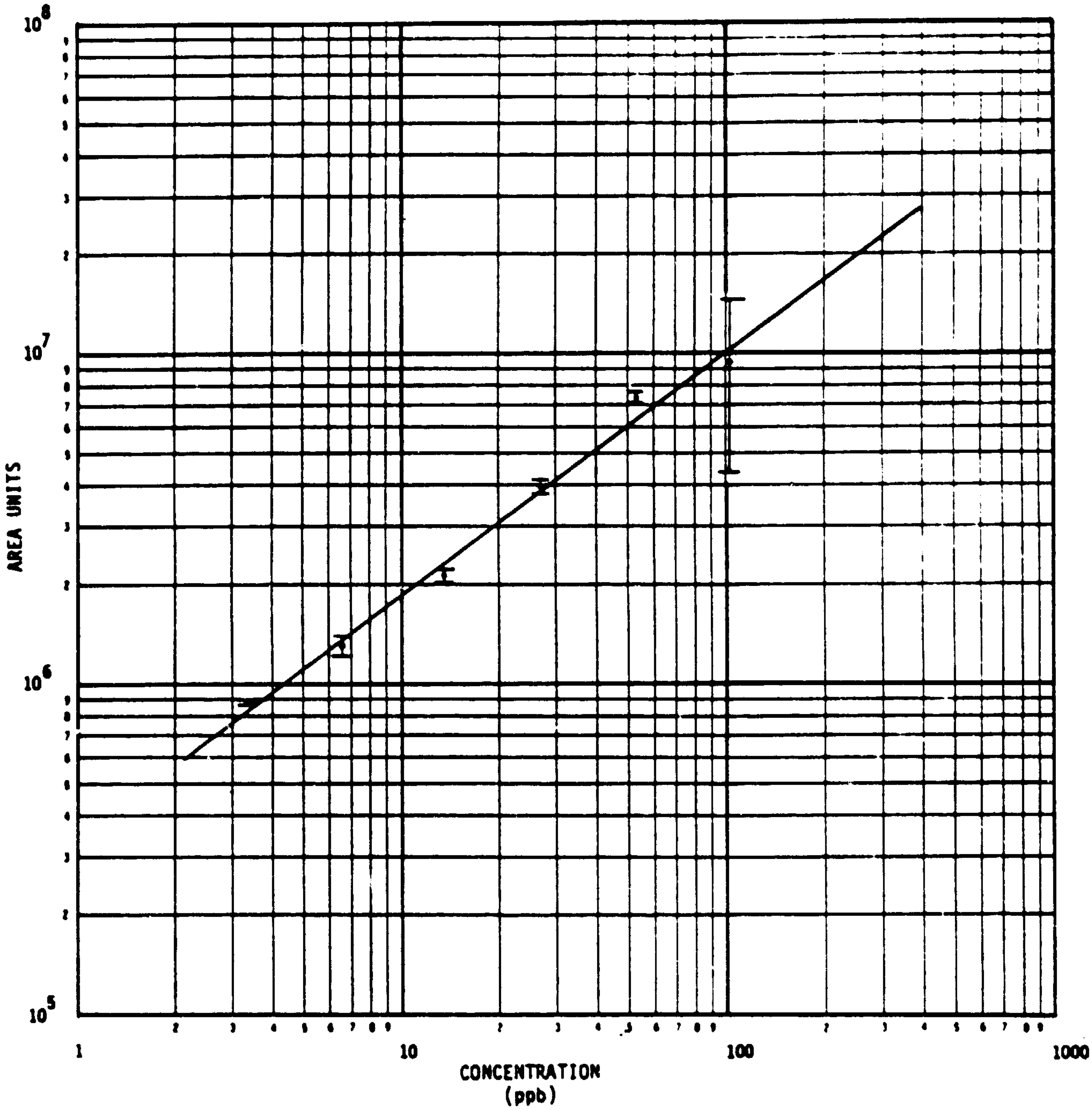

Figure 7 Calibration Curve for 1, 1, 1 - Trichloroethane - #6

$C = e^{1.352 \, \ln A - 17.22}$

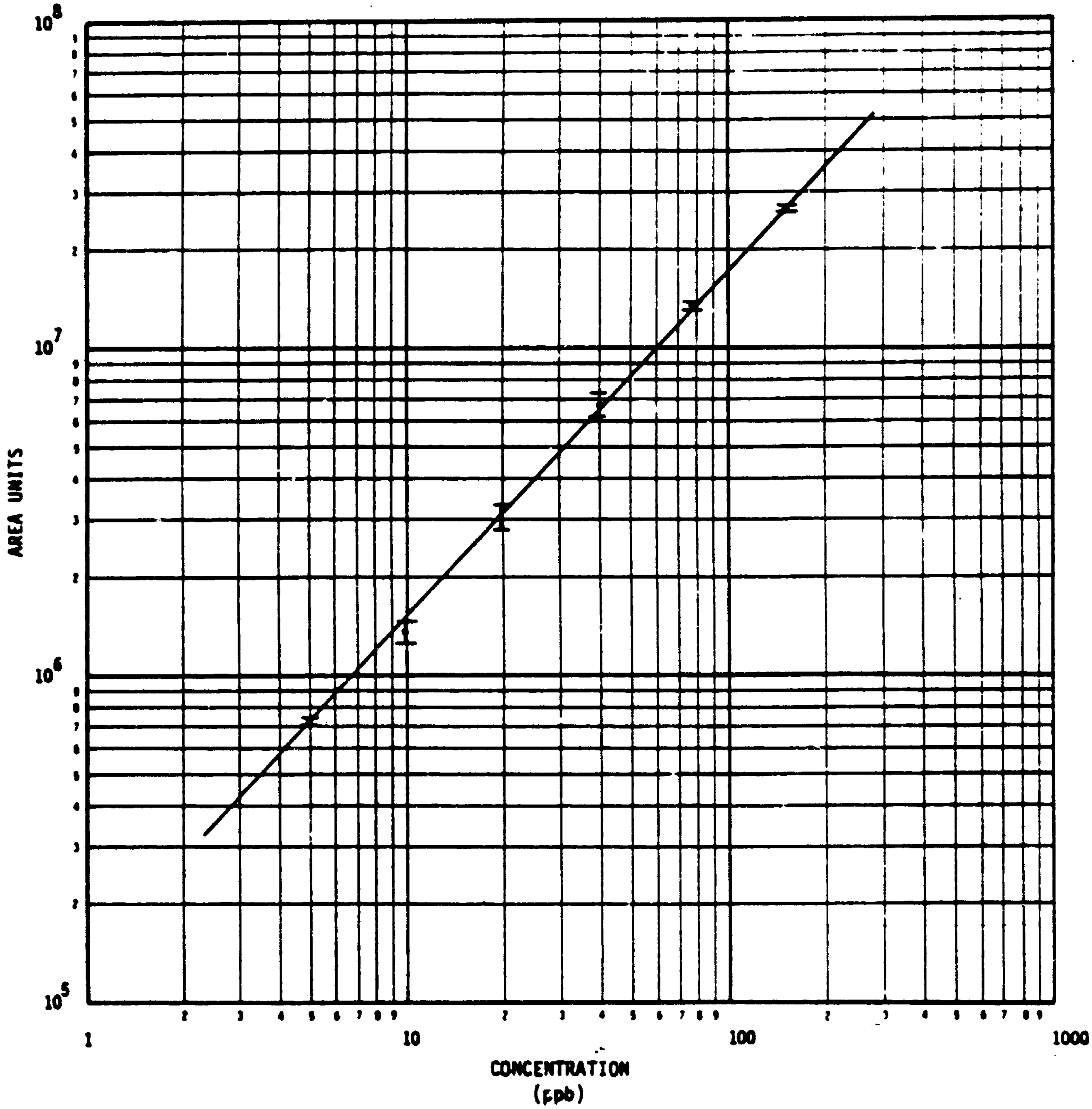

Figure 8 Calibration Curve for Bromodichloromethane - #7

$C = e^{0.9404 \ln A - 11.08}$

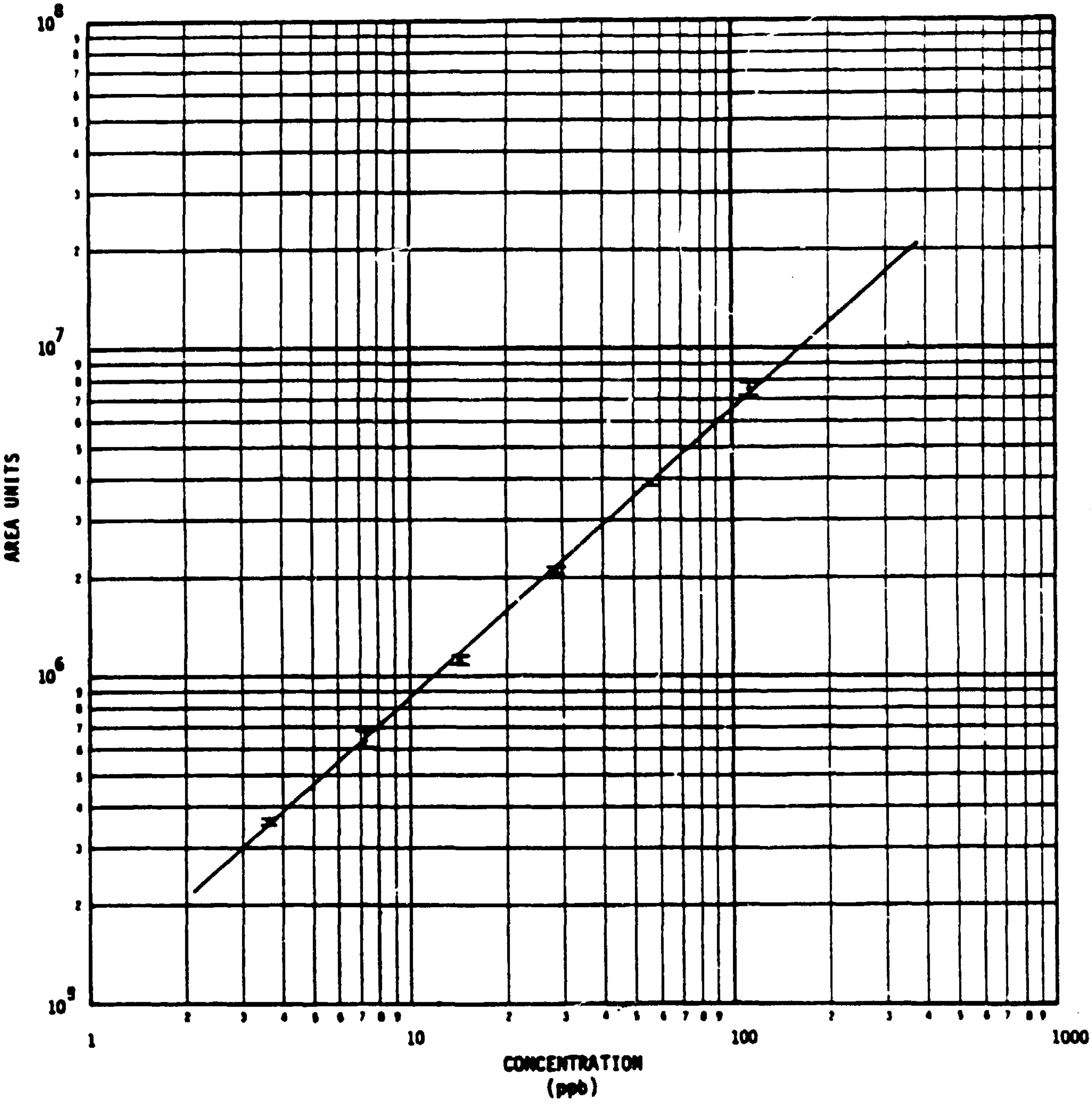

Figure 9 Calibration Curve for Trichloroethylene - #8

$$C = e^{1.136 \ln A - 13.21}$$

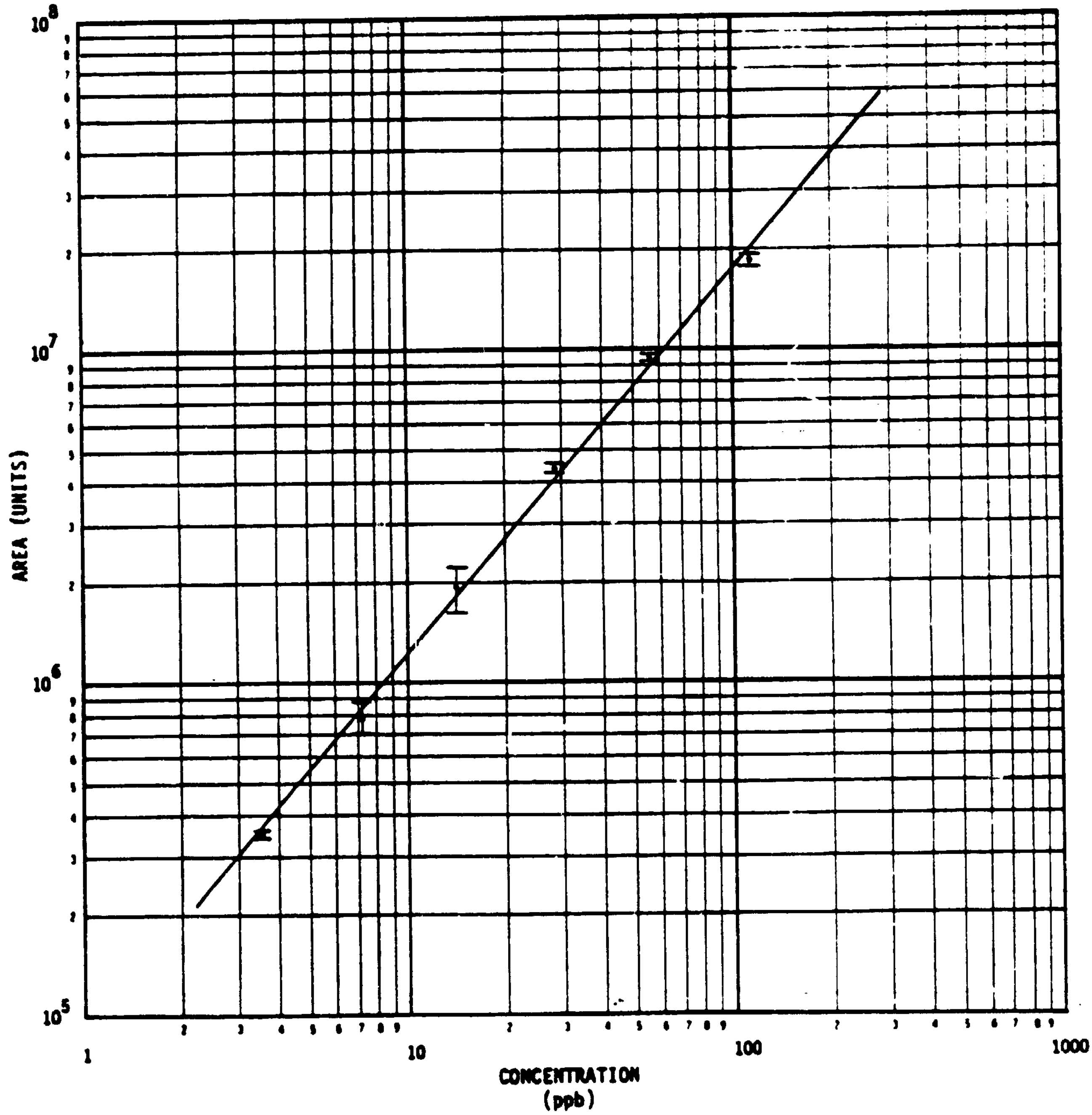

Figure 10 Calibration Curve for Dibromochloromethane - #9

$C = e^{0.8558 \ LnA - 9.668}$

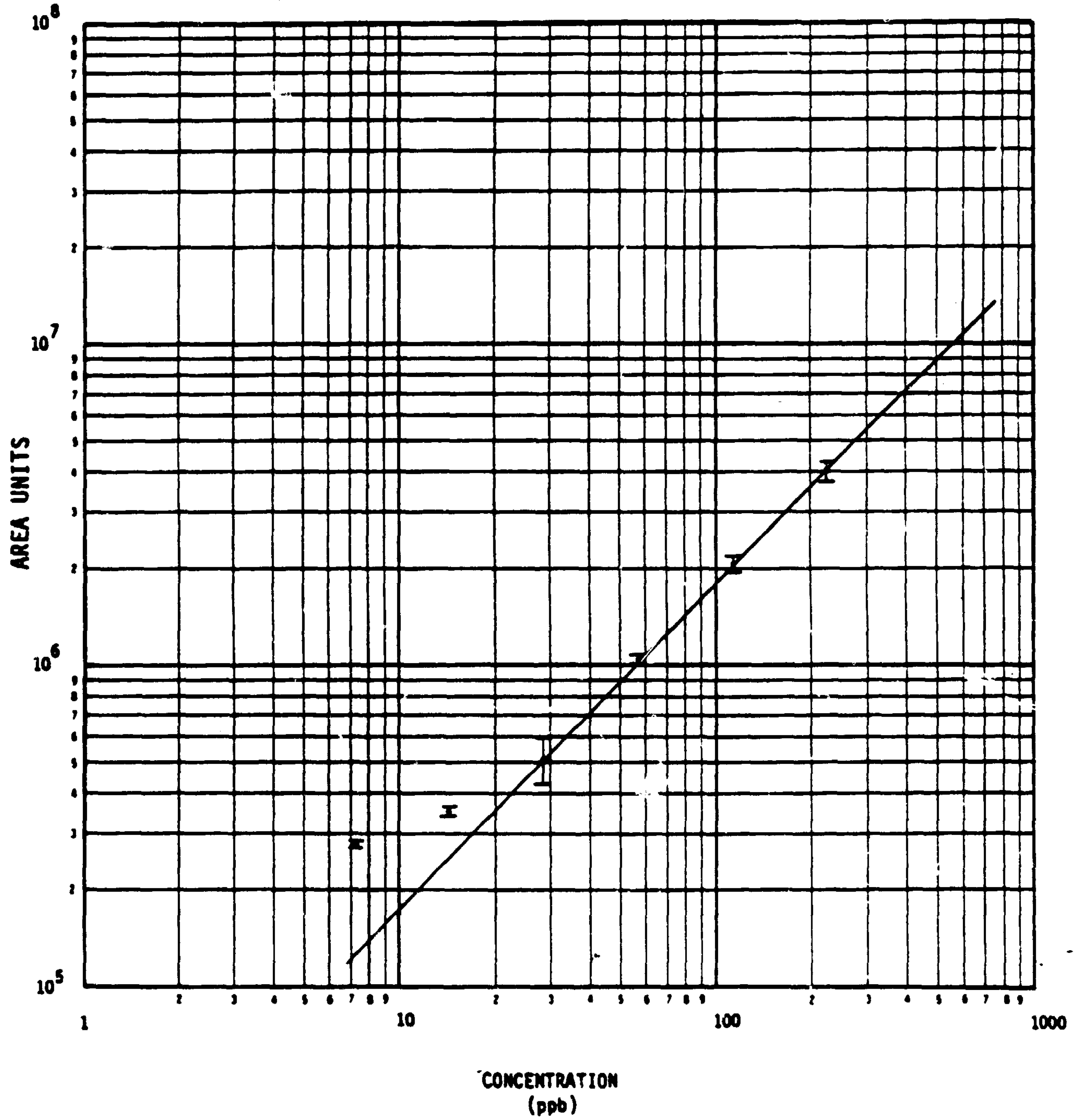

Figure 11 Calibration Curve for Bromoform - #10

$$C = e^{0.9885\ \mathrm{Ln}A - 9.64}$$

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TABLE 3 WMS-STANFORD UNIVERSITY VOLATILE ORGANIC ANALYSES COMPARISON SAMPLES 11/20/78-3/12/79

No.	Compound	Conc. Range* (ppb)	n	Correlation ∿ r	Slope m	Intercept b
1	Tetrachloroethylene	1.8 - 150.0	9	0.9696	0.9274	-1.3950
5	Chloroform	6.0 - 19.1	12	0.8388	0.3147	4.4189
6	1,1,1-Trichloroethane	3.0 - 105.0	15	0.9817	0.9767	-1.1797
7	Bromodichloromethane	0.5 - 4.0	15	0.8401	0.2294	0.5071
8	Trichloroethylene	0.2 - 36.0	12	0.9357	0.8485	0.4911
9	Dibromochloromethane	0.1 - 2.0	11	0.8706	0.1770	0.1254
10	Bromoform	0.2 - 2.0	8	0.2952	0.2655	0.3005

* Based on Stanford University results

(X, Y); (WMS, Stanford)

Monitor Labs, Inc. peripheral equipment and device controllers have been interfaced to the Data General Corporation NOVA minicomputers via data bus extensions to the ML 4100 device control chassis. The ADAM system was designed and installed by Monitor Labs and has performed without significant incident.

The EVA system was designed to utilize the RDOS capabilities for real-time operations and the ML devices for valve control. The original EVE system was configured with a Data General NOVA 1200 (32K) and a Diablo disk drive (2.5 megabytes). Intermittent core memory problems caused by overheating; software problems with multitasking caused by the insufficient memory; and disk space occurred with this configuration. The EVE system was upgraded to a Data General NOVA 3D (64K), Phoenix disk drive (10 megabytes), and communication system in May 1978. The EVE combination of the ML 4100 device control chassis with the Data General communication chassis and disk system resulted in an extension of the data bus that initially produced some signal noise. The problem was resolved after about 6 months of operation at Santa Clara by modifying the cabling to terminate the NOVA 3D data bus at the communication chassis instead of the ML 4100.

Data Reports

Report formats were developed to support a variety of data applications. These formats are described below.

Instantaneous Data Reports

Instantaneous data, updated each minute, are displayed to the operator on the CRT. The display provides the previous 1-minute value and the previous 15-minute, 30-minute, and hourly averages, and the running average for each available channel. A typical instantaneous report is shown in Figure 12. The first data set are the values for the secondary effluent, sample source 2, and the second data set are the values for the reclamation facility effluent, sample source 6. The sampling points are indicated on the flow schematic for the Santa Clara Valley Water District (SCVWD) facility, Figure 21. The instantaneous report presents a data scan that occurred at 06:00 hours. The results show consistent data for all but channels 1, 2, 8, 38, and 39 as indicated by the averages and status columns. Channel 8 for TOT OXY DEM is varying more than the specified limit and the Chemiluminescence sensor (Channels 1, 2, 38, and 39) show data were not being recorded (only the instantaneous voltage is displayed).

Daily Data Reports

The instantaneous and hourly peak values are monitored for each channel and for each sample source and reported as daily data. A typical daily data report for 24 hours is shown in Figure 13. The report includes the number of data points, the daily average, the instantaneous and hourly peak values, and the time of day each occurred for each source of water sampled throughout the day. The effluent sensors are the first data set printed, followed by each multipoint source. The total number of data points is always somewhat less than 1440 because of calibration and sensor stabilization required after the multipoint source is changed.

TIME - 227:06:00:00 SAMPLING POINT: SECONDARY EFFLUENT

CHA NO.	SENSOR	UNITS	STATUS	INST VALUE	*** AVERAGES *** 15 MIN	30 MIN	1 HR	RUNNING
1.	TOTAL BIOMASS	MIL C/M	NDTA	-0.261	0.000	17.609	17.609	17.624
2.	VIABLE BIOMASS	MIL C/M	NDTA	-0.261	0.000	0.000	0.000	13.369
5.	RES CHLORINE	MG/L		0.2	0.3	0.2	0.2	7.0
6.	TURBIDITY-SI02	MG/L		10.9	11.0	11.0	11.1	14.1
8.	TOT OXY DEM	MG/L	VARI	257.	230.	228.	227.	255.
9.	TOT ORG CARB	MG/L		12.9	12.8	12.8	12.9	12.4
10.	AMMONIA	MG/L		19.1	18.9	18.9	18.9	18.0
12.	PH	PH		7.04	7.05	7.06	7.08	7.08
13.	CHLORIDE	MG/L		358.	356.	355.	350.	375.
14.	CONDUCTIVITY	MMMHO/CM		1580.0	1574.7	1575.0	1583.4	1597.6
16.	HARDNESS	MG/L		306.	323.	334.	334.	241.
17.	SODIUM	MG/L		192.	187.	174.	170.	171.
19.	DIS OXYGEN-HW	MG/L		3.3	3.3	3.3	3.3	3.3

TIME - 227:06:00:00 SAMPLING POINT: RECLAMATION FAC. A EFFLUENT

CHA NO.	SENSOR	UNITS	STATUS	INST VALUE	*** AVERAGES *** 15 MIN	30 MIN	1 HR	RUNNING
3.	AIR COMP	PSIA		14.7	14.7	14.7	14.7	14.7
15.	TEMPERATURE#1	DEG F		70.4	70.4	70.4	70.4	70.7
18.	TURBIDITY-HW	FTU		2.80	2.80	2.81	2.83	2.30
20.	TEMPERATURE#2	DEG F		68.4	68.4	68.4	68.4	70.4
23.	EFFLUENT	PSIA		23.7	22.7	22.1	22.7	23.3
38.	TOTAL BIOMASS	MIL C/M	NDTA	-0.261	0.000	0.000	0.000	0.000
39.	VIABLE BIOMASS	MIL C/M	NDTA	-0.261	0.000	0.000	0.000	0.000

Figure 12 Typical Instantaneous Data Report

DAILY REPORT FOR: 6-RECLAMATION FAC. A EFFLUENT 9/ 3/78 24:00:00

CHA NO.	SENSOR	UNITS	DATA POINTS	DAILY AVERAGE	INSTANTANEOUS PEAK VALUE	INSTANTANEOUS PEAK TIME	HOURLY PEAK VALUE	HOURLY PEAK TIME
3.	AIR COMP	PSIA	1440	14.7	14.7	14:29	14.7	14: 0
15.	TEMPERATURE*1	DEG F	1440	80.5	86.4	14:29	85.9	14: 0
10.	TURBIDITY-HW	FTU	OUT					
20.	TEMPERATURE*2	DEG F	1440	67.4	69.2	11: 0	66.7	14: 0
23.	EFFLUENT	PSIA	1440	23.1	29.1	10:59	23.7	11: 0
30.	TOTAL BIOMASS	MIL C/M	OUT					
39.	VIABLE BIOMASS	MIL C/M	OUT					

DAILY REPORT FOR: 3-SECONDARY EFFLUENT 9/ 3/78 24:00:00

CHA NO.	SENSOR	UNITS	DATA POINTS	DAILY AVERAGE	INSTANTANEOUS PEAK VALUE	INSTANTANEOUS PEAK TIME	HOURLY PEAK VALUE	HOURLY PEAK TIME
1.	TOTAL BIOMASS	MIL C/M	6	10.39	16.93	1:44	16.93	2: 0
2.	VIABLE BIOMASS	MIL C/M	6	6.52	10.39	2:59	10.39	3: 0
5.	RES CHLORINE	MG/L	563	10.5	17.7	10:15	16.7	11: 0
6.	TURBIDITY-SI02	MG/L	720	8.4	11.6	17: 3	10.3	2: 0
8.	TOT OXY DEM	MG/L	187	62.	104.	5:20	78.	6: 0
9.	TOT ORG CARB	MG/L	563	11.8	15.3	1:33	13.8	6: 0
10.	AMMONIA	MG/L	515	12.4	22.5	2:39	20.5	3: 0
12.	PH	PH	594	7.62	7.96	5: 1	7.77	2: 0
13.	CHLORIDE	MG/L	604	278.	294.	19: 0	292.	2: 0
14.	CONDUCTIVITY	MMMHO/CM	720	1401.9	1490.0	17:10	1459.2	18: 0
16.	HARDNESS	MG/L	563	180.	663.	10:45	629.	11: 0
17.	SODIUM	MG/L	720	167.	228.	1:12	176.	18: 0
19.	DIS OXYGEN-HW	MG/L	720	2.4	2.5	7: 0	2.4	7: 0
29.	TOT HALOCARBON	PPB	OUT					

DAILY REPORT FOR: 6-RECLAMATION FAC. A EFFLUENT 9/ 3/78 24:00:00

CHA NO.	SENSOR	UNITS	DATA POINTS	DAILY AVERAGE	INSTANTANEOUS PEAK VALUE	INSTANTANEOUS PEAK TIME	HOURLY PEAK VALUE	HOURLY PEAK TIME
1.	TOTAL BIOMASS	MIL C/M	5	1.76	3.37	15:44	3.37	16: 0
2.	VIABLE BIOMASS	MIL C/M	6	0.56	1.73	4:59	1.73	5: 0
5.	RES CHLORINE	MG/L	470	3.3	5.6	12:27	4.3	12: 0
6.	TURBIDITY-SI02	MG/L	660	2.1	4.1	19: 4	3.1	16: 0
8.	TOT OXY DEM	MG/L	141	28.	54.	0:48	42.	1: 0
9.	TOT ORG CARB	MG/L	470	6.2	8.1	19:27	7.2	8: 0
10.	AMMONIA	MG/L	445	10.0	12.5	12:39	12.1	4: 0
12.	PH	PH	534	7.93	7.98	8:57	7.97	9: 0
13.	CHLORIDE	MG/L	564	268.	275.	0:54	272.	1: 0
14.	CONDUCTIVITY	MMMHO/CM	660	1382.4	1430.0	19: 1	1395.5	13: 0
16.	HARDNESS	MG/L	467	169.	2128.	12: 0	527.	12: 0
17.	SODIUM	MG/L	660	154.	220.	7: 1	156.	17: 0
19.	DIS OXYGEN-HW	MG/L	660	2.4	2.5	7: 3	2.4	8: 0
29.	TOT HALOCARBON	PPB	OUT					

Figure 13 Typical Daily Data Report

Historical Data Reports

The historical reports provide the hourly averages for the current day or any day within a 3-month period. The historical data file is a rotating file that is designed to contain 93 days of actual data. Only the sample source data recorded for each day are stored on the disk file. Whenever 93 days have been recorded, the next day is positioned at the beginning of the historical file, effectively rewinding the file for subsequent recording.

A typical historical report is shown in Figure 14. The hourly averages for the hour ending and sample source are shown for a complete day. The sample source shown for each hour indicates the multipoint source sampled for the hour. A blank indicates no data was recorded for the hour.

Coliform Biosensor Data Reports

Coliform results require 3 to 14 hours for determination following cell inoculation. The results are available for individual cells after the minimum voltage and 200 millivolt time have been determined. A typical coliform report is shown in Figure 15. The first data set for 8-25-78 are actually for a current day in which no cells have completed reaction or have attained a minimum volt level, and the second data set for 2-14-78 are for a previous day. The report includes the inoculation time, the time at which the minimum voltage was attained, the value of the minimum voltage, the reaction time, and the cell count. The coliform evaluation is not terminated until the maximum reaction time has elapsed since inoculation of the last cell. The results are reported as cells/100 ml. Figure 15 shows that total coliform were evaluated on 8-25-78 and the cell count varied from a minimum value of 190,000 for cell #1 to a maximum value of 290,000 for cell #7.

Volatile Halocarbon Concentration and Data Reports

The gas chromatograph is a modified Hewlett-Packard Model 5710/5840 that is fully automated and operates under internal program control. The processing time requires 50 minutes for a complete analysis of nine volatile halogenated hydrocarbons. An Electron Capture Detector (ECD) is used for accurate quantitating at the parts per billion (ppb) level. The gas chromatograph is normally scheduled to begin processing at the start of each hour. The GC results are printed on the calculator and transmitted to the EVE interface approximately 50 minutes after the hour. Only the number and compound area are required by EVE because a modified calibration curve is used to determine the measured concentration based on the area. The EVE calibration curve is exponential with constants for the slope and intercept ($Y = e^{ax + b}$).

The halocarbon concentrations are summed and recorded as an hourly average of total halocarbon on channel 29. The calibration curves presently used have an accuracy of $\pm$ 10% at the parts per billion (ppb) level. The brominated compounds have a threshold limit of 3 ppb and the chlorinated compounds have a threshold limit of 1 ppb.

8/24/78 HOURLY AVERAGES FOR MULTIPOINT SENSORS

CHA NO.	SENSOR	UNITS	1/6	2/3	3/3	4/6	5/6	6/3
			* * * * HOUR OF DAY/SAMPLE SOURCE * * * *					
1.	TOTAL BIOMASS	MIL C/M						
2.	VIABLE BIOMASS	MIL C/M	0.57	10.16	10.10	0.58	0.61	12.61
5.	RES CHLORINE	MG/L	2.4	6.3	6.5	2.5		7.7
6.	TURBIDITY-SIO2	MG/L	2.0	12.2	10.4	2.0	2.0	0.6
8.	TOT OXY DEM	MG/L	55.	70.	69.	50.		102.
9.	TOT ORG CARB	MG/L	8.4	14.5	14.6	9.2		14.1
10.	AMMONIA	MG/L	13.4	21.6	22.0	15.1		19.5
12.	PH	PH	7.24	7.10	7.10	7.23	7.26	7.11
13.	CHLORIDE	MG/L	292.	307.	306.	279.	279.	280.
14.	CONDUCTIVITY	MMHO/CM	1555.3	1407.7	1475.2	1543.3	1560.2	1517.5
16.	HARDNESS	MG/L	243.	141.	138.	239.		160.
17.	SODIUM	MG/L	200.	194.	194.	206.		
19.	DIS OXYGEN-HW	MG/L	2.9	2.9	2.9	2.9	2.9	2.9
29.	TOT HALOCARBON	PPB	143.		770.		78.	

CHA NO.	SENSOR	UNITS	7/3	8/3	9/6	10/3	11/3	12/6
			* * * * HOUR OF DAY/SAMPLE SOURCE * * * *					
1.	TOTAL BIOMASS	MIL C/M						
2.	VIABLE BIOMASS	MIL C/M	12.62	0.12	0.14	13.40	13.51	
5.	RES CHLORINE	MG/L	0.1		3.9	6.3	6.4	2.0
6.	TURBIDITY-SIO2	MG/L	7.6		2.0	9.7	11.4	2.9
8.	TOT OXY DEM	MG/L	99.		56.	111.	139.	120.
9.	TOT ORG CARB	MG/L	13.9		8.4	12.3	12.5	7.6
10.	AMMONIA	MG/L	19.0		14.1		19.5	16.3
12.	PH	PH	7.09		7.21	7.00	6.93	7.31
13.	CHLORIDE	MG/L	295.		261.	285.	293.	296.
14.	CONDUCTIVITY	MMHO/CM	1468.3	1523.3	1554.0	1513.5	1475.3	1533.0
16.	HARDNESS	MG/L	175.		293.	160.	153.	219.
17.	SODIUM	MG/L						155.
19.	DIS OXYGEN-HW	MG/L	2.9	2.9	2.9	2.9	2.9	2.9
29.	TOT HALOCARBON	PPB	659.		82.		620.	

CHA NO.	SENSOR	UNITS	13/6	14/3	15/3	16/6	17/6	18/3
			* * * * HOUR OF DAY/SAMPLE SOURCE * * * *					
1.	TOTAL BIOMASS	MIL C/M						11.00
2.	VIABLE BIOMASS	MIL C/M		12.40	12.36		0.82	
5.	RES CHLORINE	MG/L	1.7	6.2	6.2	2.4	2.5	6.6
6.	TURBIDITY-SIO2	MG/L	3.6	13.5	10.6	2.2	2.2	10.6
8.	TOT OXY DEM	MG/L	116.	153.	165.	113.	138.	182.
9.	TOT ORG CARB	MG/L	7.1	11.6	12.2	7.9	7.3	12.7
10.	AMMONIA	MG/L	16.5	19.1	19.7	17.7	16.8	18.2
12.	PH	PH	7.33	6.90	6.86	7.24	7.29	6.98
13.	CHLORIDE	MG/L	307.	306.	310.	295.	299.	310.
14.	CONDUCTIVITY	MMHO/CM	1539.0	1541.7	1546.0	1526.7	1538.0	1530.7
16.	HARDNESS	MG/L	221.	150.	147.	222.	227.	158.
17.	SODIUM	MG/L	151.	136.	131.	120.	123.	128.
19.	DIS OXYGEN-HW	MG/L	2.8	2.8	2.8	2.8	2.8	2.7
29.	TOT HALOCARBON	PPB			618.		196.	

CHA NO.	SENSOR	UNITS	19/3	20/6	21/6	22/3	23/3	24/6
			* * * * HOUR OF DAY/SAMPLE SOURCE * * * *					
1.	TOTAL BIOMASS	MIL C/M		0.93		20.47		1.01
2.	VIABLE BIOMASS	MIL C/M	0.97				15.13	
5.	RES CHLORINE	MG/L	6.7	2.6	2.6	6.5	6.5	2.6
6.	TURBIDITY-SIO2	MG/L	10.1	1.7	1.8	11.5	10.8	1.8
8.	TOT OXY DEM	MG/L	161.	108.	76.	102.	98.	54.
9.	TOT ORG CARB	MG/L	13.3	7.7	7.2	13.7	14.1	7.8
10.	AMMONIA	MG/L	19.0	13.6	13.4	18.0	18.9	13.7
12.	PH	PH	6.98	7.26	7.29	7.10	7.09	7.27
13.	CHLORIDE	MG/L	307.	297.	297.	298.	299.	295.
14.	CONDUCTIVITY	MMHO/CM	1514.5	1526.3	1534.5	1477.7	1468.0	1529.7
16.	HARDNESS	MG/L	152.	225.	235.	156.	149.	231.
17.	SODIUM	MG/L	128.	158.	158.	136.	122.	124.
19.	DIS OXYGEN-HW	MG/L	2.7	2.7	2.7	2.7	2.7	2.7
29.	TOT HALOCARBON	PPB	702.		89.		899.	

Figure 14 Typical Historical Data Report

COLIFORM REPORT: 8/25/78

	SENSOR 1	2	3	4	5	6	7	8
INOCULATION TIME	10:44	10:48	10:52	10:56	11: 0	11: 4	11: 8	11:12
MINIMUM VOLTS								
TIME	14:53	14:58	14:58	14:58	14:58	14:58	14:58	14:58
VALUE	36	76	-6	33	107	-13	96	40
200MV TIME								
REACTION TIME								
LOG10(CELLS/ML)								
TOTAL								
FECAL								

MAXIMUM REACTION TIME = 14 HOURS

COLIFORM REPORT: 2/14/78

	SENSOR 1	2	3	4	5	6	7	8
INOCULAT'ON TIME	24:10	24:14	24:18	24:22	24:26	24:30	24:34	24:38
MINIMUM VOLTS								
TIME	25:30	25:35	25:30	25:38	25:55	25:34	25:37	25:39
VALUE	80	84	49	112	80	92	73	83
200MV TIME	29:14	29: 2	29:12	29: 7	29:27	29:22	29:17	29:30
REACTION TIME	5: 4	4:40	4:54	4:45	5: 1	4:52	4:43	4:52
CELLS/100ML								
TOTAL	1.9E5	2.6E5	2.3E5	2.8E5	2.0E5	2.4E5	2.9E5	2.4E5
FECAL								

Figure 15 Typical Coliform Data Report

Reports are normally available every hour for trace concentrations of the brominated and chlorinated halocarbon compounds for the multipoint sample source. A typical report is shown in Figure 16 and includes the calibration number, compound name, hour of day, and sample source for each halocarbon.

Daily and Monthly Reports

Plotting capability is provided by separate programs for daily and monthly results. The NOVA 3D resources are allocate for FVE report generation in the foreground and plotting in the background memory partitions. The hourly plot program will graph the hourly averages of any three channels for the same day. The monthly plot program will graph the daily averages of any one channel for any month. The plot data are recalled from the historical data file that is shared by the EVE report generation program.

A typical hourly plot is shown in Figure 17. Three channels are plotted for the multipoint sample sources 1 and 3. The data points are annotated with the sample source number that is identified at the top of the graph. The scaling parameters are selected by the operator for each channel during the plotting process.

A typical monthly plot is shown in Figure 18. The daily average, standard deviation, hourly peak, and hourly peak time are plotted for the month. The sample source is indicated by the square plot symbol and a highlighted sample source identification at the top of the graph. The daily averages are indicated by the square symbol for each day plotted. The hourly peak values are indicated at the top of the lower plot.

Sample Source Trend Report

Hourly average values of a parameter over a period of a month for a given point in the treatment process can be determined using the format illustrated in Figure 19. The average for each hour of the day that the process was sampled is reported for each day of the month. The data are also summarized in terms of the daily average.

Statistical Report

The performance of a single process or group of processes in terms of percent removal can be reported as illustrated in Figure 20. Influent and effluent values are compared, including number of days sampled, monthly averages, daily and hourly variations (1σ), and the average and variation (1σ) in daily removal. Figure 20 shows these data for reclamation plant influent and effluent and thus reflects plant overall monthly performance.

8/24/78 HALOCARBON CONCENTRATIONS - PPB

CAL NO.	COMPOUND	* * * * HOUR OF DAY/SAMPLE SOURCE * * * * 1/6	2/3	3/3	4/6	5/6	6/3
1.	TETRACHLOROETHYLENE	10.4		100.8		14.8	
2.	METHYLENE CHLORIDE	5.9		19.9			
3.	1.1-DICHLOROETHYLENE	1.6					
4.	1.2-DICHLOROETHYLENE	42.2					
5.	CHLOROFORM	32.1		87.2		22.9	
6.	1.1.1-TRICHLOROETHANE	9.9		220.1		10.4	
7.	BROMODICHLOROMETHANE	4.9		5.3		3.9	
8.	TRICHLOROETHYLENE	20.2		300.4		19.3	
9.	DIBROMOCHLOROMETHANE	3.8		9.8		3.1	
10.	BROMOFORM	3.7		2.1		3.5	

CAL NO.	COMPOUND	* * * * HOUR OF DAY/SAMPLE SOURCE * * * * 7/3	8/3	9/6	10/3	11/3	12/6
1.	TETRACHLOROETHYLENE	76.4		12.7		51.0	
2.	METHYLENE CHLORIDE	9.2				8.2	
3.	1.1-DICHLOROETHYLENE			1.6			
4.	1.2-DICHLOROETHYLENE					15.2	
5.	CHLOROFORM	82.5		27.7		62.8	
6.	1.1.1-TRICHLOROETHANE	156.4		10.2		126.1	
7.	BROMODICHLOROMETHANE	7.1		4.1		7.4	
8.	TRICHLOROETHYLENE	313.5		19.8		333.0	
9.	DIBROMOCHLOROMETHANE	11.3		3.2		12.0	
10.	BROMOFORM	2.6		3.2		4.5	

CAL NO.	COMPOUND	* * * * HOUR OF DAY/SAMPLE SOURCE * * * * 13/6	14/3	15/3	16/6	17/6	18/3
1.	TETRACHLOROETHYLENE			62.3		14.8	
2.	METHYLENE CHLORIDE			8.0		6.3	
3.	1.1-DICHLOROETHYLENE					1.7	
4.	1.2-DICHLOROETHYLENE					81.2	
5.	CHLOROFORM			50.1		35.6	
6.	1.1.1-TRICHLOROETHANE			102.1		9.6	
7.	BROMODICHLOROMETHANE			5.2		5.9	
8.	TRICHLOROETHYLENE			375.4		31.9	
9.	DIBROMOCHLOROMETHANE			11.7		4.3	
10.	BROMOFORM			2.6		4.5	

CAL NO.	COMPOUND	* * * * HOUR OF DAY/SAMPLE SOURCE * * * * 19/3	20/6	21/6	22/3	23/3	24/6
1.	TETRACHLOROETHYLENE	117.3		17.7		128.2	
2.	METHYLENE CHLORIDE	17.2				60.2	
3.	1.1-DICHLOROETHYLENE						
4.	1.2-DICHLOROETHYLENE					140.5	
5.	CHLOROFORM	84.0		21.0		106.6	
6.	1.1.1-TRICHLOROETHANE	98.6		9.8		95.6	
7.	BROMODICHLOROMETHANE	5.1		3.6		7.3	
8.	TRICHLOROETHYLENE	365.7		29.8		331.1	
9.	DIBROMOCHLOROMETHANE	11.2		3.3		11.7	
10.	BROMOFORM	2.4		3.8		2.3	

Figure 16 Typical Gas Chromatograph Data Report

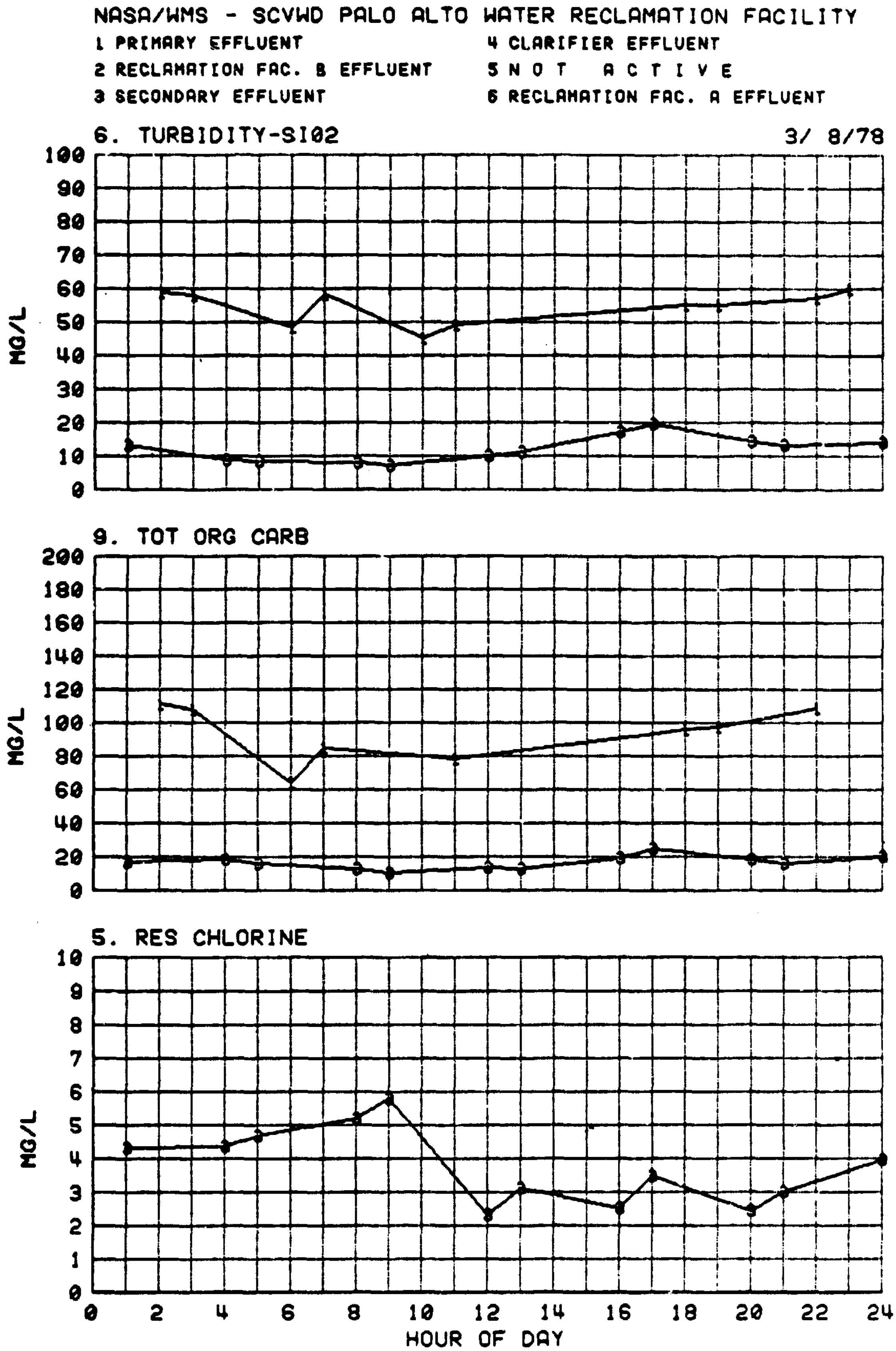


Figure 17 Typical Hourly Plot (1 of 3)

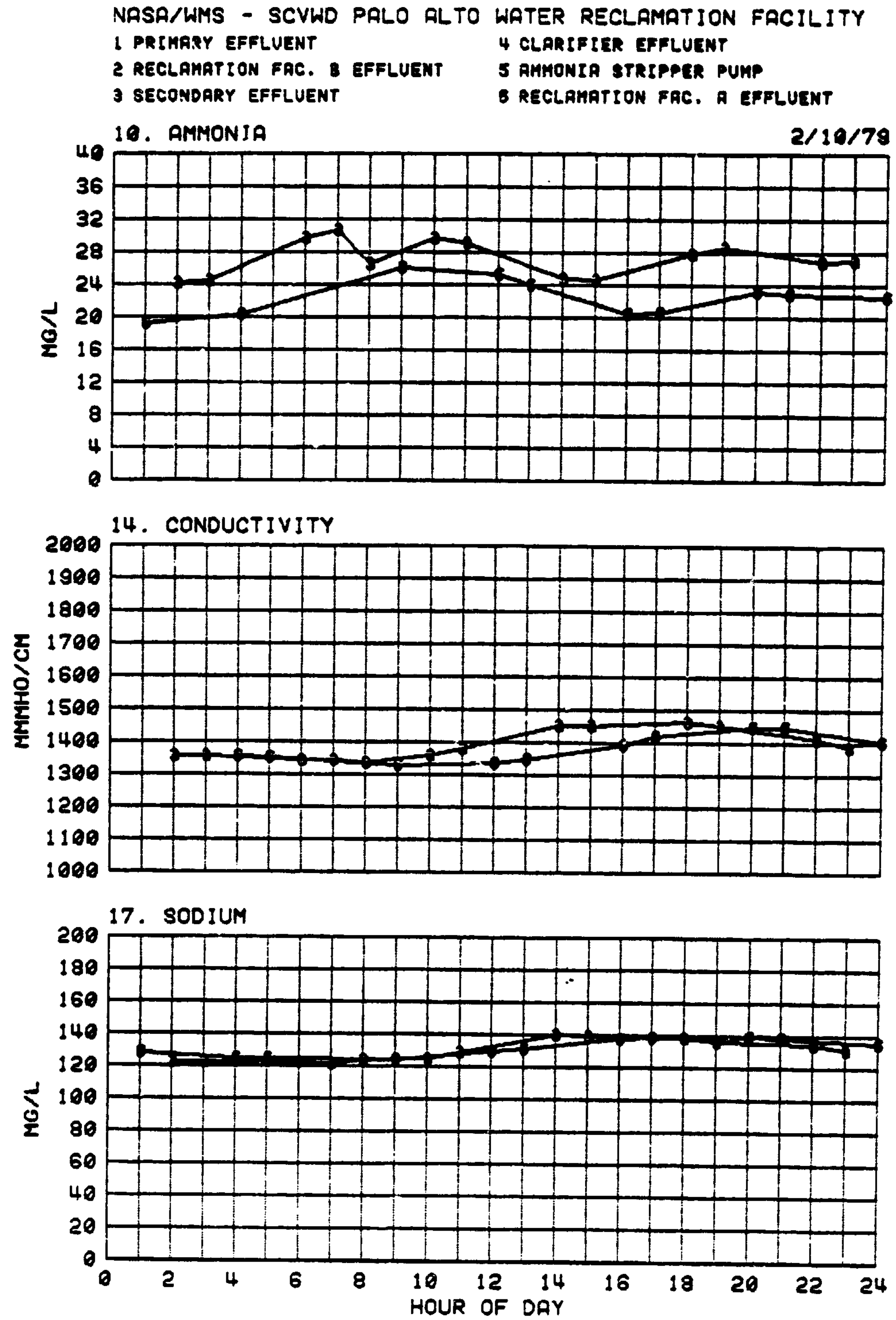


Figure 17 Typical Hourly Plot (2 of 3)

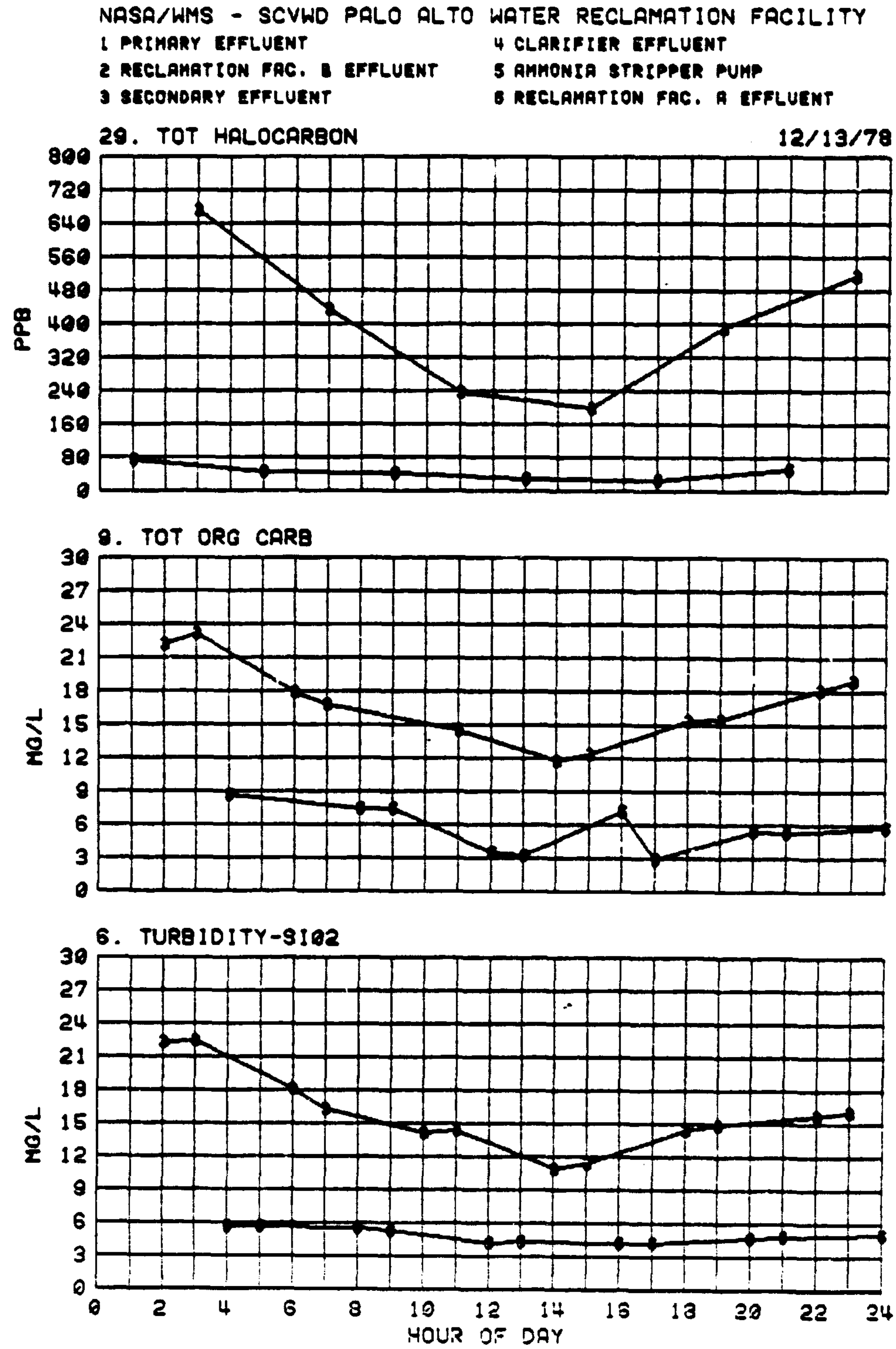


Figure 17 Typical Hourly Plot (3 Of 3)

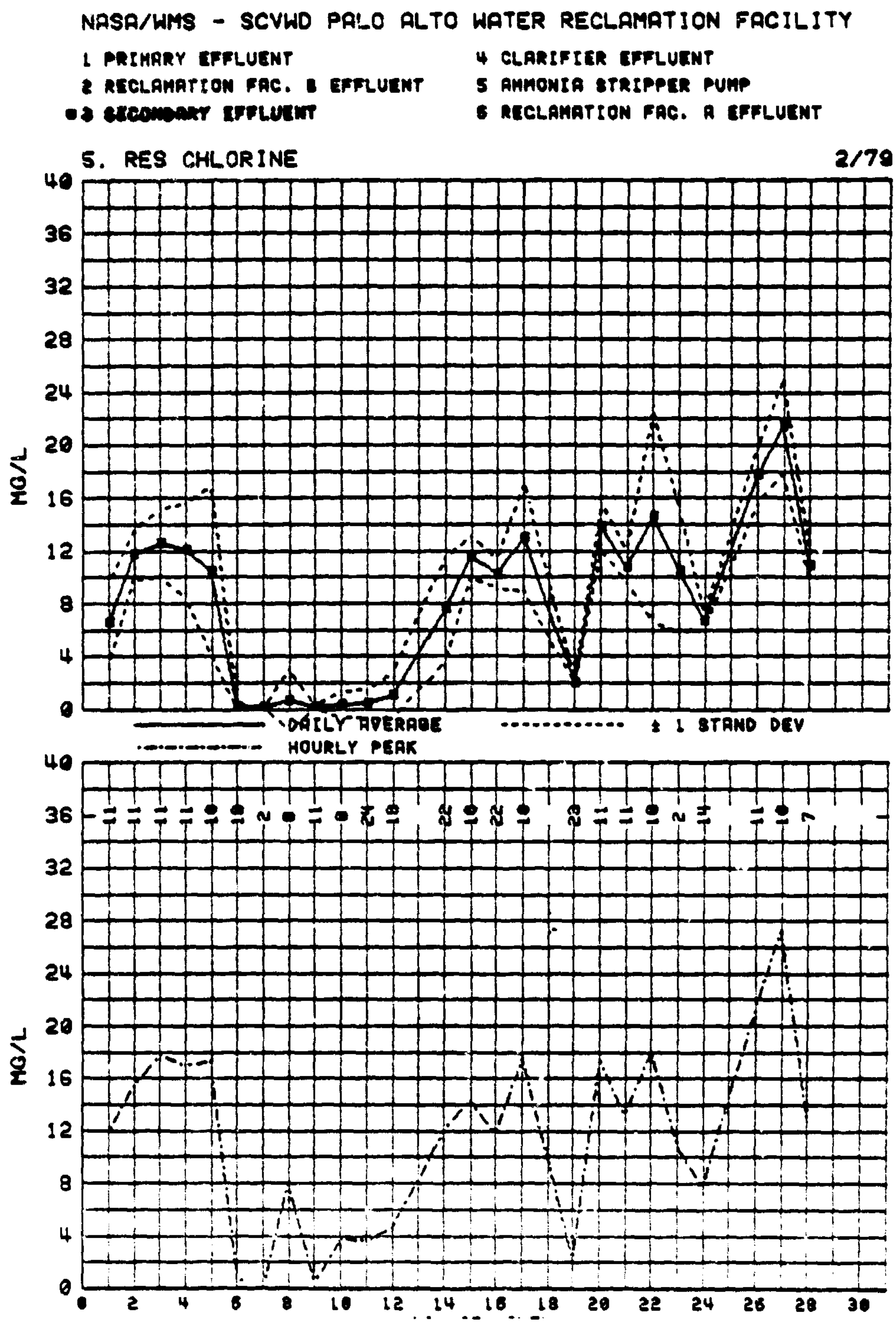


Figure 18 Typical Monthly Plot

TURBIDITY-SI02
(MG/L)
HOURLY AVERAGES
FOR JUL 1979

SAMPLE SOURCE 3 - NH3 STRIPPED/RECARBONATED

	1	2	3	4	5	6	7	8	9	10	11	12
1 S												
2 M												
3 T												
4 W	8.1	7.0					7.0	8.0				
5 T	8.7	8.9					9.0	9.2				
6 F	8.7	8.3					8.7	8.9				
7 S	11.6	11.3					10.0	10.0				
8 S	7.9	8.0					7.3	7.9				
9 M	8.1	8.4					8.3	8.5				
10 T	7.7	7.5					7.3	7.7				
11 W	8.3	8.3					8.5	8.5				
12 T	9.0	10.4					9.0	8.5				
13 F												
14 S												
15 S												
16 M												
17 T	7.6	7.0					8.1	8.4				
18 W		9.2						9.5				
19 T		8.0						8.5				
20 F		7.1						6.9				
21 S		6.7						6.0				
22 S		6.0						7.4				
23 M		16.4						14.2				
24 T												
25 W												
26 T												
27 F												
28 S		7.2						7.0				
29 S		8.2						8.0				
30 M		8.9						8.7				
31 T		7.6						9.9				

	13	14	15	16	17	18	19	20	21	22	23	24	DAILY AVG
1 S													
2 M													
3 T	10.2	10.9					9.2	8.9					11.0
4 W	7.7	6.9					8.5	8.7					7.9
5 T	9.0	10.5					9.3	9.0					9.3
6 F	11.5	13.9					17.6	17.2					11.9
7 S	8.1	8.2					7.0	8.0					9.4
8 S	8.0	7.7					7.9	8.0					7.9
9 M	9.1	9.1					7.2	7.5					8.3
10 T	7.9	8.2					7.7	8.4					7.0
11 W	8.0	6.0					8.1	8.9					8.1
12 T													9.4
13 F													
14 S													
15 S													
16 M	6.2	6.7					8.5	7.5					7.2
17 T	8.7	8.0						8.3					8.2
18 W		7.1						6.6					8.1
19 T		5.4						4.4					6.6
20 F		6.5						6.4					6.7
21 S		6.0						6.6					6.7
22 S		11.4						16.7					10.5
23 M		11.3											14.0
24 T													
25 W													
26 T													
27 F		8.1						6.3					7.2
28 S		6.0						6.5					6.0
29 S		5.0						5.9					7.0
30 M		4.5						5.0					6.0
31 T		9.0						9.3					9.1

Figure 19 Typical Sample Source Trend Data Report

STATISTICAL DATA FOR JUN 1979

SAMPLE SOURCE 2 - PALO ALTO SECONDARY EFFLUENT

CHA	SENSOR	UNITS	SAMPLING FREQUENCY	MONTHLY AVERAGE	DAILY AVG VARIATION	HOURLY AVG VARIATION
1.	TOTAL BIOMASS	MIL C/M	11	5.381	1.1495	1.9382
2.	VIABLE BIOMASS	MIL C/M	12	1.382	0.2339	0.6840
5.	RES CHLORINE	MG/L	11	11.153	3.1300	3.3204
6.	TURBIDITY-SIO2	MG/L	15	25.781	4.2681	6.8323
9.	TOT ORG CARB	MG/L	15	12.243	2.0620	2.7746
10.	AMMONIA	MG/L	15	21.683	4.5300	5.6334
11.	NITRATE	MG/L	2	1.777	2.9063	2.1501
12.	PH	PH	15	6.945	0.1606	0.1085
14.	CONDUCTIVITY	MMMHO/CM	15	1250.139	60.6159	60.6781
15.	TEMPERATURE*1	DEG F	15	74.236	1.8011	2.6045
16.	HARDNESS	MG/L	9	166.711	53.7395	55.6903
17.	SODIUM	MG/L	15	132.683	10.8470	23.4195
20.	AMBIENT TEMP	DEG F	15	76.543	3.5442	4.5790
29.	TOT HALOCARBON	PPB	4	554.352	156.2437	263.3189

SAMPLE SOURCE 6 - RECLAMATION FACILITY EFFLUENT

CHA	SENSOR	UNITS	SAMPLING FREQUENCY	MONTHLY AVERAGE	DAILY AVG VARIATION	HOURLY AVG VARIATION	PERCENT REMOVAL DAILY AVG	PERCENT REMOVAL STD DEV
1.	TOTAL BIOMASS	MIL C/M	23	0.582	0.2154	0.3511	89.10	5.81
2.	VIABLE BIOMASS	MIL C/M	24	0.155	0.1231	0.2432	80.14	10.74
5.	RES CHLORINE	MG/L	25	2.618	0.3839	0.8632	76.52	11.82
6.	TURBIDITY-SIO2	MG/L	29	3.696	0.4575	0.5801	85.67	3.13
9.	TOT ORG CARB	MG/L	29	1.966	0.8118	0.9555	83.94	7.25
10.	AMMONIA	MG/L	27	16.551	2.8270	3.2153	23.30	13.55
11.	NITRATE	MG/L	11	6.482	1.6143	2.1092	*-264.	451.65
12.	PH	PH	29	7.535	0.2941	0.3163	-0.49	2.52
14.	CONDUCTIVITY	MMMHO/CM	29	1200.261	51.3690	59.5482	3.96	2.41
15.	TEMPERATURE*1	DEG F	29	73.829	1.3628	1.8932	0.55	0.52
16.	HARDNESS	MG/L	28	156.534	49.2360	46.6497	6.10	29.06
17.	SODIUM	MG/L	29	110.410	10.0745	28.1044	10.76	4.67
20.	AMBIENT TEMP	DEG F	29	75.148	2.9270	3.5210	1.63	1.14
29.	TOT HALOCARBON	PPB	4	92.576	85.6589	97.8129	83.30	37.20

Figure 20 Typical Statistical Report

SCVWD WATER RECLAMATION FACILITY DESCRIPTION

General

The SCVWD Palo Alto Reclamation Facility is a pilot facility designed to treat 0.09-m^3/s (2 mgd). Figure 21 shows the basic processes in the Reclamation Facility, which has as an influent the chlorinated, nitrified, filtered secondary effluent from the 1.53-m^3/s (35 mgd) Regional Water Quality Control Plant located in Palo Alto. The reclamation plant includes the following: High-lime treatment, single-stage recarbonation, breakpoint chlorination for further nitrogen removal, mixed-media filtration, activated carbon sorption with carbon regeneration, ozonation, chlorination for disinfection, and storage. Innovative design of the plant allows flexibility in the sequence of the unit processes. For instance, the water can be filtered prior to or after activated carbon treatment, or both, depending on the need to protect the carbon beds or to eliminate carbon fines in the effluent. This flexibility was provided to permit research and testing of various alternatives prior to building a larger plant.

The facility has a direct digital computer control system that allows operators to alter control parameters. Process configurations are easily changed by the engineering staff. The computer supplies operational data to personnel on shift, while operating the plant.

The following are general descriptions of the processes. Table 4 describes capacity parameters for the processes.

Control and Instrumentation

A Modcomp II/221 computer with 64K words of main memory, two moving head disk drives with 2.6M words of memory, one fixed head disk with 512K words of memory, one REMAC multiplexer unit, three CRT's, a card reader, and a printer are utilized for plant data acquisition and control. The software utilized is a modified version of a standard control package called FLICK.

All instruments in the plant, as listed on Table 5, are standard commercially available devices.

The need for exceptional process flexibility (i.e., arranging unit processes in any desired order) led to the selection of a DDC (digital data control) system with no conventional analog backup control. It was felt that such a hardwired backup, as found in many plants, would restrict process flexibility to an unacceptable extent. Also, because of the "pilot" nature of this plant, a backup computer system was not justifiable. Because of the lack of a backup system, outages due to the control system were much more frequent than would be experienced in a conventional plant where usual backup and redundancy measures were utilized.

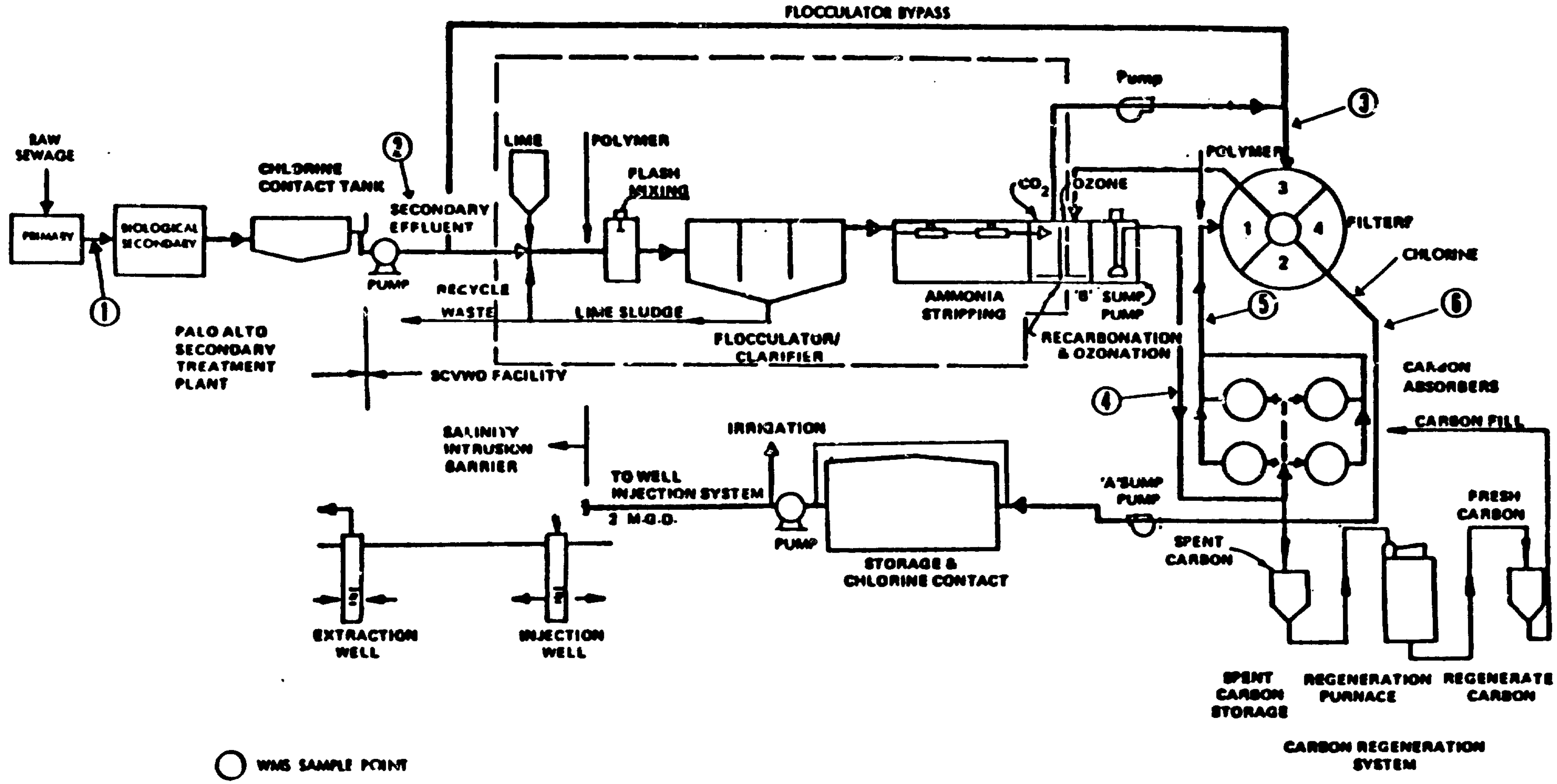


Figure 21 SCVWD Water Reclamation & Injection/Extraction Well Facility at Palo Alto, California

Chemical Clarification

Chemical treatment is effective in removing suspended solids, colloidal solids, and some dissolved constituents, such as heavy metals and phosphates. During the initial periods of operation, removal of ammonia by air stripping was implemented for the reclamation system. Therefore, since this process requires a high pH, lime was selected as the chemical of choice. A secondary benefit was achieved, since the high pH resulting from additional lime is also considered to be quite effective in pathogen destruction.

The process consists of separate rapid mix, flocculation, and sedimentation basins. Lime is added in a slurry form to the rapid mix basin. The feed rate is automatically controlled to achieve the optimum pH of approximately 11. The dose to achieve this pH was 100 to 200 mg/l as calcium oxide. The water flows from the bottom of the flash mix basin to a center column in the flocculator clarifier. The influent enters the center column of the tank at its bottom, rises up the center column, and comes out through the side openings at the column near the top. The flocculation basin contains two flocculating mixers within a circular mixing compartment. These provide complete mixing so as to develop a substantial rapid settling floc. After mixing and blending, the influent exits from the bottom of the flocculating compartment and flows radially outward in the clarification compartment. Heavier solids resulting from the process settle to the bottom of the tank. The tank's effluent passes over a weir into a shallow trough around the periphery of the tank.

TABLE 4

SCVWD-WRF/PA UNIT PROCESS CHARACTERISTICS

AT 0.09 m^3/s (2 MGD)

Flash Mix

Lime Feed Capacity:	2700 kg/day (3 tons/day)
Process Volume:	15.9 m^3 (560 cu. ft.)
Mixer Horsepower:	5 hp
Detention Time:	3 minutes

Flocculator/Clarifier

Type: Circular	Center Feed, Peripheral Weir,
Diameter:	16.8 meters (55 feet)
Depth:	3.4 meters (11 feet)
Flocculator Detention Time:	0.5 hr.
Clarifier Detention Time:	1.9 hr.

TABLE 4

SCVWD-WRF/PA UNIT PROCESS CHARACTERISTICS

(Continued)

Aeration (Ammonia Stripping) - Aeration pumps were not operated during this test period.

Tank Dimensions:	16.8 m L x 9.1 m W x 4.3 m D (55 ft. L x 30 ft. W x 14 ft. D)
No. of Aerators:	2
Combined Horsepower:	100 hp
Circulation Fan Horsepower:	30 hp
Detention Time:	2.1 hr.

Recarbonation

Tank Dimensions:	6.4 m L x 2.1 m L x 2.1 m W x 4.2 m D (21 ft. L x 7 ft. W x 13.75 ft. D)
Mixer Horsepower:	10 hp
Stack Gas Feed Capacity:	550 SCFM
Detention Time:	11 minutes

Ozonation

Tank Dimensions:	6.4 m L x 2.1 m W x 4.1 m H (21 ft. L x 7 ft. W x 13.5 ft. H)
Ozonator Capacity:	42.6 kg/day (94 lb/day)
Detention Time:	10.5 minutes

Filters*

Number of Filters:	4
Type:	Mixed Media
Surface Area (each):	20.5 m^2 (221 sq. ft.)
Media Depth:	0.9 m (3 ft.)
Hydraulic Loading:	7.1 $m^3/sec/m^2$ (3.1 gpm/sq. ft.)

Granular Activated Carbon

Number of Columns:	4
Type:	Upflow
Diameter:	3.0 m (10 ft.)
Bed Depth:	6.1 m (20 ft.)
Total Carbon Volume:	177.8 m^3 (6280 cu. ft.)
Carbon Type:	Calgon Filtrasorb 300 (8 X 30 mesh)
Hydraulic Loading:	10.1 $m^3/sec/m^2$ (4.4 gpm/sq. ft.)
Empty Bed Contact Time:	34 minutes

*Filters may be assigned to pre-GAC and post-GAC filtration in any combination. Hydraulic loading value given is for two filters on each service.

TABLE 5

PLANT INSTRUMENTATION

INSTRUMENT TYPE	NUMBER	INSTRUMENT TYPE	NUMBER
Flow	10	Dissolved Oxygen ppm	1
Level	19	Sludge Density %	1
Pressure psi	5	Tachometer RPM	1
Temperature C^o	4	Analog Output Test % Max	1
Turbidity FTU & NTU	6	Valve Monitor % Open	18
pH	3	Valve Monitor % Closed	2
Conductivity MHO	1	Pump Monitor % Max	5
Residual Chlorine ppm	1		

The results of lime clarification at Palo Alto have shown this process to be effective in reducing turbidity, organics, suspended solids and heavy metals.

Recarbonation

Following settling, the effluent flows through an open tank, formerly used for air stripping, into the recarbonation basin for adjustment of the pH. Stack gas from the existing sludge incineration furnaces of the Palo Alto Regional Water Quality Control Plant is transferred to the recarbonation basin. The stack gas, providing the carbon dioxide source, and the liquid are thoroughly mixed by a flash mixer before leaving the chamber. A sediment trap is provided for removal of contaminants from the stack gas before it enters into the blower. The pH in the recarbonation chamber is automatically controlled by the in-plant computer and determines the amount of stack gas needed and automatically adjusts the opening at the motorized gas inlet valve to provide the proper recarbonation pH. During the test period, this pH was selected to be 7.0.

Mixed-Media Filtration

The recarbonated effluent is then pumped to two open gravity multimedia filter basins designed for a hydraulic loading rate of 7.1 $m^3/sec/m^2$ (3.1 gpm/ft^2). The purpose of the mixed-media filtration is additional removal of suspended solids and floc carried over from preceding steps. Filtration is performed prior to granular activated carbon sorption since the possibility of fouling by suspended solids and colloidal matter exists. The filter media are 910 cm (36 inches) deep and consist of coarse coal, sand, and garnet supported by a layer of sand and garnet gravel.

Ozonation

Following mixed-media filtration, the flow is directed to an ozonation chamber. Ozonation was provided to evaluate its effectiveness for enhanced disinfection and trace organics removal. The ozonation system consists of an ozonator, diffusers, and baffles. Ozone is an unstable form of oxygen, which is produced in nature when oxygen in the atmosphere is exposed to an electrical discharge, such as lightning. It is also produced artificially, as in an ozonator, by passing clean, dry air through electrodes when high-voltage electrical discharges occur. The ozonator is capable of generating 42.6 kilograms (94 pounds) of ozone at 1% minimum concentration in 24 hours.

Granular Activated Carbon Sorption

From the ozone chamber, the water is pumped to the carbon towers and flows upward through the diffusers at the underdrain plate of the carbon column. Effluent discharges through the collection lauders located near the top of the towers. Each tower is 3.0 meters (10 feet) in diameter, 9.1 meters (30 feet) in overall height, and contains a 6.1 meter (20 foot)-high column of granular activated carbon. All four carbon towers are identical. The contactors operate in parallel, each having an empty bed contact time of 34 minutes. The hydraulic loading rate for each column is 10.1 $m^3/sec/m^2$ (4.4 gpm/sq ft). Following GAC sorption, the flow is diverted through the other two mixed-media filters. The purpose here is to remove any carbon fines that may have washed over the tower weirs. Finally, chlorine is added to provide a residual of about 1 mg/l and then the flow is directed to a storage tank for future use.

PLANT/PROCESS PERFORMANCE EVALUATION

WMS data on the operating characteristics of the plant were collected beginning in 1978 through February 1981. During that 3-year timeframe the plant has operated in various configurations which are summarized in Table 6. The table shows that changes have occurred to plant influent processing as well as to in-plant configurations.

Figure 21 illustrates the process stream from raw wastewater to well injection. Table 7 describes the reclamation plant design criteria and a physical description of equipment. Table 8 presents the reclamation plant effluent discharge limits.

Nominal Input/Output Characteristics

It was found that five parameters best represented the effectiveness of process contaminant removal under various operating conditions and plant configurations. These parameters are TOC, total halocarbons, turbidity, and total and viable biomass. Figure 22 summarizes percent removal performance based on daily averages of plant input/output measurements. Figure 23 illustrates the same data in terms of concentrations. It may be generally concluded from these data that (1) flocculation significantly improves effluent quality and (2) with the exception of biomass, effluent quality depends on a variable influent quality, thus constant effluent quality may not be expected.

The above data represent a summation of unit process performance illustrated in Figures 24 through 28. These figures represent the actual measurements (Appendix A) reduced to a mathematical expression relating process output to input over the observed range of inputs. For example, TOC removal in the reclamation plant for an influent value of 15 mg/lit can be computed from the data presented in Figure 24, as follows:

Table 6 Process Configurations for Test Periods

Test Period Symbol	Test Period	Primary Settling	Fixed Film Reactor	Aeration (Activated Sludge)	Aeration (Nitrification)	Clarification	Dual Media Filtration	Chlorination	Chemical Clarification pH	Aeration	Recarbonation	Mixed Media Filtration	Ozone Dosage, mg/L	GAC Unit	Mixed Media Filtration	Chlorine Dosage, mg/L	Reclamation Plant Flow, MGD
		Reclamation Plant Influent Processing							Reclamation Plant Processes								
A	09/03/80 - 02/28/81	x	x		x	x	x	x	11	-	x	x	4	1,2,4	x	2	1.5
B	05/07/80 - 08/28/80	x	x		x	x	-	x	11	-	x	x	4	1,2,4	x	2	1.5
C	02/12/80 - 05/06/80	x	-	x		x	-	x	11	-	x	x	4	1,2,4	x	2	1.5
D	11/11/79 - 02/11/80	x	-	x		x	-	x	11	x	x	x	-	4	x	3	1.5
E	10/09/79 - 11/10/79	x		x		x	1/2 FLOW → 1/2 FLOW →		11	x	x	x	-	4	x	2	2.0
F	08/11/79 - 10/08/79	x	-	x		x	-	-	11	x	x	x	-	3,4	x	3	1.0
G	05/21/79 - 07/28/79	x	-	x		x	-	x	11	x	x	-	-	3,4	x	4	1.0
H	03/31/79 - 05/02/79	x	-	x		x	-	x	9.5	-	x	x	5	3,4	x	4	1.0
I	11/28/78 - 03/19/79	x	-	x		x	-	x	-	-	-	x	11	2	x	5	0.5
J	11/13/78 - 11/27/78	x	-	x		x	-	x	-	-	-	x	11	1	x	5	0.4
K	6/11/78 - 9/30/78	x	-	x		x	-	x	11	x	x	x	11	1	x	5	0.2-0.8
L	4/1 /78 - 6/10/78	x	-	x		x	-	x	-	-	-	x	11	1	x	5	0.5
M	1/1/78 - 3/30/78	x	-	x		x	-	x	11	x	x	x	11	1	x	5	0.5

Table 7 Water Reclamation Plant Design Criteria

INCOMING FLOW CHARACTERISTICS

Flow (full treatment), mgd	2
Biochemical Oxygen Demand (5-day), mg/l	20
Chemical Oxygen Demand, mg/l	30
Suspended Solids, mg/l	20
Ammonia, mg/l	25
MBAS, mg/l	2
Turbidity, jtu	30
Coliform, MPN/100 ml	Less than 1000

DESIGN OBJECTIVES

	Average	Maximum
Biochemical Oxygen Demand, mg/l	1	2
Chemical Oxygen Demand, mg/l	10	15
Suspended Solids, mg/l	1	5
Ammonia, mg/l	2	5
MBAS, mg/l	0.1	0.2
Turbidity, jtu	0.3	5
Coliform, MPN (Median)/ 100 ml less than	2.2	23

LIME CLARIFICATION SYSTEM

Lime Storage Capacity, Tons	40
Capacity Lime Feed System, Tons/day	3
Detention Time Rapid Mixing, min.	3
Flocculator/Clarifier Diameter, ft.	55
Flocculator/Clarifier Depth, ft.	11
Flocculator Detention Time, hrs.	0.5
Settling Detention Time, hrs.	1.9

AMMONIA STRIPPING

Tank Length, ft.	55
Tank Width, ft.	30
Tank Depth, ft.	14
Detention Time, hrs.	2.1
Number Aerators	2
Combined Aerator Horsepower	100
Horsepower/1000 cf	4.3

RECARBONATION

Tank Length, ft.	21
Tank Width, ft.	7
Tank Depth, ft.	13.75
Detention Time, min.	11

OZONATION SYSTEM

Tank Length, ft.	21
Tank Width, ft.	7
Tank Depth, ft.	13.5
Detention Time, min.	10.5
Capacity Ozonator, lbs/day	90

FILTERS (@ 2 mgd/2 filters split flow)

Number of Filters	4
Surface Area Each, $ft.^2$	221
Filter Media Depth (nominal), ft.	3
Hydraulic Loading, $gpm/ft.^2$	3.1

CARBON ADSORBTION SYSTEM

Number Adsorbers	4
Length Column, ft.	20
Diameter Column, ft.	10
Total Carbon Volume, 100 $ft.^3$	62.8
Hydraulic Loading, $gpm/ft.^2$	4.4
Detention Time, min.	34
Assumed Carbon Loading, lbs. COD/lb. Carbon	0.3
Number Carbon Storage Tanks	2
Total Carbon Storage Capacity, 100 $ft.^3$	39
Carbon Regeneration Furnace Area, $ft.^2$	25
Carbon Regeneration Furnace Loading, $lbs/ft.^2/hr.$	4.2

BACKWASH WASTE STORAGE

Tank Length, ft.	30
Tank Width, ft.	30
Tank Depth, ft.	13
Capacity, 1000 gals.	88

FINAL STORAGE

Tank Diameter, ft.	70
Tank Operating Depth, ft.	20
"A" Water Storage Capacity, 1000 gals.	154
"B" Water Storage Capacity, 1000 gals.	415

Table 8 Reclamation Plant Discharge Water Quality Permit Requirements

	GROUND WATER INJECTION			IRRIGATION		
	30 DAY AVG.	MAX.	MIN.	7 DAY AVG.	MAX.	MIN.
BOD_5, MG/LIT	1.0	2.0	-	-	40.0	-
COD, MG/LIT	10.0	15.0	-	-	-	-
pH	-	8.5	7.0	-	-	-
TURBIDITY, JTU	-	5.0	-	-	-	-
TOTAL NITROGEN, MG/LIT	5.0	10.0	-	-	-	-
MBAS, MG/LIT	0.1	0.2	-	-	0.1	-
DISSOLVED SULFIDE, MG/LIT	-	0.1	-	-	-	1.0
DISSOLVED OXYGEN, MG/LIT	2.0	-	1.0	-	-	-
MPN, #/100 ML	2.2 (7 Day)	-	-	23	-	-

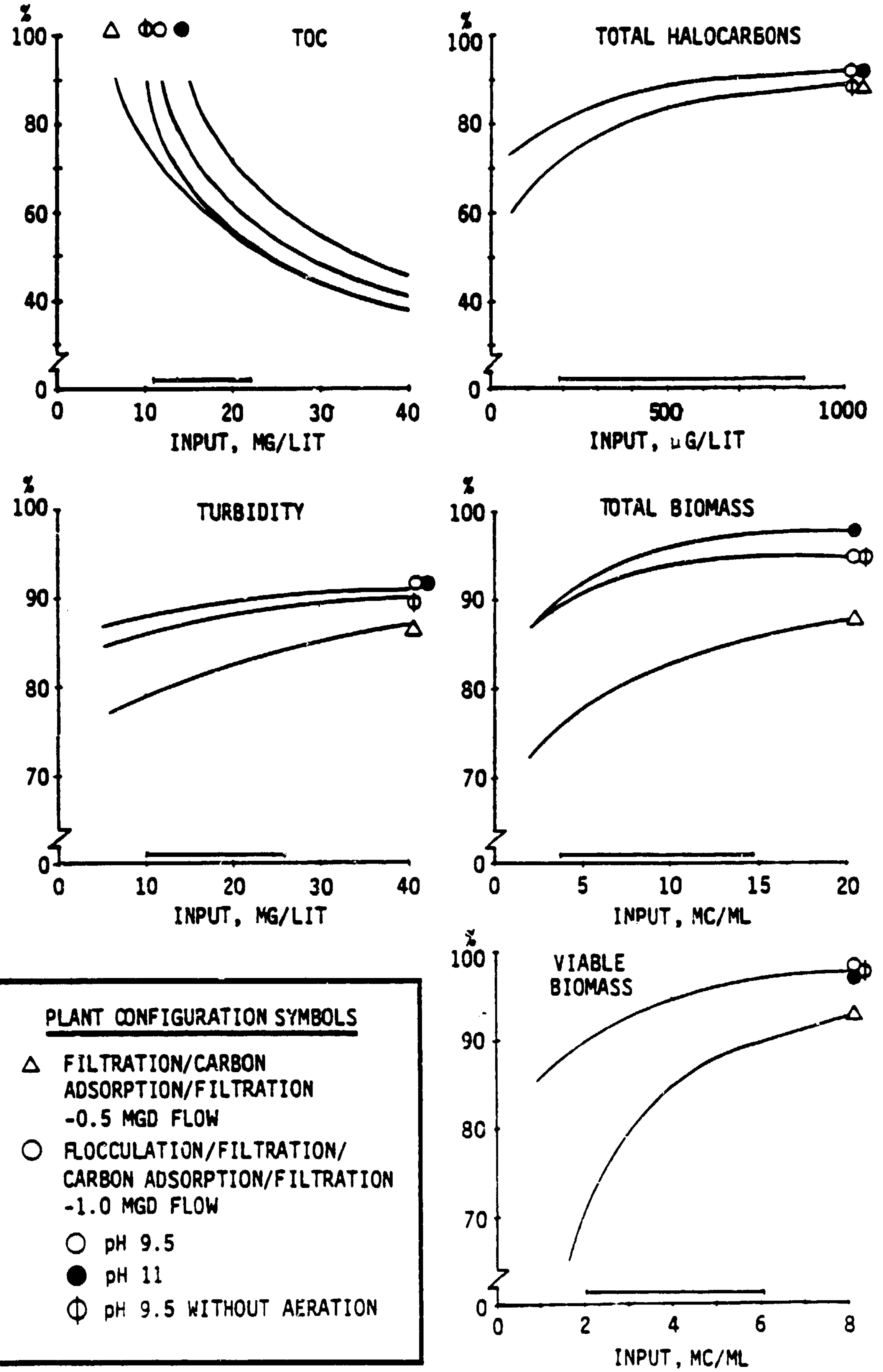


Figure 22 Reclamation Plant Nominal Steady-State % Removal Characteristics (1 σ Input Range Indicated)

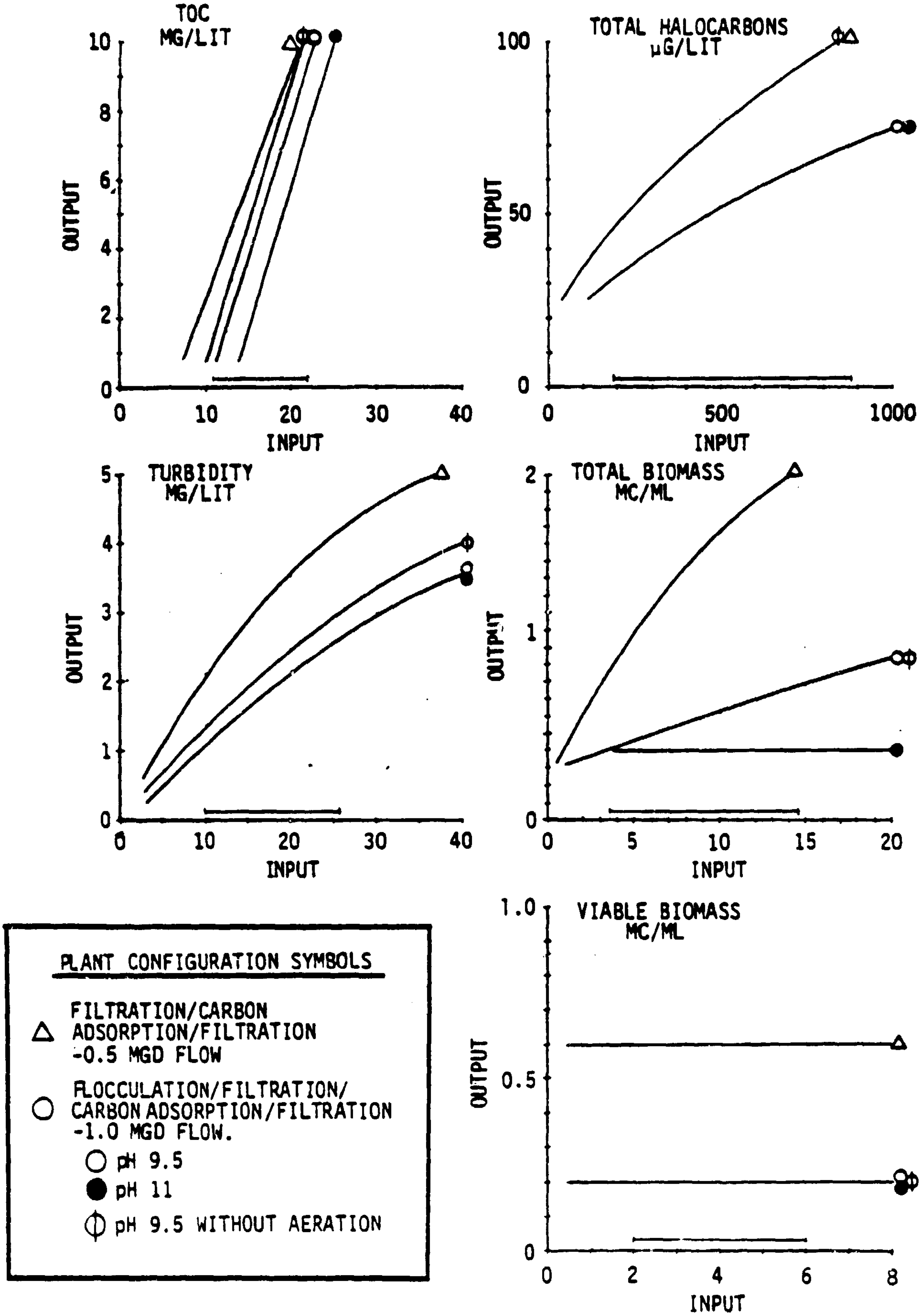


Figure 23 Reclamation Plant Nominal Steady-State Input/Output Characteristics (1 σ Input Range Indicated)

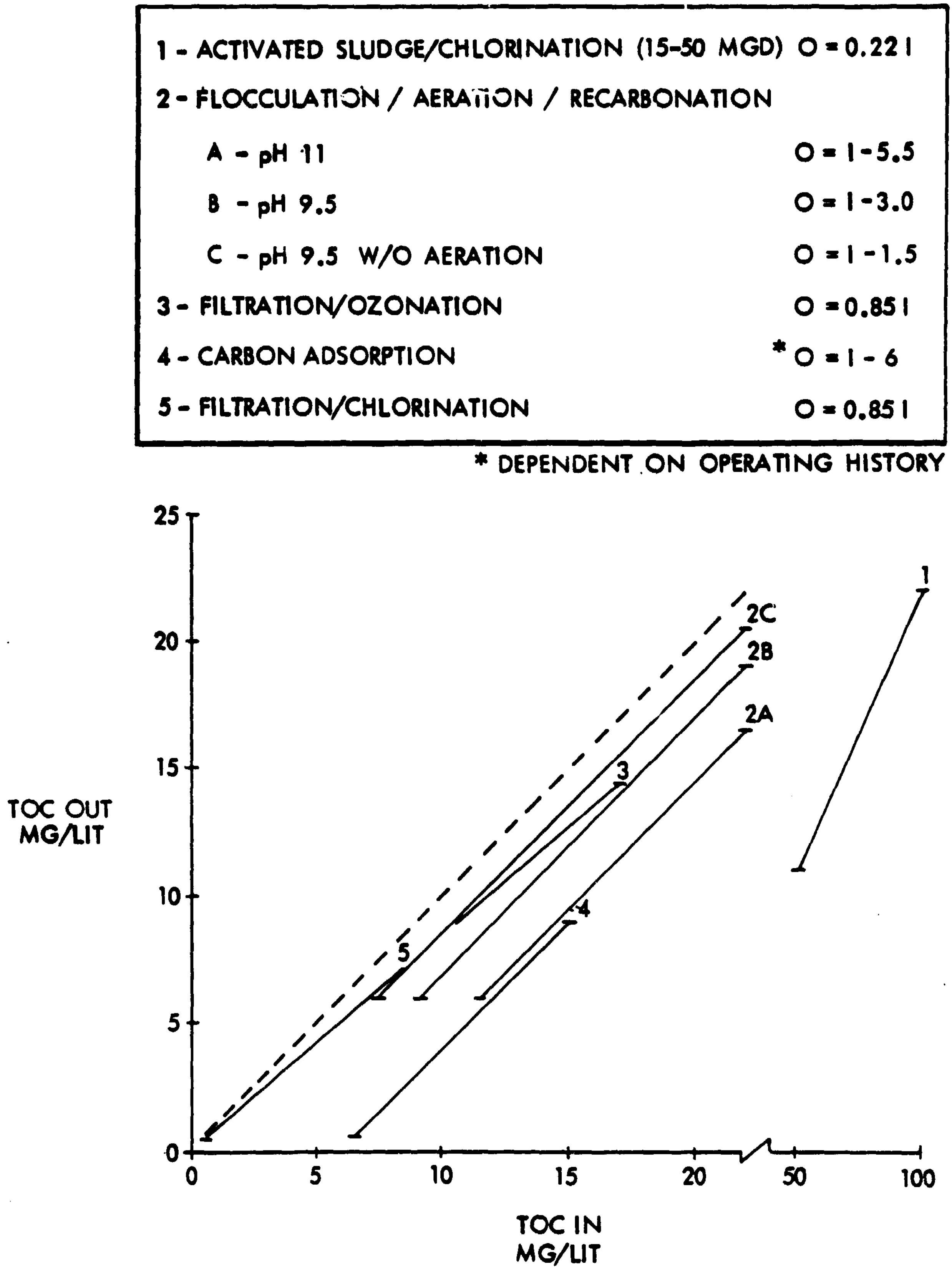


Figure 24 Unit Process Steady-State Input (I) /Output (O) Characteristics at 1 mgd

1 - ACTIVATED SLUDGE/CHLORINATION (15-50MGD)	O = 0.35I
2 - FLOCCULATION/AERATION/RECARBONATION	
A - pH 11	O = 0.25I
B - pH 9.5	O = 0.25I
C - pH 9.5 W/O AERATION	O = 0.53I
3 - FILTRATION/OZONATION	O = 0.75I
4 - CARBON ADSORPTION	* $O = 5.6 I^{0.5}$
5 - FILTRATION/CHLORINATION	O = I

* DEPENDENT ON OPERATING HISTORY

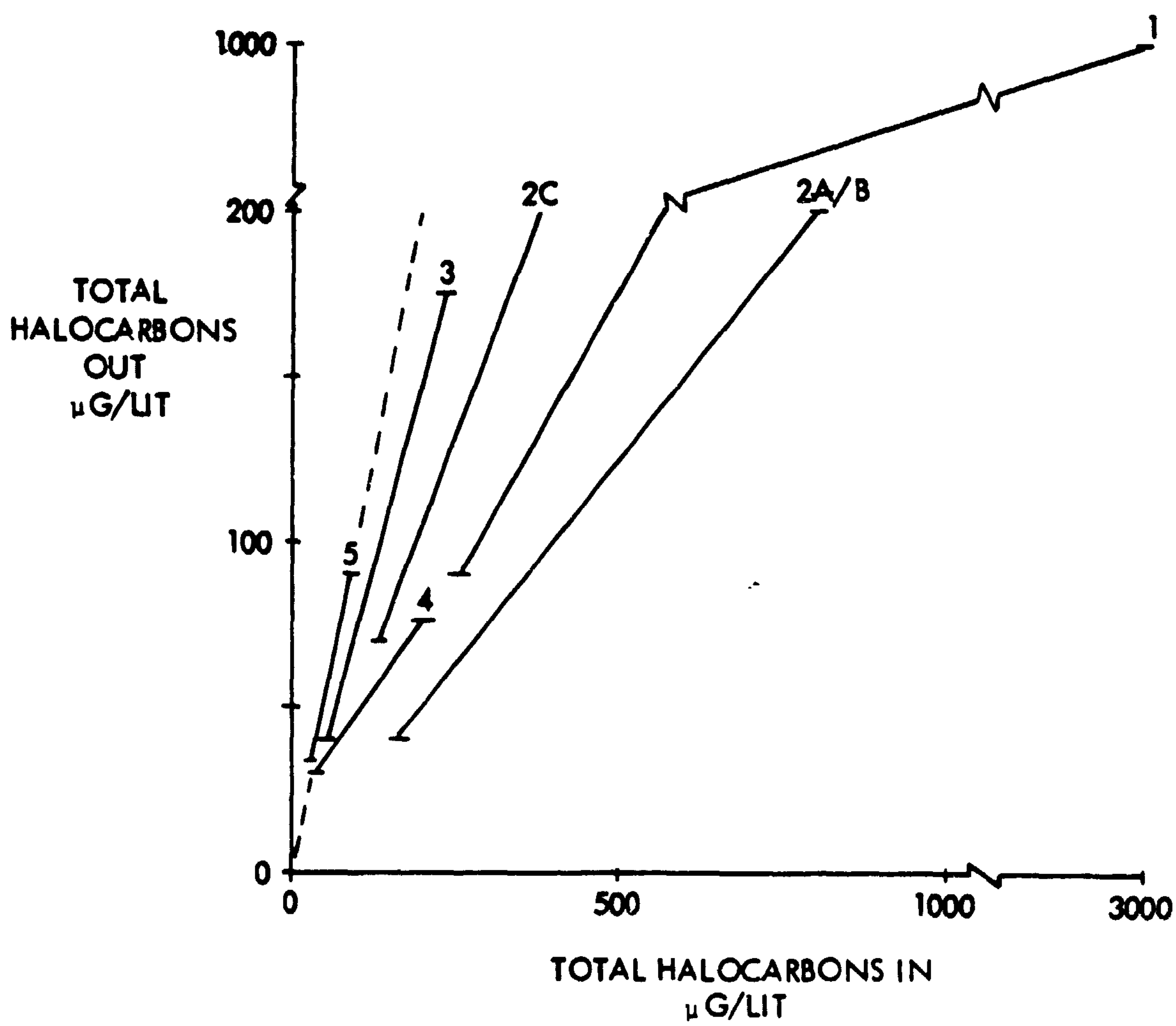


Figure 25 Unit Process Steady-State Input(I)/Output (O) Characteristics at 1 mgd

1 - ACTIVATED SLUDGE/CHLORINATION (15-50 MGD) $O = 0.3I$

2 - FLOCCULATION/AERATION/RECARBONATION

A - pH 11 $O = 0.5I$

B - pH 9.5 $O = 0.5I$

C - pH 9.5 W/O AERATION $O = 0.6I$

3 - FILTRATION/OZONATION/CARBON ADSORPTION $O = 0.25I$

4 - CARBON ADSORPTION W/O FILT/O_3 $O = 0.45I$

5 - FILTRATION/CHLORINATION $O = Ie^{-I/15}$

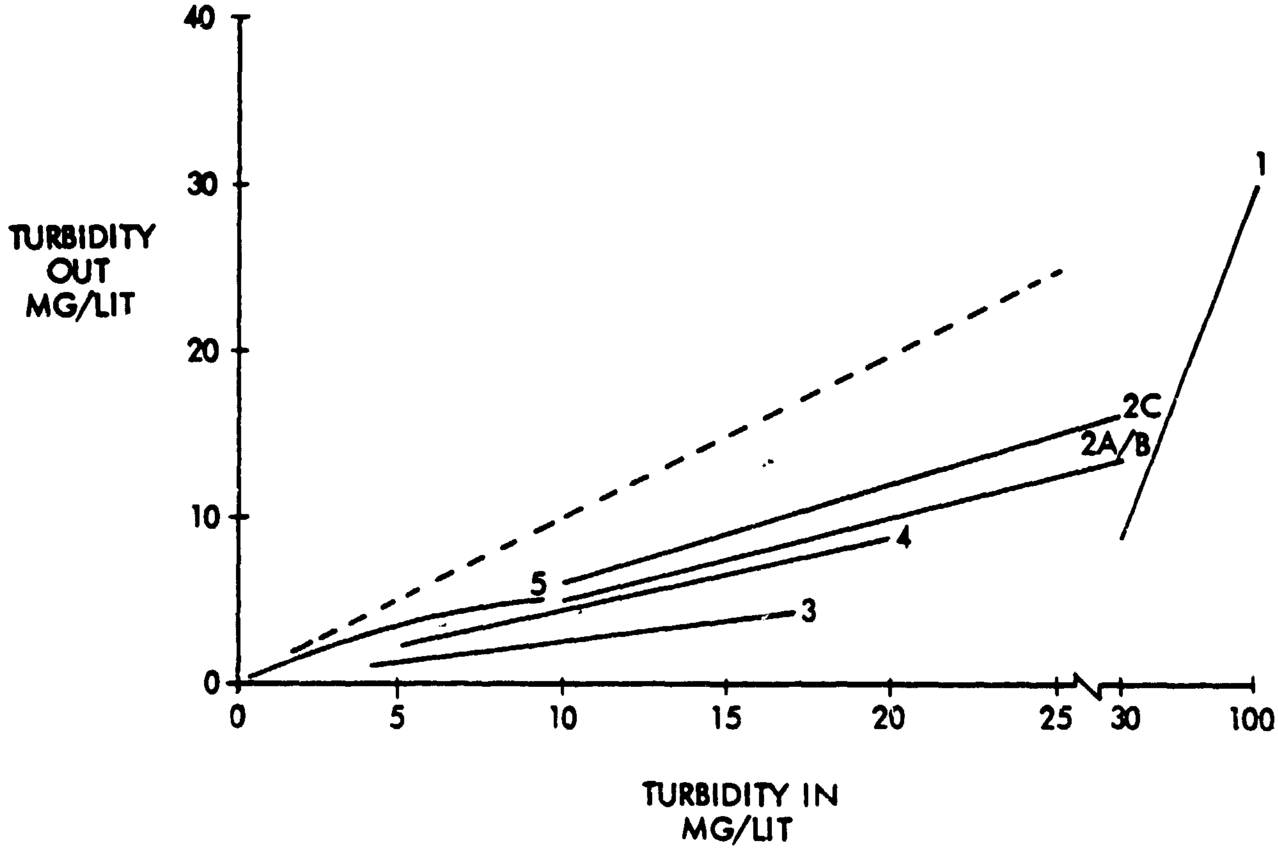


Figure 26 Unit Process Steady-State Input(I)/Output (O) Characteristics at 1 mgd

2 - FLOCCULATION/AERATION/RECARBONATION	
A - pH 11	O = 1.0
B - pH 9.5	O = 0.21
C - pH 9.5 W/O AERATION	O = 0.21
3 - FILTRATION/OZONATION	O = 0.21
4 - CARBON ADSORPTION	O = I +0.3
5 - FILTRATION/CHLORINATION	$O = Ie^{-I/7}$

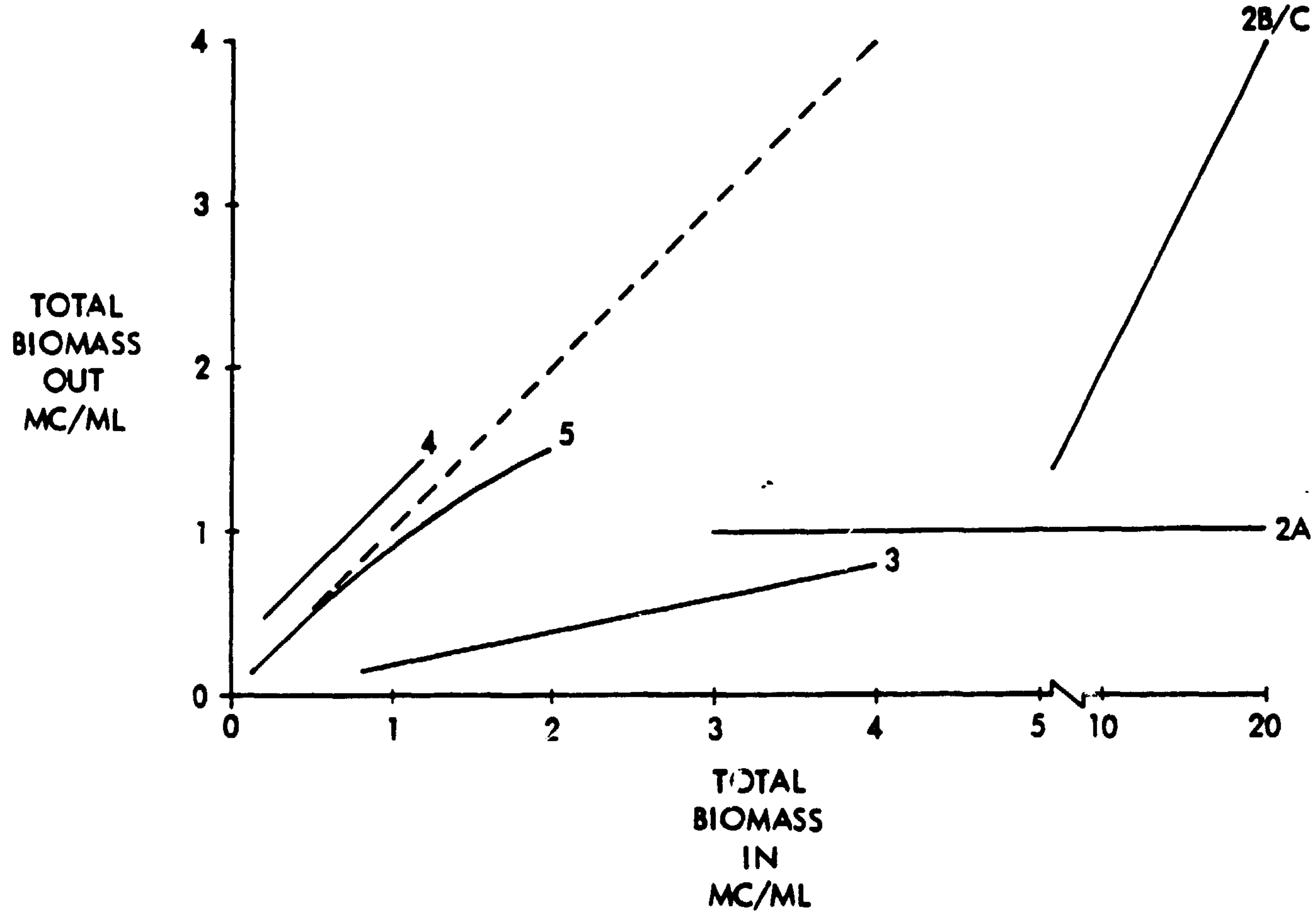


Figure 27 Unit Process Steady-State Input(I)/Output (O) Characteristics at 1 mgd

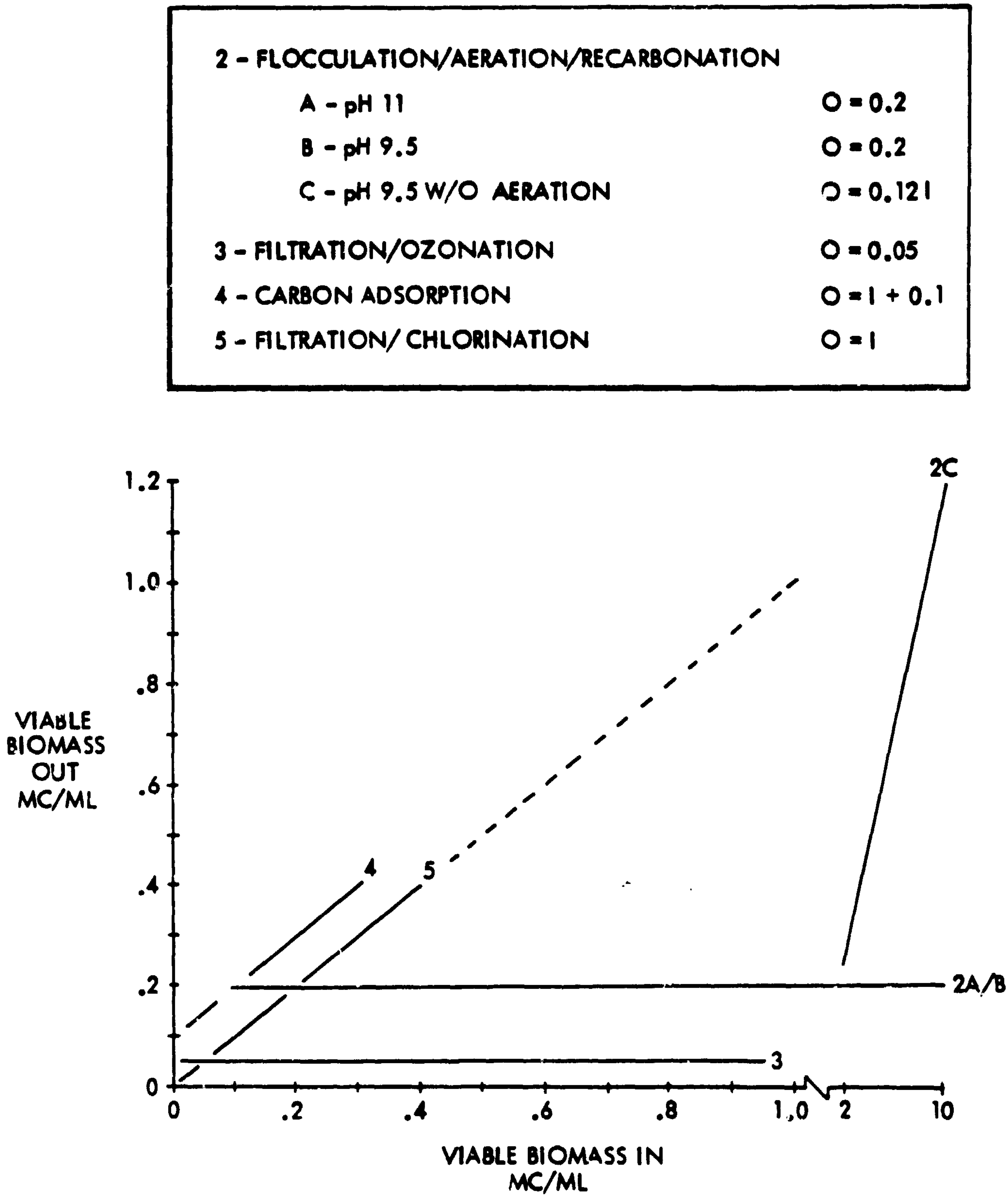


Figure 28 Unit Process Steady -State Input(I)/Output (O) Characteristics at 1 mgd

For process stream; Floc (pH 11)/aeration/filt/O_3/GAC/filt/Cl_2

$$\text{TOC OUT} = \{[(\text{TOC In} - 5.5)\ 0.85] - 6\}\ 0.85$$
$$= \{[(15 - 5.5)\ 0.85] - 6\}\ 0.85$$
$$= 1.8 \text{ mg/lit}$$

$$\%\ \text{REMOVAL} = (\text{TOC IN} - \text{TOC OUT})\ 100/\text{TOC IN}$$
$$= (15 - 1.8)\ 100/15$$
$$= 88\%$$

For process stream; Filt/O_3/GAC/Filt/Cl_2

$$\text{TOC OUT} = [0.85\ (\text{TOC IN}) - 6]\ 0.85$$
$$= [0.85\ (15) - 6]\ 0.85$$
$$= 5.7 \text{ mg/lit}$$

$$\%\ \text{REMOVAL} = (\text{TOC IN} - \text{TOC OUT})\ 100/\text{TOC IN}$$
$$= (15 - 5.7)\ 100/15$$
$$= 62\%$$

The unit process performance data presented in Figures 24 through 28 were determined during testing from April through July 1979. In mid-August 1979, the flocculation process pH sensor in the system for controlling lime dosage was found to be caked with sludge and had a calibration error which resulted in low values. In order to estimate the impact this may have had on previous data, a dosage test was performed and compared with plant operating records of lime consumption. Analysis of these data, Table 9, indicates that the pH was low throughout the test period and that the pH 9.5 and pH 11 performance data presented in this report probably are representative of performance within a pH range of 9-9.5 and 10-11, respectively. The sludge covering the pH probe may also have reduced sensor response time thereby contributing to the data scatter observed in Appendix A.

In addition to the removal characteristics provided by the five key parameters, ammonia, nitrate/nitrite, dissolved oxygen and biomass provided information concerning biological activity in the process stream, while dissolved oxygen, pH and total residual chlorine reflected operational status of the plant. The charts in Appendix B summarize representative WMS data and comparable lab data taken during this test program.

The reclamation processes which produced the most significant changes in the measured parameters may be described as follows:

TOC	Equal removal by flocculation and GAC; controllable by pH and activated carbon operating history/environment.

Table 9 Estimated Flocculation pH Based on Lime Consumption and Influent Alkalinity

		pH Set Point	A Alkalinity, MG/LIT($CaCO_3$) Avg. ± 1σ	D Average Lime Dosage, MG/LIT	Calculated* Average pH
APRIL		9.5	237 ± 17	114	9.4
MAY		11	179 ± 30	211	10.6
JUNE		11	192 ± 21	204	10.4
JULY		11	176 ± 23	213	10.7
AUGUST	1-15	11	190 ± 16	297	11.2
	16-31	11	157 ± 12	216	11.0 (REFERENCE)

* $pH = 8.55 + 455\ V$

Where,

V = Volumetric ratio of lime slurry to plant influent - equation fits the results of dosage test for pH range 9 to 11.2 and alkalinity of 200 mg/lit with a correlation coefficient of 0.998.

and,

$pH = 8.55 + 1.78 \left(\frac{D}{A}\right)$ Assuming dosage/alkalinity ratio is constant for a given pH (Reference 18)

Total Halocarbons	Removal by aeration (or purging including the effects of aeration and recarbonation with CO_2).
Turbidity	Removal by flocculation.
Biomass	Removal by flocculation; growth in GAC.
Dissolved Oxygen	Quantity added by aeration is removed by biological growth in GAC and filters; frequent filter backwash is necessary to maintain a residual in the effluent.
Conductivity Chloride, Solium Hardness	No change.
Ammonia	Equal removal by aeration (below design requirement) and GAC (by biological conversion).
Nitrate/Nitrite	Increases due to biological growth in GAC.
Total Residual Chlorine	Removal in GAC
pH	Neutralization by recarbonation.

As shown above, flocculation is a key process in attaining high effluent quality; however, to date, tests to determine optimum operating parameters for this process have not been performed. Testing has been planned and preparations are in progress. The data presented herein represent a fixed set of operating parameters, e.g., a sludge recirculation rate of 600 GPM and a wasting rate of 50 GPM, over an uncertain pH range (as discussed above).

Influent Variations

A consistent source of variation in plant effluent quality results from the diurnal flow of raw wastewater into the primary and secondary processes. Organic and suspended solids removal in the activated sludge process is directly related to detention time (input flow) which normally varies by a factor of two each day. Secondary effluent quality has comparable variations. The pattern of the diurnal flow cycle results in highest effluent quality at midday and lowest quality at midnight. The consistency of this pattern is apparent in Figure 29, which shows the time of day of peak values and Figure 30 which shows the daily profile.

To confirm the relationship between flow and effluent quality, a math model (Appendix C) was developed to determine suspended solids (biomass) and organics (non-volatile TOC) in the secondary effluent as a function of influent concentration, plant operating parameters and hourly flow variations. The results illustrated in Figures 31 and 32, show that measured biomass values can be duplicated by a model representing variable performance in the secondary process clarifiers. The results show that effluent quality is high at a time where, based

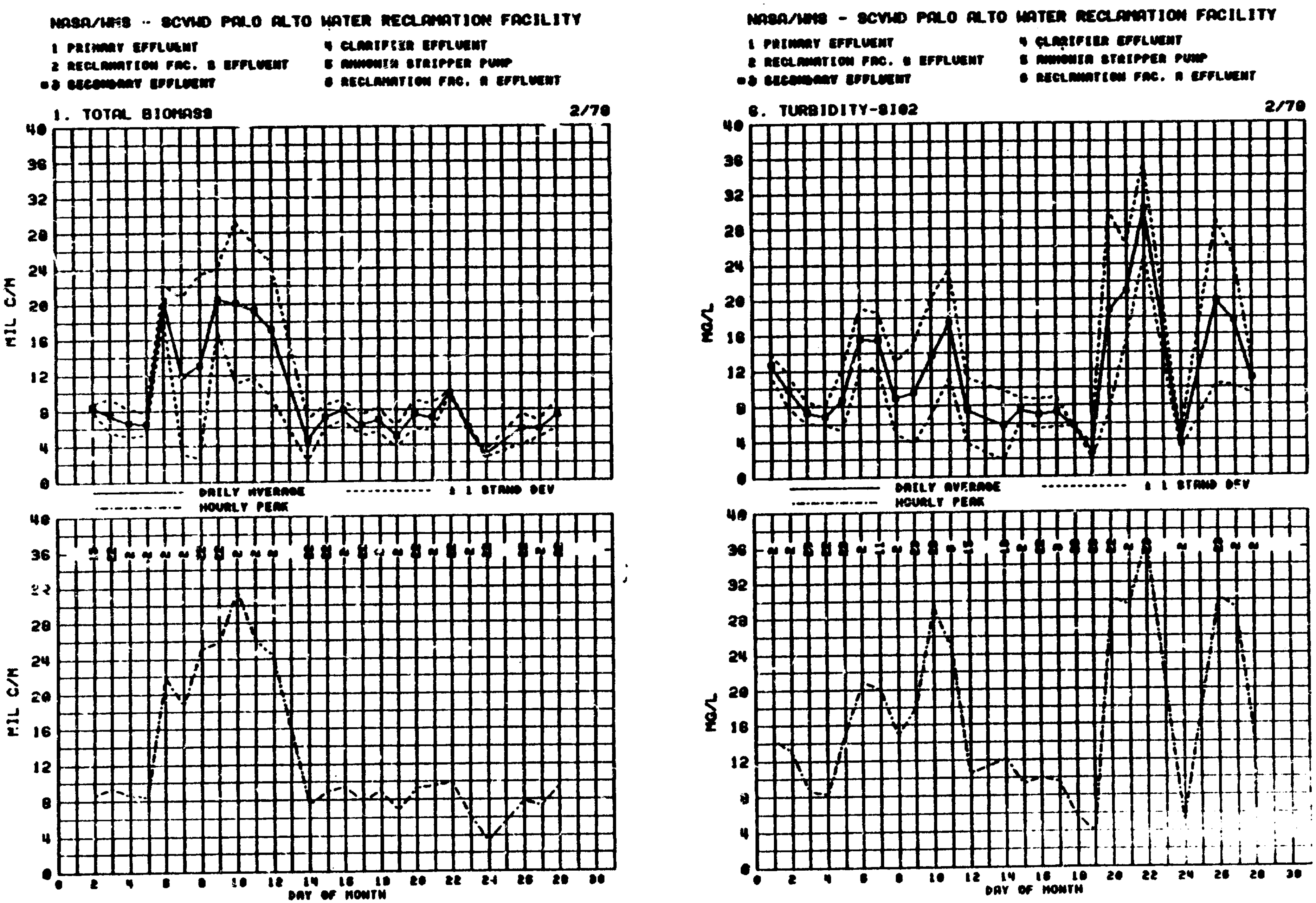


Figure 29 Monthly Plot Indicating Hour of Peak Concentrations

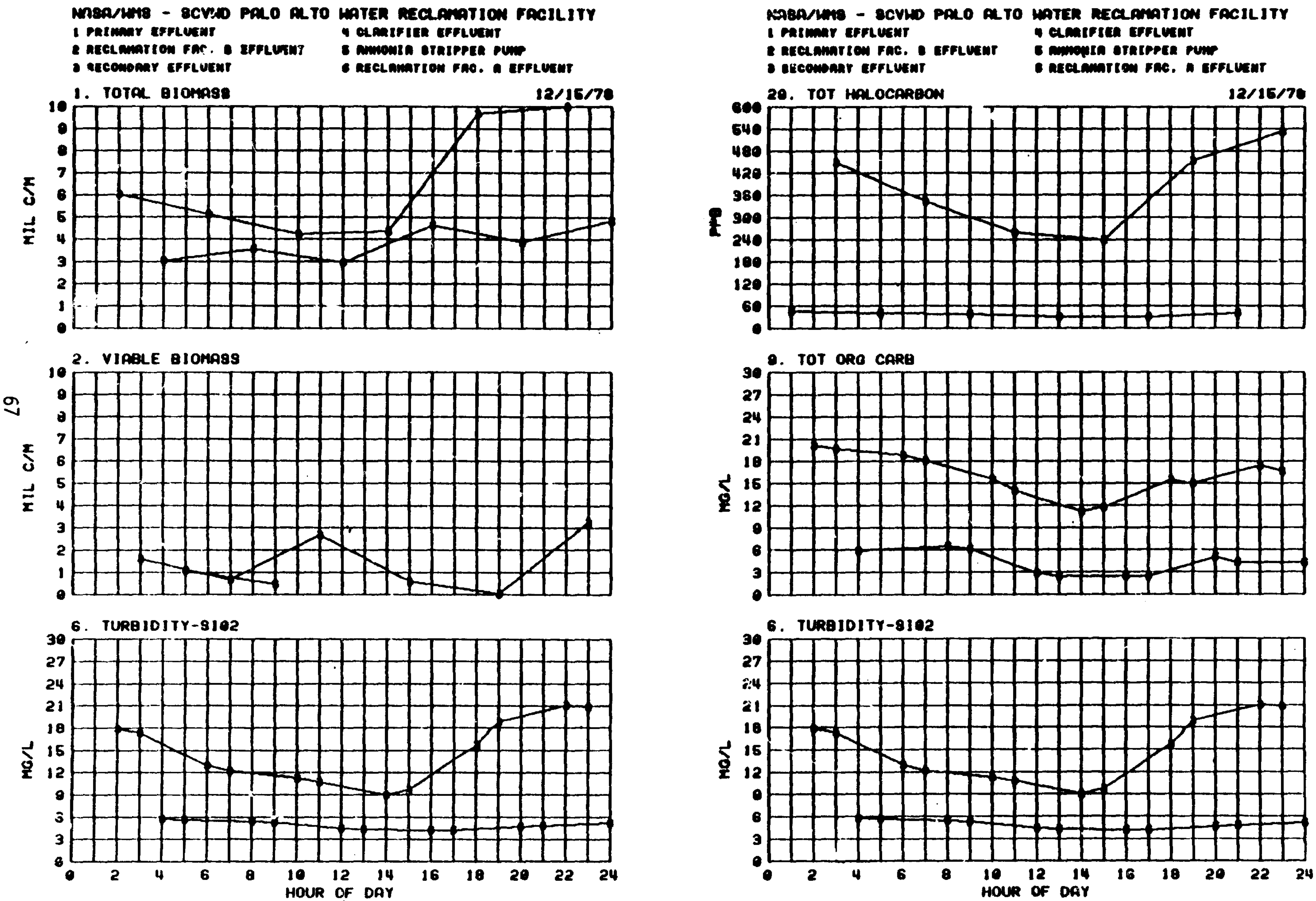


Figure 30 Hourly Plot Indicating Diurnal Cycle (1 of 3)

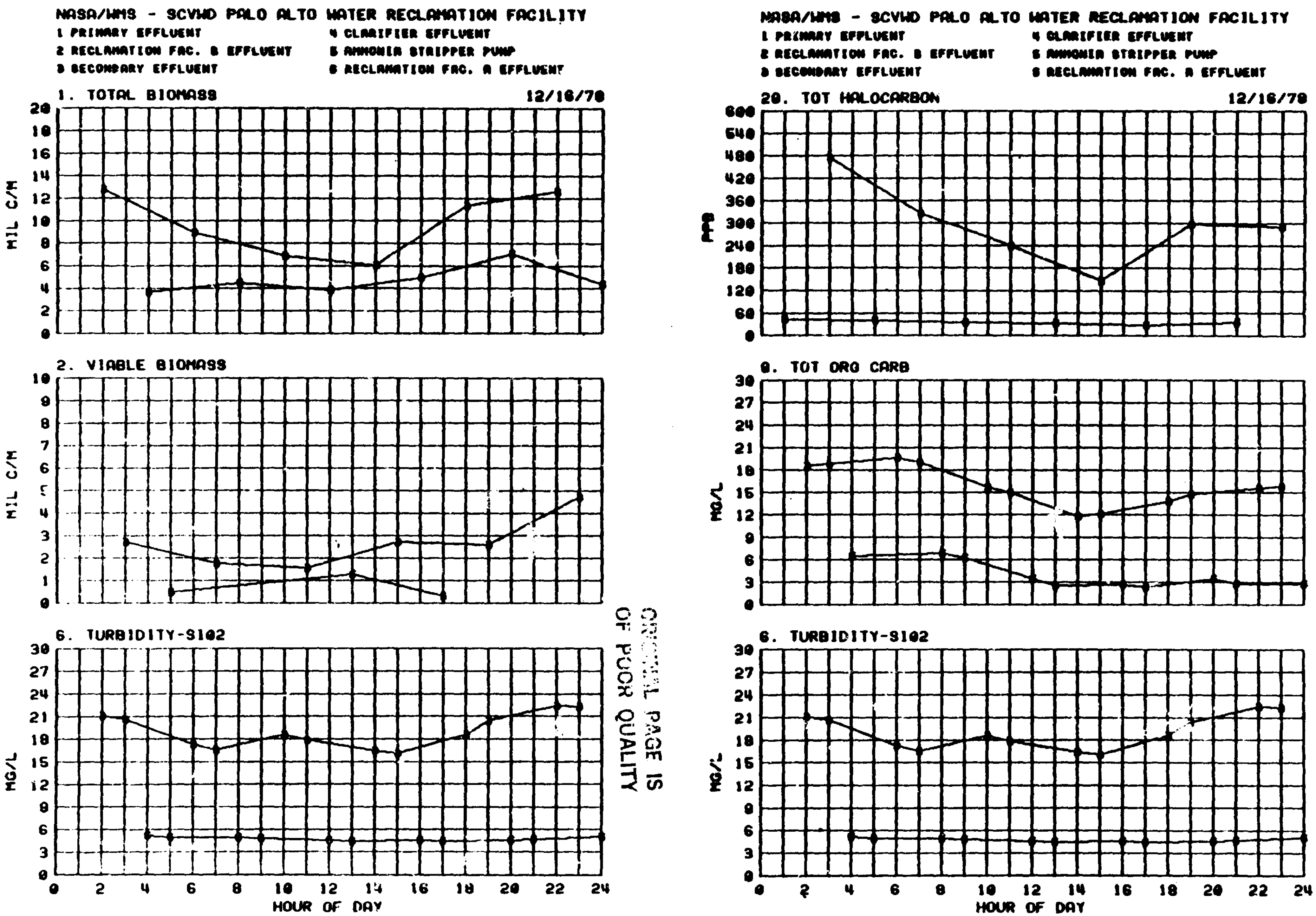


Figure 30 Hourly Plot Indicating Diurnal Cycle (2 of 3)

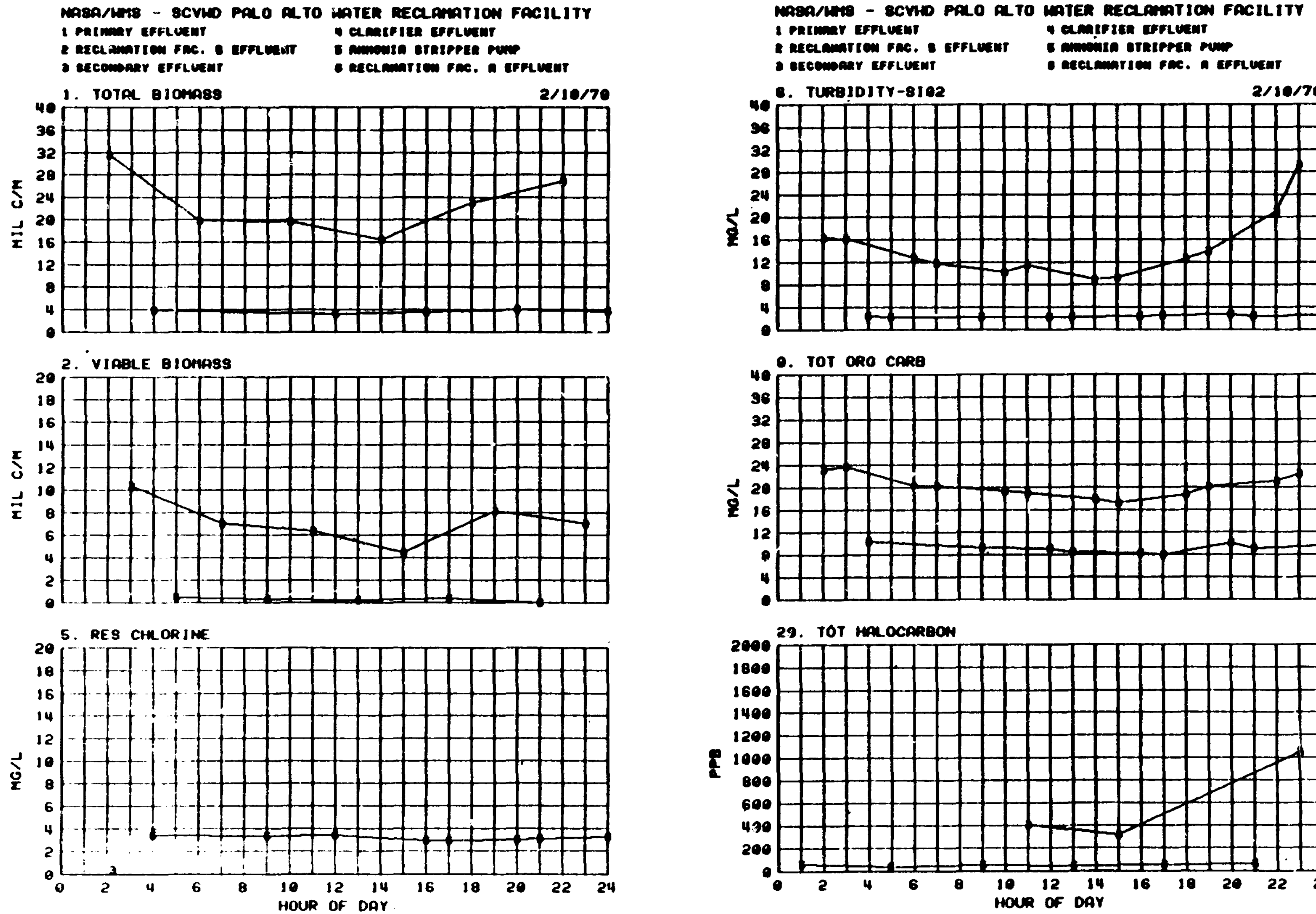


Figure 30 Hourly Plot Indicating Diurnal Cycle (3 of 3)

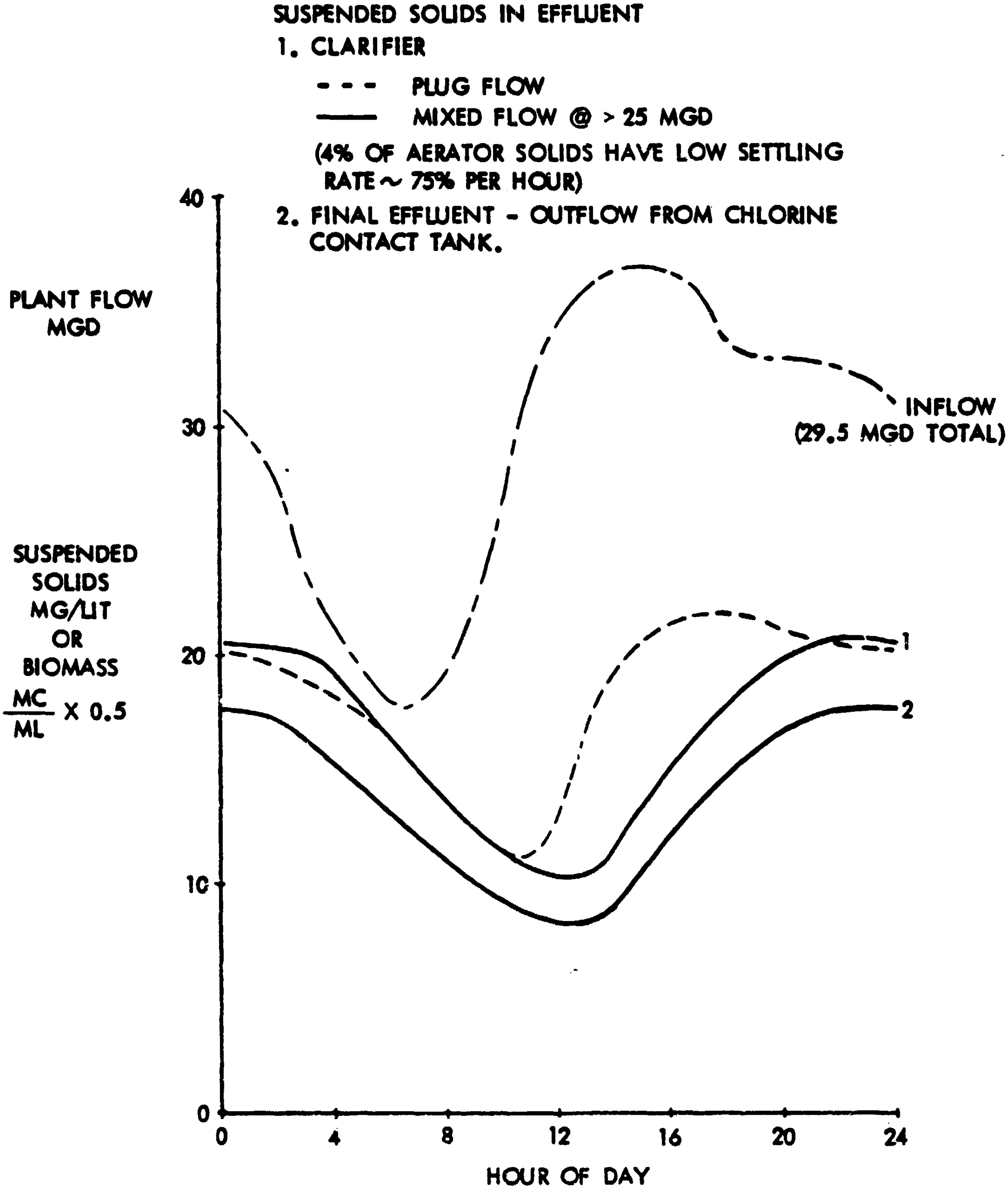


FIGURE 31

MATH MODEL SIMULATION OF PROCESS SOLIDS IN ACTIVATED SLUDGE PROCESS EFFLUENT

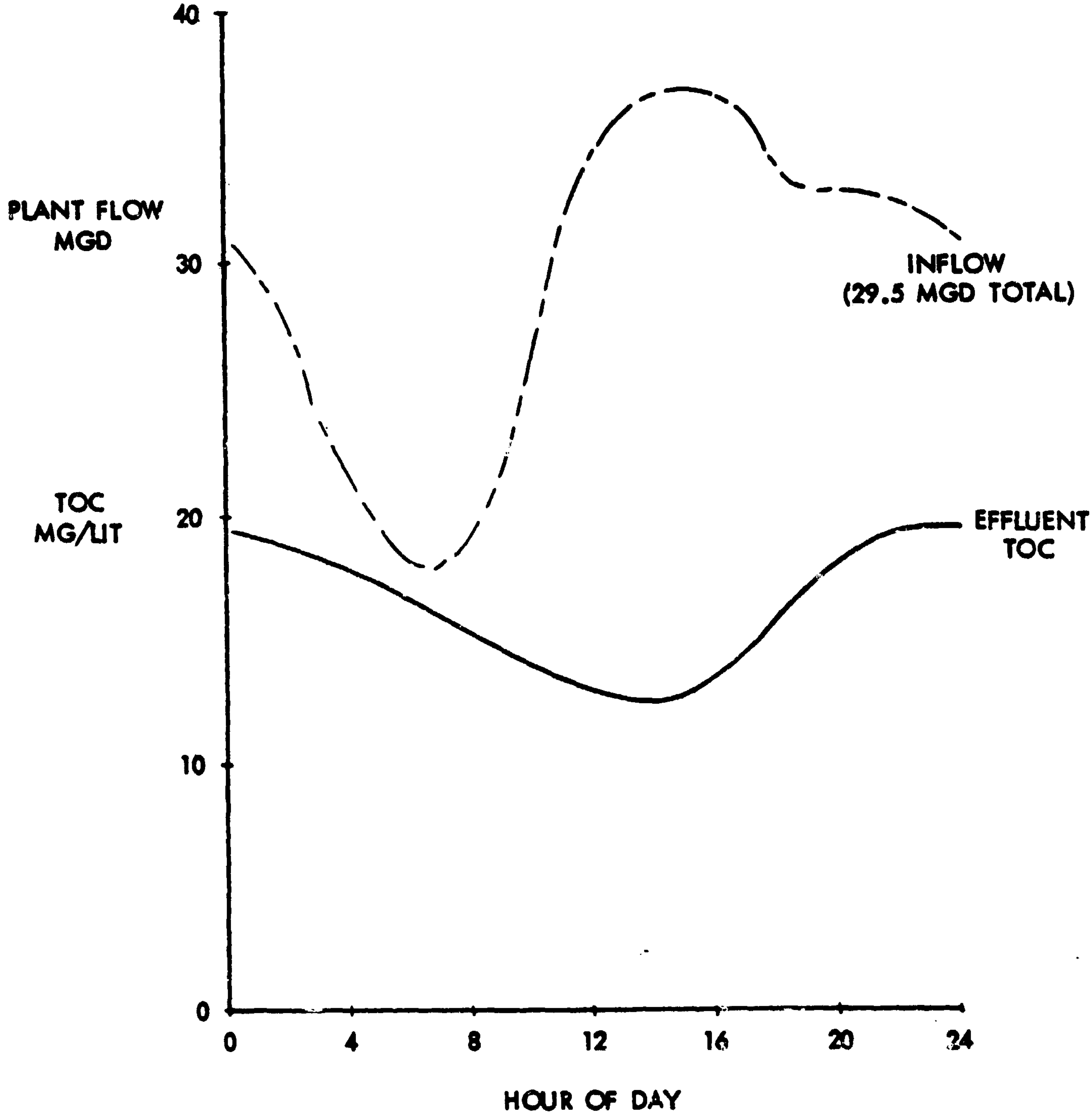


FIGURE 32

MATH MODEL SIMULATION OF NON-VOLATILE ORGANICS only on detention times, lower quality might be expected. It is interesting to note that the non-ideal performance (mixed flow in the clarifiers) results in a better overall quality effluent than might otherwise be predicted. This is attributable to the daily "morning break" where flow falls below 25 MGD and ideal (plug flow) settling occurs. It is expected that wet weather or a large increase in plant flow due to local growth, where high flows were sustained, would produce a significant decrease in secondary effluent quality.

The potential exists for utilizing the biosensor to improve secondary effluent quality. If the return sludge rate and wasted sludge rate (Appendix C) were controlled for optimum biological solids in the aerator, the conditions which result in the excusions in effluent quality might be reduced. However, no testing has yet been performed to prove this concept due to other priorities.

The observed diurnal cycle might have some influence on plant operational procedures. For example, the normal procedure for determining conformance of the secondary effluent to discharge permit requirements (240 coliform per 100 ml, 7 day average) is by grab sample collected at noon each day; however, based on the diurnal cycle, a higher biological population in the effluent would be expected around midnight. A small group of samples were collected and analyzed which showed that prior to disinfection the biological population was indeed higher at midnight (Table 10) as measured by coliform, biomass and turbidity, but the plant disinfection strategy (constant concentration of chlorine dosage) appeared adequate for the higher number of coliform. A control strategy that recognized not only dosage and contact time, but also quantity of biological material, while maybe desirable, was not justified in this short testing period, where coliform was the only standard of performance.

The changes in secondary effluent quality due to the diurnal cycle could have an influence on reclamation plant operations as will be discussed later in this section.

Major variations in total halocarbons follow a weekly cycle. Figure 33 shows that these variations result in high concentrations midweek and low concentrations on the weekend. Some of these compounds are commonly used solvents and the weekly cycle presumably reflects work patterns of local industry.

Typical concentrations of the nine individual compounds comprising the total halocarbons are shown in Figure 34, which also shows process removals. Significant removals occur in the purging processes, e.g., aeration (activated sludge) aeration (ammonia stripping) and recarbonation, and across the GAC.

Carbon Adsorption

Organics removal decreased with operating time as the adsorbent surface of the granular activated carbon (GAC) became saturated. For example, Figure 35 shows that chloroform removal suddenly decreased after processing about 20 mgal. After processing 35 mgal, the GAC was saturated at the average influent concentration of 39 μg/lit and the effluent was characterized by a great deal of data scatter as the GAC alternately adsorbed and desorbed in concert with the influent concentration. The performance of two other carbon towers, at plant configurations

Table 10 Diurnal Variation in Biological Quality

	PRE-CHLORINATION			POST CHLORINATION				
	TOTAL BIOMASS MC/ML	VIABLE BIOMASS MC/ML	COLIFORM #/100 ML	TOTAL BIOMASS MC/ML	VIABLE BIOMASS MC/ML	COLIFORM #/100 ML	TURBIDITY MG/LIT	TOTAL RESIDUAL CHLORINE MG/LIT
NOON								
4-30-79	9.8	1.9	1.65×10^5	3.7	0.4	-	11	8
5-1-79	16.4	4.7	2.30×10^5	4.2	0.3	2	14	7
5-2-79	10.2	2.4	1.15×10^5	4.1	0.3	8	14	7
5-3-79	8.1 11.1	1.7 2.7	7.0×10^4 1.32×10^5	3.4 3.9	0.4 0.4	5 5	17 14	8 8
MIDNIGHT								
5-7-79	28.1	10.9	3.30×10^5	6.1	-	8	28	7
5-8-79	17.6	3.9	3.30×10^5	8.3	2.7	5	17	7
5-9-79	16.8	10.0	$\geq 2.4 \times 10^7$	7.4	4.0	2	12	6
5-10-79	39.9 25.5	20.5 11.3	1.40×10^5 $\geq 7.8 \times 10^5$	9.9 7.9	5.5 4.1	2 4	15 17	5 6

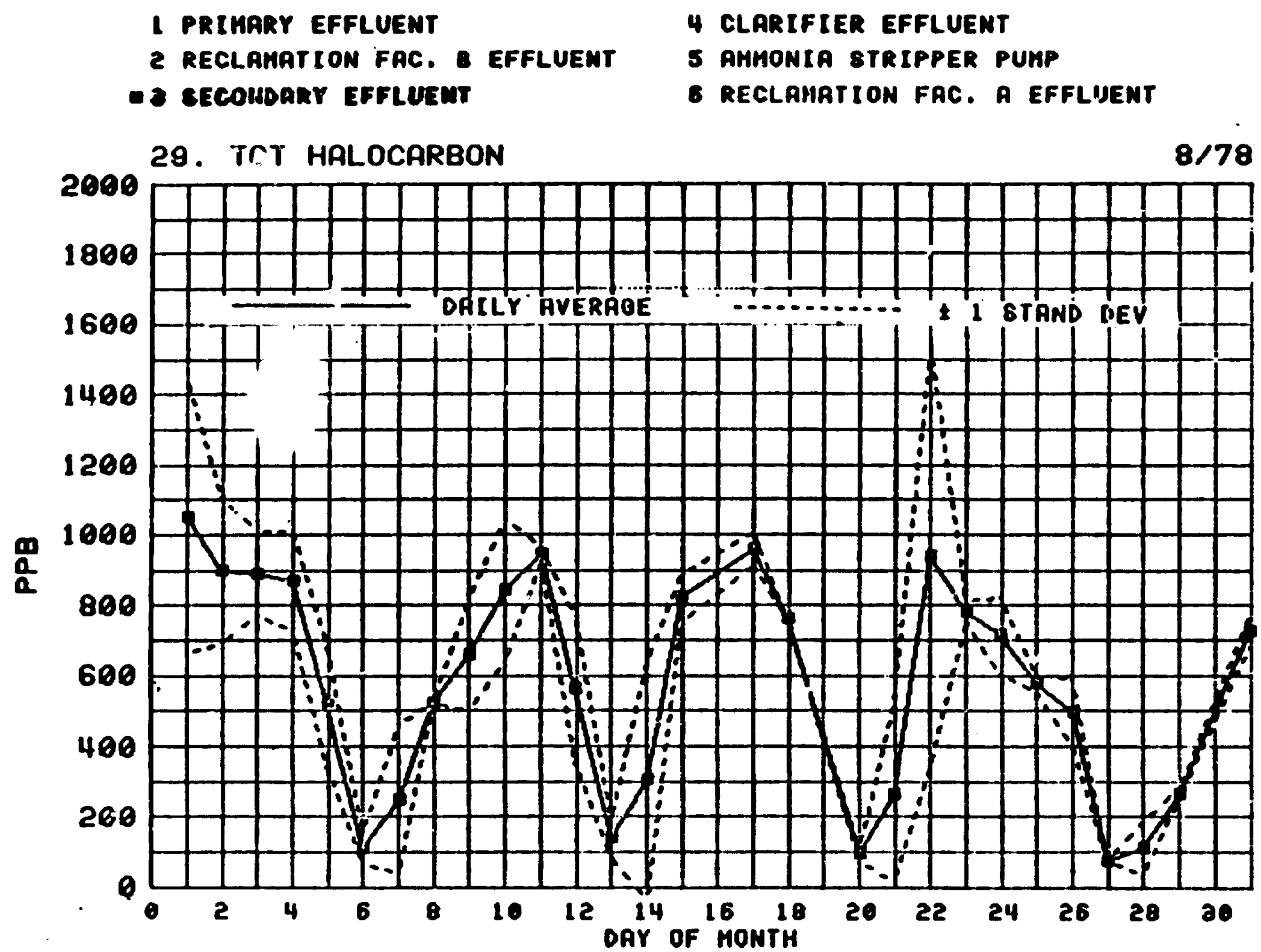


Figure 33 Total Halocarbons in Reclamation Facility Influent Water (Secondary Effluent from Palo Alto Wastewater Plant).

April Averages (ug/LIT) ± 1σ

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → (1 MGD) → FLOCCULATION AMMONIA STRIPPING* RECARBONATION → FILTRATION OZONATION → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

Compound	Day	Primary effluent	Activated Sludge Chlorine Contact Avg. % Removal	Conc.	Flocculation Ammonia Stripping* Recarbonation Avg. % Removal	Conc.	Filtration Ozonation Avg. % Removal	Conc.	Granular Activated Carbon Avg. % Removal	Conc.	Filtration Chlorination Avg. % Removal	Effluent
TETRACHLOROETHYLENE	WED.	298±162	63	109 ± 55	62	41 ± 14	44	23 ± 9	83	4 ± 1	0	4 ± 2
	SUN.	15± 5	20	12 ± 9	42 (83)	7 ± 3	43	4 ± 1	75	1 ± 1	0	1 ± 1
METHYLENE CHLORIDE	WED.	320±128	92	27 ± 27	56	12 ± 10	33	8 ± 4	-213	25 ± 7	12	22 ± 5
	SUN.	27±15	96	1 ± 0	-3000 (>99)	31 ± 23	23	24 ± 24	-4	25 ± 7	4	24 ± 7
1,2 DICHLOROETHYLENE	WED.	101±34	69	31 ± 9	-3	32 ± 10	-9	35 ± 17	11	31 ± 9	16	26 ± 10
	SUN.	67±11	52	32 ± 15	-3 (5)	33 ± 14	-15	38 ± 13	47	20 ± 11	-15	23 ± 10
CHLOROFORM	WED.	44±30	32	30 ± 15	40	18 ± 5	6	17 ± 4	76	4 ± 2	0	4 ± 1
	SUN.	20±4	C	20 ± 4	25 (69)	15 ± 3	0	15 ± 2	73	4 ± 1	0	4 ± 2
1,1,1 TRICHLOROETHYLENE	WED.	227±126	66	78 ± 38	74	20 ± 10	45	11 ± 7	91	1 ± 1	0	1 ± 1
	SUN.	17±8	41	10 ± 8	50 (95)	5 ± 3	40	3 ± 2	67	1 ± 1	0	1 ± 1
BROMODICHLOROMETHANE	WED.	3±1	-33	4 ± 2	25	3 ± 1	0	3 ± 1	33	2 ± 1	50	1 ± 1
	SUN.	2±1	-100	4 ± 2	0 (71)	4 ± 1	25	3 ± 1	67	1 ± 1	0	1 ± 1
TRICHLOROETHYLENE	WED.	150±62	65	52 ± 50	62	20 ± 8	30	14 ± 10	86	2 ± 0	50	1 ± 0
	SUN.	22±5	68	7 ± 2	43 (87)	4 ± 1	25	3 ± 1	67	1 ± 0	0	1 ± 0
DIBROMOCHLOROMETHANE	WED.	<1	<-100	2 ± 0	50	1 ± 1	0	1 ± 1	0	1 ± 0	0	1 ± 0
	SUN.	1±1	-100	2 ± 0	50 (64)	1 ± 1	0	1 ± 1	0	1 ± 0	0	1 ± 0
BROMOFORM	WED.	6±3	67	2 ± 1	0	2 ± 1	0	2 ± 1	0	2 ± 1	0	2 ± 1
	SUN.	2±1	0	2 ± 1	0 (39)	2 ± 1	0	2 ± 1	0	2 ± 1	0	2 ± 1
TOTAL HALOCARBONS (MONTHLY AVERAGES)		990±858	68	313 ± 210	47 (75)	167 ± 86	25	126 ± 54	46	68 ± 28	12	59 ± 21

* AERATORS WERE OUT OF SERVICE DURING APRIL.
( ) TYPICAL REMOVAL WITH AERATORS IN SERVICE (MAY AVERAGES)

Figure 34 Weekly Cycle of Halocarbon Concentrations (Influent Concentration Varies From a Maximum at Mid-week to a Minimum at Weekend)

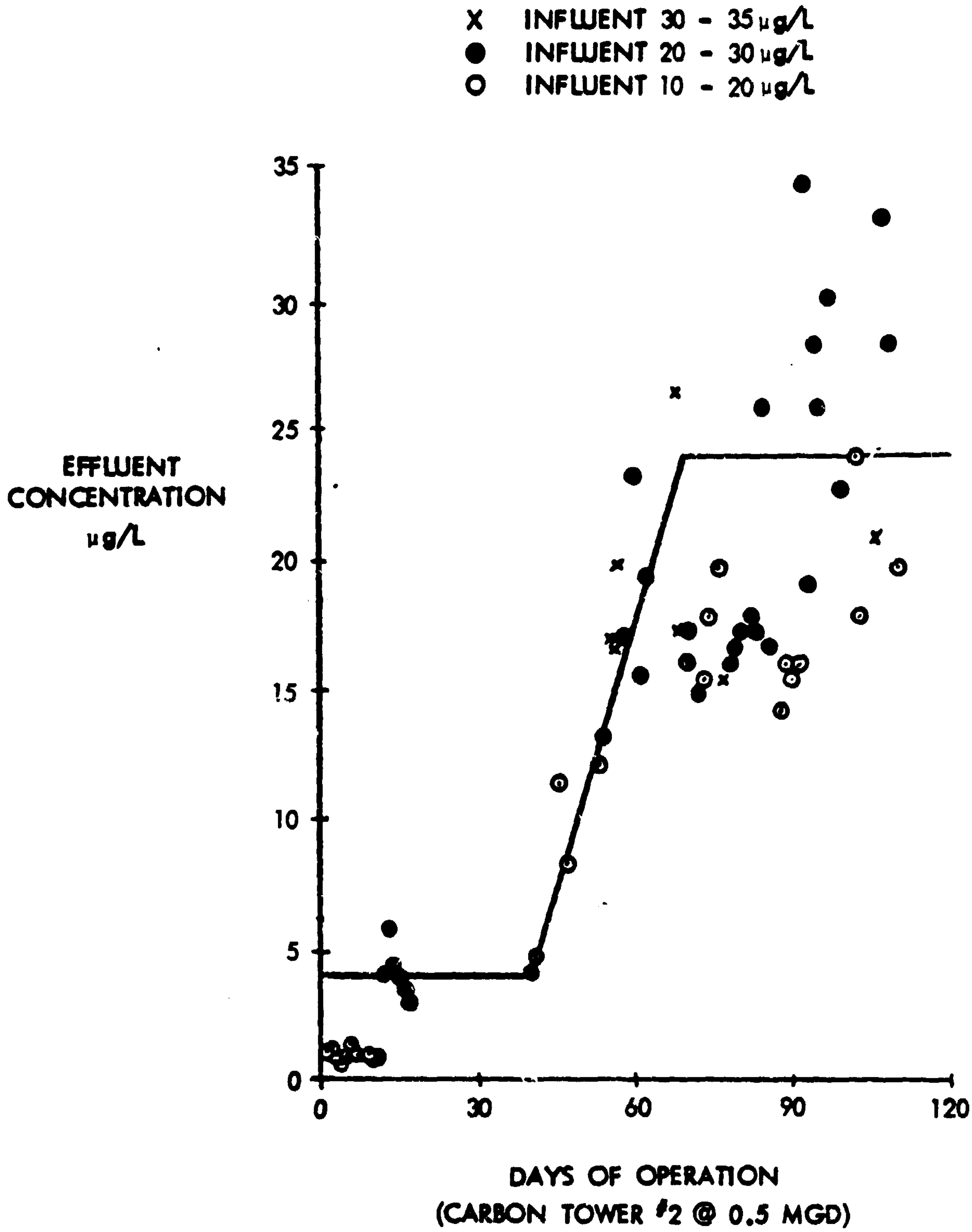


Figure 35 Useful Life Activited Carbon Column (1 of 4) for Chloroform Removal at 39 g/Lit Average Influent Concentration (20 Mgal at Breakthrough and 35 Mgal at Saturation)

which resulted in different influent concentrations, were similarly monitored. Figure 36 presents an analysis of these data showing GAC adsorption capacity for chloroform over a range of influent concentrations. Average carbon regeneration rates necessary to maintain active chloroform removal can be computed based on this capacity curve using the following equation:

$$R = 33{,}500\ Q\ \frac{C_i - 7}{C_i^{1.77}}$$

Where R = Activated carbon average regeneration rate, lb/day

Q = Flow, mgd

C_i = Average influent chloroform concentration, μg/lit

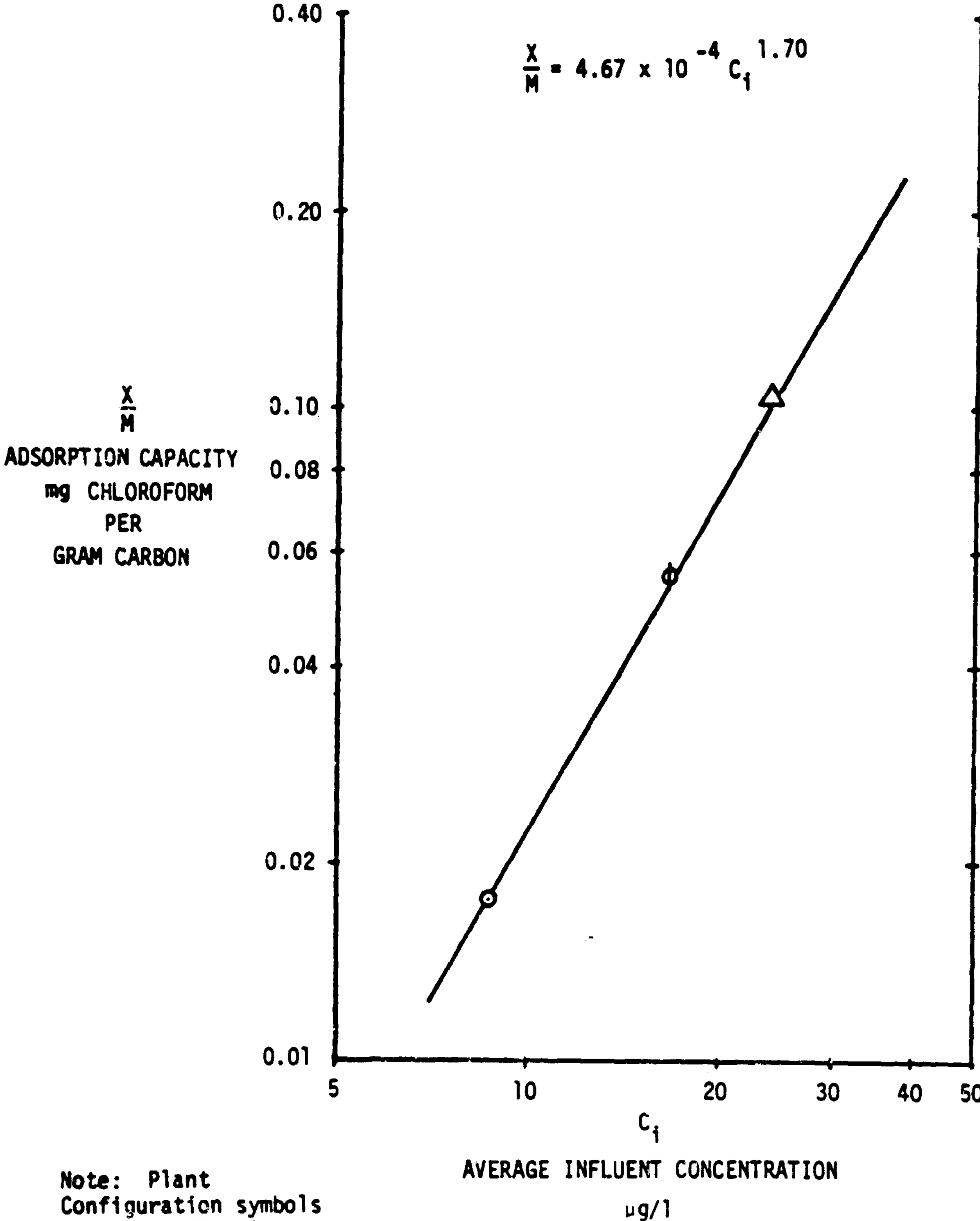
Thus, for the 3 plant configurations tested, the following regeneration rates would have been required at plant rated flow to prevent GAC saturation.

	Plant Configuration	C_i	R @ 2 mgd
Δ	FILT/GAC/FILT	39 μg/lit	3274 lb/day
ϕ	FLOC/FILT/GAC/FILT	28	3862
o	FLOC/AER/FILT/GAC/FILT	15	4441

Or, if a limit were placed on the average effluent concentration, say 30 μg/lit, regeneration would be required only for the first configuration listed above.

These regeneration rates are much higher than the plant contractor's est te of 1000 lb/day to maintain COD removal capability, and would represent a signi cant operating expense if used as criteria for carbon regeneration. However, trihalomethanes are not currently restricted by the plant's discharge permit. These data may be of interest in the future since the EPA is contemplating limits on trihalomethanes for drinking water supplies (Reference 2). It should be noted that chloroform was the first of the nine trace organics measured to saturate the GAC, thus a different effective carbon life will result if other measures are used as indicators.

TOC removal, for example, stabilized for a period, after 2-3 months of operation - Figure 37. Apparently, biological activity in the GAC had reached equilibrium where the quantity of non-volatile organics adsorbed equalled the quantity consumed by the bacterial population. Bacterial growth is apparent from the measured biomass elution from the column, the decrease in dissolved oxygen and the nitrification across the column (Appendix B, April-July 1979). The rate of the biological growth was undoubtedly affected when, after 55 days of operation, ozonation, which preceded GAC in the process stream, was turned off. Also, growth may have been inhibited for the first month of operation due to a low dissolved



Note: Plant Configuration symbols are identified in Appendix A

Figure 36 **Chloroform Adsorption Capacity of Granular Activited Carbon (GAC)**

oxygen, due to inoperative aerators. Subsequent performance stabilization may have reflected the healthier growth environment, e.g., plenty of oxygen and no ozone. This biological cleaning may offer a less expensive alternative to the heating method of carbon regeneration. This is discussed further in Section 8.

Decay in performance began again after 5 months of operation. The cause is not known, but the decay was accompanied by a decrease in the earlier observed rate of biomass elution, suggesting reduced biological activity.

The rate of performance decay, Figure 37, during the first 2 months of operation, 1 mg/lit per month, indicates that an average carbon regeneration rate of 700-800 lb/day at 2 MGD would be required to maintain peak performance. This corresponds to the plant contractor's estimate of 600-1000 lb/day.

POTENTIAL WMS APPLICATIONS FOR PROCESS CONTROL

Several opportunities are available in the reclamation plant to utilize automated water quality data for process control. These are listed in Table 11. In addition, the number of available processes in the plant and the flexibility in selecting on-stream processes presents another control option, e.g., process stream configuration control. For example, listed in Table 12 is the maximum influent concentration to various process streams where discharge permit limits for COD (10 mg/lit) would not be exceeded. Also shown are the cost of consumables associated with the processes. This illustrates that the process stream could be selected based on the most economical way of treating specific influent conditions. If this example concept had been used during July 1979, flocculation and aeration would have been unnecessary for most of the month (1σ TOC range was 9.2 to 14.6 mg/lit) and a significant portion of the potential savings of $4,600 could have been realized. Of course this example was simplified to demonstrate the concept and the impact on removals of other contaminants must also be considered.

Alternately, plant flow could be controlled to maintain the highest quality effluent. During periods of low demand, the configuration and flow could be adjusted for peak performance and the water delivered or stored for later mixing with the effluent during high demand periods.

This concept of storage and selective dispensement of high quality water may be a necessary alternative if discharge permit limits are not to be exceeded. As illustrated in Figure 23, for example, the TOC limit of 4 mg/lit (COD of 10 mg/lit) can be exceeded for expected influent conditions.

Biologically regenerated GAC offers another potential opportunity for significant savings by process control. If the GAC can be operated at conditions faborable to biological growth, it may be possible to reduce or eliminate the expense of carbon regeneration with minimum impact on effluent quality. For example, if the four GAC columns could be scheduled such that flow to one of the columns were terminated during periods of low influent organics, the bacteria in this column would have the opportunity to "clean house" under favorably quiescent conditions. Improved performance would be expected when this column was again placed on-line during periods of high influent organic concentrations.

C-2

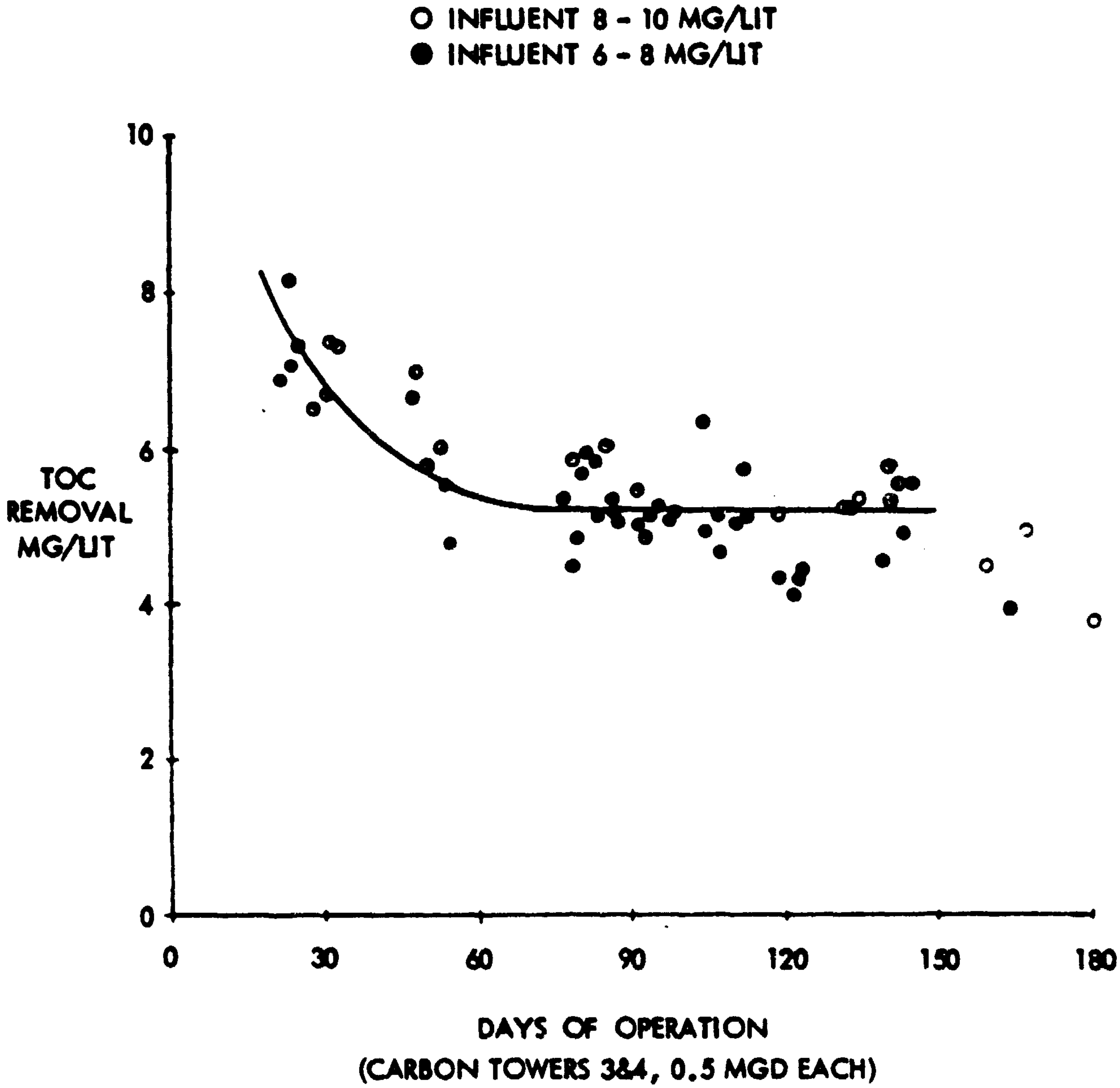


Figure 37 Rate of Activited Carbon Saturation with Non-Volatile Hydrocarbons

Table 11 Reclamation Plant Systems Amenable to Automatic Computer Control

Process	Control Parameters	Potential Criteria
Flocculation		
Chemical Feed Rate	pH or Inorganic Carbon (Alkalinity)	Constant pH
	pH/Turbidity, Biomass or TOC	Variable pH based on influent
Sludge Return Rate	Flow/Turbidity or Biomass in/out	Relationship to be determined
Sludge Wasting Rate	Sludge density or turbidity	Relationship to be determined
Aeration (Ammonia stripping)	DO, Total Halocarbons, Flow	0, 1 or 2 pumps based on influent THC and effluents DO
Recarbonation	pH	Constant pH (7-8)
Filtration	ΔP, DO	Backwash at limit
GAC	TOC, Total Halocarbons	Carbon regeneration rate based on removal performance
Chlorination	Flow	Constant dosage
	or Total Residual Chlorine	Constant residual
Ozonation	Flow	Constant dosage
Flow	Turbidity, TOC, Total Halocarbons, Biomass	Regulate flow to store/deliver highest quality effluent during periods of low demand.

Table 12 Configurations/Costs of Controlling Effluent COD ≤10 Mg/Lit at 1 mgd

PROCESS STREAM	MAX. INFLUENT TOC FOR ≤ 4 MG/LIT IN THE EFFLUENT	CONSUMABLE COSTS, $/DAY			
		LIME	GAC	ELECTRICITY FOR AERATION	TOTAL
FLOC(pH 11)/AER(2)/FILT/GAC/FILT	18.1	70	150	80	300
FLOC(pH 9.5)/AER(2)/FILT/GAC/FILT	15.6	28	150	80	258
FLOC(pH 9.5)/AEC(1)/FILT/GAC/FILT	14.9	28	150	40	218
FLOC(pH 9.5)/FILT/GAC/FILT	14.1	28	150	0	178
FILT/GAC/FILT	12.6	0	150	0	150
FLOC(pH 11)/AER(2)/FILT	4.7	70	0	80	150
FLOC(pH 9.5)/FILT	4.7	28	0	0	28
FILT	4.7	0	0	0	0

BASIS

1. COD/TOC RATIO OF 2.5
2. CARBON REGENERATION AT 500 LB/MGAL, $0.3/LB. (ESTIMATE BASED ON 100% ESCALATION OF 1973 OPERATION AND MAINTENANCE COSTS QUOTED IN REFERENCE 19)
3. LIME DOSAGE AT 280 MG/LIT FOR pH 11, 112 MG/LIT FOR pH 9.5 - $60/TON
4. ELECTRICAL ENERGY AT $0.04/KWH
5. NOMINAL STEADY-STATE TOC REMOVAL PERFORMANCE (FIGURE 7-4)

Opportunities to utilize these off-periods are available daily, due to the diurnal cycle, on weekends, and during certain seasons. However, wet weather, seasonal variations and random upsets in the secondary process suggest that the off-periods should be dictated by the influent quality considerations rather than by time period scheduling in order to assure product water quality.

During the column off-periods excess flow might be routed to the other three columns, resulting in some performance penalty, but proper selection of influent critiera would prevent exceeding effluent discharge limits.

A disadvantage may be the reduced capability for removal of trace hydrocarbons, e.g., chloroform. Testing may be necessary to demonstrate the total impact of biological regeneration, but the potential savings, $300/day @ 2 mgd, warrants due consideration.

SECTION 3

PART II FIELD DEMONSTRATION TEST RESULTS

This portion of the Technical Summary covers the test data recorded during the test period July 1980 through February 1981. This portion of the test period was jointly funded by NASA, the EPA, the California State Department of Water Resources, and the Santa Clara Valley Water District. Data were recorded on WMS and subsystem downtime and on maintenance and operations cost. Similar data were recorded by the Santa Clara Valley Water District for the reclamation plant. Additional test data were recorded on the quality of the water at various points within the reclamation plant as measured by the sensors within the WMS and the City of Palo Alto Laboratory. These data were used to evaluate the performance, reliability, availability, and costs of the reclamation plant, its individual processes, and the WMS and its components. Major problems encountered in the operation of the WMS and the reclamation plant are discussed.

TEST OBJECTIVES

The objectives of the test program described in this report were as follows:

1. To determine the steady-state performance (ability to remove contaminants) of the water reclamation facility unit processes based on WMS data.

2. To determine unit process and plant availability. Availability is defined as the portion of the time that an item operates on demand. Availability was measured as follows:

   $A = 100T/(T + D)$

   where, A = availability, %
   T = operating time, hours
   D = Downtime for repair, hours
   $T + D$ = total available operating time, hours

   Once established, availability can be used to estimate annual repair time; thus, for a continuously operated item:

   $D = (1-A/100)\ (365\ \text{days/year})\ (24\ \text{hours/day})$

3. To determine plant reliability. Reliability is defined as the percentage of the operating time that an item performs within specified limits. For the water reclamation plant, reliability was measured as the percentage of time that a water quality parameter was within specified effluent limits. The WMS data were statistically evaluated based on a lognormal data distribution model and compared to an MCL (maximum concentration limit). The MCL's are based on references 9, 10, 11, 12, and 13. The percentage of time that a measured parameter was less than the MCL represented plant reliability for that parameter.

The product of multiplying availability times reliability gives the portion of the total available operating time that an item will perform within given limits.

P = (A)(R)

where, P = performance achieved
R = reliability, %

4. To determine plant operating and maintenance costs.

5. To determine similar parameters for the WMS; i.e., performance, availability, reliability, and operating and maintenance costs.

CONCLUSIONS

1. The following conclusions relative to process performance are based on the WMS data:

   a. Chemical clarification removed over 90% of the influent suspended solids (biomass) and as much as 30% of the organic contaminants (TOC).

   b. Flocculation (floc) carryover from the chemical clarification process results in additional loading on the mixed-media filters. This caused decreased filter run times; i.e., more frequent backwashing.

   c. Except for some reduction in trace halocarbons and biomass, the contribution of ozone to water quality does not appear to be significant at the concentrations used in the study.

   d. The removal of ammonia during treatment was not significant. Some biological oxidation to nitrate occurred in the GAC towers.

   e. A reduced level of many dissolved contaminants is characteristic of water processed by activated carbon, when its useful life is not exceeded. However, the COD effluent limit of 10 mg/l is difficult to achieve without significant cost incurred by continuously regenerating carbon.

   f. Just prior to and during the first few weeks of this test period, processing of the influent to the reclamation plant was changed from an activated sludge reactor to a fixed-film reactor with nitrification and dual-media filtration. These changes generally reduced the contaminant levels to the reclamation plant. Data from a 1-month period, which are representative of conditions before these changes, have also been included in this report.

2. The capability to collect and process data for convenient and improved analysis of water quality information has been demonstrated. Over three million water quality measurements were recorded during the test period and are summarized in this report.

3. Both the reclamation plant and the WMS were designed and constructed as experimental test beds where reliability was of secondary importance to flexibility. Neither system was intended to function as an operational system. Rather, they were intended for testing various concepts and configurations for water treatment, automated quality monitoring and process control. Consequently, the numbers quoted in this report for availability and reliability are not meaningful of the performance that should be expected from operational systems. Rather, the data reported here provide a focus on problem areas which strongly influence reliability. This experience should guide the future design of reliable operational systems.

4. Automated monitoring provides a mechanism for better effluent quality control. Where real-time monitoring is not available, plant- or influent-initiated upsets may go undetected until laboratory test results are received by the operators, which may be several hours or days later. Such a method of operation places a severe restriction on quality control, especially where direct water reuse is involved, and would be unacceptable, for example, in manned spaceflight. Automated, real-time monitoring provides the capability to immediately identify abnormal conditions when they occur, in time to do something about them.

5. Automated water quality monitoring will be an economic necessity in the future as effluent quality control restrictions are tightened. The costs of repetitive laboratory analyses will become prohibitive, thereby increasing the demand for automated sensing, analysis, and reporting.

6. Automated water monitoring offers the potential for reduced water production costs through process and plant configuration control.

7. There is a need for improved reliability of many of the available components used for automated water quality monitoring.

8. The sophistication and advanced technology of some water quality sensors often require highly skilled personnel to isolate and resolve problems. These skills are generally unavailable in many wastewater plants.

9. Interference problems which had previously plagued the NASA-developed coliform sensor have been resolved. However, the complex plumbing arrangement necessary to operate a totally automated multicell sensor is prone to random contamination which, when experienced, has been difficult to eliminate. During the current test period, approximately 1 month of operating time was lost because of contamination. A configuration with less complexity should reduce this problem. Since the potential for reducing the coliform detection time from 72 hours by the laboratory MPN test to 11 hours by the electrode test is quite significant, the system is worthy of further development.

10. Problems have occurred because of different suppliers for WMS computer equipment. In the case of the reclamation plant these problems were avoided by virtue of having single contractor responsibility.

11. The experience of both the reclamation plant and the WMS has been that a computer service contract is key to maximizing system availability.

12. The high labor cost (three-fourths of water production cost) indicates that more attention should be given to maintainability in the design of water treatment and instrumentation systems.

13. Early implementation of a preventive maintenance program for the plant machinery and instrumentation systems can significantly reduce downtime.

14. Process and instrumentation checkout and verification are essential prior to turning the plant over to the operators.

15. The value of plant process instrumentation is significantly reduced if operators are not trained to properly interpret the data.

RECOMMENDATIONS

1. Much of the data collected by the WMS over the 3 1/2 years of operation at SCVWD-WRF/PA, prior to that reported here, have received only cursory review. During that period the plant was operated in several configurations with influent conditions ranging from high quality secondary effluent, which is presented in this report, to low quality influent, including settled primary effluent. The capability now exists and these data should be analyzed, similar to the analysis presented in this report, to show a full range of performance of plant processes.

2. Data exist for periods with and without an operating ozonator. These data should be analyzed to clearly show the net effect of ozonation in a real-world environment and to evaluate cost effectiveness.

3. A test program should be performed to identify key control parameters for effective chemical clarification by lime treatment. The experience at SCVWD-WRF/PA has been that the cost of the process in terms of labor and downtime may offset the benefits in water quality improvement.

4. When using lime for chemical clarification, it is recommended that a filtration step be included prior to GAC sorption. This will reduce the possibility of clogging the GAC with coagulant and/or calcium carbonate precipitant.

5. The potential for reducing activated carbon regeneration costs by operating the towers in a "biologic activated carbon" mode (no regeneration) should be explored.

6. Many operational difficulties after plant startup could be avoided by design verification testing, more intense and continuous operator training, and established requirements for a preventive maintenance program before acceptance from the contractor.

7. The requirements for the installation of computer systems in wastewater plants must consider the environmental requirements of the equipment. Computers must operate in dust and vibration free conditions.

8. Maintain a daily log to be used for recording plant and process downtime, the cause of the downtime, and the number of man-hours required to correct the problem.

9. Maintain a comprehensive record of materials and consumables, including the process in which they are used.

10. The WMS as configured is not ideal. The mobility design criteria dictated its design. The following factors should be considered in designing an in-place integrated plant water quality monitoring system:

    a. Locate electronic equipment in an area away from potential contact with process or other chemical exposure.

    b. Use state-of-the-art computer technology to simplify the data acquisition system. New improved equipment is available almost daily.

    c. Use a single contractor for all computer equipment.

    d. The system should be designed for automatic fault detection. If not, the time required to diagnose electronics failures typically will far exceed the time required to correct the problem.

    e. All sensors should be evaluated with regard to serviceability and cost of consumables prior to purchasing.

    f. Design the sampling system to ensure continuous, adequate sample flow to all sensors.

    g. Take into consideration extensive requirements for drains, vents, air conditioning, and electrical power.

    h. Take into consideration storage requirements for consumables and spares.

    i. Include some laboratory area to do periodic wet chemistry verification work.

11. The NASA-developed biosensor has demonstrated the capability to quantify biological activity at the low concentration levels present in reclamation processes. However, its potential in monitoring and controlling biological treatment processes, such as activated sludge, has not been explored. A vital need for such a capability has been previously identified (reference 14).

12. The NASA-developed coliform sensor should be reconfigured to eliminate complex plumbing thereby improving reliability. The sample size should be increased to provide a minimum sensitivity of one organism per 100 ml. The potential benefits of single analysis units for automated analysis and also for laboratory applications have been previously identified (reference 14).

WMS PERFORMANCE EVALUATION

The true measure of performance by developmental systems, such as the WMS, is the contribution made toward producing effective operational systems. This means that problem areas are uncovered and possible solutions are tested before commiting the design of operational systems.

Much experience has been accumulated from WMS operations. Solutions to some identified problems are yet unresolved due to practical constraints (time and money). Available resources to date have been allocated primarily to functional considerations including the understanding of sensor characteristics (standardization requirements, interferences, data collection and validation), and software development to support a variety of potential data applications (sensor and system control, treatment process characterization, and plant process control). Reconfiguring the system to totally eliminate data errors and minimize downtime has received lower priority attention.

Predicting performance of some future operational system in terms of availability, reliability and O&M costs of an existing preprototype setup is approximate, at best, and is subject to misinterpretation. Nonetheless, such data are presented in the following paragraphs. The reader should recognize that this information contains measured performance of production hardware (commercial sensors) as well as preprototype systems (biological analyzers, GC analyzer, and computer software) whose production configurations have not yet been established and tested.

Hardware age contributed to the failure frequency. The biological sensors, for example, contain some NASA surplus hardware, primarily valves, which are approximately 10 years of age. The age of most of the commercial sensors is about 4-5 years or less.

Sample Collection and Distribution System

The sample collection and distribution system was used to collect and distribute samples from six locations which included water of a quality ranging from City of Palo Alto final ef ent to tertiary treated wastewater. The system worked very well throughout the test period. Fifty micron-woven stainless steel filters were used for filtration purposes for the test period. The filters are .08 cm thick and .10 cm in diameter. Two filters are located in the filter housing and are both used concurrently. Because of the high flow rate of sample across the filter surface and the backflushing action, the system had no difficulty removing particles and debris from the sample stream. What did present a problem was grease contained in the City of Palo Alto effluent during the last part of July and the first part of August. Also during the same time period, the high amount of lime present in effluent from the flocculator/clarifier also clogged the filters. During July, a malfunction in the reclamation facility resulted in the filters becoming clogged with carbon fines. In order to prevent a loss of sample flow during this problem period, the normal procedure of cleaning the filters on Monday, Wednesday, and Friday was modified to clean the filters five times a week. Figure 3 in Volume I shows the flow schematic for the system.

The only persistent problem that occurred during the test period was the buildup of debris in the pump recirculation valve which resulted in increased sample flow and the introduction of air bubbles to the sample. One backflush cylinder and control relay failed during the test period. Four sample valves failed also during the test period. Additionally, the main sample pump had to be rebuilt because of a bearing failure.

Chemiluminescence Biosensor

The chemiluminescence biosensor currently processes and measures total and viable bacteria once during each 1-hour period. Typical values measured in the various wastewater effluents monitored by the WMS are illustrated in Figure 38. The sensor is routinely calibrated using a Coulter electronic particle counter and the firefly luciferase - ATP assay for total and viable bacteria, respectively.

The biosensor mechanically and electronically operated satisfactorily during the test period. There were, however, several minor problems encountered during this time. The flow cell became clogged with precipitant from the reagents. This problem was solved by disassembling and flushing the flow cell. The drain line became clogged with calcium carbonate and had to be replaced. Several pilot valves and the diaphragm in the compressed air pressure regulator failed and had to be replaced.

Correlation of the viable bacteria results of the biosensor presents special problems. Various values for viable bacteria can be obtained depending on the type of method employed. Each method measures a particular parameter associated with viability. The ATP method and luminol - CO method are measures of metabolism while the standard plate count method is a measure of the ability of a cell to reproduce and form colonies in an artificial environment. For this reason the luminol method cannot be expected to produce the same results as the plate counts. The ATP results have shown correlation with the luminol data; however, it is known that ATP levels within bacteria can fluctuate depending on environmental conditions and growth phase. For this reason, the ATP method can be used for "ball park" comparison and some deviations should be expected, the most consistent correlation occurs with the Coulter electronic particle counter.

Gas Chromatograph

The GC operated quite well during the first part (July through September) of the test period. However, early in October, the preparatory columns lost carrier gas flow for several hours because of a malfunction of the shutoff valve on the carrier gas cylinder. As a result, the two preparatory columns began exhibiting an excessive amount of column bleed, which totally masked the compounds being monitored. Efforts to reduce the column bleed by baking out the columns at above normal operating temperatures were unsuccessful. Two new preparatory columns were ordered to allow the analyzer to be put back on line as soon as possible. However, when the new preparatory columns arrived and

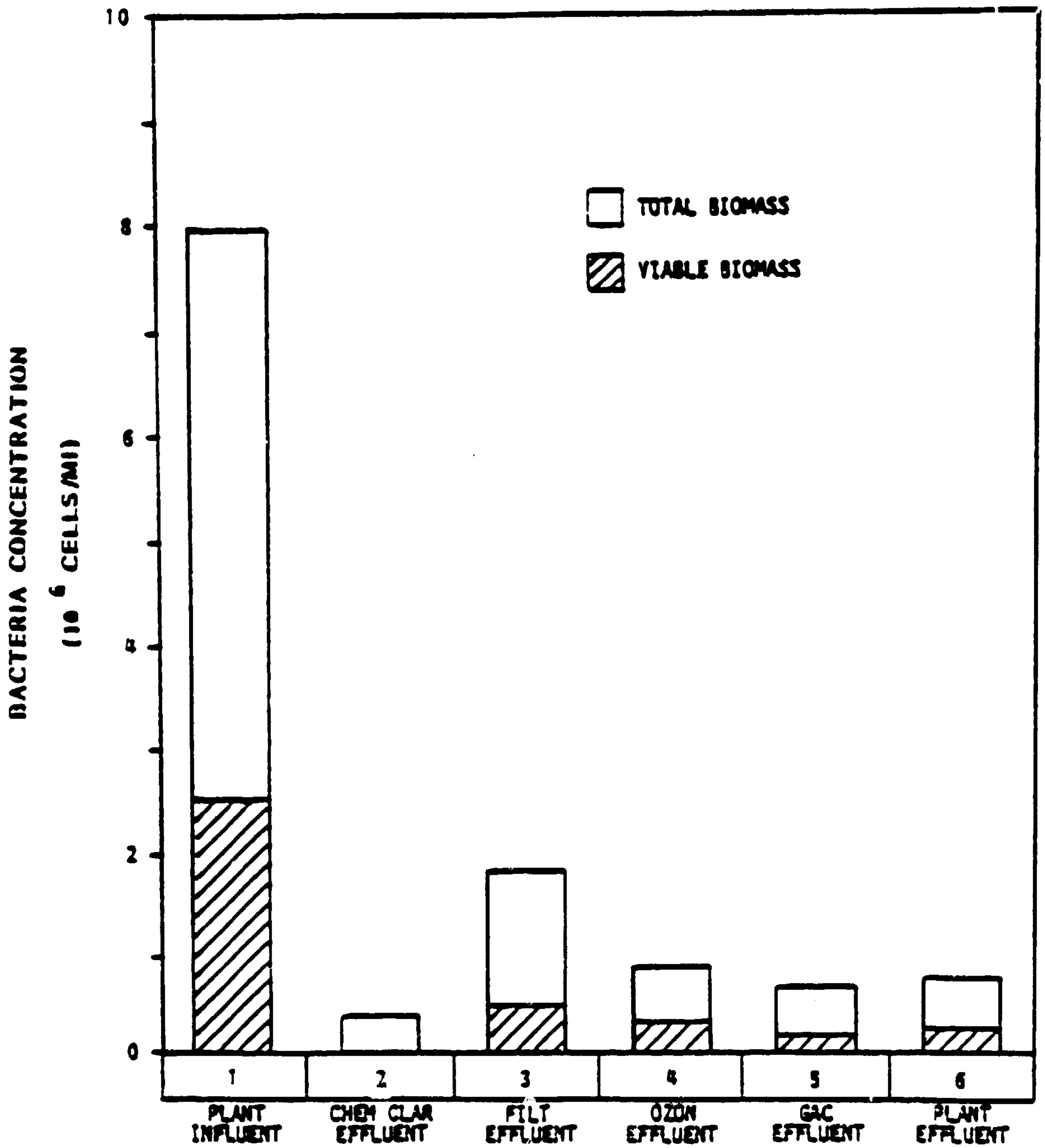


Figure 38 **Total and Viable Bacteria Levels in Various Waste-Water Effluents**

were installed, they showed a high baseline signal. Procedures to reduce the baseline signal were immediately started. The procedures called for raising the operating temperature of the preparatory GC to increasingly higher temperatures (from 105°C to 150°C) and injecting ultrapure water into the preparatory columns to reduce the baseline to a usable level. This procedure was extremely time consuming. The baseline was determined to be at a usable level just prior to shutting the WMS down for the Christmas holidays. The Bendix automatic injector was found to be leaking air into the sampling chamber during the column bakeout period. Replacement parts were ordered and the injector rebuilt. The preparatory column oven and the analytical oven were shut down for the Christmas holidays, and both carrier gases were allowed to continue flowing. It was believed that this would prevent the columns from becoming contaminated; however, when the GC ovens were brought back up to operating temperature the columns showed extreme column bleed. Once again, the lengthy process of baking out the columns was begun. This process was still underway at the end of the test period. As a result, the GC only collected data for the months of July, August, and September. This fact is reflected in a very low availability.

Total Organic Carbon Analyzer

The new low temperature ultraviolet light TOC analyzer was operational for the test period. Overall the analyzer worked quite well. Stability and response time were greatly improved over the old high temperature unit. Overall maintenance time was reduced considerably. The analyzer was modified to allow for computer-controlled automatic calibration. This system consisted of two Teflon air-actuated slider valves, two pilot valves, and two microswitches.

Several problems did occur during the test period. The first problem encountered was that the sparging system was not removing all of the inorganic carbon from the sample. This problem was corrected by adding 9.1 m of 0.5 cm inside diameter tubing to increase the contact time for conversion of inorganic carbon to CO_2. Additionally, a change was made in the TOC calibration curve in the ADAM minicomputer. Two separate pump tubing failures occurred. The first of these was in the sample pump and resulted in some erroneous data. The second failure took place in the pump leading to the ultraviolet light reaction chamber. This was much more serious as it allowed the ultraviolet lamp to overheat and subsequently two of the three lamps failed. The water separator and sparger assembly developed a significant crack and had to be replaced.

Hardness Analyzer

The operation of the analyzer was hampered by one persistent problem. The analyzer was found to be very susceptible to interferences from residual chlorine levels above 0.5 mg/l. The interference effect would cause the analyzer to show excessively high (400-1,000 mg/l) values. Additionally, the high amount of lime being added in the reclamation chemical clarification process flash mixer in July and August resulted in lime accumulation in the electrode chamber. The reagent tubing in the reagent container periodically clogged with debris suspended in the reagent container. With these exceptions, the analyzer's overall performance was good during the test period. The hardness analyzer is extremely expensive to operate in terms of labor and materials costs.

Nitrate Analyzer

The nitrate analyzer's operation during the test period was limited. The main cause of the problem was the extremely high level of nitrate in the City of Palo Alto effluent. In July it was found that the analyzer was reading 9 mg/l on a sample having a lab verified value of 19 mg/l. The apparent cause was that above 9 mg/l the colormetric system was unable to differentiate darker shades of blue. A decision was made to order a new autodiluter system to return the color of the sample to a usable level. The new diluter took over 6 weeks to arrive from the manufacturer since it is a nonstock item. Once the new metricone was installed, an effort was made to immediately calibrate the analyzer and put it back on line. However, at that point a problem was discovered with the transmission of the sensor status and data signal to the ADAM minicomputer. This problem was finally resolved after several weeks of troubleshooting. Once again, an attempt was made to put the analyzer back on line. However, it was found that the sensor would not stay in calibration for more than a few hours of operation. The manufacturer was contacted in an effort to resolve this problem. It is believed that the high levels of nitrate in the samples were causing the cadmium in the reduction chamber to become spent very quickly. The test period ended before a lasting fix was found for this problem.

pH Analyzer

The Great Lakes Instrument Model 70 pH Analyzer provided good, reliable data. The sensor required calibration on an average of once a month during the test period. There wasn't any serious fouling of the probe as a result of sampling secondary effluent or the high lime content in the clarifier effluent. When the probe was removed for calibration, the electrode was checked for any accumulations of foreign material. The electrode tip was cleaned in a 0.1 N acid solution if a significant accumulation was found. For calibration, a pH standard of 7 was first used; followed by a pH standard of 10 to check the slope.

Total Residual Chlorine Analyzer

Overall the analyzer operated very well and provided reliable data throughout the test period with a minimum of problems. The only lengthy downtime the analyzer encountered was due to the unavailability of the needed reagent from the manufacturer. The manufacturer has apparently worked out a new production schedule to resolve this problem. The analyzer is fairly expensive to operate in terms of routine maintenance and consumables.

Sodium Analyzer

The Beckman Sodium Analyzer provided good data throughout the test period. However, the analyzer's flow system repeatedly clogged during the test period. This and the need to refill the zero and span standard containers on a daily basis require a high number of man-hours of effort each week. It has been found that it is necessary to disassemble and clean the flow system once a week with dilute hydrochloric acid. This is because the anhydrous ammonia used in the analyzer causes the particles in the sample to clump and settle in the flow system. The anhydrous ammonia is necessary to adjust the pH level of the sample prior to introducing it to the electrode chamber. A problem was encountered with the gravity flow system that feeds electrolyte to the analyzer's reference electrode. A pressurized system was installed and the problem resolved, except for one occasion when the reference electrode tip clogged. This was resolved by placing the tip in boiling deionized water.

Temperature Analyzer

The analyzer provided good reliable data throughout the test period except during the last week of operation when the Action-Pac amplifier failed. Additionally, the socket to which the amplifier is attached was replaced at the beginning of the test period. The probes' output was checked once each month against that from a glass thermometer inserted into the sample stream.

Turbidity Analyzer

The Sigrist Photometer Turbidimeter worked extremely well throughout the entire test period. The analyzer provided excellent data with a minimum of routine or unscheduled maintenance. The only component which failed during the test period was the replaceable light source. The only routine maintenance required by the instrument was a once-a-week cleaning of the mirror in the flow cell and a check of the calibration. The TJ25 flow cell was used throughout the test period.

Coliform Detector

Prior to the beginning of the test period, the coliform detector was reworked to the four-broth, four-buffer cell configuration as previously described. This change significantly enhanced the capability of the detector to eliminate false positive reactions caused by noncoliform bacteria. These changes were necessitated when it was discovered that several noncoliform bacteria strains found in the Reclamation Plant effluent were capable of imitating the electrode response generated by coliform bacteria.

The majority of the effort expended on the coliform detector was divided between testing the new sensor configuration and solving an internal contamination problem which will be discussed in this section.

Specially selected samples of coliform and noncoliform bacteria and mixtures of the two were tested in an extensive effort to prove the validity of the buffer cell principle. When evaluating each experiment, a 200 mv change in the buffer cell electrode was accepted as evidence of coliform growth in the nutrient cell. The buffer cells repeatedly showed negative reactions for the noncoliform bacteria strains that were producing positive reactions in the broth cells. Based on these results, it was determined that the proper operating procedure is to use the millivolt output of the buffer cells to determine the presence of coliform bacteria and to use the broth cells millivolt output results to determine the initial coliform concentrations. As an example, if the broth and buffer cells showed positive results, the time required for the broth cells to show a 200 mv change would be plotted on the calibration curve to determine the initial coliform concentration. In all instances, this additional criterion was sufficient to allow for differentiation between coliform and noncoliform samples. Consequently, the reconfiguration of the coliform sensor has been deemed a success in dealing with the problem of false positives.

One major problem that surfaced during testing of the coliform sensor was that of internal bacterial contamination. The contamination problem was evidenced by the fact that on numerous occasions a sample which was known to be sterile showed growth in the nutrient cells. It was concluded that a significant population of bacteria was surviving the sensor's normal sterilization process and resided internally within the sensor at various times. Repeated washing and flushing of the sensor with various bacteriocides reduced but did not permanently eliminate the problem.

Presently, it is believed that the contaminating bacteria have been residing either within the sensor's pneumatic valve parts or inside the Teflon lines leading to the cells. As the sliding parts of the valves began to wear and their tolerance increased, small pools of nutrient and previous samples were discovered within the valves. In many instances, the leaks were not visible from the outside of the valves until the problem was well advanced. It is also thought that a bacterial and protein matrix may have been built up inside the sensor's tubing. In either case, the proposed solution for the contamination problem is a routine schedule of replacement for the coliform sensor's internal parts. It is believed that this action, along with close monitoring of internal valve tolerances, would alleviate the contamination problem.

In conjunction with the samples mentioned thus far, more than 20 samples of reclaimed effluent were tested for coliform concentrations. No positive reactions were observed in any of the reclaimed water samples. Correlating MPN tests substantiated the coliform results. It should be noted that the permissible number of coliforms in finished reclaimed effluent is 2.2/100 ml while the lower confidence limit for the coliform sensor is approximately 10/100 ml.

Mechanically, the coliform sensor operated very well during the test period. The few instances of component failure can be attributed to the sensor's age as it had seen more than 4 years of continuous service prior to the test period. It is believed that the parts that failed did so because they had reached the end of their useful lives. The following component failures were encountered during the test period:

1. Several PVC fittings on the hot water tank failed and were replaced with stainless steel.

2. Two temperature control boards failed during the test period. In each instance a single capacitor failed and was replaced.

3. Two electrodes began to give erratic readings and were replaced.

4. Several of the pneumatic valves began to leak fluids. In each instance new bushings were installed and the valve fittings were readjusted.

Table 13 shows the number of false positives which occurred during the test period. The data show that out of 48 broth cell tests made with Reclamation Plant effluent there were 8 false positive reactions. For the same samples there were zero false positive from the buffer cells. The results are even more impressive for the City of Palo Alto secondary effluent samples. Based on these data, the broth/buffer cell configuration appears to have successfully resolved the problem of false positive reactions caused by noncoliform bacteria.

TABLE 13

COMPARISON OF COLIFORM FALSE POSITIVES

	Reclamation No. of False Positives	Effluent Reliability	Secondary No. of False Positives	Effluent Reliability
Broth Cells	8/48	83.3%	19/40	53.3%
Buffer Cells	0/48	100.0%	0/40	100.0%

Ammonia Analyzer

The analyzer provided reliable data during the majority of the test period; however, several problems did occur which hampered operation. One problem which occurred repeatedly was air bubbles blocking sample flow in the gravity feed system. This was determined to be a flaw in the design of the analyzer. The metricone motor failed in July 1980, as did the signal amplifier unit. A problem with the colorimetric system was found in February 1981. The proper color change was not taking place in the flow system. The problem was traced to the pH value of the sodium hypochlorite reagent which was below the acceptable range of 7-8. The pH was adjusted upwards and the analyzer calibrated. The procedure for preparation of the reagent was modified to verify the pH of the sodium hypochlorite before preparing the reagent.

The analyzer is equipped with the WMS autostandardization system and was automatically calibrated once each day. Because of the frequency of reagent preparation,the analyzer was quite labor intensive.

Conductivity Analyzer

The Beckman analyzer performed throughout the test period without any significant problems. Periodically the flow cell was removed from the flow system and checked for buildup on the cell walls. The values were routinely compared with the two conductivity analyzers in the laboratory at the reclamation facility.

Dissolved Oxygen Analyzer

The Delta Scientific analyzer performed reliably throughout the test period without any major problems. One Teflon electrode membrane failure occurred. The calibration of the analyzer was routinely checked using a Hach wet chemistry dissolved oxygen kit.

Deionized Water System

The system reliably provided high quality deionized water to the various parts of the WMS. The one problem which periodically occurred was bacteria contamination in the reverse osmosis storage tanks. As a result of this contamination it was necessary to sanitize the entire system once every 30 days. The RO60 reverse osmosis cartridge was found to have a useful life of 6 months with the available tap water. This is approximately one-half the expected useful life. The recommended procedure for storing the reverse osmosis cartridge during an extended shutdown period calls for shutting off the tap water flow to the cartridge and placing it in a formaldehyde solution. This procedure did not seem to work satisfactorily for the 2 week shutdown at Christmas. It was found that the best procedure was to leave the tap water flowing and run the effluent from the cartridge to the drain.

Data Acquisition and Report Generation System

Numerous hardware failures occurred for both computer systems during the test period. Some were hard failures and could easily be traced to printed circuit boards for the peripheral device control interfaces such as A/D, terminals and the magnetic tape unit. In addition, one computer memory board failure occurred on the average of every 3 months. Other failures were intermittent and could not be isolated to either software or hardware when one of the computers would halt. On the average, one failure occurred every week that resulted in approximately 16 hours downtime, although normally 8 hours per week can be expected.

Except for one software error in the NOVA 3D operating system that produced intermittent computer halts throughout the test period and was corrected in February 1981, all the failures could be traced to the hardware. A substantial number of failures were directly the result of poor electrical contacts. This problem may have been aggravated by the instances of chlorine gas entering within the WMS trailer when the WRF/PA had an equipment failure. The computer equipment is approaching the limit of its useful lifetime and can be expected to fail more frequently.

Some downtime was associated with software development activities during August 1980 and cannot be realistically charged to equipment availability. Also, the failures in January 1981 were the direct result of the equipment being turned off during the last 2 weeks of 1980. If these times are not considered, the average downtime is reduced to 5.5 hours per week.

WMS Availability

WMS availability (percent of time the subsystems/sensors operated on demand) was monitored during the test period. The operating time and downtime periods for each of these are summarized in Table 14. The downtime recorded for each of the sensors/subsystems includes actual repair times and downtime attributed to waiting for necessary reagents or parts.

TABLE 14

WMS AVAILABILITY/RELIABILITY

WMS OPERATING ELEMENTS	DOWN TIME (HRS)/ OPERATING TIME (HRS)/	(%) AVAILABILITY	ERRONEOUS DATA (HRS)/ TOTAL DATA (HRS)	(%) RELIABILITY	SIGNIFICANT PROBLEM(S)
Sampling System	11/3931	99.7	246/3916	94.5	Periodic Plant Process Upsets
Computer System	551/4454	87.6	371/3903	90.5	Printed Circuit Board Failures
Biosensor	171/3633	95.3	110/3418	96.8	None
Coliform Detector	17[1]/97[1]	82.5	0/88	----	Contamination and Hardware Failures
TOC	355/3553	90.0	148/3111	95.2	Failure of UV Lamps
Residual Chlorine	870/3672	76.3	15/2994	99.5	Temporary Unavailability of Reagent
Turbidity	1/3739	99.9	4/3737	99.9	None
D.O.	2/3729	99.9	20/3724	99.5	None
Ammonia	267/3324	92.0	448/3055	85.3	Pump and Valve Failures, Reagent Problems
Nitrate/ Nitrite	3366/3587	6.2	39/221	82.4	Cadmium Reduction System Malfunction
pH	3/3764	99.9	48/3744	98.7	None
Conductivity	0/3770	100.0	3/3753	99.9	None
Temperature	38/3762	99.0	11/3719	99.7	Corrosion of Contacts in Socket
Hardness	84/3504	97.6	1249/3420	63.5	Interference of Residual Chlorine

TABLE 14 (Continued)

Sodium	100/3689	97.3	259/3591	92.8	Buildup of Debris in Electrode Holder
G.C.	2613/3635	28.1	100/1022	90.2	Column Bleed in Preparatory G.C.
D.I. Water	271/5447	95.0	0/5282	----	None
A.C. System[2]	3/5832	99.9	0/5756	----	None

NOTE:

[1]Coliform Detector Operations and Downtime Reported in Days.

[2]A. C. System is a dual unit, each independent of the other.

WMS Reliability

Sensor/subsystem reliability (percent of operating time the data generated were valid) is summarized in Table 14. These values are calculated based on the number of hourly averages determined to be erroneous divided by the total number of hourly averages recorded. This calculation was made for each individual sensor/subsystem.

WMS Operations and Maintenance Cost Summary

This section deals with the operations and maintenance costs for each of the sensors/subsystems. This is intended to cover all consumables, hardware and labor required for 8 months of continuous operation. This cost estimate is based on actual expenses incurred during the test period and as such may vary depending on the age of the hardware. An additional goal of the program was to determine, when possible, the life expectancy of the various subsystems. These data where available are reported in Appendix G.

The O&M costs for the sensors/subsystems of the WMS are summarized in Table 15. Extrapolation of these data gives a projected annual O&M cost of $94,125.

The distribution of costs may be summarized as follows:

	Labor	Materials	Total
Operations	18.0%	4.9%	22.9%
Maintenance	57.6%	19.5%	77.1%
Total	75.6%	24.4%	100.0%

These calculations are based on the detailed data contained in Appendix G. Appendix G additionally contains a list of the recommended spares for each sensor/subsystem.

TABLE 15

OPERATIONS AND MAINTENANCE COST OF
WATER MONITOR SYSTEM

JULY 1, 1980 THROUGH FEBRUARY 23, 1981

1/	Operations	Maintenance	Totals
Sampling System			
Materials and Supplies	$ 340	$ 220	560
Labor	300	190	490
Computer System			
Materials and Supplies	1070	2230	3300
Labor	4140	13600	17740
Biosensor			
Materials and Supplies	180	240	420
Labor	450	2080	2530
Coliform Detector			
Materials and Supplies	300	470	770
Labor	2900	3070	5970
Gas Chromatograph			
Materials and Supplies	200	670	870
Labor	1380	4500	5880
TOC Analyzer			
Materials and Supplies	790	940	1730
Labor	340	860	1200
Residual Chlorine Analyzer			
Materials and Supplies		1480	1480
Labor	70	1370	1440
Turbidity Analyzer			
Materials and Supplies		60	60
Labor	60	110	170
Dissolved Oxygen Analyzer			
Materials and Supplies		100	100
Labor	30	110	140
Ammonia Analyzer			
Materials and Supplies		790	790
Labor	570	4320	4890
Nitrate/Nitrite Analyzer			
Materials and Supplies		960	960
Labor	220	1500	1720
pH Analyzer			
Materials and Supplies		50	50
Labor	60	220	280
Conductivity Analyzer			
Materials and Supplies			
Labor		110	110
Temperature Analyzer			
Materials and Supplies		130	130
Labor	20	110	130

TABLE 15 (Continued)

Hardness Analyzer			
Materials and Supplies		1950	1950
Labor	140	1830	1970
Sodium Analyzer			
Materials and Supplies	200	150	350
Labor	400	1890	2290
Deionized Water System			
Materials and Supplies		1370	1370
Labor	240	270	510
General Lab Supplies		400	400
TOTALS	$14,400	$48,350	$62,750

Projected Yearly O&M Cost = $94,125

1/ NOTE:

Labor costs of $37/hr. for engineering; $27/hr. for all others.

2/ NOTE:

Includes operator time for implementing new software.

Summary

As previously mentioned, the purpose for developmental systems is to identify problems before committing to the design of an operational system. The experience with the WMS has shown that the following will be key considerations when building reliable and inexpensive operational systems:

1. The ideal sensor: is an electrode; can be located in the sample; requires no reagents; is not subject to interference from other constituents in the sample; is fail-safe; i.e., it fails in a readily identifiable manner; is easily maintained; is rugged; has proven reliability in a variety of applications; resists fouling by solids or grease; is stable for long periods without calibration; does not require sample preconditioning, i.e., filtering, concentration, fixed flow rate, etc.; does not require complex electronics for control or signal conditioning; provides a direct continuous readout of a controllable parameter. Most water quality sensors do not meet all these specifications. Some conductivity cells and dissolved oxygen electrodes which are available on the market meet many of these requirements. Most other sensors introduce complexities which must be managed.

2. Colorimetric procedures and gravity flow through small tubing should be avoided in unattended automated sensor applications.

3. Operators should be trained to understand the significance of each measurement and the failure modes of the sensors. Competent vendors will provide such detailed information on the characteristics of their sensors. The comprehensiveness of the vendor's operating manual is often a good indicator of the quality of the product.

4. Sensors utilizing proprietary reagents should be avoided unless a contracted delivery schedule is prearranged.

5. The system design should provide fault detection, alarm, and alternate operating modes for significant failure modes:

   a. Loss of sample.

   b. Air in sample (where it interferes with the analyses).

   c. Loss of sensor sensitivity, i.e., reagent, sample, etc.

   d. Filter plugging.

   e. Erroneous data.

6. Automatic standardization is a necessary requirement for unattended operation of most chemical sensors.

7. Computer systems hardware and software should be provided with error detection and correction capability. The ability to detect and correct single bit errors in the computer main memory can substantially increase reliability.

8. Direct memory access or high speed I/O channel programs should be provided when communicating with other computer systems. This will allow data to be transferred directly into main memory rather than a less reliable transfer by an applications program via a low speed device, i.e., RS232.

9. Dial-up/auto-answer communications provide the capability for remote failure diagnosis. Troubleshooting thereby can be accomplished without specialists being retained on-site.

DATA PROCESSING

In addition to the real-time data display and trend plotting, the EVE report generation system has data processing capability for a lognormal distribution analysis and a linear regression analysis. A lognormal distribution was chosen to interpret the data obtained from monitoring based on the study performed by McCarty, et al, at Stanford University (reference 3). The Stanford study evaluated parameters for several probability models using various sets of organic and inorganic concentration data from Water Factory 21 in Orange County, California. Models for normal and lognormal probability distributions were selected for analysis because they produced reasonable data fits and provided ease of statistical interpretation. It was concluded that the lognormal distribution adequately represented the results at least 92% of the time and thus provided an adequate description of the probability for organic and inorganic materials at Water Factory 21. (The lognormal distribution was rejected for only ammonia and conductivity.)

Verification of the validity of the lognormal distribution is provided in the Stanford study, and no attempt was made to consider other probability models for this study. The lognormal distribution has a strong theoretical justification based on the assumption that fluctuations are proportional rather than additive. The chi square statistic was determined for each parameter as a method to evaluate the validity of the lognormal distribution and determine if the data were normally distributed. The results indicate a high correlation exists for most parameters.

A linear regression analysis was performed on all monitored data to evaluate the relationship between parameters across the reclamation plant and among processes. The least-square line obtained by the linear regression allows a determination of the standard error of estimate and the coefficient of correlation and thus provides a means of evaluating the direct dependence of the variables.

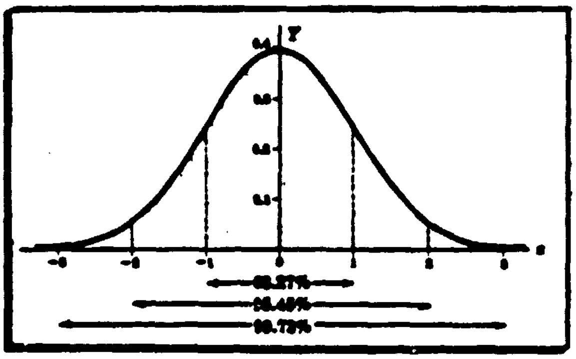
Characteristics of the Lognormal Distribution

Normally distributed data will plot as a straight line on probability paper if the ordinate scale is arithmetic, while lognormally distributed data will plot as a straight line if the ordinate scale is logarithmic. Normal distribution is one of the most important examples of continuous probability distribution and is defined by the following equation (reference 6):

$$Y = \frac{1}{\sigma\sqrt{2\pi}} e^{-(X-\mu)^2/2\sigma^2}$$

Where μ = mean, σ = standard deviation, and X is expressed in standard units with $Z = (X-\mu)/\sigma$

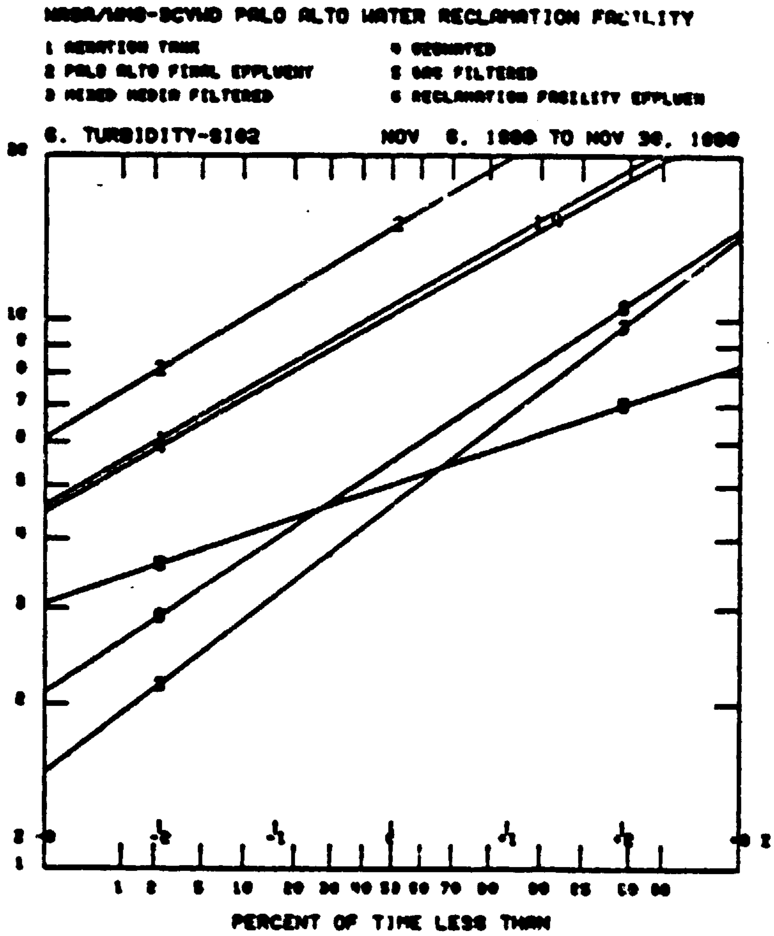
In such cases, Z is normally distributed with mean zero and variance 1. A graph of the standardized normal curve is shown below with the areas included between Z = -1 and +1, Z = -2 and +2, and Z = -3 and +3 as equal to 68.27%, 95.45%, and 99.73% of the total area under the curve which is one.



In order to analyze a set of data, the average and standard deviation of the logs are determined by common statistical procedures. The average so obtained represents the intercept, and the standard deviation represents the slope of the regression line for the lognormal distribution.

Computer plots of these results were generated for each parameter and for each period of interest. A representation of a typical result is shown in the following figure. The ordinate presents the log over the data range and the abscissa presents the percentage of time the total population was less than the measured value. The Percent of Time Less Than corresponds to the probability of occurrence for a measured value. The data range represents the daily average obtained from the hourly average which was determined from sample rates of 1 minute for all measurements with the exception of the G.C. and biomass measurements, which were recorded once each hour.

It should be noted that in the heading, on the following figure, the reclamation plant influent (Palo Alto final effluent) is sample source #2 and not #1. This is because prior to this test period, sample source #1 was primary effluent, and the aeration tank was not a sampling point. Since a large amount of data had been collected and stored on computer tape, it was decided to leave the Palo Alto final effluent as sample source #2 so as not to hinder statistical analysis of the historical data.



SAMPLE SOURCE	MONTHLY AVERAGE		ONE SIGMA		LOG(Y)=F(Z) SLOPE		LOG(Y)=F(Z) INTERCEPT		SAMPLE SIZE
1	0.1100E	2	0.3104E	1	0.1218E	0	0.1004E	1	16
2	0.1520E	2	0.4[illegible]	1	0.1273E	0	0.1167E	1	16
3	0.5[illegible]E	1	0.2[illegible]E	1	0.1632E	0	0.[illegible]E	0	16
4	0.1055E	2	0.2[illegible]E	1	0.1203E	0	0.1010E	1	16
5	0.5[illegible]E	1	0.[illegible]E	0	[illegible]	-1	0.7015E	0	16
6	0.3[illegible]E	1	0.2[illegible]E	1	0.14[illegible]E	0	0.7[illegible]E	0	22

The Z-score is also shown on the abscissa for comparison. The 50% or zero value for Z represents the geometric mean. This plot is a good example of the waterfall decrease in the dependent variable across each process and readily shows the range of data for the report period.

The normal distribution function Q(x) is defined by Hasting's best approximate equation (reference 7),

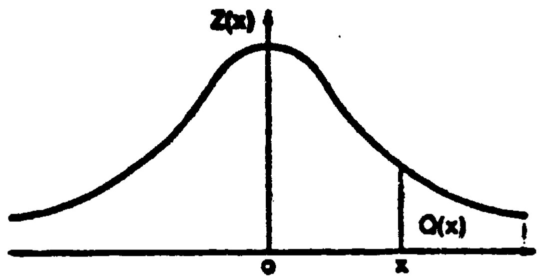
$$Z(x) = \frac{\epsilon^{-x^2/2}}{\sqrt{2\pi}}$$

$$Q(x) = Z(x)[b_1t + b_2t^2 + b_3t^3 + b_4t^4 + b_5t^5]$$

$$t = \frac{1}{1 + px}$$

$p = .231642$	$b_3 = 1.78148$
$b_1 = .319382$	$b_4 = -1.82126$
$b_2 = -.356564$	$b_5 = 1.33027$

where Q(x) = area under the standardized normal curve from 0 to +Z



The test for normality or goodness of fit is based on the χ^2 (chi square) distribution at the 95% confidence level for 2 degrees of freedom,

$$\chi^2_{.95} = 5.99 \text{ (based on Z being a function of } \mu \text{ and } \sigma\text{)}$$

$$\text{where } \chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

f_o = observed or actual frequency

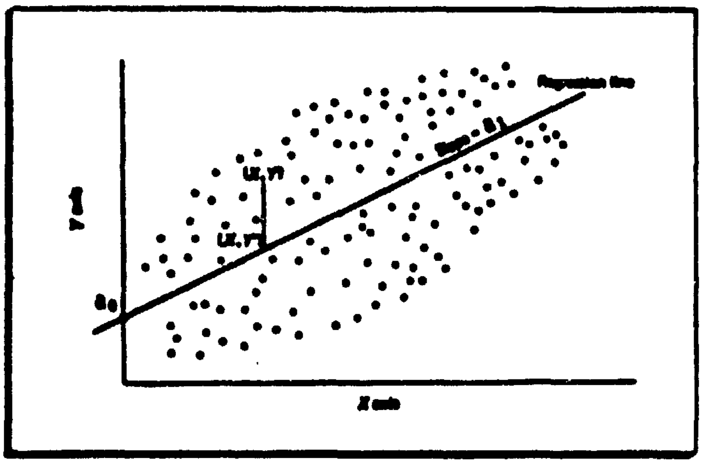
f_e = estimated frequency based on a normal distribution

The chi square statistic has been calculated for each parameter at each sample point to evaluate the goodness of fit to the postulated lognormal distribution. There is only one chance in twenty of chi square exceeding 5.99 if the data are normally distributed. Thus, the lognormal distribution model may be rejected with 95% confidence when the value exceeds 5.99. Much of the data presented in this report is adequately described by a lognormal distribution, however, there are exceptions, as shown in Appendix D.

Characteristics of the Linear Regression

In a linear regression analysis, values of the dependent variable are predicted from a linear function of the form

Where Y' is the estimated value of the dependent variable Y; the constant a (referred to as the Y intercept) is the point at which the regression line crosses the Y axis and represents the predicted value of Y when X = 0; and the constant a (usually referred to as the regression coefficient) is the slope of the regression line and indicates the expected change in Y with a one-unit change in X (reference 7).



The regression method involves the evaluation of a and a in such a way that the sum of the squared residual is smaller than any possible alternative values, i.e.;

$$(Y - Y')^2 = \text{minimum}$$

where $Y - Y'$ = residual or difference between the actual and estimated value of Y for each case

The optimum values of a and a are obtained from

$$a_1 = \frac{\Sigma(X - \bar{X})(Y - \bar{Y})}{\Sigma(X - \bar{X})^2} = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{N\Sigma X^2 - (\Sigma X)^2}$$

$$a_0 = \bar{Y} - a_1\bar{X} = \frac{(\Sigma Y)(\Sigma X^2) - (\Sigma X)(\Sigma XY)}{N\Sigma X^2 - (\Sigma X)^2}$$

The Standard Error of Estimate is a measure of the accuracy of the prediction equation. It is the standard deviation of actual Y values from the predicted Y' values or

$$\sigma_E = \text{Standard Error} = \sqrt{\frac{\Sigma(Y - Y')^2}{N - 2}}$$

The Standard Error is interpreted as the "average residual."

The linear correlation coefficient is the ratio of the explained variation to the total variation or

$$r = \sqrt{\frac{\text{explained variation}}{\text{total variation}}} = \sqrt{\frac{\Sigma(Yest - \bar{Y})^2}{\Sigma(Y - \bar{Y})^2}}$$

where Yest = estimated value obtained from linear regression

$\bar{Y}$ = average of dependent variable

Y = dependent variable

and is determined by

$$r = \frac{m\sqrt{\sigma x}}{\sqrt{\sigma y}}$$

where m = slope of regression line

σx = standard deviation of independent variable

σy = standard deviation of dependent variable

Results of the regression analysis for the report periods are presented in Appendix A. Linear ($Y = a + a X$), parabolic ($Y = a + a X + a X$), and logarithmic ($\text{Log}Y = a + a \text{Log}X$) regressions were performed for each parameter across each process and across the reclamation plant. Results indicate that linear and logarithmic regressions generally provide a good prediction for the downstream parameter. In some cases, particularly for the halocarbons and total organic carbon, the logarithmic regression produced a superior improvement in the correlation coefficient compared to the linear and parabolic regressions.

A typical example of a statistical summary and regression analysis is shown in Tables 16 and 17. The monthly average is determined from the hourly averages. The daily average variation is the standard deviation of the daily averages. The hourly average variation is the standard deviation of the hourly averages. The percent removal is determined from

$$\% \text{ removal} = \frac{I - 0}{I} \times 100\%$$

where I = influent value

0 = effluent value

for sample source 1 to 6 across the plant. The percent removal across each process is determined from

$$\% \text{ removal} = \frac{(I - 0)\text{process}}{(I - 0)\text{plant}} \times 100\%$$

where (I-0)plant = measured concentration removal across the plant

(I-0)proccess = measured concentration removal across the process

In this manner, the removal efficiency of each process can be compared for the plant.

TABLE 16 SAMPLE STATISTICAL DATA

STATISTICAL DATA FOR SEP 3, 1980 TO FEB 28, 1981

SAMPLE SOURCE 1 - PALO ALTO SECONDARY EFFLUENT

CHA	SENSOR	UNITS	SAMPLING FREQUENCY	MONTHLY AVERAGE	DAILY AVG VARIATION	HOURLY AVG VARIATION
1.	TOTAL BIOMASS	MIL C/ML	97	2.016	1.1199	1.7654
2.	VIABLE BIOMASS	MIL C/ML	99	0.559	0.3026	0.5906
5.	RES CHLORINE	MG/L	91	4.034	1.9418	2.0983
6.	TURBIDITY-SIO2	MG/L	114	13.050	5.1524	5.9096
7.	DIS OXYGEN	MG/L	114	6.167	1.0291	1.9818
10.	AMMONIA	MG/L	88	5.141	10.1695	13.4274
11.	NITRATE	MG/L	1	224.087	0.0000	0.0000
12.	PH	PH	115	5.601	0.4526	0.5157
13.	TOT ORG CARBON	MG/L	96	9.742	2.4224	2.8073
14.	CONDUCTIVITY	MMMHO/CM	115	1234.413	62.6263	110.6204
15.	TEMPERATURE#1	DEG F	114	71.576	2.4593	3.4832
16.	HARDNESS	MG/L	88	327.246	334.3398	390.5041
17.	SODIUM	MG/L	108	158.729	12.6491	16.5998
20.	AMBIENT TEMP	DEG F	123	73.063	1.7708	3.0392
29.	TOT HALOCARBON	PPB	29	92.881	117.4967	159.5066

SAMPLE SOURCE 6 - RECLAMATION FACILITY EFFLUENT

CHA	SENSOR	UNITS	SAMPLING FREQUENCY	MONTHLY AVERAGE	DAILY AVG VARIATION	HOURLY AVG VARIATION	PERCENT REMOVAL DAILY AVG	PERCENT REMOVAL STD DEV
1.	TOTAL BIOMASS	MIL C/ML	115	0.295	0.4231	0.8168	85.38	26.53
2.	VIABLE BIOMASS	MIL C/ML	116	0.141	0.3947	0.6425	74.84	120.17
5.	RES CHLORINE	MG/L	104	2.022	1.1813	2.1562	49.88	47.73
6.	TURBIDITY-SIO2	MG/L	138	4.682	1.7975	3.9064	64.22	18.61
7.	DIS OXYGEN	MG/L	138	6.191	1.6235	1.4985	-0.39	34.39
10.	AMMONIA	MG/L	97	4.215	12.7591	8.1426	18.01	79.43
11.	NITRATE	MG/L	3	16.479	9.0534	9.0534	0.00	0.00
12.	PH	PH	138	6.480	0.5129	0.4489	-0.55	0.87
13.	TOT ORG CARBON	MG/L	106	3.750	1.3529	1.2533	61.51	15.05
14.	CONDUCTIVITY	MMMHO/CM	138	1313.281	65.5476	75.7599	-6.39	5.09
15.	TEMPERATURE#1	DEG F	137	71.301	1.7635	1.9501	0.00	0.00
16.	HARDNESS	MG/L	89	390.219	306.4944	332.9058	-19.24	83.13
17.	SODIUM	MG/L	130	153.705	13.1527	15.5863	0.00	0.00
20.	AMBIENT TEMP	DEG F	147	73.149	2.2023	2.6701	0.00	0.00
29.	TOT HALOCARBON	PPB	28	106.872	103.9368	164.2026	-15.06	52.13

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TABLE 17 SAMPLE REGRESSION ANALYSIS

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.2141	0.0400	0.4055	0.1124	92
2.	VIABLE BIOMASS	MIL C/ML	0.1577	-0.0368	0.3941	0.0291	93
5.	RES CHLORINE	MG/L	1.7591	0.0312	1.0366	0.1402	87
6.	TURBIDITY-SIO2	MG/L	4.4161	0.0015	1.4065	0.1627	109
7.	DIS OXYGEN	MG/L	2.6072	0.5467	1.1081	0.6637	109
10.	AMMONIA	MG/L	-1.0724	1.0158	4.6096	0.8964	75
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0
12.	PH	PH	4.0657	0.3535	0.4493	0.3327	110
13.	TOT ORG CARBON	MG/L	1.5039	0.2310	1.3211	0.3777	87
14.	CONDUCTIVITY	MMHO/CM	551.0430	0.6210	56.2356	0.5751	110
15.	TEMPERATURE#1	DEG F	30.3030	0.5749	1.1896	0.7604	109
16.	HARDNESS	MG/L	175.3407	0.6246	230.5027	0.7105	56
17.	SODIUM	MG/L	49.4841	0.6430	0.4651	0.6913	104
20.	AMBIENT TEMP	DEG F	20.7091	0.7181	1.0060	0.7813	119
29.	TOT HALOCARBON	PPB	15.9007	0.9306	20.5553	0.9720	22

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.1043	0.1523	-0.0216	0.4032	0.1547
2.	VIABLE BIOMASS	MIL C/ML	0.1541	-0.0222	-0.0113	0.3941	0.0298
5.	RES CHLORINE	MG/L	1.2779	0.2494	-0.0242	1.0254	0.2019
6.	TURBIDITY-SIO2	MG/L	2.1270	0.3504	-0.0117	1.4407	0.2925
7.	DIS OXYGEN	MG/L	4.2649	-0.0540	0.0517	1.0877	0.6789
10.	AMMONIA	MG/L	-0.2070	0.6453	0.0088	4.5430	0.8993
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	-0.6066	4.4506	-0.3235	0.4266	0.5146
13.	TOT ORG CARBON	MG/L	7.3318	-0.8341	0.0456	1.2102	0.5297
14.	CONDUCTIVITY	MMHO/CM	-3142.5810	6.6745	-0.0025	53.3058	0.6314
15.	TEMPERATURE#1	DEG F	-129.0141	4.9116	-0.0294	1.0383	0.8310
16.	HARDNESS	MG/L	-37.9160	1.5098	-0.0004	208.3962	0.7941
17.	SODIUM	MG/L	-279.7527	4.7522	-0.0126	8.0106	0.7297
20.	AMBIENT TEMP	DEG F	151.2825	-2.0750	0.0207	1.0012	0.7837
29.	TOT HALOCARBON	PPB	19.3210	0.8472	0.0002	20.4795	0.9722

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.6996	0.2628	0.2500	0.4833
2.	VIABLE BIOMASS	MIL C/ML	-1.0099	0.3956	0.3897	0.6575
5.	RES CHLORINE	MG/L	0.0674	0.2346	0.2836	0.3904
6.	TURBIDITY-SIO2	MG/L	0.4964	0.1155	0.1314	0.3497
7.	DIS OXYGEN	MG/L	0.4108	0.4641	0.0880	0.6431
10.	AMMONIA	MG/L	-0.1634	0.8007	0.3558	0.8683
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	0.4067	0.3927	0.0308	0.3939
13.	TOT ORG CARBON	MG/L	0.2524	0.3075	0.1325	0.2588
14.	CONDUCTIVITY	MMHO/CM	1.3144	0.5839	0.0188	0.5659
15.	TEMPERATURE#1	DEG F	0.7571	0.5917	0.3071	0.7682
16.	HARDNESS	MG/L	0.9152	0.6520	0.1050	0.6922
17.	SODIUM	MG/L	0.4393	0.7043	0.0234	0.7036
20.	AMBIENT TEMP	DEG F	0.5609	0.6994	0.0060	0.7618
29.	TOT HALOCARBON	PPB	0.0769	1.0003	0.1527	0.9806

RECLAMATION PLANT/PROCESS PERFORMANCE EVALUATION

This portion of the report was originally intended to describe the steady-state performance of the plant beginning in July 1980 through the end of February 1981. As shown in Table 18, the reclamation plant influent, effluent from the secondary treatment process, changed during this period from that for which the reclamation plant was originally designed; i.e., activated sludge to fixed-film reactor (deep trickling or roughing filter)/nitrification/dual-media filtration. These changes were in the process of stabilization for much of the summer of 1980. Also, once stabilized, these changes had a substantial effect on concentration levels of certain water quality parameters in the reclamation plant influent.

Thus, in order to provide the desired steady-state performance data which are representative of plant capability, the results of two different periods, A and H, are presented. Plant and influent processing during these two test periods is shown in Table 18. In some respects, period H, even though only a 1-month period, may be more representative than period A of conditions normally present in tertiary treatment. The configuration differences of these two periods are summarized below:

	Period A	Period H
Influent Processing		
Activated Sludge		X
Fixed-Film Reactor/ Nitrification/ Dual-Media Filtration	X	
Granular Activated Carbon		
New		X
Exhausted	X	
Chemical Clarification		
pH 9.5		X
pH 11	X	

Presented below are plant and process input/output data for periods A and H, plant and process availability and O&M costs as measured for the 8-month period beginning July 1, 1980, through February 28, 1981, and plant reliability for the two test periods.

Table 18 Process Configurations for Test Periods

		RECLAMATION PLANT INFLUENT PROCESSING							RECLAMATION PLANT PROCESSES								
TEST PERIOD SYMBOL	TEST PERIOD	PRIMARY SETTLING	FIXED FILM REACTOR	AERATION (ACTIVATED SLUDGE)	AERATION (NITRIFICATION)	CLARIFICATION	DUAL MEDIA FILTRATION	CHLORINATION	CHEMICAL CLARIFICATION PH	AERATION	RECARBONATION	MIXED MEDIA FILTRATION	OZONE DOSAGE, MG/L	GAC UNIT	MIXED MEDIA FILTRATION	CHLORINE DOSAGE, MG/L	RECLAMATION PLANT FLOW, MGD
A	09/03/80 - 02/28/81	x	x		x	x	x	x	11	-	x	x	4	1,2,4	x	2	1.5
B	05/07/80 - 08/28/80	x	x		x	x	-	x	11	-	x	x	4	1,2,4	x	2	1.5
C	02/12/80 - 05/06/80	x	-	x		x	-	x	11	-	x	x	4	1,2,4	x	2	1.5
D	11/11/79 - 02/11/80	x	-	x		x	-	x	11	x	x	x	-	4	x	3	1.5
E	10/08/79 - 11/10/79	x →	→	x →	→	x →	1/2 FLOW → (both streams)	→	11	x	x	x	-	4	x	2	2.0
F	08/11/79 - 10/08/79	x	-	x		x	-	-	11	x	x	x	-	3,4	x	3	1.0
G	05/21/79 - 07/28/79	x	-	x		x	-	x	11	x	x	-	-	3,4	x	4	1.0
H	03/21/79 - 05/02/79	x	-	x		x	-	x	9.5	-	x	x	5	3,4	x	4	1.0
I	11/28/78 - 03/19/79	x	-	x		x	-	x	-	-	-	x	11	2	x	5	0.5
J	11/13/78 - 11/27/78	x	-	x		x	-	x	-	-	-	x	11	1	x	5	0.4
K	6/11/78 - 9/30/78	x	-	x		x	-	x	11	x	x	x	11	1	x	5	0.2-0.8
L	4/1 /78 - 6/10/78	x	-	x		x	-	x	-	-	-	x	11	1	x	5	0.5
M	1/1/78 - 3/30/78	x	-	x		x	-	x	11	x	x	x	11	1	x	5	0.5

Input/Output

Figure 39 shows the location of sampling points in the process stream and the sampling schedule. Plant influent and effluent concentrations for the two test periods are summarized in Table 19. It should be noted that for period A, the pH of the influent was significantly lower because of nitrification at the city plant.

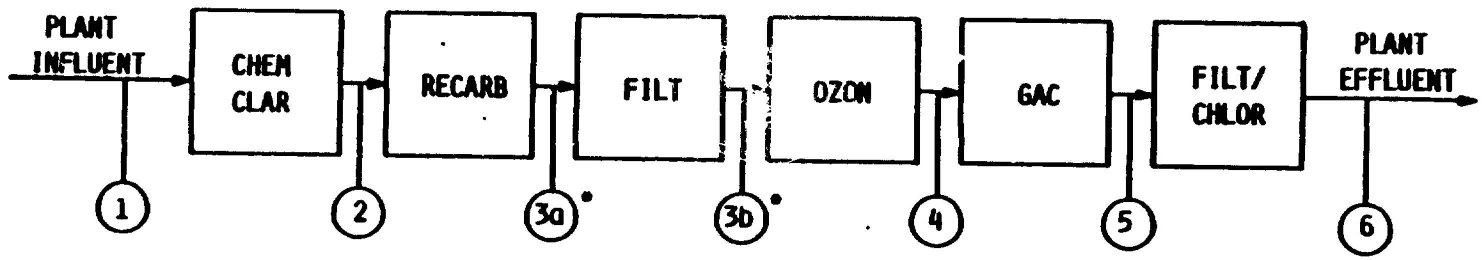
The percentage change in concentration across each of the processes is shown in Table 20. The change in a parameter as the water flows through each process can be followed horizontally, from left to right, for both test periods. Large negative values indicate that the process caused a significant reduction of this constituent. The overall effectiveness of each of the processes can be judged by examining the numbers vertically. It is readily apparent from this table that the chemical clarification and activated carbon sorption processes had the greatest influence on changes in water quality.

The results of a statistical analysis of process performance are presented for each WMS parameter in Figures 40 through 59. The upper graph compares plant input to output for the two test periods based on a lognormal distribution model and a $\pm 3\sigma$ data range (99.7% of the data). The plot also shows results of measurements made on primary effluent during the H test period, thus providing a graphic illustration of total treatment results beginning with settled raw wastewater through secondary treatment and, finally, through tertiary treatment. Additionally, comparison of the reclamation plant influent data for the two test periods shows the differences in performance of the secondary processes in each of the test periods.

The data displayed in the bottom graphs show process performance and were developed by a linear least-squares fit of each process output as a function of plant influent concentration based on a log-log model; i.e., $\log O = m \log I + b$. The results of this analysis are plotted in terms of percent removal and output/input for the influent concentration range indicated by the above lognormal distribution. The resulting curves allow the reader to follow a parameter through the plant (sampling points are consecutively numbered) and determine the cumulative contaminant removal as water progressed from process to process.

Figure 40, for example, shows in the upper graph the statistical distribution of the measured total biomass in the plant influent and effluent for test periods A and H. Total biomass in the primary effluent is also shown. The plotted curve illustrates how often the measured data were less than a particular value. Ideally there were an equal number of data points above and below the 50% point which is thus the mean of the data population. The variation of the data is reflected by the slope of the curve, where a horizontal line indicates that there was no variation. As a further illustration of the interpretation of these plots, the lower graphs in Figure 40 show the contribution of individual processes to contaminant removal. The period A results showed, for example, that most all the biomass in the influent was removed in chemical clarification, whereas the subsequent process, mixed media filtration, introduced additional biomass into the water stream, indicating that bacteria are growing and being continually eluted from the filter media.

SAMPLING POINTS



SAMPLING TIME ~ HOUR OF DAY

1	2	3a	3b	4	5	6
3	2	4	4	5	6	1
9	8	10	10	11	12	7
15	14	16	16	17	18	13
21	20	22	22	23	24	19

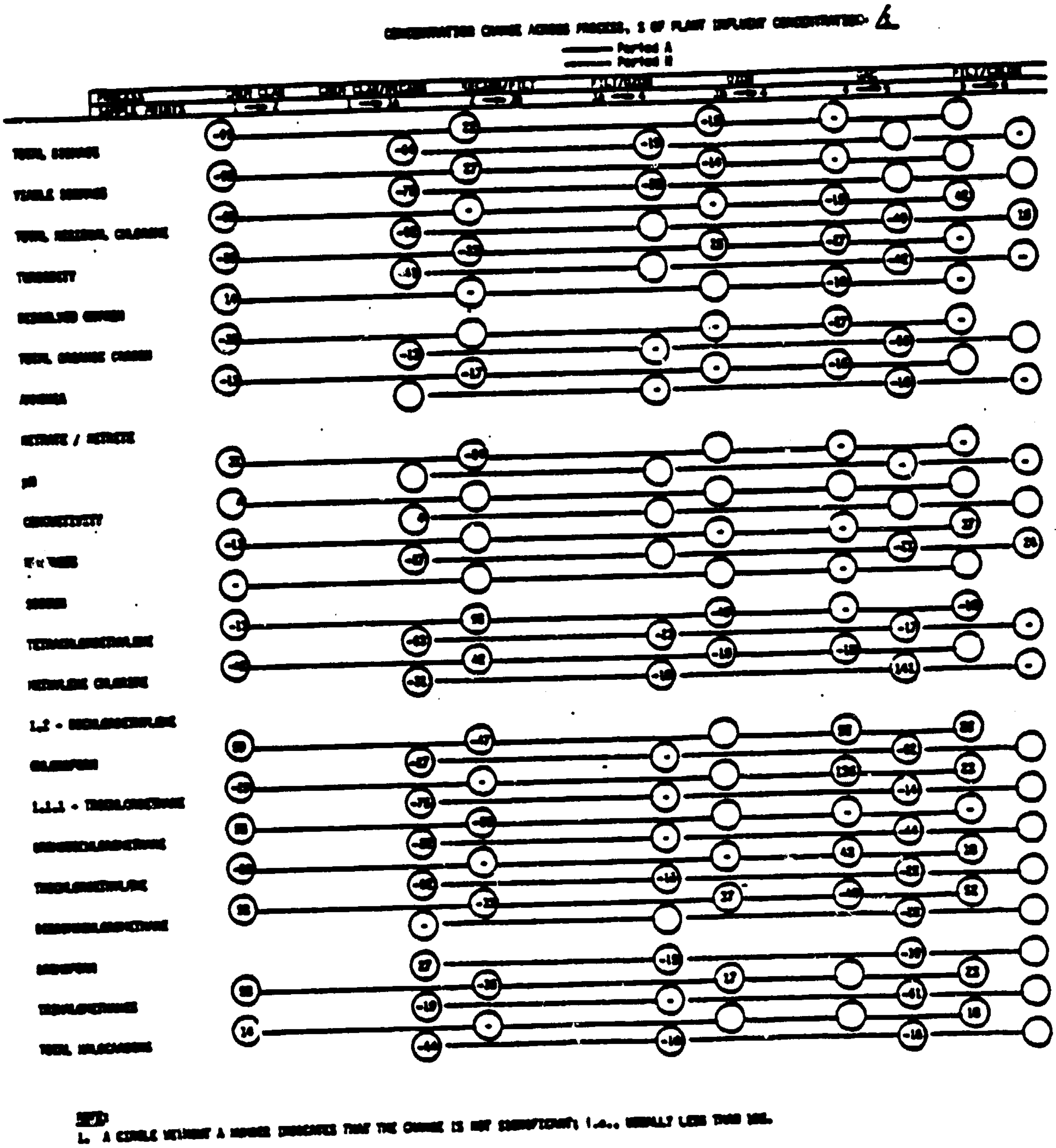
* SAMPLING POINT 3a WAS ACTIVE BEFORE JULY 11, 1980 (INCLUDING TEST PERIOD H).
SAMPLING POINT 3b WAS ACTIVE BEGINNING JULY 11, 1980 (INCLUDING TEST PERIOD A).

Figure 39 **Sampling Schedule**

TABLE 19 PLANT PERFORMANCE FOR TWO TEST PERIODS (GEOMETRIC MEAN)

		PERIOD A			PERIOD H		
		INFLUENT	EFFLUENT	% CHANGE	INFLUENT	EFFLUENT	% CHANGE
TOTAL BIOMASS	mc/ml	1.7	0.2	-87.2	13.8	2.4	-82.4
VIABLE BIOMASS	mc/ml	0.4	0.1	-84.0	3.1	0.2	-92.9
TOTAL RESIDUAL CHLORINE	mg/L	3.5	1.7	-53.0	9.5	1.9	-79.9
TURBIDITY	mg/L	12.9	4.4	-65.8	18.8	2.9	-84.4
DISSOLVED OXYGEN	mg/L	5.8	6.0	2.4	-	-	-
TOTAL ORGANIC CARBON	mg/l	9.4	3.6	-62.2	13.8	3.3	-76.4
AMMONIA	mg/l	2.4	1.3	-43.5	18.7	16.4	-12.7
NITRATE / NITRITE	mg/l	SENSOR NOT ON LINE					
pH	pH	5.6	6.1	8.5	7.0	7.2	2.7
CONDUCTIVITY	μmho/cm	1233.	1312.	6.4	1466.	1560.	6.4
HARDNESS	mg/l	269.	327.	21.3	367.	296.	-19.5
SODIUM	mg/l	158.	153.	-3.2	-	-	-
TETRACHLOROETHYLENE	μg/l	3.1	2.9	-6.7	51.6	3.6	-93.0
METHYLENE CHLORIDE	μg/l	16.7	10.0	-40.4	10.5	20.8	98.6
1,2-DICHLOROETHYLENE	μg/l	0.0	0.0	0.0	0.0	0.0	0.0
CHLOROFORM	μg/l	11.5	23.1	100.4	24.5	4.9	-79.8
1,1,1-TRICHLOROETHANE	μg/l	1.5	3.4	125.1	21.8	1.3	-94.2
BROMODICHLOROMETHANE	μg/l	13.7	18.2	32.7	3.7	1.2	-67.0
TRICHLOROETHYLENE	μg/l	1.5	1.8	19.9	20.8	1.5	-92.7
DIBROMOCHLOROMETHANE	μg/l	7.4	12.9	73.9	1.5	1.1	-29.0
BROMOFORM	μg/l	0.0	0.0	0.0	1.7	1.3	-21.6
TRIHALOMETHANES	μg/l	33.4	57.0	70.6	31.7	8.3	-73.8
TOTAL HALOCARBONS	μg/l	62.1	77.4	24.7	191.0	38.4	-79.9

TABLE 20 PROCESS PERFORMANCE FOR TWO TEST PERIODS (GEOMETRIC MEAN)



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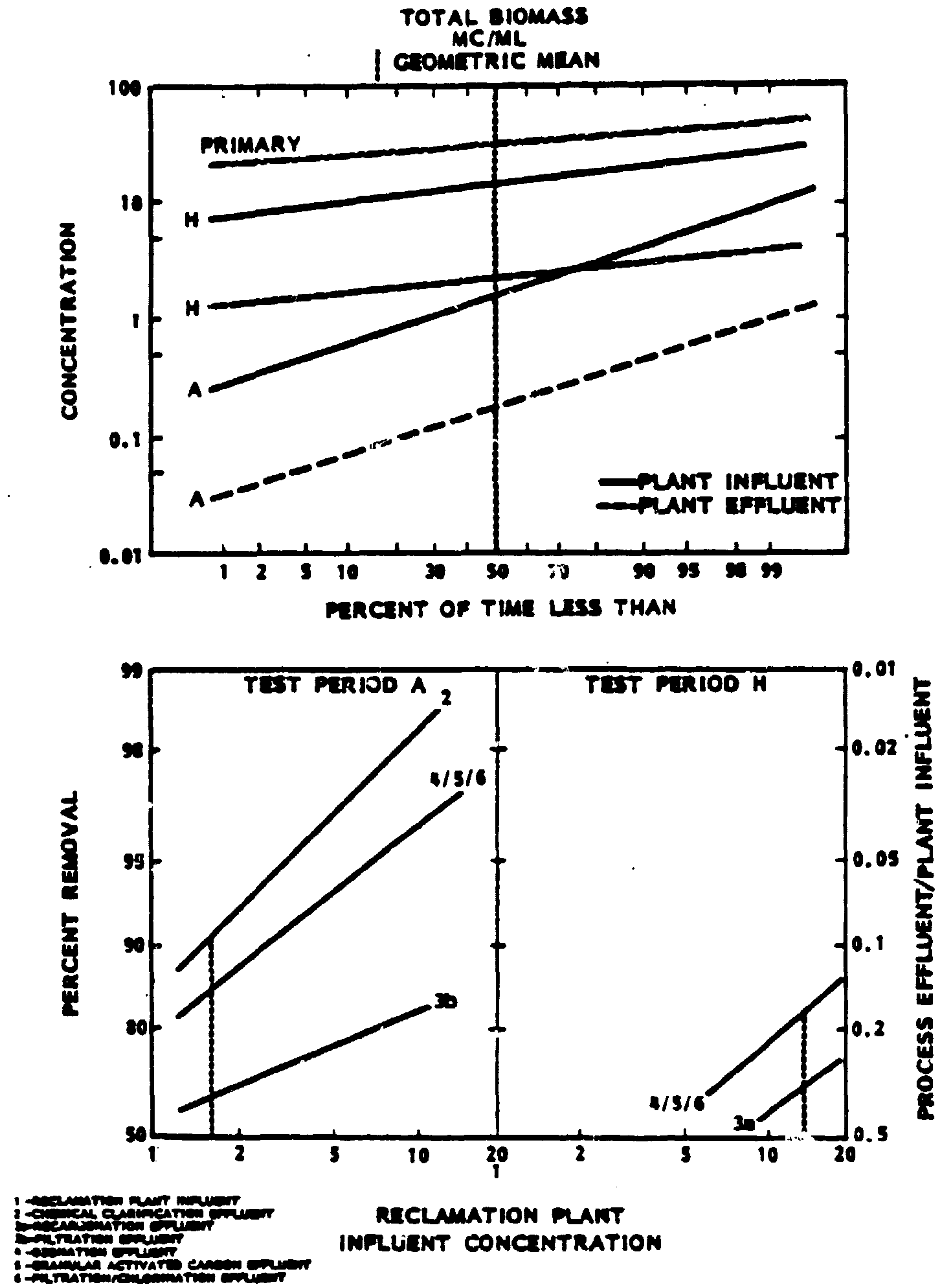

Figure 40 Data Distribution & Process Removal Characteristics

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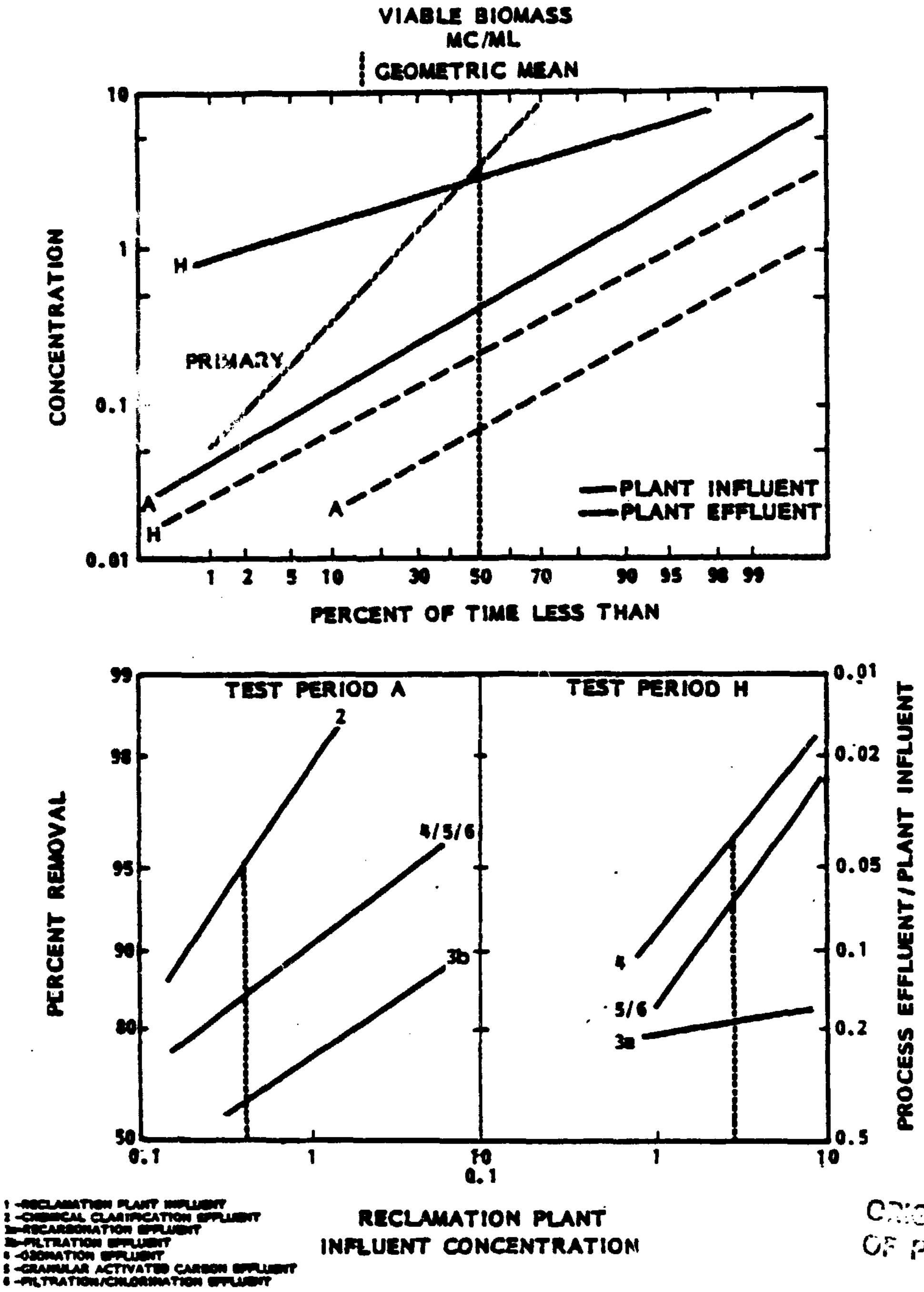

Figure 41 Data Distribution & Process Removal Characteristics

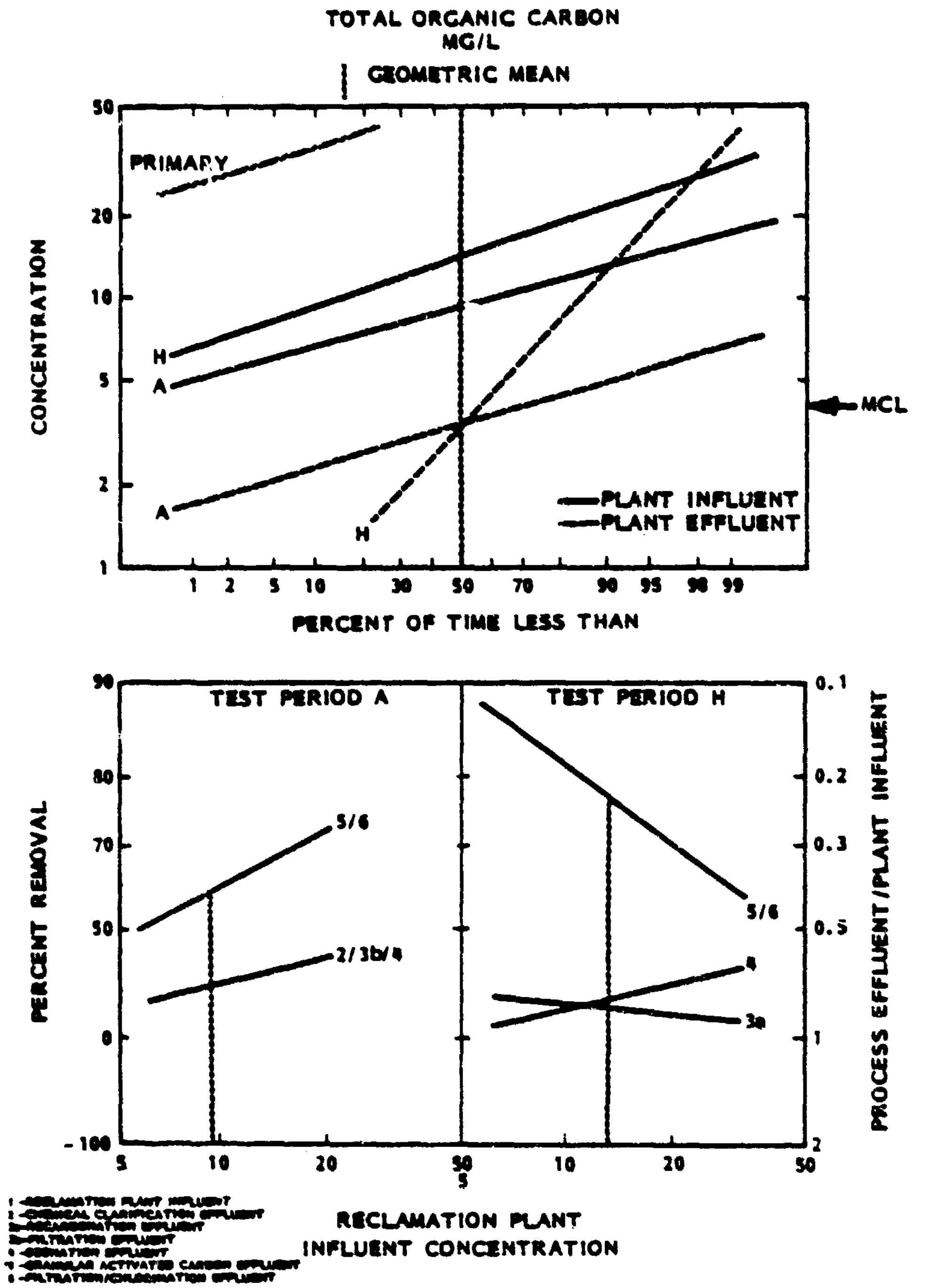

Figure 42 Data Distribution & Process Removal Characteristics

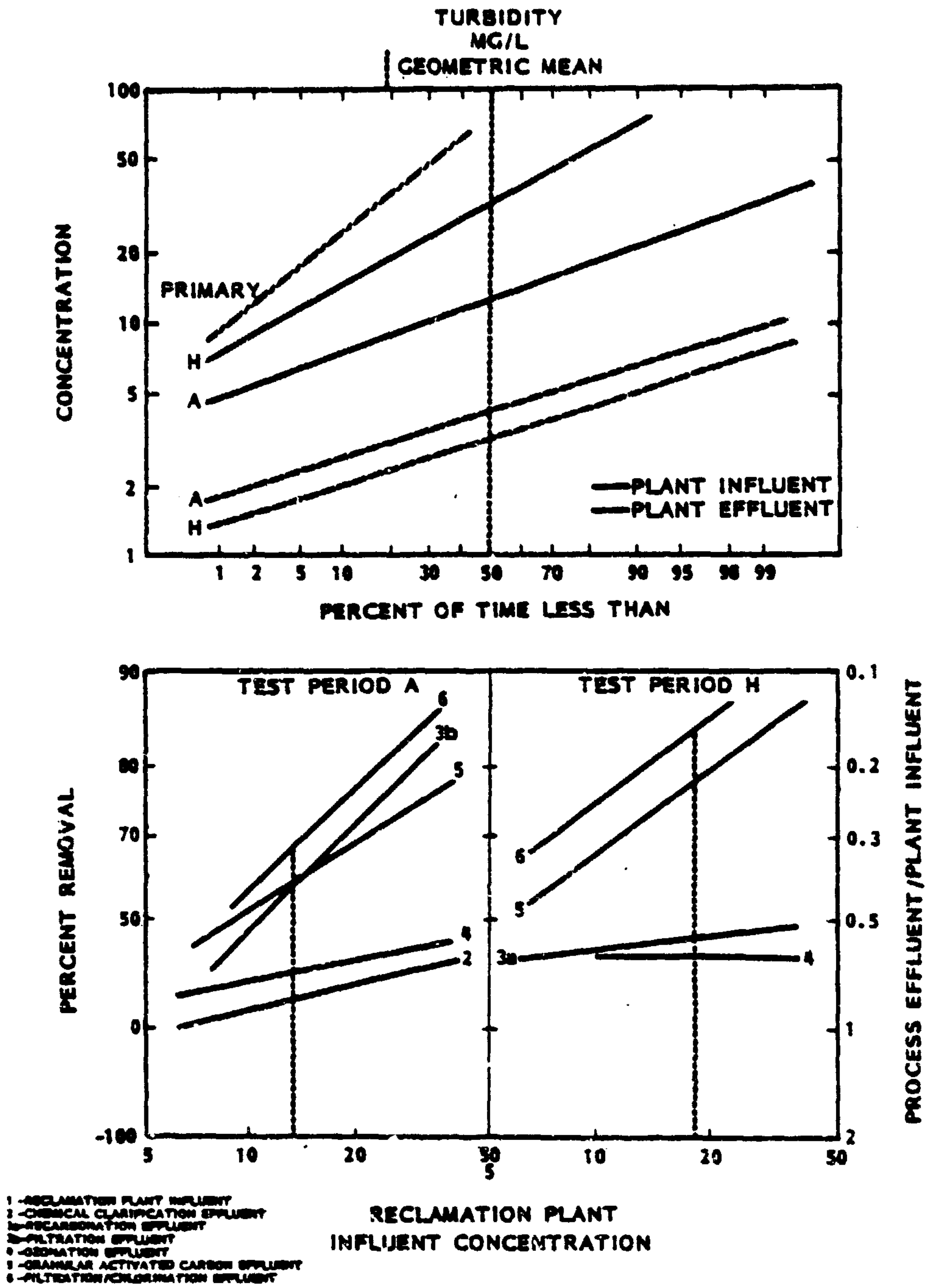

Figure 43 Data Distribution & Process Removal Characteristics

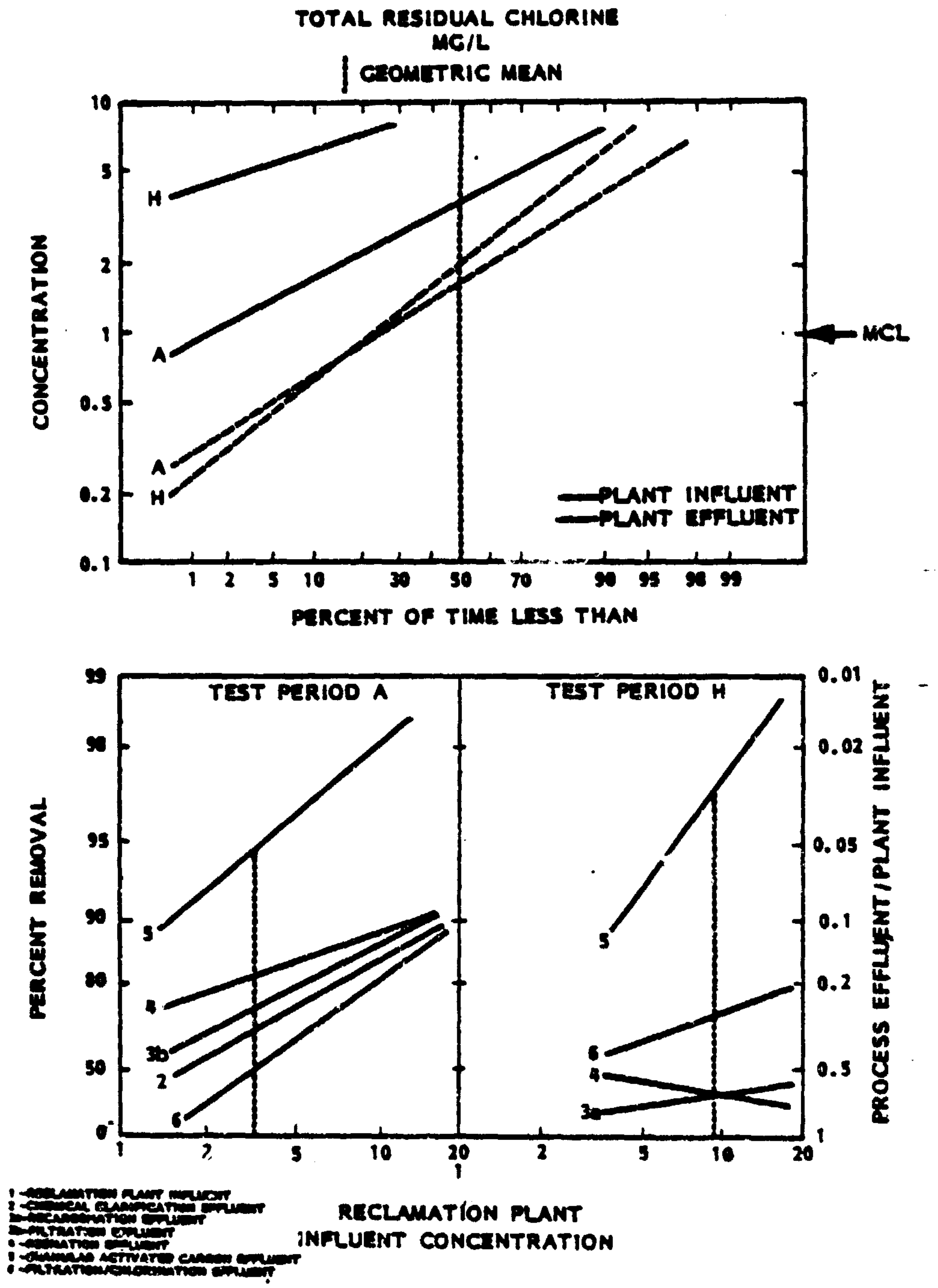

Figure 44 Data Distribution & Process Removal Characteristics

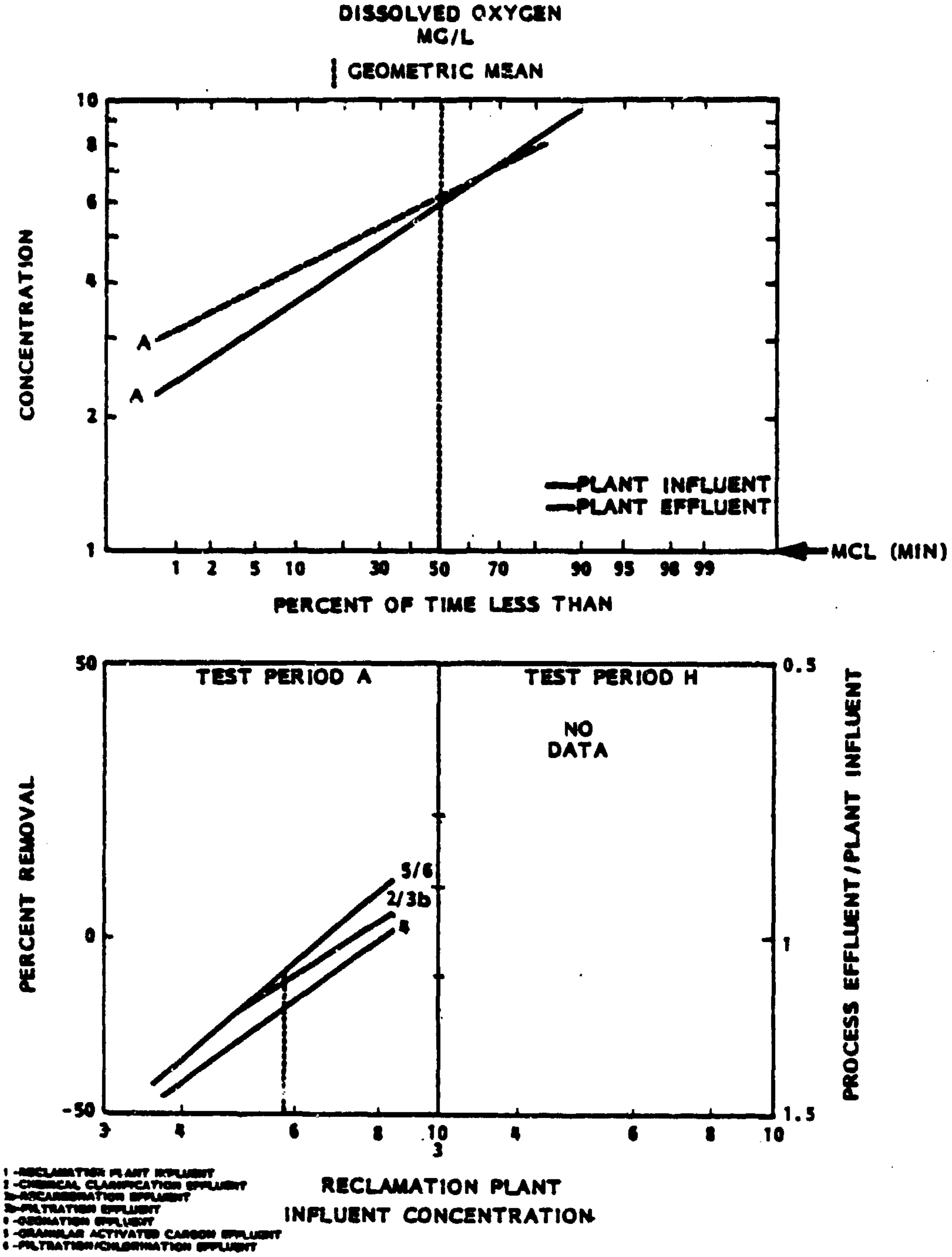

Figure 45 Data Distribution & Process Removal Characteristics

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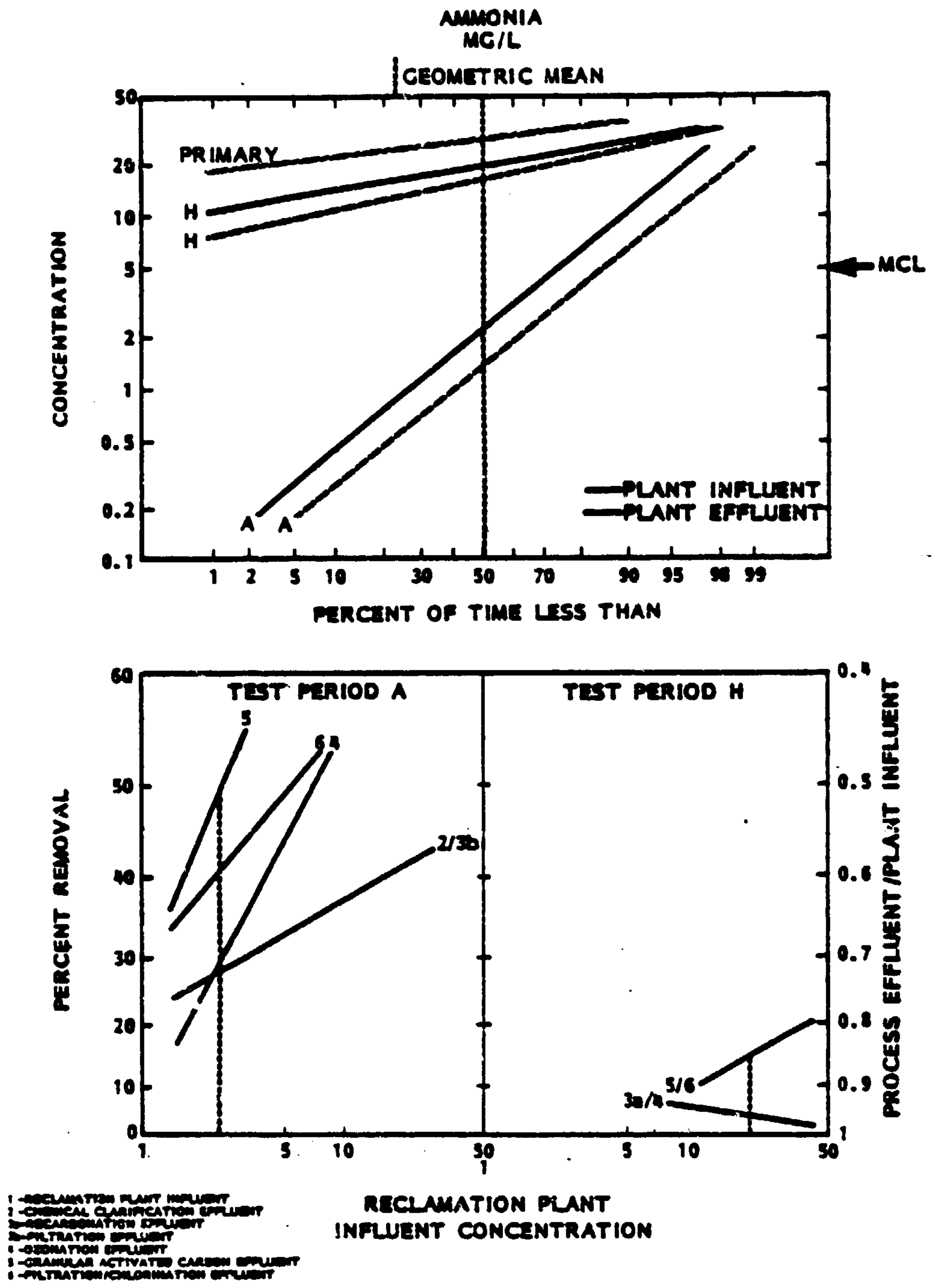

Figure 46 Data Distribution & Process Removal Characteristics

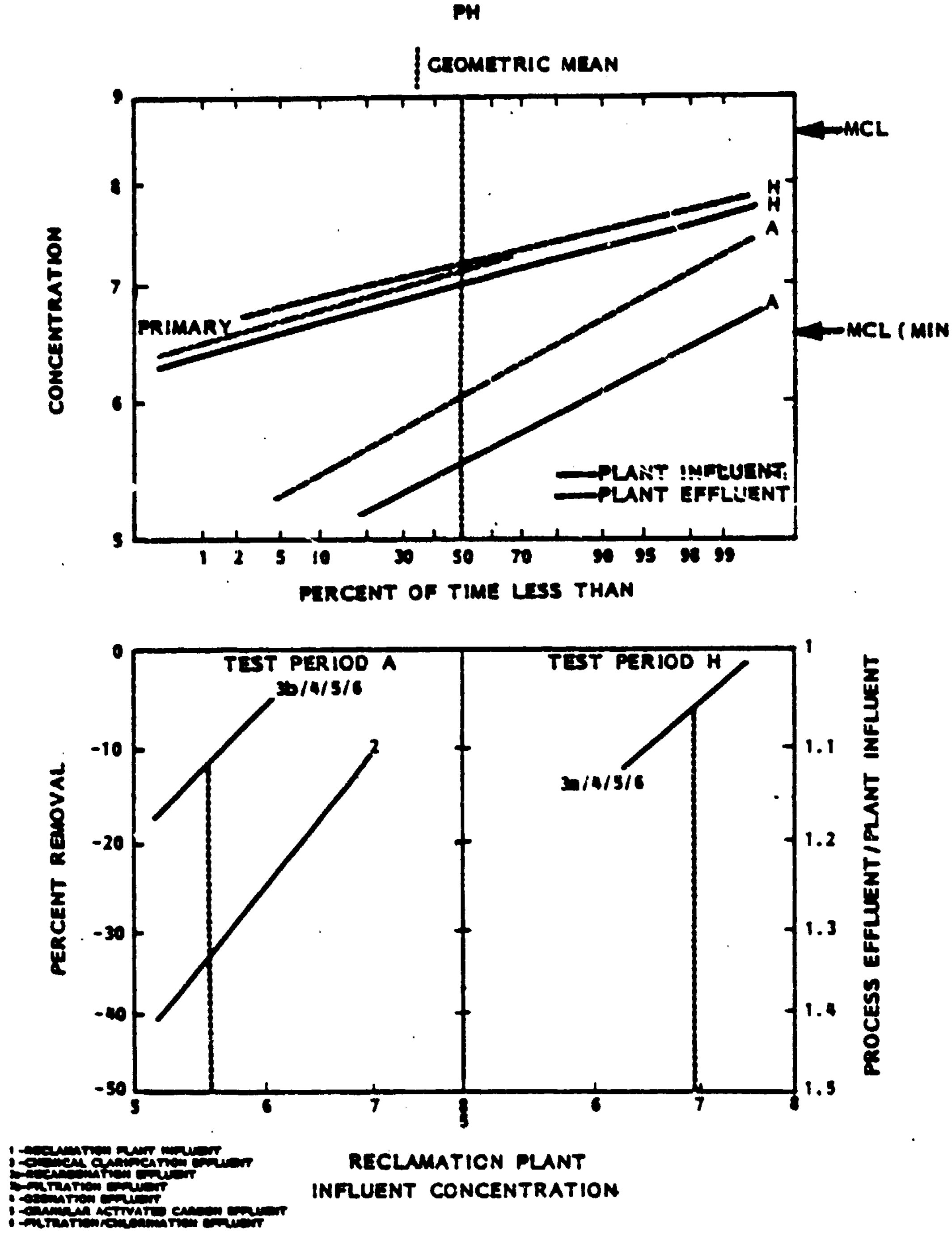

Figure 47 Data Distribution & Process Removal Characteristics

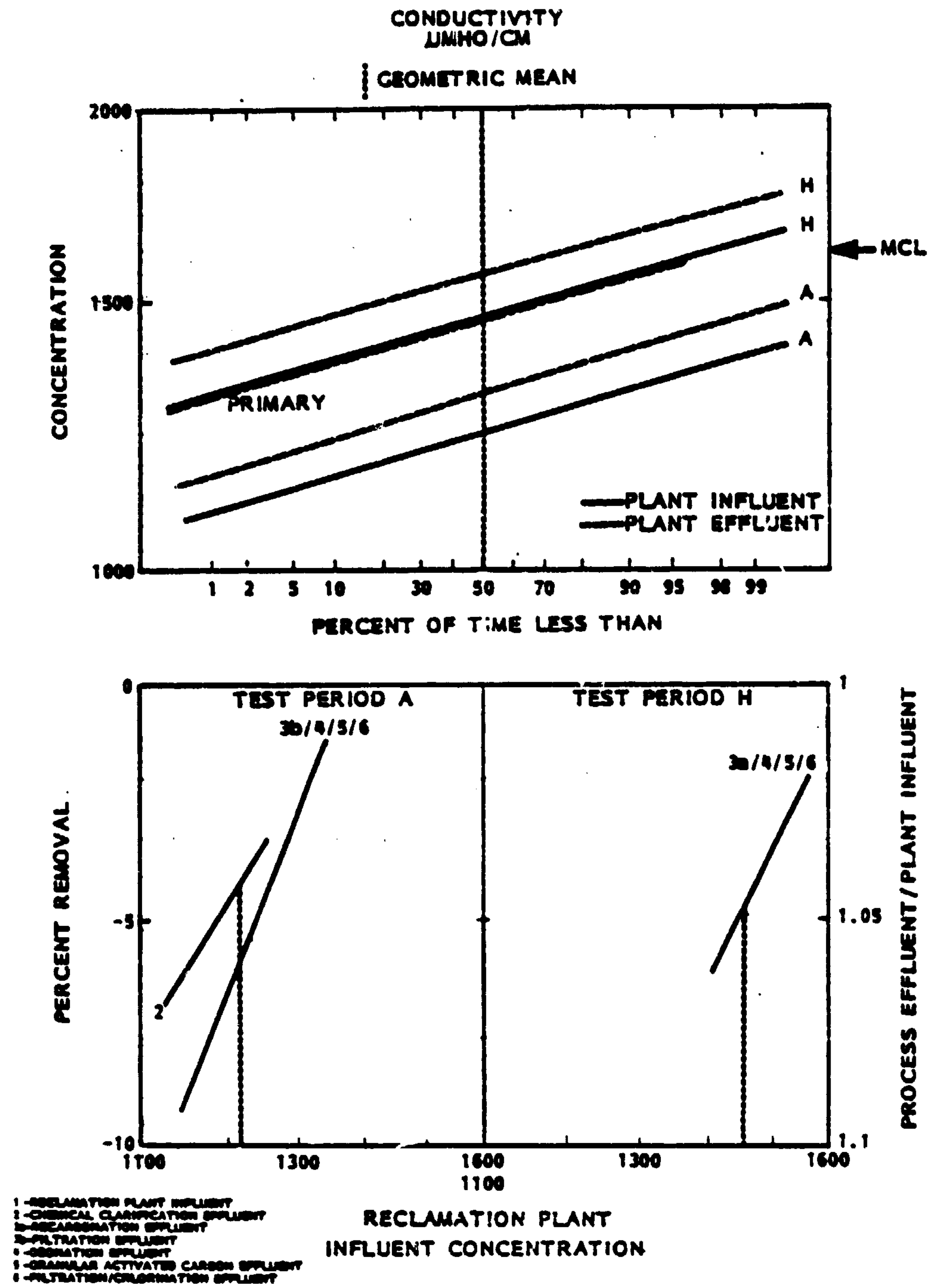

Figure 48 Data Distribution & Process Removal Characteristics

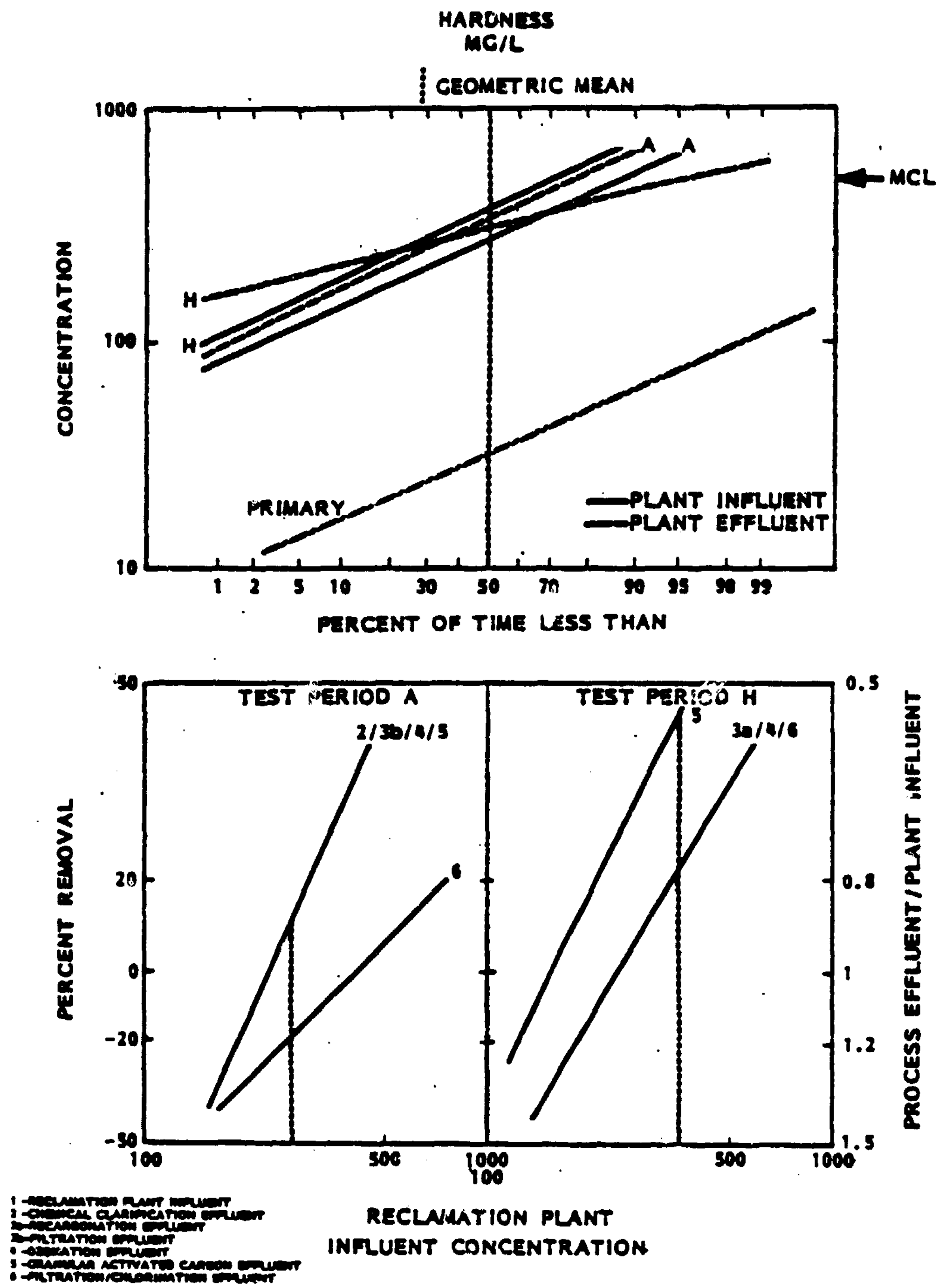

Figure 49 Data Distribution & Process Removal Characteristics

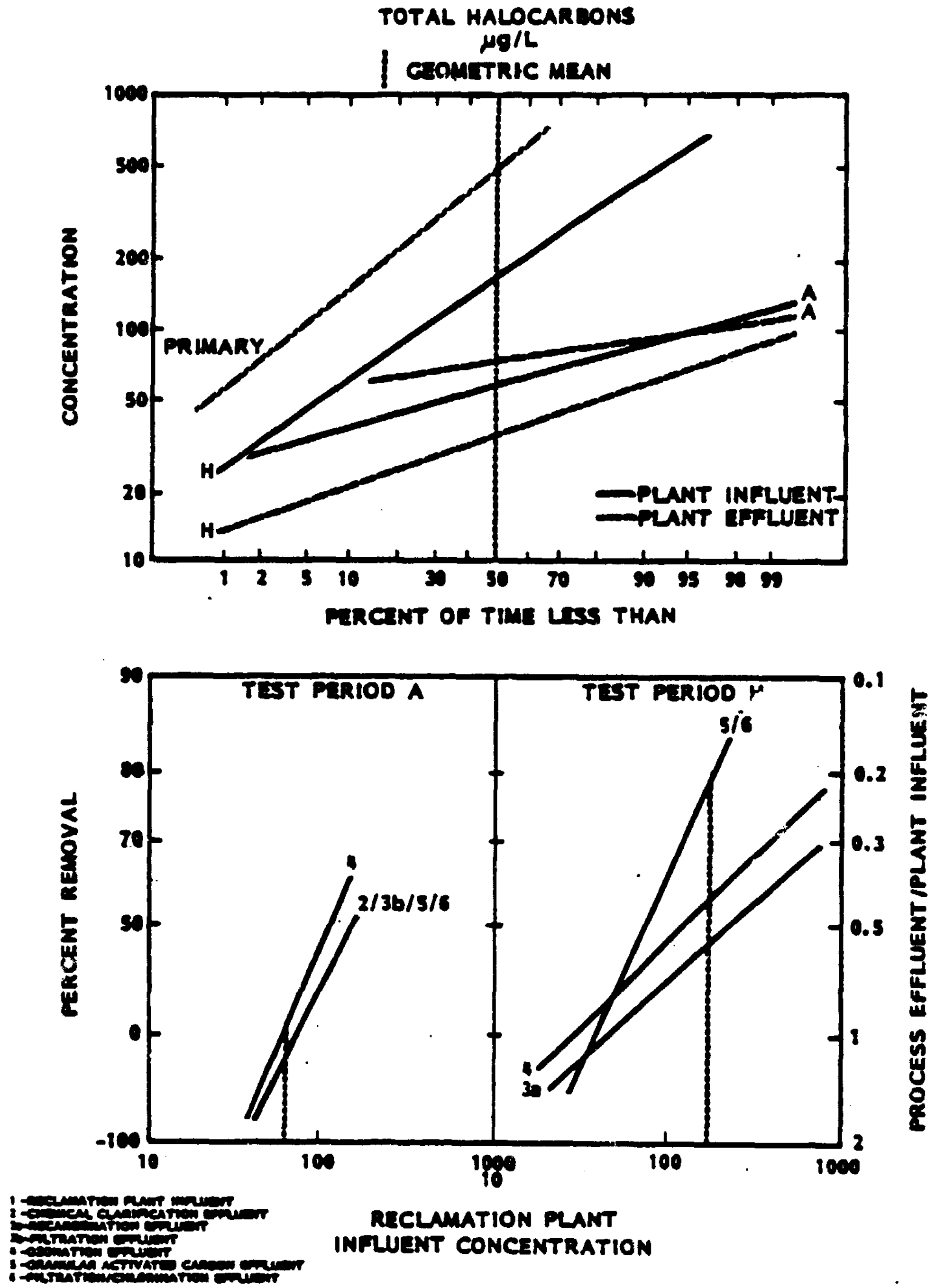

Figure 50 Data Distribution & Process Removal Characteristics

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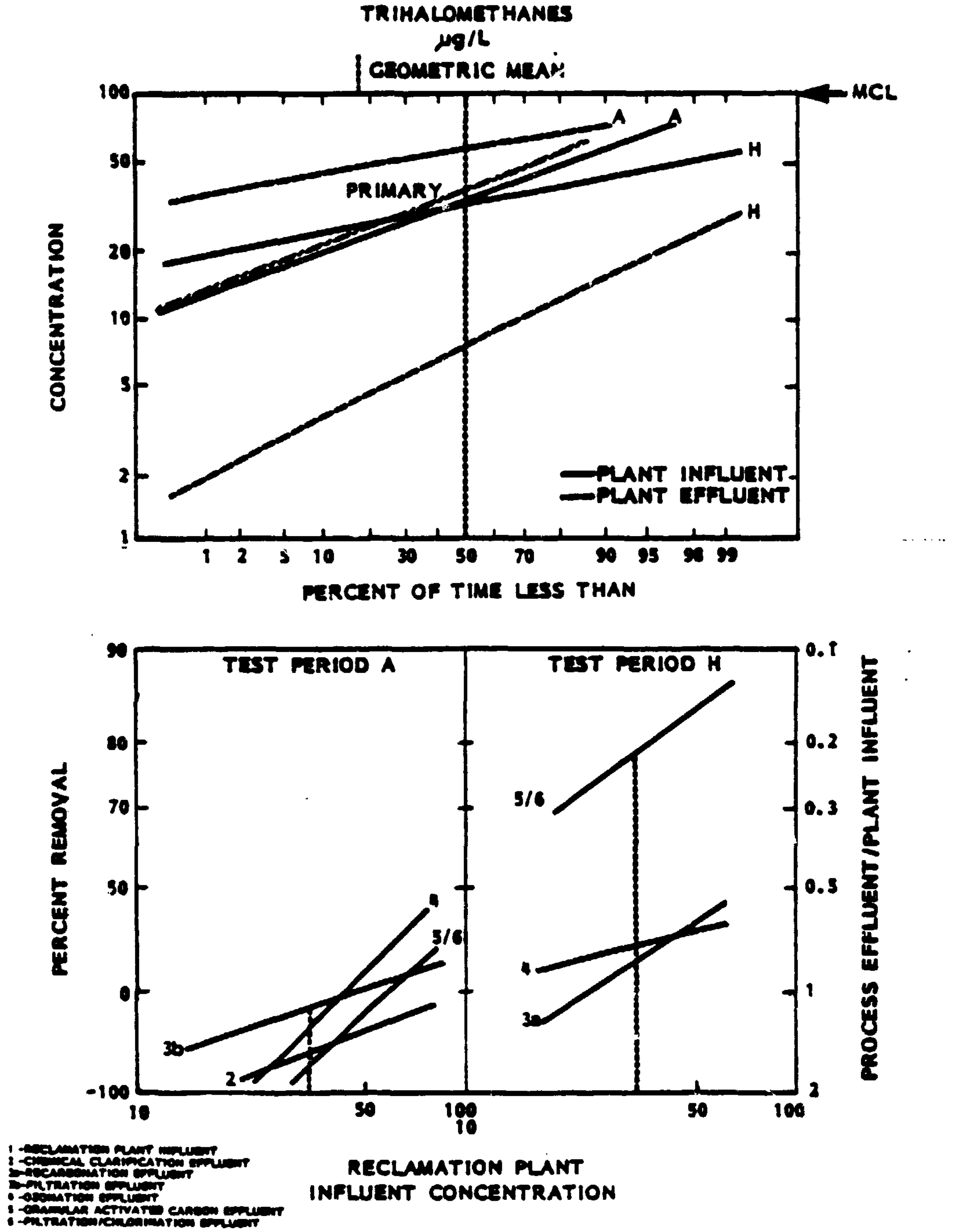

Figure 51 **Data Distribution & Process Removal Characteristics**

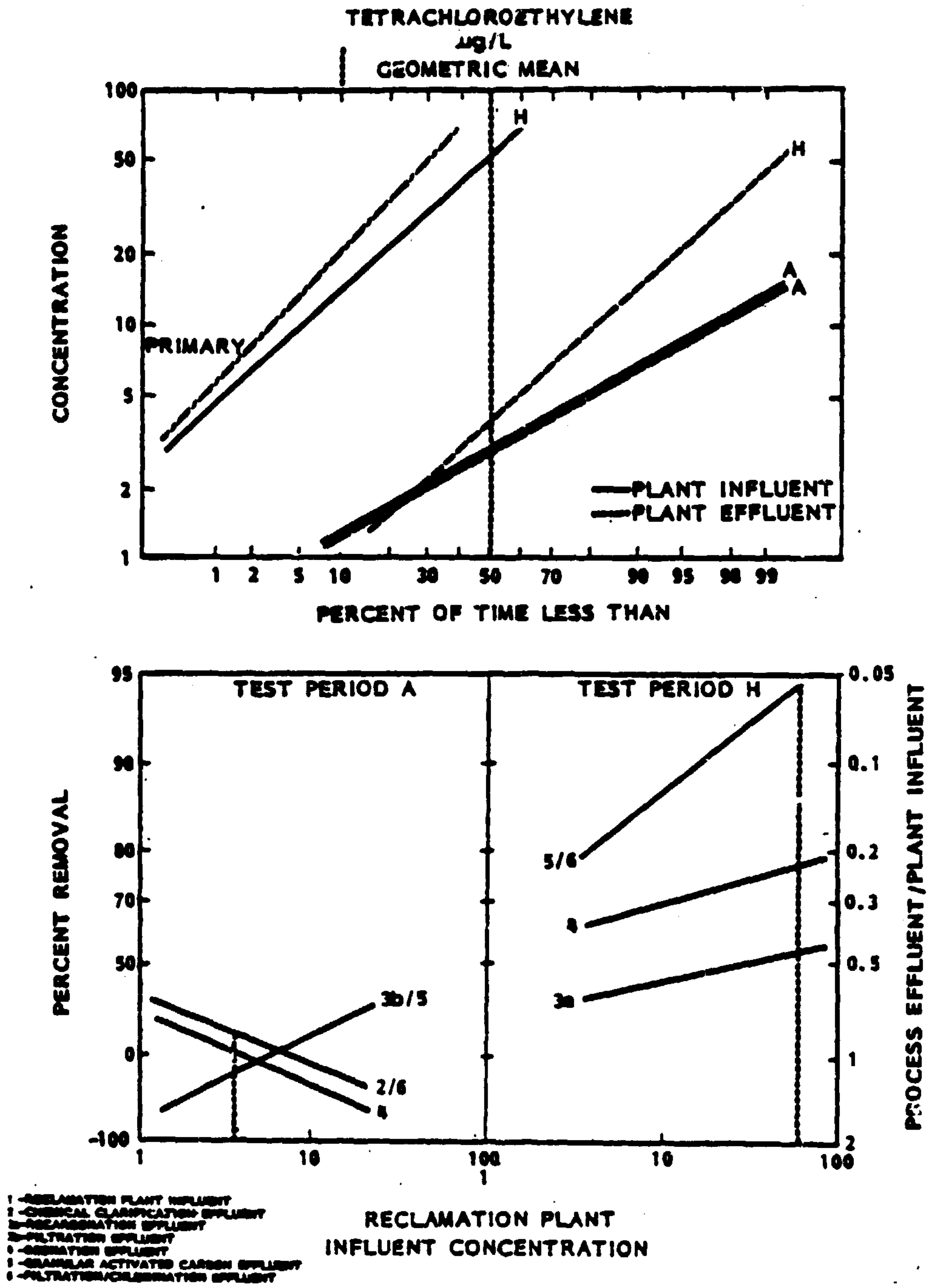

Figure 52 **Data Distribution & Process Removal Characteristics**

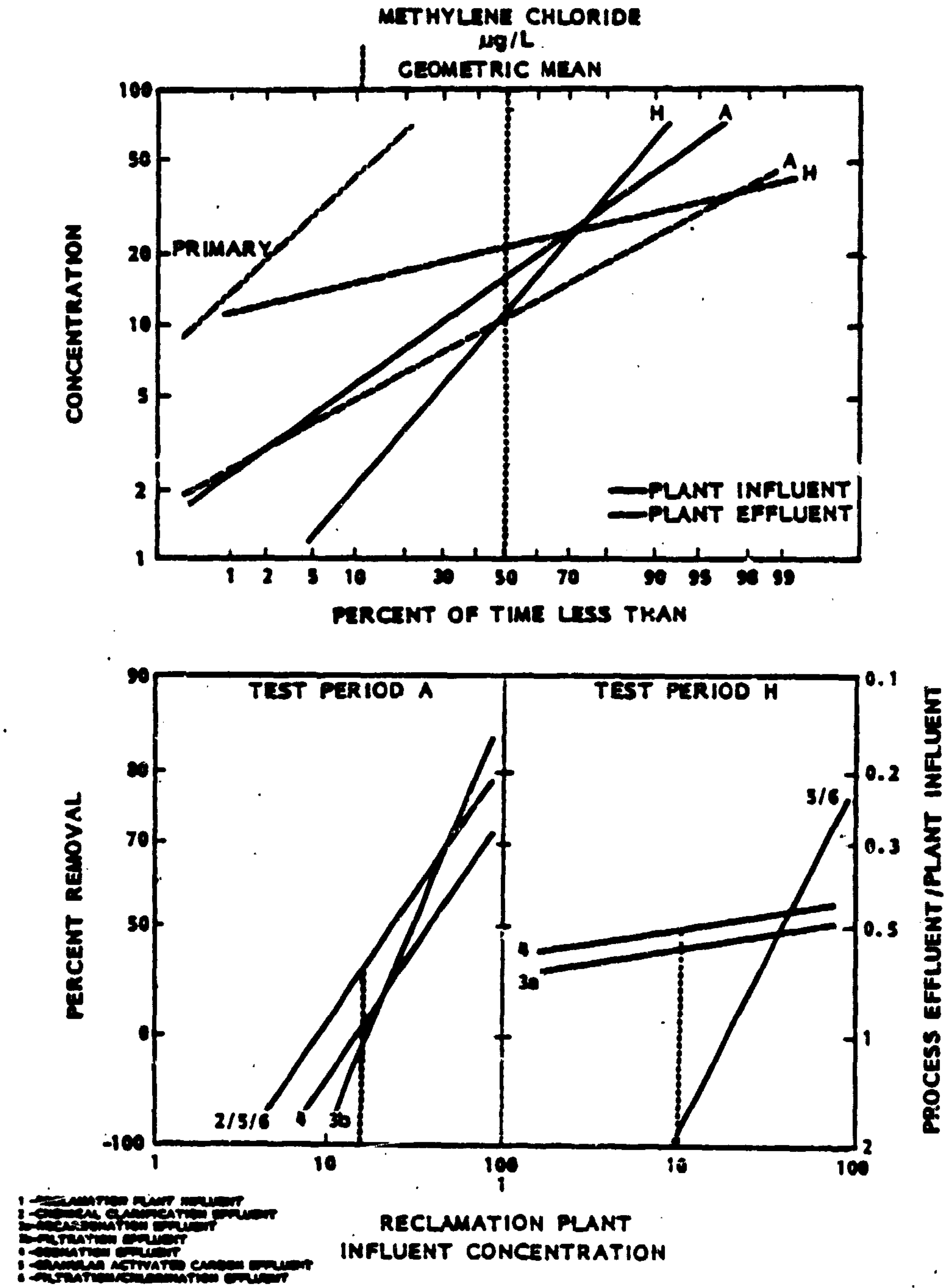

Figure 53 Data Distribution & Process Removal Characteristics

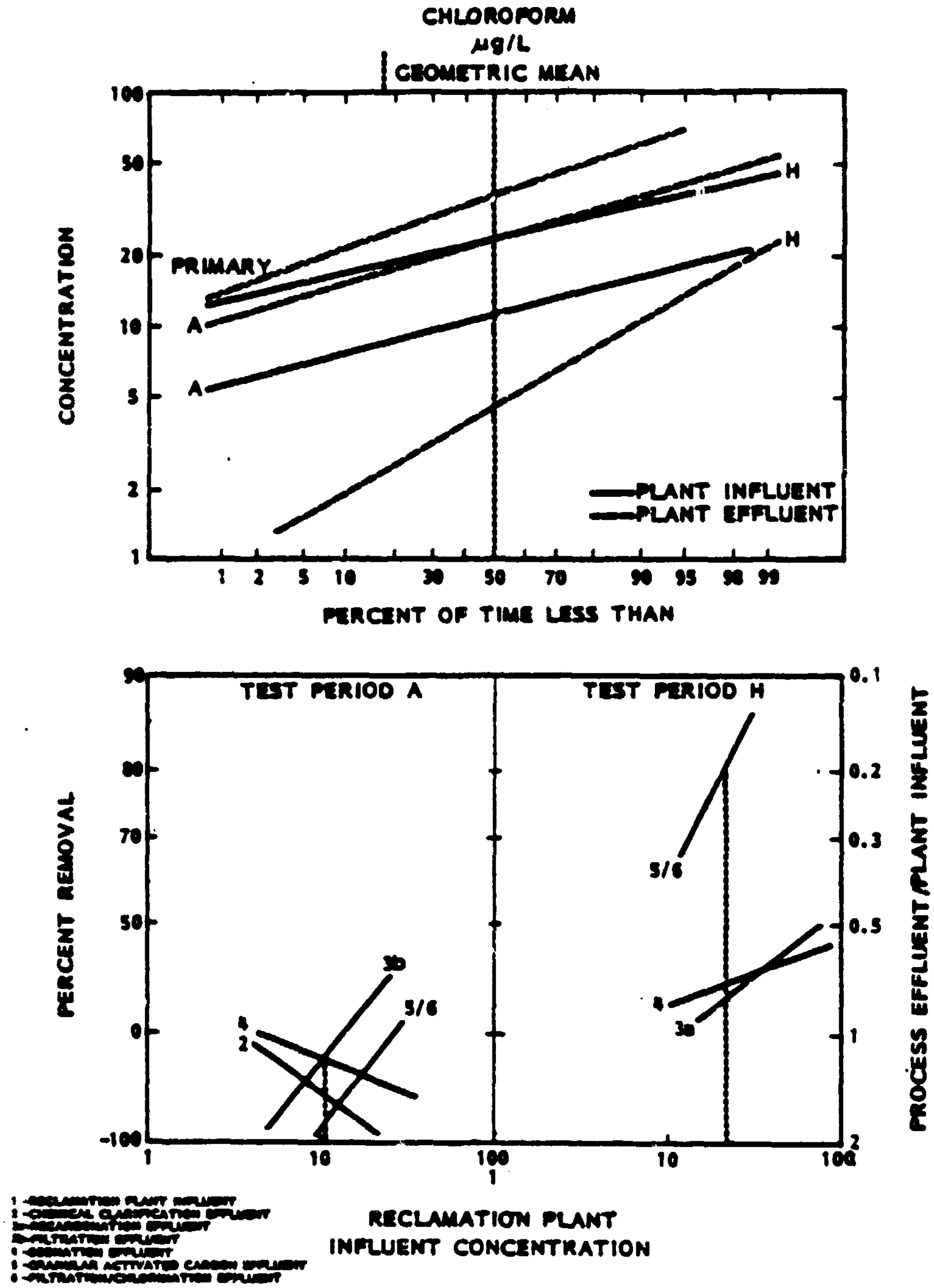

Figure 54 Data Distribution & Process Removal Characteristics

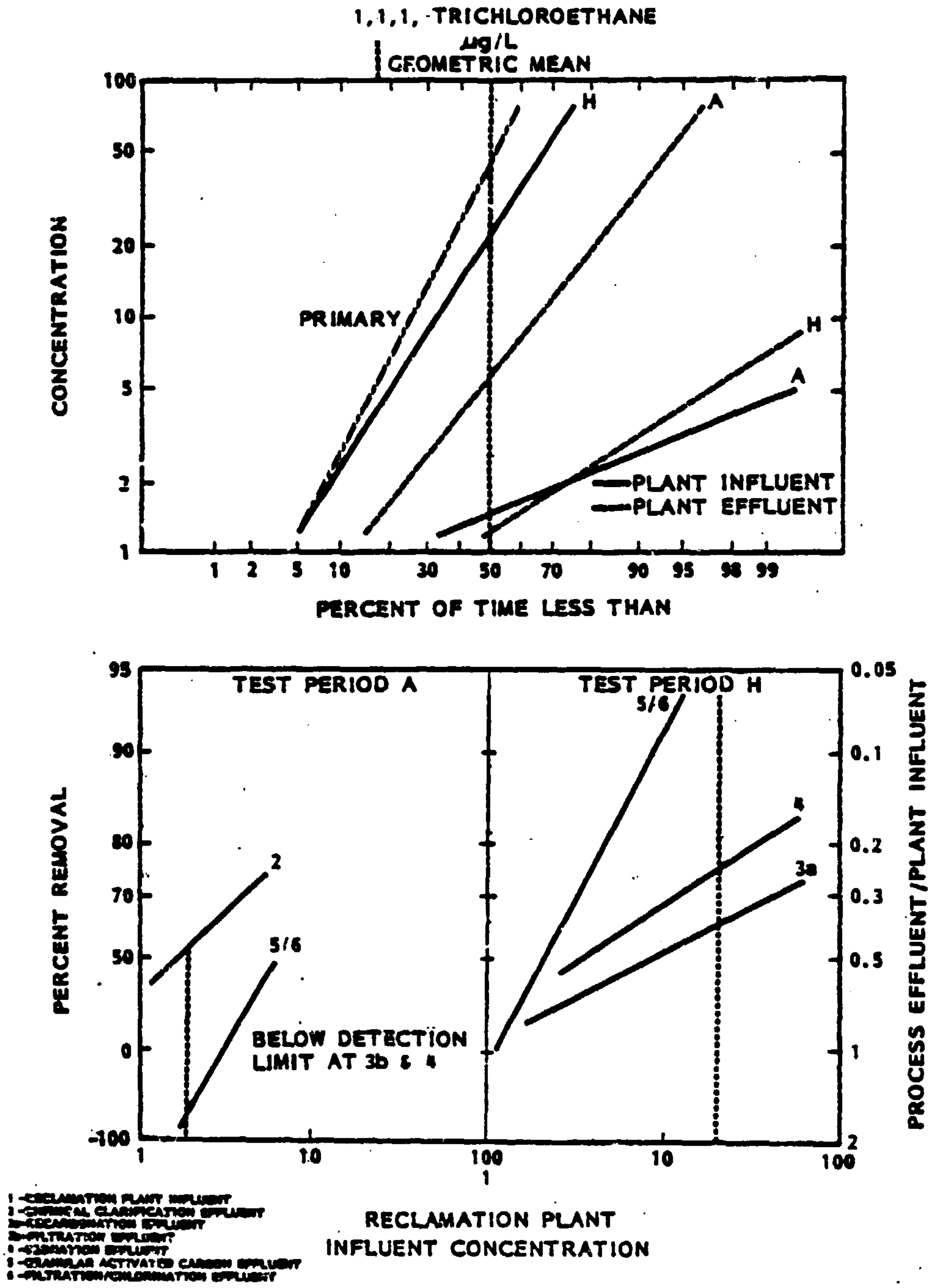

Figure 55 **Data Distribution & Process Removal Characteristics**

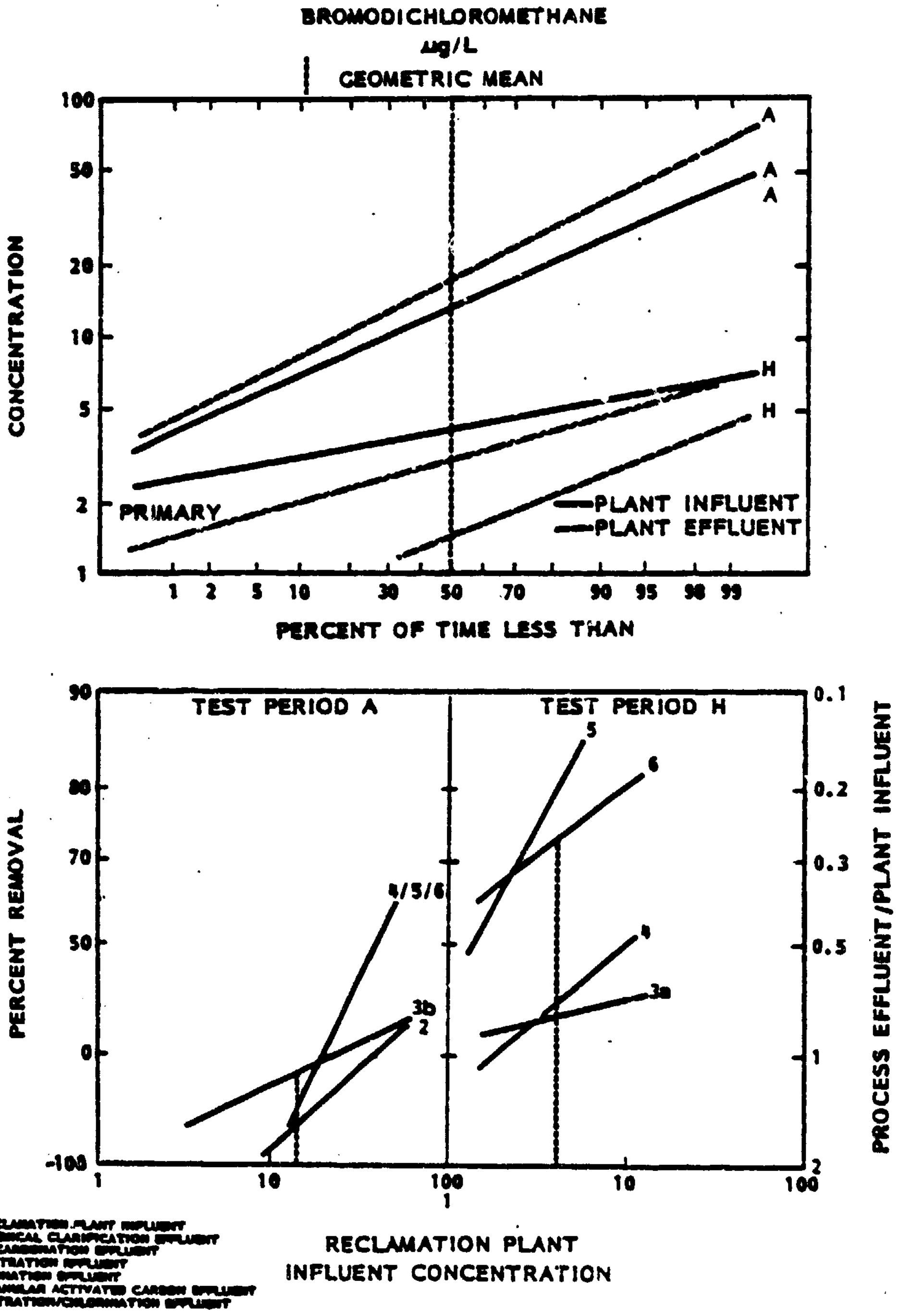

Figure 56 **Data Distribution & Process Removal Characteristics**

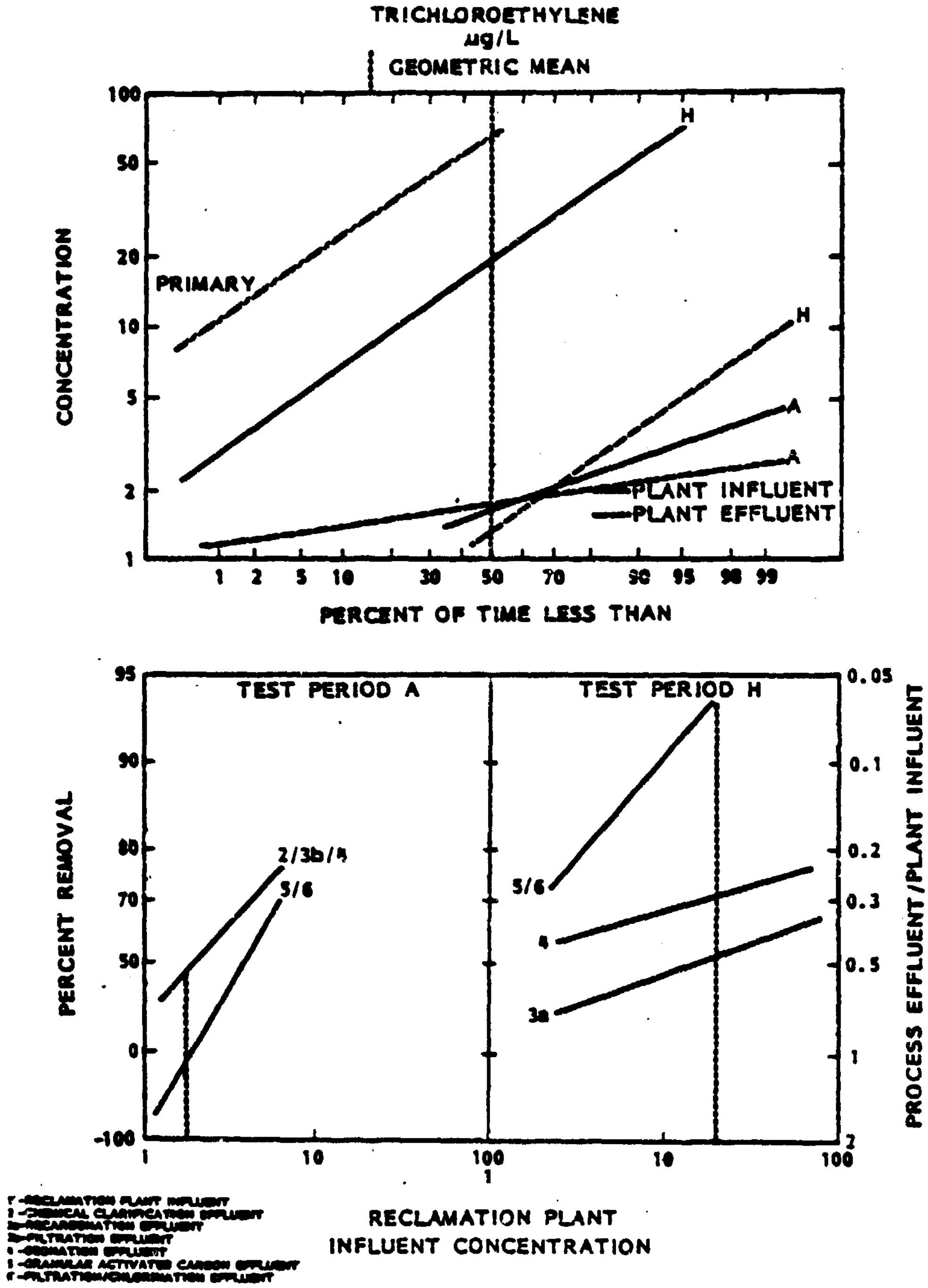

Figure 57 Data Distribution & Process Removal Characteristics

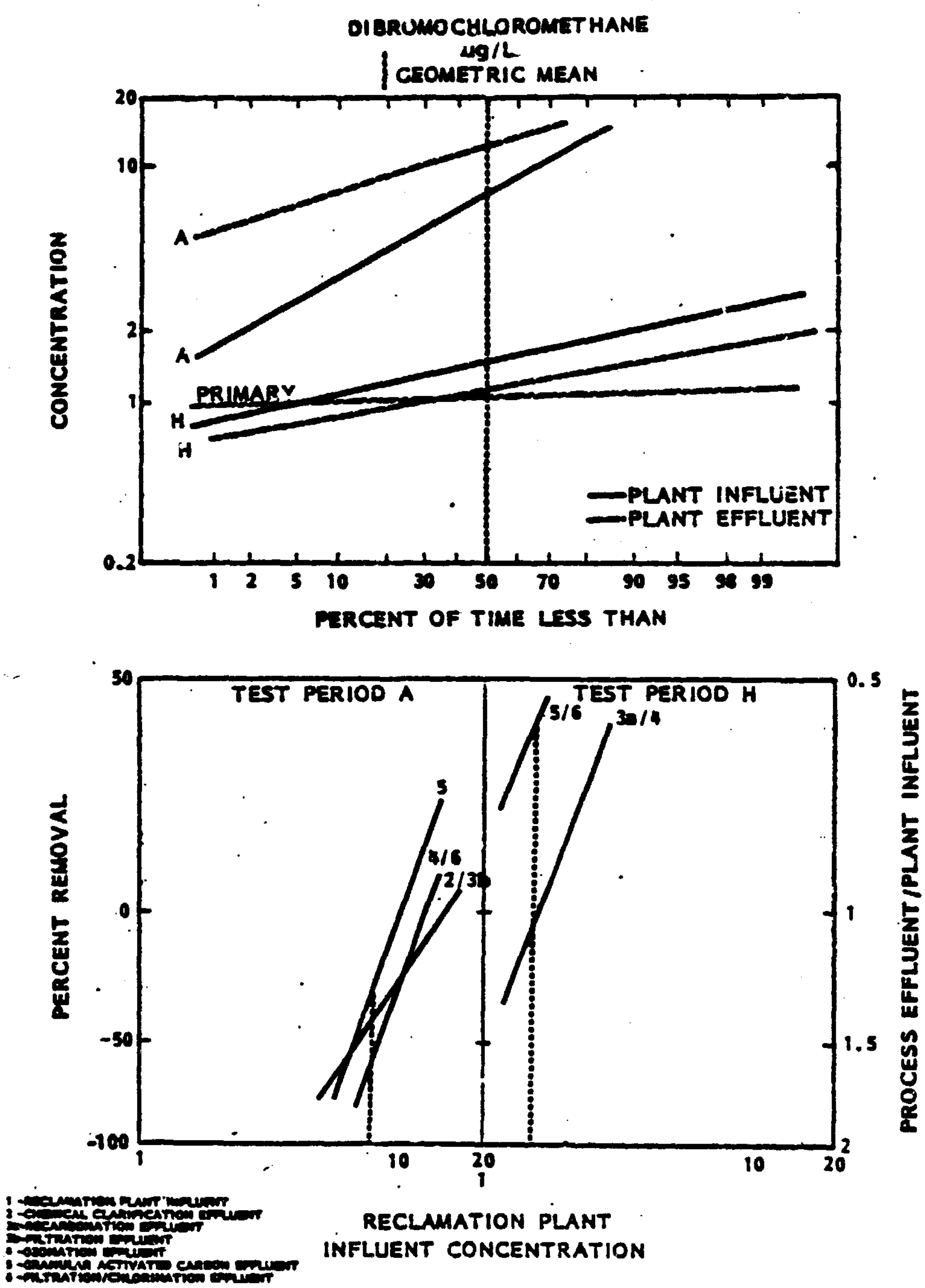

Figure 58 **Data Distribution & Process Removal Characteristics**

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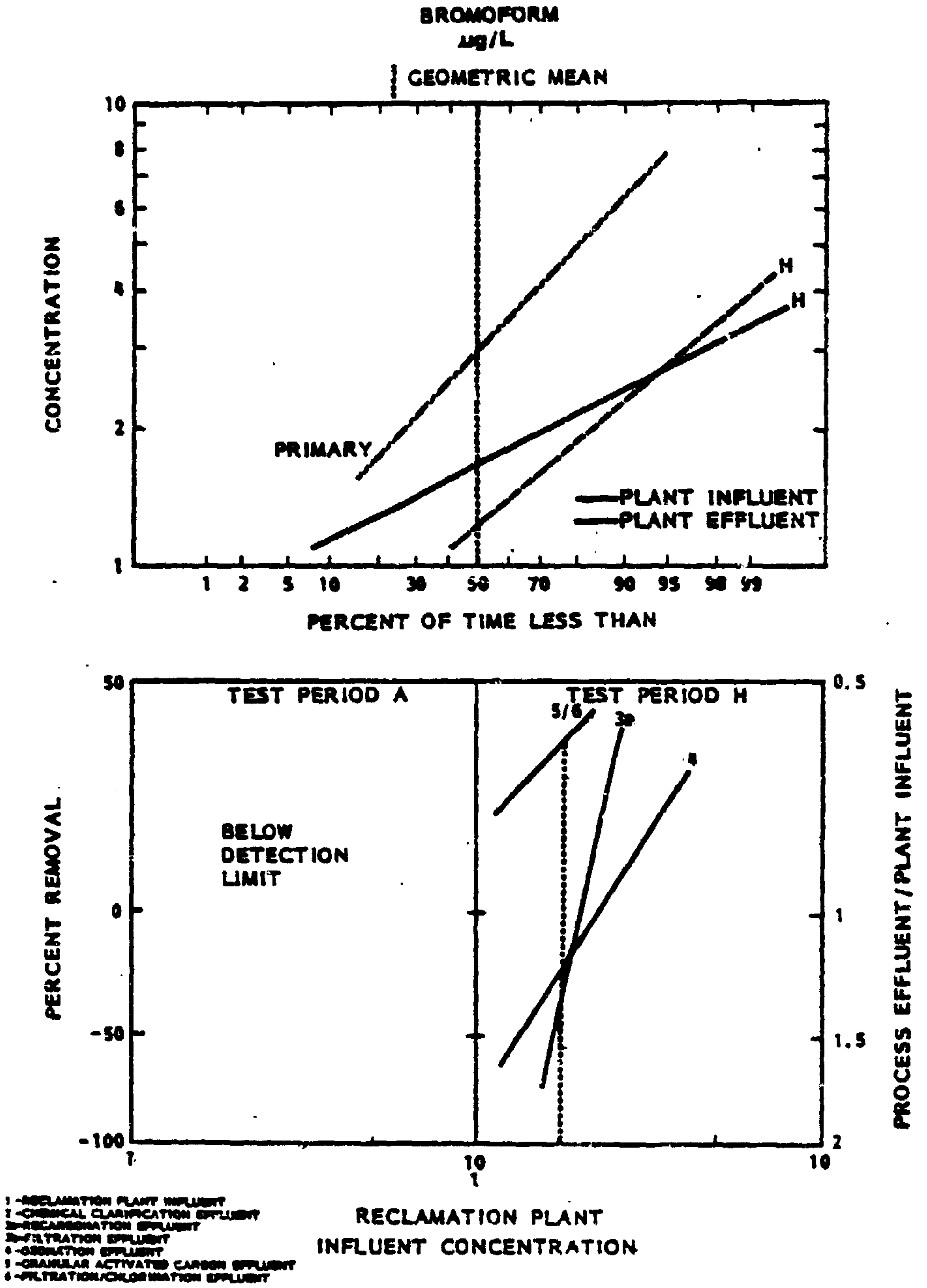

Figure 59 **Data Distribution & Process Removal Characteristics**

The computerized data analysis from which figures 40 through 59 were constructed is included in Appendix D.

Table 21 shows the results of a test to determine whether process performance can be reliably described, as above, by simple statistical procedures; i.e., by the mean and the standard deviation. Values of chi square are shown for the lognormal data distribution model. If the data for a test period fit the assumed model, a value of 6 or less will be obtained in 19 of 20 trials (test periods), thus, the model may be rejected for values greater than 6 with at least 95% confidence.

Table 21 shows that these values ranged from near zero, indicating a near perfect fit of the data to the model, to 66, indicating an extremely poor fit. Over half (57 percent) of the measurements had chi square values of 6 or less. The parameters which most consistently showed normality were: methylene chloride, total halocarbons, viable biomass, conductivity, hardness, trihalomethanes, chloroform and pH. Total biomass, ammonia and TOC showed a pronounced change in normality between the two test periods.

It is proposed that the chi square value may reflect process stability; i.e., a high value preceded by a low value in the water treatment process train indicates that this process is susceptible to random and unexplained upsets. On the other hand, a low value preceded by a high value shows that the process is tolerant to influent upsets. Table 22 shows the number of parameters which had a significant change between the influent and effluent of processes. Chemical clarification followed closely by ozonation generally reflected a greater stabilizing effect while GAC seemed to have the greatest tendency for unexplained upsets.

A consistently high chi square value may indicate that this particular water constituent or its sensor is inherently unstable. Only one measurement, trichloroethane, failed to show any lognormal distribution characteristics. On the other hand, if the chi square values were always low, say less than 1, the data may be "too good" and the responsiveness of the sensor might be suspect. Such consistently low values did not occur.

The following summarizes significant plant characteristics reflected by the data:

1. Influent Processing: The change in secondary treatment from activated sludge to fixed-film reactor/nitrification/dual-media filtration resulted in a significant reduction in reclamation plant loading for many contaminants.

2. Chemical Clarification:

    a. When operating at pH 11, essentially all the biomass is removed in the sludge and/or by cell lysis (disintegration at high pH). Biomass removal was less effective at the lower pH of 9.5 in period H where about 60% was removed.

TABLE 21
CHI SQUARES
OF PROCESS EFFLUENTS
FOR TWO TEST PERIODS

——— Period A ------- Period H

PROCESS	Period	PRIMARY	SECONDARY	CHEM CLAR	CHEM CLAR/RECARB	RECARB/FILT	FILT/OZON	OZON	GAC	FILT/CHLOR
TOTAL BIOMASS	A		12	1		4		1	6	6
	H	23	2		7		24		9	24
VIABLE BIOMASS	A		33	5		6		3	1	6
	H	9	4		3		4		14	3
TOTAL RESIDUAL CHLORINE	A		6	1		7		2	81	12
	H		10		15		2		35	17
TURBIDITY	A		6	9		20		8	22	6
	H	50	2		29		20		9	3
DISSOLVED OXYGEN	A		38	8		8		4	11	19
TOTAL ORGANIC CARBON	A		11	13		14		15	1	9
	H	12	6		3		2		1	1
AMMONIA	A		12	9		9		16	19	24
	H	3	7		4		8		10	4
NITRATE / NITRITE										
pH	A		14	0		19		6	7	6
	H	6	5		4		7		5	4
CONDUCTIVITY	A		2	12		3		4	6	11
	H	2	6		8		4		3	6
HARDNESS	A		12	1		5		3	4	12
	H	1	3		0		3		2	7
SODIUM	A		3	4		4		7	1	8

TABLE 21 (Continued)
CHI SQUARES
OF PROCESS EFFLUENTS
FOR TWO TEST PERIODS

——— Period A ------- Period H

PROCESS	Period	PRIMARY	SECONDARY	CHEM CLAR	CHEM CLAR/RECARB	RECARB/FILT	FILT/OZON	OZON	GAC	FILT/CHLOR
TETRACHLOROETHYLENE	A		8	27		2		10	5	6
	H	9	13		9		5		1	4
METHYLENE CHLORIDE	A		1	3		4		5	1	1
	H	2	3		3		1		4	2
1,2 - DICHLOROETHYLENE										
CHLOROFORM	A		8	1		6		8	7	3
	H	3	7		4		3		5	6
1,1,1 - TRICHLOROETHANE	A		25	8		24		56	15	16
	H	7	12		8		9		8	12
BROMODICHLOROMETHANE	A		9	6		1		4	3	17
	H	5	13		5		1		11	11
TRICHLOROETHYLENE	A		6	3		4		39	2	2
	H	7	4		2		12		15	30
DIBROMOCHLOROMETHANE	A		7	1		1		0	5	4
	H	21	7		6		2		66	34
BROMOFORM	H	2	2		30		4		3	4
TRIHALOMETHANES	A		9	8		1		0	5	3
	H	2	4		5		0		8	8
TOTAL HALOCARBONS	A		3	1		2		2	0	2
	H	3	7		4		[illegible]		2	9

TABLE 22

SIGNIFICANT CHANGES IN
NORMAL DISTRIBUTION ACROSS PROCESSES

NUMBER OF PARAMETERS

	MORE NORMALLY DISTRIBUTED		LESS NORMALLY DISTRIBUTED	
	PHYSICAL/ CHEMICAL/ BIOLOGICAL SENSORS	GC	PHYSICAL/ CHEMICAL/ BIOLOGICAL SENSORS	GC
SECONDARY (PERIOD H)	4	1	1	3
CHEM CLAR/RECARB (PERIOD A)	5	2	1	0
CHEM CLAR/RECARB (PERIOD H)	1	4	3	1
RECARB/FILT (PERIOD A)	1	3	2	0
FILT/OZON (PERIOD H)	2	5	3	1
OZON	3	0	1	2
GAC (PERIOD A)	2	3	2	2
(PERIOD H)	0	2	2	3
FILT/CHLOR (PERIOD A)	2	1	5	1
(PERIOD H)	3	0	1	1

b. The turbidity measurement indicates that only about 25% of the suspended solids removed in the plant are removed by chemical clarification. In light of the biomass data, which indicate that a much larger portion of the suspended solids is removed in the clarifier, this small decrease in turbidity is attributed to floc carryover. Experience with fouling of downstream equipment by calcium carbonate deposits supports this interpretation.

c. More TOC was removed; i.e., 3 versus 1.5 mg/l, when operating at the higher pH of period A (with aeration at pH 11, TOC removal increased to 5.5 mg/l during period G. The aerators were not operational during periods A and H).

d. The concentration of the trihalomethanes is increased. This is probably due to the additional time that the chlorine is in contact with organics in the clarifier. This allows more chlorinated organic formation time.

e. Ionic activity associated with lime treatment increases the conductivity. This suggests the possibility of controlling lime dosage using a conductivity sensor rather than pH sensor for operational reliability reasons; however, the durability of the conductivity probe in this environment has not been tested. The pH control currently used has been a consistent problem because of pH probe fouling in the high solids environment.

f. An apparent pH anomaly was noted during period A. While the pH was controlled at 11 in the flash mixer, the measured value in the aerator sump tank just ahead of recarbonation was approximately 7. In previous test periods these two pH values have been nearly the same. The noted difference remains unexplained.

3. Ozonation:

a. Ozonation results in a reduction in few of the measured parameters. (Presented here are the complete data collected during the test period. There were times during this period when the ozonator was not operating because of equipment failure. These periods are known, and an analysis could be performed to quantify the effect of ozonation by comparing ozonator operating data with ozonator nonoperating data. Because of time constraints, that analysis has not been done.)

b. The increase in turbidity after ozonation appears to be an anomaly. This increase may result from entrained gases in the effluent sample. If so, they are very fine particles since they are not visible to the naked eye.

It may be assumed that turbidity is not a reliable measure of the presence of suspended solids wherever entrained gases are introduced into the process stream. Sample points 2, 3b, 5, and 6 may thus be the only reliable points for measuring suspended solids by turbidity since gases may essentially be removed in the preceding process; i.e., clarification or filtration.

If the ozonation effluent data are ignored, Figure 43 shows that much of the work of removing particulate matter, at least that which reflects light at 25 degrees, is done in the first filtration and not in the GAC as the data may seem to indicate. The plant's experience with persistent flocculant carryover from the clarifier with the accompanying calcium carbonate deposits on downstream equipment may support this interpretation of the data; e.g., there is no significant decrease in turbidity (suspended solids) before the initial filtration and the decrease in organic material (TOC and Biomass) in the chemical clarification is offset by an increase in calcium carbonate precipitant.

4. Mixed Media Filtration:

   a. Biological growth in the first filtration step results in an increase in biomass in downstream processes.

   b. The first filtration step provides the largest portion of the plant's turbidity removal. As discussed previously, this removal is largely floc carryover from chemical clarification.

   c. The addition of dual-media filtration in the secondary plant (period A) reduced the amount of solids in the reclamation influent and thus substantially increased the time periods between backwashes in the reclamation plant filters.

5. Granular Activated Carbon:

   a. A reduced level of many contaminants is characteristic of water processed by GAC, when its useful life is not exceeded. The virgin carbon used during period H resulted in a pronounced reduction in most organic materials. The exhausted carbon in the system during period A was saturated resulting in an increased rather than a decreased concentration for many of the measured trace organics.

   b. All halocarbons are reduced in new GAC except methylene chloride, which is produced. In contrast, methylene chloride was removed by exhausted carbon during period A.

   c. Most halocarbon concentrations were increased by GAC processing in period A because the carbon had been previously saturated at levels higher than the period A influent levels.

   d. It is common to find biomass elution from GAC especially under favorable growth conditions; i.e., high dissolved oxygen, pH < 11, no ozone. Some growth was apparent during period H. Promoting biological growth in the GAC may extend its useful life (reference 4).

   e. Most of the plant's ammonia removal occurs in the GAC probably by biological activity; i.e., by nitrification.

f. Mean TOC removal varied from 7.7 mg/l (O/I of 0.29) for new carbon in period H to 2.6 mg/l (O/I of 0.60) for exhausted carbon in period A. The TOC removal in period A is attributed to biological activity. In the adsorption operating mode, new GAC may be more accurately characterized as a constant TOC quantity removal process rather than as a percentage removal process (note the negative slope in Figure 42, period H, sample source 5). A different performance characteristic is obtained in the biological mode of period A.

g. Stanford University's Civil Engineering Department has conducted a test program to characterize activated carbon performance with operating age (reference 5). Composite samples were continuously collected for a period of 7 months (test period C) with the SCVWD-WRF/PA operating with three parallel carbon columns: The first containing virgin carbon, the second containing regenerated carbon, and the third containing exhausted carbon. Composite samples of the influent and the effluent of each column were periodically analyzed (usually once a week) for various organic compounds to determine the change in carbon removal performance with time. These data are presented in Appendix E.

Included with the Stanford data in Appendix E are comparable WMS measurements made during the same time period. However, the WMS data were taken at a point after mixing of the effluent of the three columns. Thus, an average of the Stanford effluent data was computed to provide a data comparison which should be valid assuming equal flow through each of the three columns and good mixing ahead of the sampling point.

A least-squares fit of the Stanford data for two of the measurements, TOC and chloroform, is shown in Figure 60, where performance is plotted as a function of age.

The data for chloroform indicate an effective operating life of 77 days with an adsorption capacity of 0.066 mg/gm carbon at 13.8 g/l. This value is consistent with previous test results with virgin carbon (reference 4). As indicated by the data in Appendix E, the GAC performance for chloroform is typical of the other volatile organics.

The Stanford data for TOC indicate an effective operating life approaching 179 days indicating an adsorption capacity of 63.2 mg TOC/gm carbon at 8.5 mg/l. However, at about 130 days, a discontinuity in the data indicates that action of biological growth on the carbon reached an equilibrium for the remainder of the test period with a TOC removal of about 5600 gms/day (0.28 mg TOC/gm carbon/day).

LEAST SQUARES FIT (DATA FROM APPENDIX B)

TOC

$$\left.\begin{aligned} O/I &= 0.123 + \frac{BV}{8700} \\ &= 0.123 + \frac{D}{204} \end{aligned}\right\} \quad r = 0.96,\ T = 8.5\ \text{MG/L}$$

CHLOROFORM

$$\left.\begin{aligned} O/I &= \log^{-1}\left[1.87 \log (BV) - 6.58\right] \\ &= \log^{-1}\left[1.87 \log D - 3.53\right] \end{aligned}\right\} \quad r = 0.92,\ T = 13.8\ \mu\text{G/L}$$

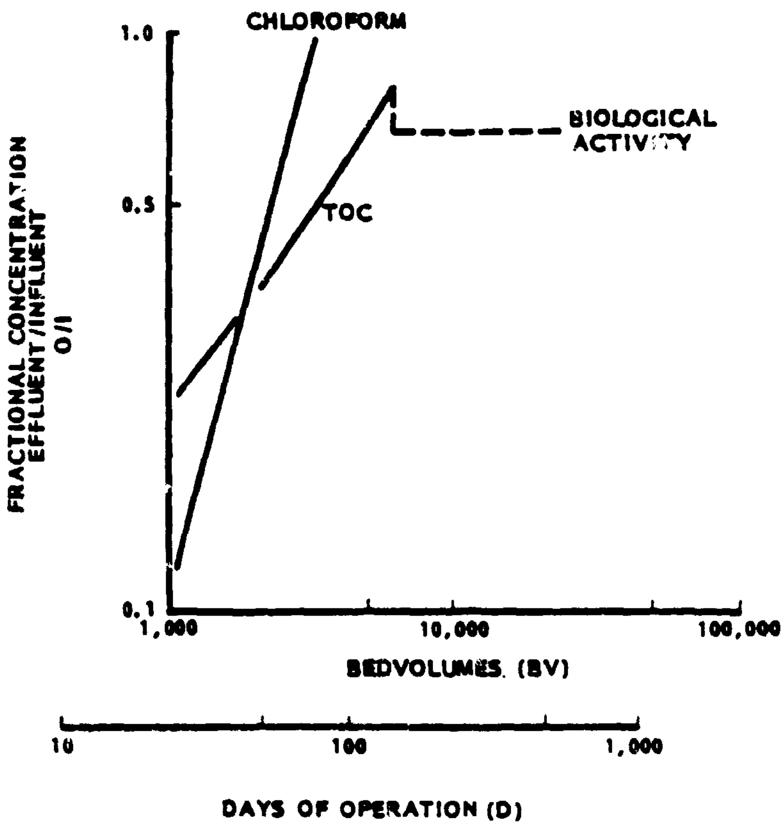

Figure 60 Time History of Granular Activated Carbon Performance

Better TOC removal by biological activity has been measured during previous test periods. During test periods F and G where the aerators were operating and the ozonator was not operating, over 50% better TOC removal performance in the GAC was indicated (reference 4). These results suggest that conditioning the influent to the GAC can have a significant influence on TOC removal performance and, thus, on carbon regeneration costs. These costs are discussed in a later paragraph.

Plant/Process Availability

Plant and process availability (percent of time the plant/process operates on demand) was monitored during the test period. The objective of operating the plant continuously for the 8-month (5832-hour) test period was met except for 69 hours when plant influent was unavailable, and when plant equipment failed. The operating time and downtime-for-repair periods for each of the processes are summarized in Table 23. Equipment failures experienced during the 8-month test period resulted in an estimated 20 days annually when the plant would be unable to deliver product; i.e., reclaimed water.

Included in this analysis is consideration of product storage capacity. Plant shutdowns of less than 8 hours were not recorded as plant downtime since reclaimed water could be delivered at the operating flow of 0.066 m^3/sec. for up to 8 hours from the 1893 m^3 effluent storage tank.

The individual processes did not have the capability to continue process operations when equipment failed because there was negligible intermediate storage. Therefore, the downtimes recorded for each of the processes are actual repair times. However, in many cases equipment failures did not result in plant shutdown because the capability to bypass nonoperating processes was afforded by plant design flexibility.

The problems necessitating process equipment repair are outlined in Appendix C. There were three predominant problems:

1. Calcium carbonate encrustations on equipment causing pump malfunctions and scale buildup on the inside walls of piping, thereby reducing flow capacity.

2. Plumbing failures within the ozonator.

3. Carbon furnace equipment component failures. Carbon was regenerated from the unused tower during the test period. The operator efforts required to do this were quite intensive. After complete regeneration of this tower, it was decided to cease any further regeneration. This decision was based on labor requirements and the fact that Stanford University's research involved long-term sorption characteristics of activated carbon without regeneration.

   The increased labor was due primarily to carbon furnace failures which included jamming of 1) the dewatering screw, 2) the horizontal feed screw, 3) the carbon drop chute, 4) the outlet at the base of the

TABLE 23
AVAILABILITY OF
PALO ALTO RECLAMATION FACILITY
JULY 1, 1980 THROUGH FEBRUARY 28, 1981

	OPERATING TIME, HR.	DOWNTIME, HR.	AVAILABILITY, %	ESTIMATED YEARLY DOWNTIME, DAYS
CHEMICAL CLARIFICATION	4,993	654	88.4	43
RECARBONATION	4,825	91	98.1	7
OZONATION	4,160	1,217	77.4	83
MULTIMEDIA FILTRATION	5,324	0	100.0	0
CARBON SORPTION [1]	5,324	0	100.0	0
CHLORINATION	5,324	0	100.0	0
COMPUTER	5,324	81	98.5	6
PLANT (PRODUCT DELIVERY)	5,455	308	94.7	20

NOTE:

1. CARBON REGENERATION FURNACE WAS NOT OPERATED DURING THE TEST PERIOD.

carbon furnace as it enters the quench tank, and 5) the bottom of the spent carbon storage tank during carbon transfer. Also, the burner temperature control sensors malfunctioned quite frequently which resulted in improper temperatures within each hearth of the multiple hearth furnace. The operators spent considerable time unjamming the previously mentioned problem areas, and the operation required close attention during the regeneration process. Miscellaneous breakdowns included boiler breakdown, I.D. fan failures, and clogging at the outlet of the quench tank which added to the problems. This necessitated the discontinuance of further attempts to regenerate carbon.

Plant Reliability

Figure 61 illustrates the method of determining plant reliability. The data distribution curve, Figures 40 to 59, at the MCL establishes the probability (reliability) that plant effluent will not exceed the MCL.

Plant reliability (percent of operating time that the plant effluent was within given limits) is summarized in Table 24. Some of these limits are illustrative only in that they are not discharge limits on this particular plant but are potential limits should the plant effluent be used for potable or irrigation purposes.

Plant O&M Costs

The O&M costs of the plant during the 8-month test period are presented in Table 25. Extrapolation of these data gives a projected annual plant production cost of $311,400. Water production costs were $0.16 per 1000 liters.

The distribution of costs as determined from the totals shown in Table 18, including all categories, may be summarized as follows:

	Labor	Materials	Total
Operations	49.4%	25.5%	74.9%
Maintenance	22.5%	2.6%	25.1%
Total	71.9%	28.1%	100.0%

The labor costs shown under the subheading General Plant Operations include preventative maintenance on all equipment contained within the reclamation facility. It also includes maintenance that require less than 4 hours of effort. Operator process monitoring, filter backwashing, plant rounds keeping, and miscellaneous water quality testing are included in this category. Plant operators', electricians', and mechan[illegible]s' labor constitutes the majority of the cost in this category. This subhead[illegible]g is to cover those undefinable labor costs that could not be allocated specifically to a unit process.

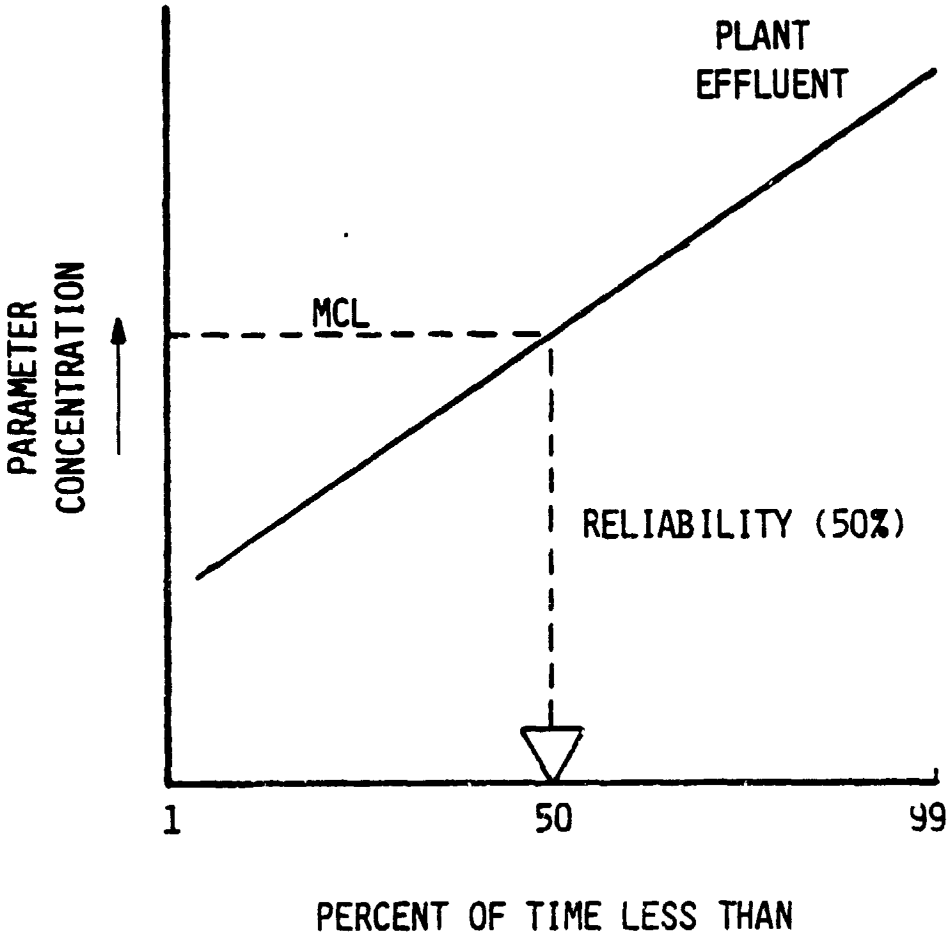

Figure 61 **Determination of Reliability (Example)**

TABLE 24

RELIABILITY OF PALO ALTO RECLAMATION FACILITY

	MAXIMUM CONCENTRATION LIMIT MCL	MINIMUM CONCENTRATION LIMIT MCL (MIN)	REFERENCE	RELIABILITY	
				PERIOD A	PERIOD H
CHEMICAL OXYGEN DEMAND	10 mg/l	-	9	65.0% [1]	57.8%
TRIHALOMETHANES	100 mg/l	-	10	>99.9%	>99.9%
TOTAL NITROGEN	5 mg/l	-	9	86.1% (NH_3) [2]	<0.0%
pH	8.5	6.5	9	18.7%	99.9%
DISSOLVED OXYGEN	-	1 MG/L	9	>99.9%	-
HARDNESS	500 mg/l	-	11	78.6%	97.3%
SODIUM	250 mg/l	-	12	>99.9%	-
TOTAL RESIDUAL CHLORINE		1 MG/L	9	76.2%	77.5%
CONDUCTIVITY	1600umho/cm	-	13	>99.9%	70.9%
TURBIDITY	5 NTU		9	-	-

NOTES:

1. ASSUMES COD/TOC RATIO OF 2.5.
2. BASED ON AMMONIA OR NITRATE CONCENTRATION.

TABLE 25

OPERATIONS & MAINTENANCE COSTS OF
PALO ALTO RECLAMATION FACILITY
JULY 1, 1980 THROUGH FEBRUARY 28, 1981
1/

	OPERATIONS	MAINTENANCE	LAB	ADMINISTRATION & ENGINEERING	TOTALS
CHEMICAL CLARIFICATION					
LIME	$19,290	-	-	-	$32,890
LABOR	-	$13,600	-	-	
RECARBONATION					650
LABOR	-	650	-	-	
OZONATION					3,960
LABOR	-	3,960	-	-	
MULTIMEDIA FILTERS	-	-	-	-	-
CARBON ADSORPTION	-	-	-	-	-
CHLORINATION					580
CHLORINE	580	-	-	-	
COMPUTER					13,770
LABOR	-	13,770	-	-	
GENERAL PLANT OPERATIONS 2/					155,740
ELECTRIC	30,650	-	-	-	
GAS	2,360	-	-	-	
MATERIALS & SUPPLIES	-	5,440	-	-	
LABOR	64,870	-	23,110	29,310	
TOTALS	$117,750	$37,420	$23,110	$29,310	$207,590

TOTAL WATER COST = $0.16 PER M^3 ($0.60 PER 1000 GAL.)

PROJECTED YEARLY O & M COST = $311,400

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NOTES

1. LABOR COST OF $37/HR. FOR ENGINEERING; $27/HR. FOR ALL OTHERS. ◁
2. CARBON WAS NOT REGENERATED DURING THE TEST PERIOD.
3. INCLUDES PREVENTIVE MAINTENANCE AND MINOR MAINTENANCE REQUIRING LESS THAN FOUR HOURS LABOR.

▷ THE COSTS REPORTED HERE MAY BE UNIQUE TO THE EQUIPMENT & SYSTEM DESIGN OF THIS PARTICULAR FACILITY. CARE MUST BE EXERCISED IN EXTRAPOLATING THESE COSTS TO OTHER SYSTEM DESIGNS OR DIFFERENT PLANT CAPACITIES.

These costs did not include carbon replacement/regeneration since exhausted carbon was used throughout the test period. If carbon had been regenerated, the costs could have increased significantly.

Figure 62 illustrates potential water cost based on a $0.227 per kilogram carbon regeneration cost and a TOC effluent upper limit of 4 mg/l. The figure shows the strong cost dependence on influent conditions and performance reliability. For example, the water production cost presented above ($0.16 per 1000 liters) would about double for plant influent conditions of test period A, if 99 percent reliability were achieved. For the lower quality influent of test period H, the production cost could have more than doubled.

It should be noted that a significant but unconfirmed assumption was made in developing Figure 62; i.e., the performance achieved by continuously regenerated carbon, based on average carbon age existing in the column, will be the same as that obtained when the column contains all carbon of the same age. This assumption allows the carbon performance of Figure 60 to be used in computing continuous regeneration rates. The linear decay in performance seems to substantiate the assumption; however, the resulting computed costs should be considered approximate until actual tests confirm the postulated performance.

The sudden tail-off of the cost curve for period A occurs at about 50% reliability below which steady-state biological growth on the carbon maintains performance without the necessity of carbon regeneration.

It is significant to note that if over 50% reliability is to be maintained, costs will be incurred which will significantly increase the cost of water production.

BASIS

1. COD LIMIT OF 10 mg/l. COD/TOC RATIO OF 2.5.
2. INFLUENT CONCENTRATIONS OF FIGURE 20.
3. PERFORMANCE WITH CONTINUOUS CARBON REGENERATION IS THE SAME AS THAT SHOWN IN FIGURE 60 BASED ON AVERAGE CARBON AGE.
4. CARBON REGENERATION COST OF $0.227 PER KILOGRAM.

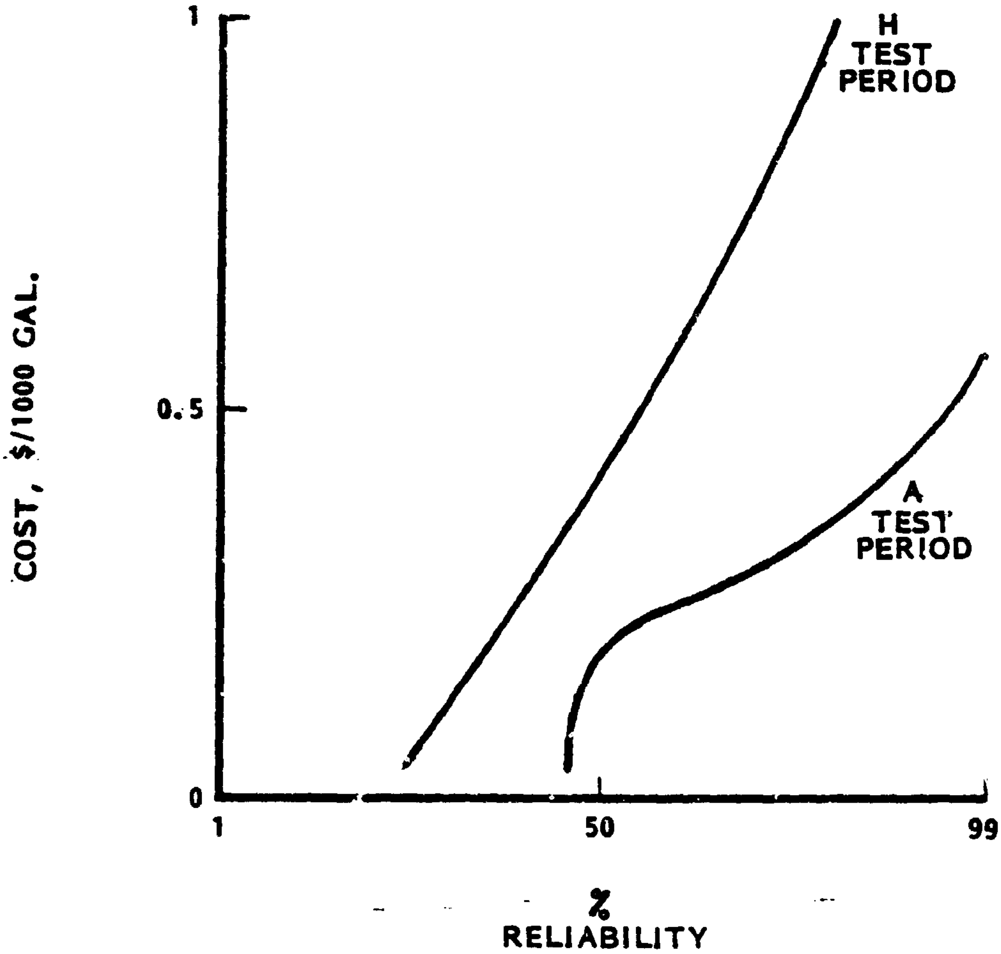


Figure 62 Relationship Between Cost & Reliability for Complying With COD Discharge Limit by Granular Activated Carbon Regeneration

SECTION 4

FUTURE APPLICATIONS

A primary responsibility of the Santa Clara Valley Water District is to insure an adequate quantity and quality of water supplies for Santa Clara County, California. The existing needs are met from local and imported supplies. Local supplies are from the natural yields of the County's three interconnected subbasins and the yields of the major tributary surface drainage areas into District reservoirs. Water is imported into Santa Clara County from the South Bay Aqueduct of the California State Water Project. In addition, water is imported through the City of San Francisco's Hetch-Hetchy Aqueduct by various cities in North Santa Clara Valley. Imported water is needed in Santa Clara County even during an average rainfall year, and a new importation supply from the Bureau of Reclamation San Felipe Division of the Central Valley Project is being constructed to fill this need.

The Santa Clara Valley Water District is committed to developing alternative supplies including reclaimed water. There are, however, barriers to reuse - principally economic and assurance of safety (i.e., water quality). The Palo Alto Reclamation Plant and the NASA WMS have been crucial projects for exploring these barriers.

Early in the Palo Alto Reclamation Project, the Santa Clara Valley Water District concluded that on-line water quality analysis would be essential to the successful marketing of high quality reclaimed water, and contacted NASA for their help and expertise in this area.

It was felt that even though there are wet chemistry analyses available for determination of water quality, these tests would be unacceptable because it often takes days before the results are obtained, long after the water would have been reused.

With the WMS, the effluent quality can be monitored on a real-time basis. If for any reason the effluent quality deteriorates, then the effluent can be diverted to waste. The WMS also was helpful in evaluating reclamation unit processes by monitoring quality improvement in each unit process. This permitted evaluation of the effectiveness of each treatment process and unit process economics. Results from the experiment indicate that such monitoring of treatment plant effluents on a continuous basis can better enable treatment plant operators to achieve optimal performance from each unit process.

The long term future applications of automated water quality monitoring appears bright but its immediate future is not well defined. Several factors need clarification, such as, the legal aspects of "product liability" of reclaimed water, and current EPA and DOH monitoring requirements for potable and wastewater. Since the demand for potable water is continuing to increase and the sources of pristine water are not increasing, it appears certain that wastewater will have to be reused. If water is to be reused, it is important that its quality be assured on a continuous basis. Automation is the only economically feasible (see cost comparison in Table 26) means of meeting such a need. The use of continuous monitoring data from the WMS as control functions for the treatment plant process control computer can result in a closed loop control of the wastewater reclamation plant resulting in reduced chemical and power usage in the various treatment processes. These benefits will be optimized by the use of closed loop control. Estimated costs of a comparable number of analyses by typical laboratory techniques are shown. These estimates are based on the results of a telephone survey conducted by the Santa Clara Valley Water District.

TABLE 26

ESTIMATED COSTS AND SAVINGS
FOR AUTOMATED INSTRUMENTATION

	LAB		WMS
CAPITAL COSTS, $			
SENSORS/SUPPORT EQUIPMENT	—	SAME	—
AUTOMATION (COMPUTER, PUMPS, VALVES, ETC)	—		$150,000
O&M COSTS (ANALYSIS AND REPORTING), $/DAY			
1 SAMPLE/DAY (BASED ON 30 MAN-HOURS FOR 22 LAB ANALYSES @ $27/M-H.)	$800		$260
6 SAMPLES/DAY (BASED ON 75 MAN-HOURS FOR 22 LAB ANALYSES @ $27/M-H.)	$2,000		$260
MINIMUM CAPITAL PAYOUT TIME FOR AUTOMATION, DAYS			
1 SAMPLE/DAY	—		278 DAYS
6 SAMPLES/DAY	—		86 DAYS

REFERENCES

1. "Boeing/NASA Water Monitor System Computer Operating Manual," Volumes I and II, D2-118621-1A, Poel, September 11, 1978.

2. "National Interim Primary Drinking Water Regulations," EPA-570/9-76-003.

3. "Advanced Treatment for Wastewater Reclamation at Water Factory 21," McCarty et al, EPA Technical Report Number 236, January 1980.

4. "Water Monitor System Technical Summary Report," Jeffers, Brooks, Thomas, Nibley, and Poel, The Boeing Company, September 26, 1979.

5. EPA Grant R804431, Stanford University From Robert S. Kerr Environmental Lab.

6. "Schaum's Outline of Theory and Problems of Statistics," Spiegel, Rensselear Polytechnic Institute, McGraw-Hill Book Company.

7. "Statistical Package for the Social Sciences," Nie, et al, McGraw-Hill Book Company, Second Edition, 1975.

8. "Operation and Maintenance Manual for the Water Reclamation Plant at Palo Alto, California," Santa Clara Valley Water District, Santa Clara County, California, December 1977. Jenks and Harrison.

9. "Wastewater Reclamation Requirements for the Santa Clara County Flood Control and Water District and the City of Palo Alto for Direct Injection of Reclaimed Wastewater into the upper aquifer of the Santa Clara Valley Groundwater Basin near Palo Alto," Order Number 73-71, and correspondence dated August 23, 1977, California Regional Water Quality Control Board, San Francisco Bay Region.

10. "National Interim Primary Drinking Water Regulations Control of Trihalomethanes in Drinking Water." Environmental Protection Agency 40CFR, Part 141, pp. 68624-68707, Federal Register Volume 44, Number 231, Thursday, November 29, 1979, Rules and Regulations.

11. "European Standards for Drinking Water," 2nd. Ed. 1970. World Health Organization.

12. "Guidelines for Interpretation of Water Quality for Agriculture," University of California Cooperative Extension, UC - Committee of Consultants, January 15, 1975.

13. "California Domestic Water Quality and Monitoring Regulations," California Health and Safety Code. Section 4026, Division 5, Part 1, Chapter 7 Water and Water Systems, California Administrative Code. Articles 1-8, pp. 1701-1719, 1977.

14. "Final Report on Water/Wastewater Management user Requirements Committee Meeting of February 14, 1974," Public Technology Incorporated for NASA Office of Applications, July 15, 1974.

15. "NASA JSC Water Monitor System - City of Houston Field Demonstration," Taylor et al, July 1979. NASA Reference Publication 1041.

APPENDIX A

PROCESS INPUT/OUTPUT CHARACTERISTICS

FOR PART I OF THE TEST PERIOD

JANUARY 1978 TO SEPTEMBER 1979

APPENDIX A

PROCESS INPUT/OUTPUT CHARACTERISTICS

Two points should be noted in evaluating the enclosed data, both of which probably contributed to data scatter:

1. Each point represents a daily average of 4 measurements of both the process input and output taken at regular 6 hour intervals. No compensation has been made for hydraulic lag. The lag would have negligible effect on certain processes such as the carbon towers where detention time is 34 minutes; however, data relating plant input to output can have significant error during an influent change since the average detention time is 9-10 hours and up to 24 hours is required to fully respond to a step change. No attempt was made to edit data which occurred during upsets.

2. A faulty flocculation process control sensor resulted in pH below the set-point. Subsequent analysis of plant operating records indicate that the data identified herein at pH 9.5 should be considered in the range 9 to 9.5 and data identified as pH 11 should be considered in the range of 10 to 11.

PROCESS CONFIGURATION SYMBOLS

□ BIOLOGICAL SECONDARY (ACTIVATED SLUDGE)/CHLORINATION

○ FLOCCULATION (pH 9.5)/AMMONIA STRIPPING/RECARBONATION/ FILTRATION/OZONATION/CARBON ADSORPTION (UNITS 3 & 4)/ FILTRATION/CHLORINATION - FLOW 1 MGD

Φ SAME AS ○ WITHOUT AMMONIA STRIPPING (AERATION)

● SAME AS ○ WITH pH 11

◐ SAME AS ● WITHOUT OZONATION

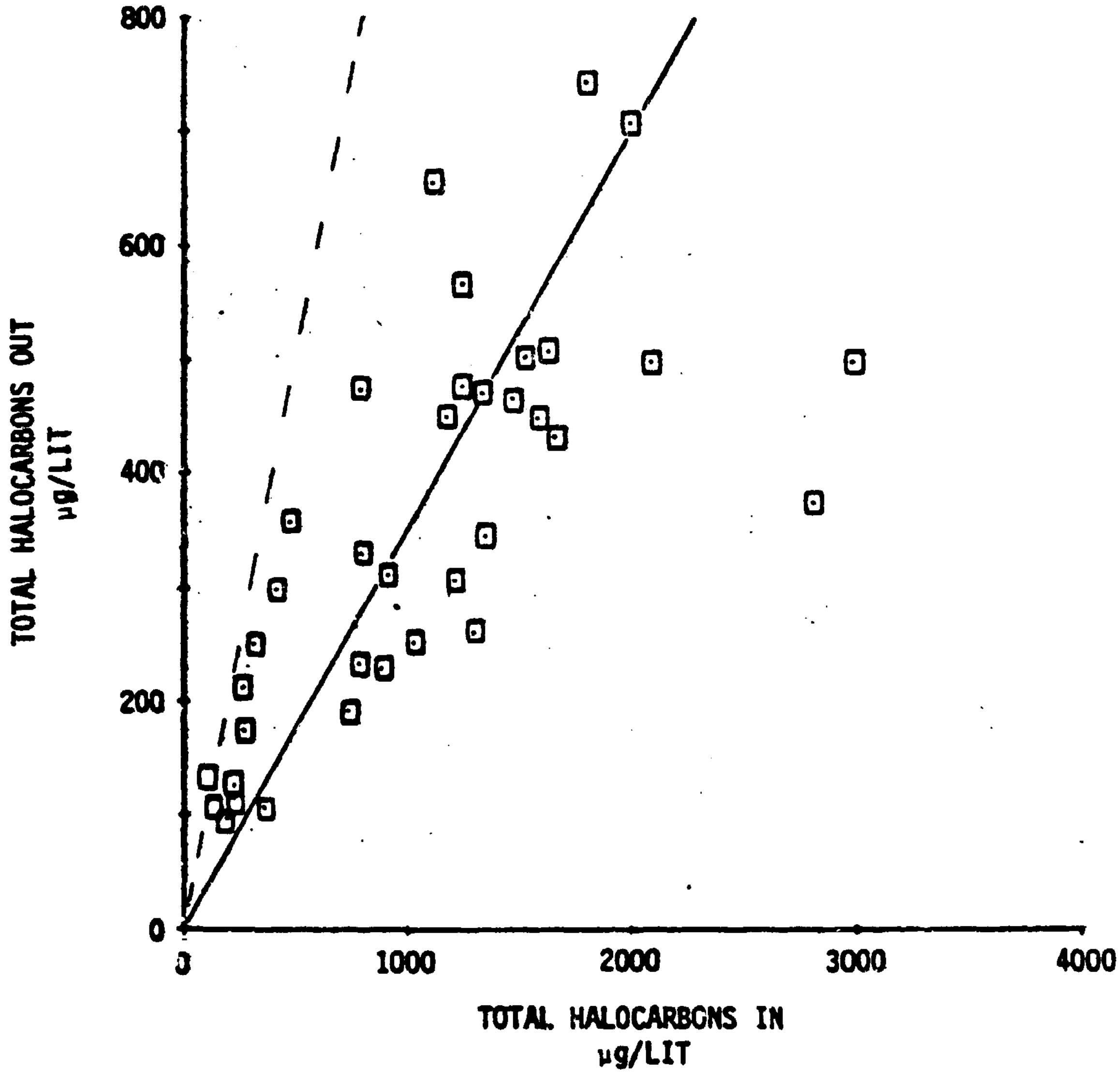
-●- ⏀ SAME AS ● WITHOUT FILTRATION/OZONATION

△ FILTRATION/OZONATION/CARBON ADSORPTION (UNIT 2)/ FILTRATION/CHLORINATION - FLOW 0.5 MGD

▲ SAME AS △ WITHOUT OZONATION

ACTIVATED SLUDGE/CHLORINATION

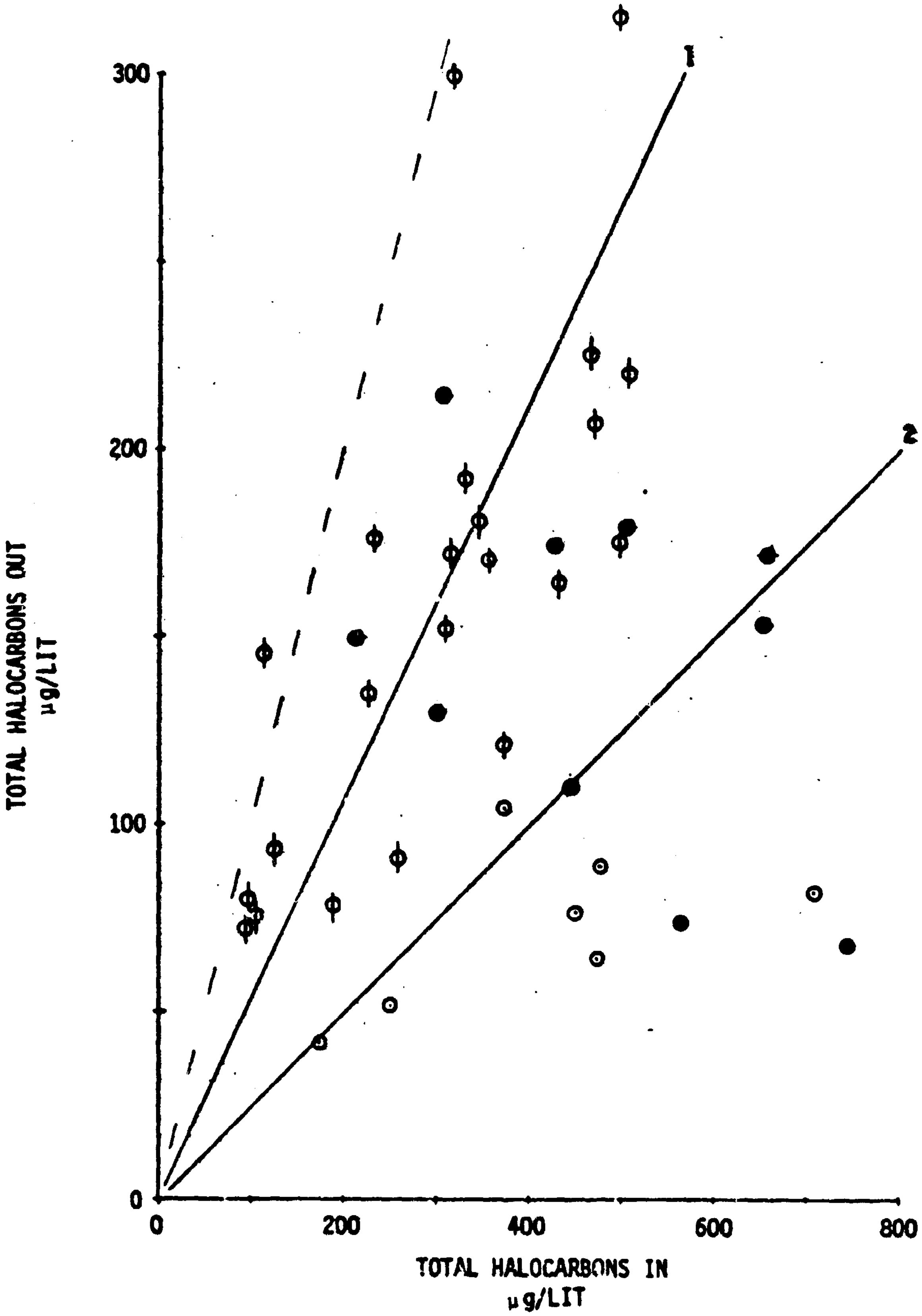
NOMINAL REMOVAL = 65%



FLOCCULATION/AMMONIA STRIPPING

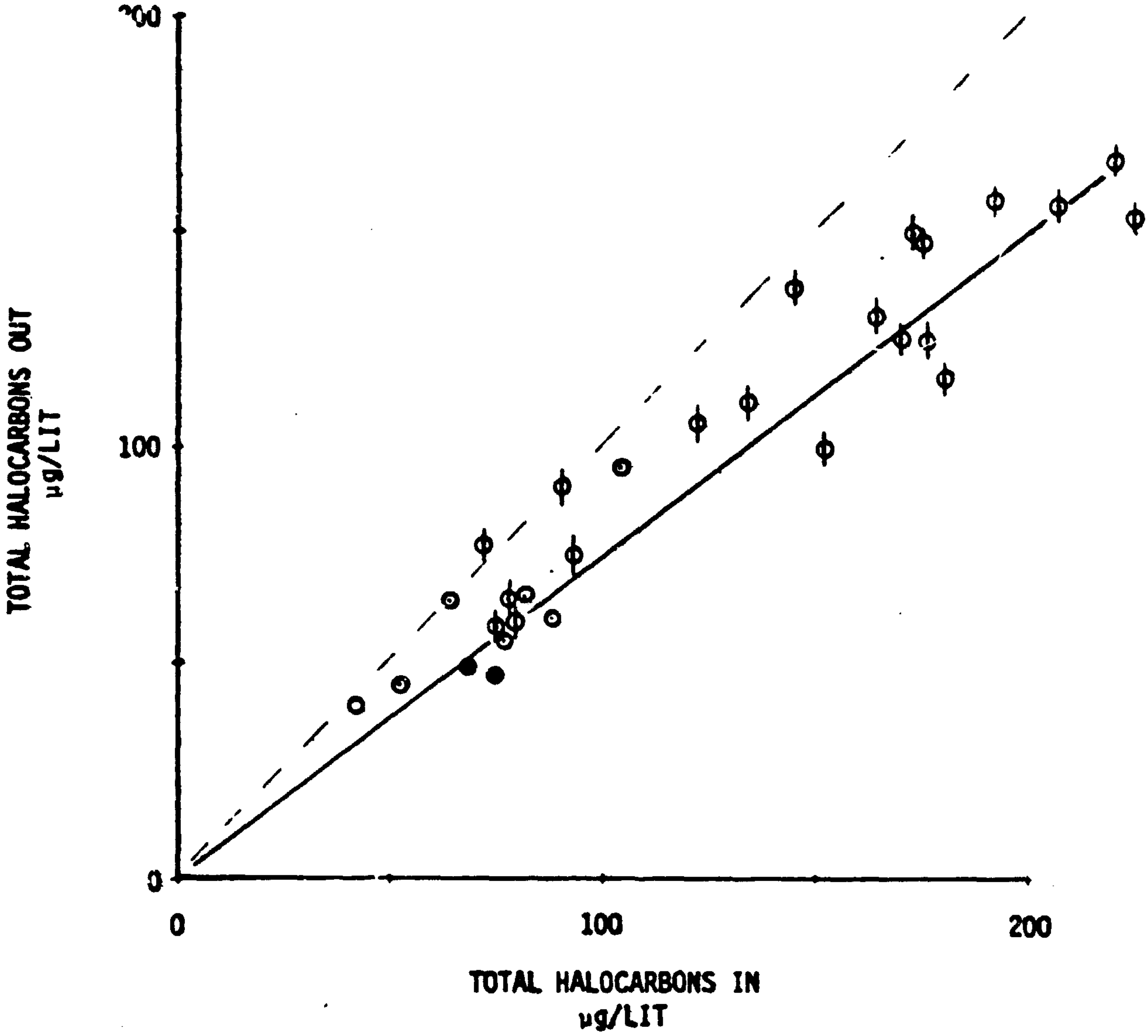
1. 47% REMOVAL WITHOUT AMMONIA STRIPPING

2. 75% REMOVAL WITH AMMONIA STRIPPING



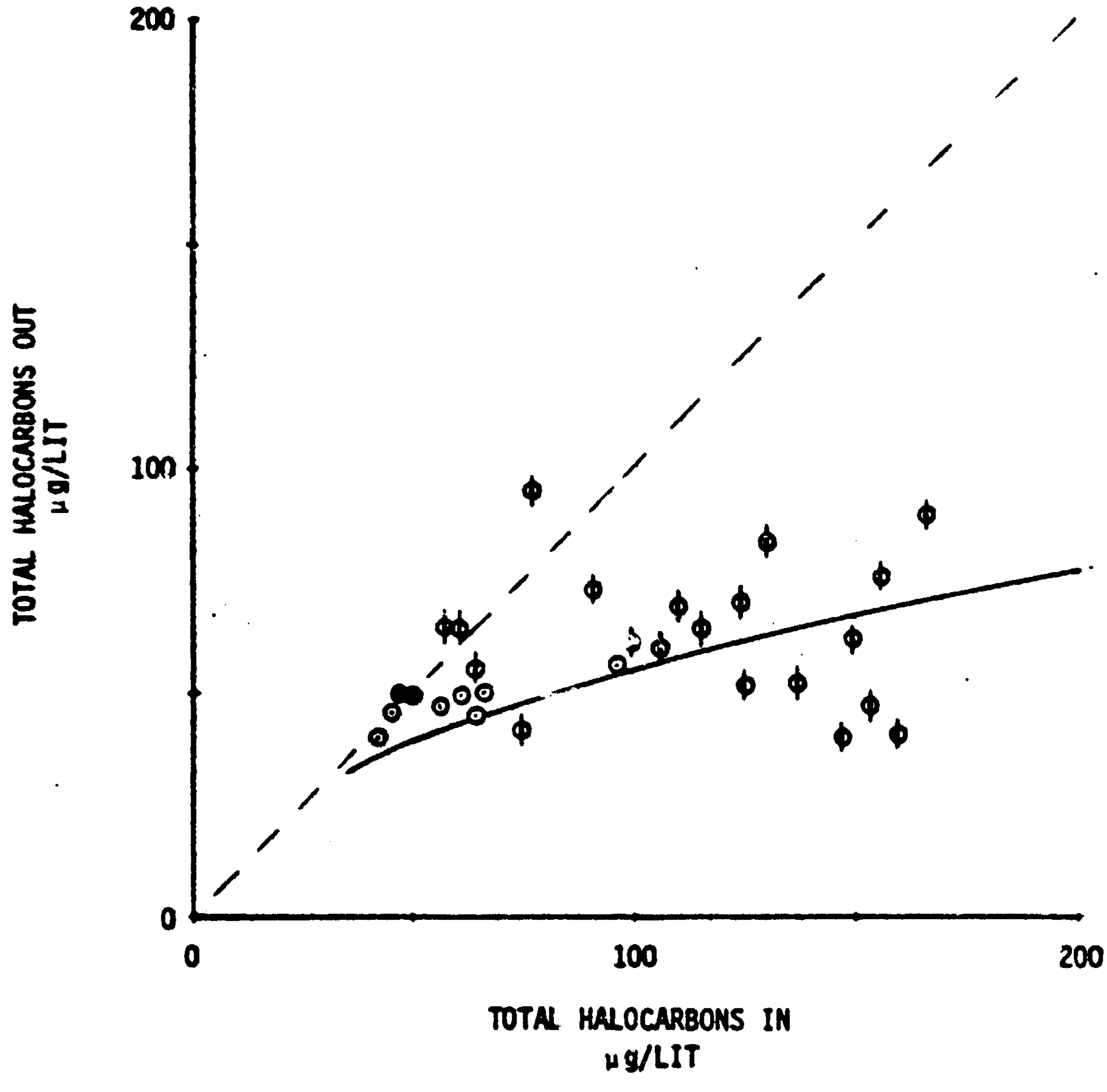
FILTRATION/OZONATION

NOMINAL REMOVAL = 25%

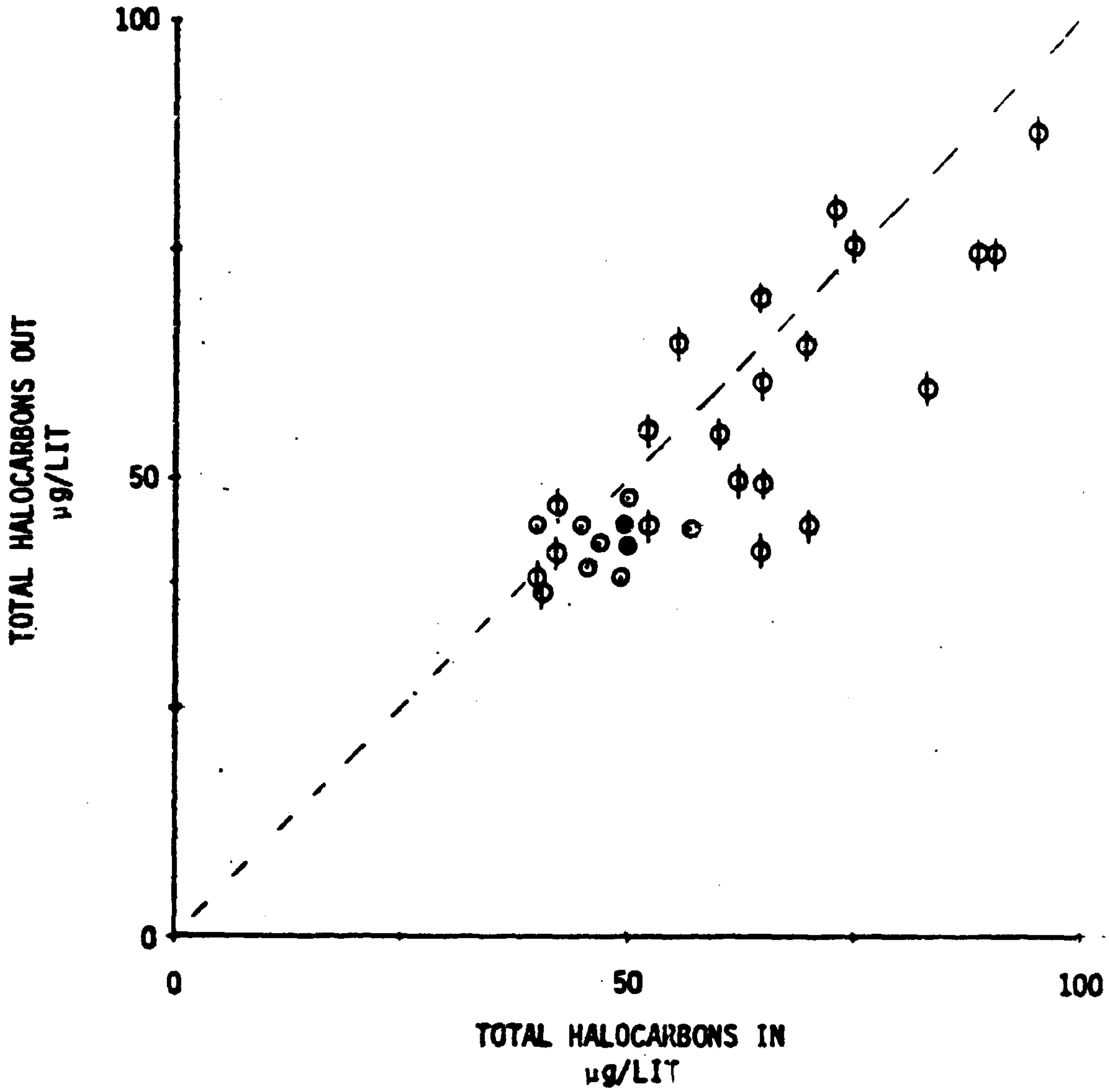


CARBON ADSORPTION

NOMINAL REMOVAL = $I - 5.6I^{0.5}$ µg/LIT

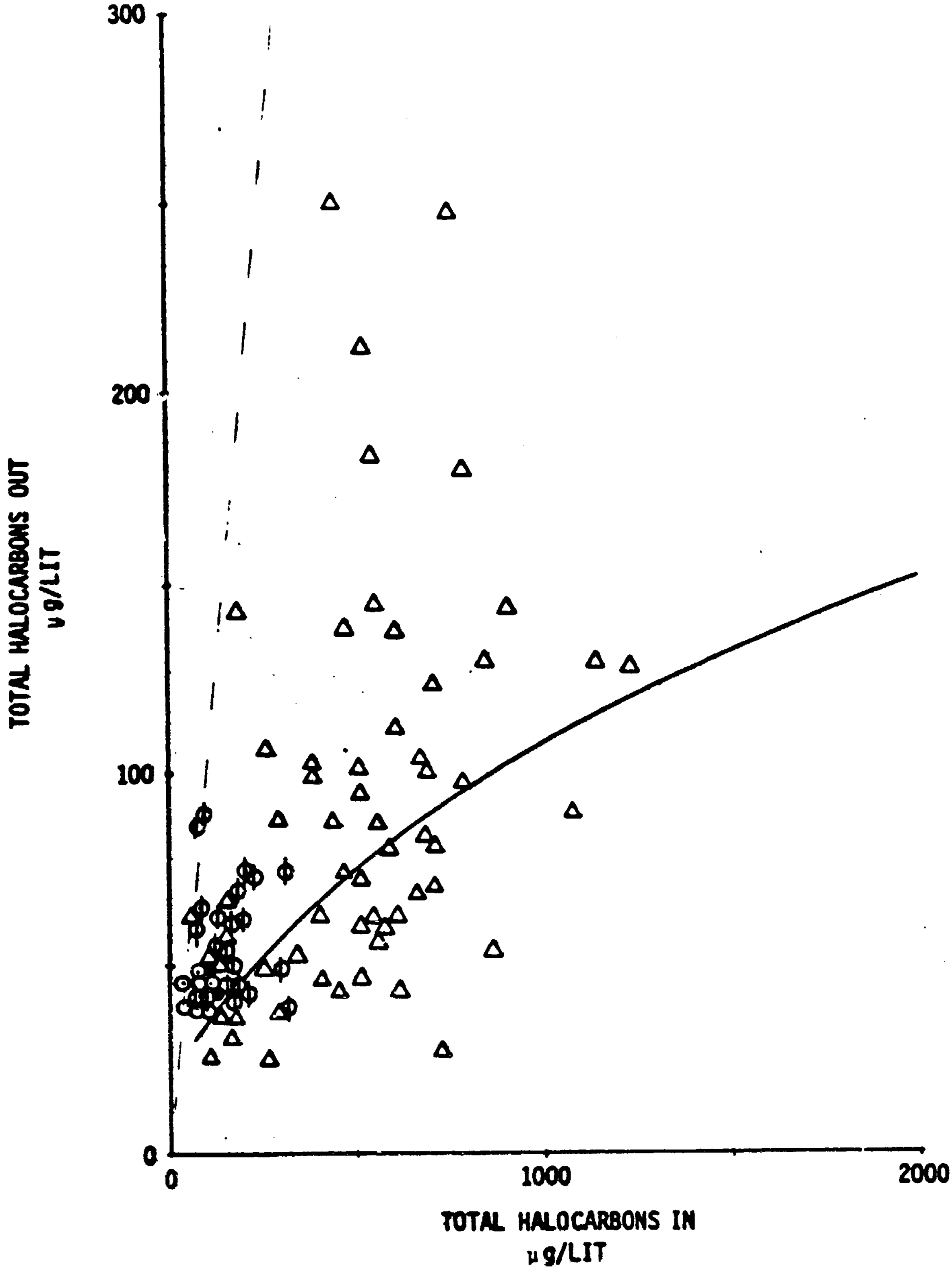


FILTRATION/CHLORINATION

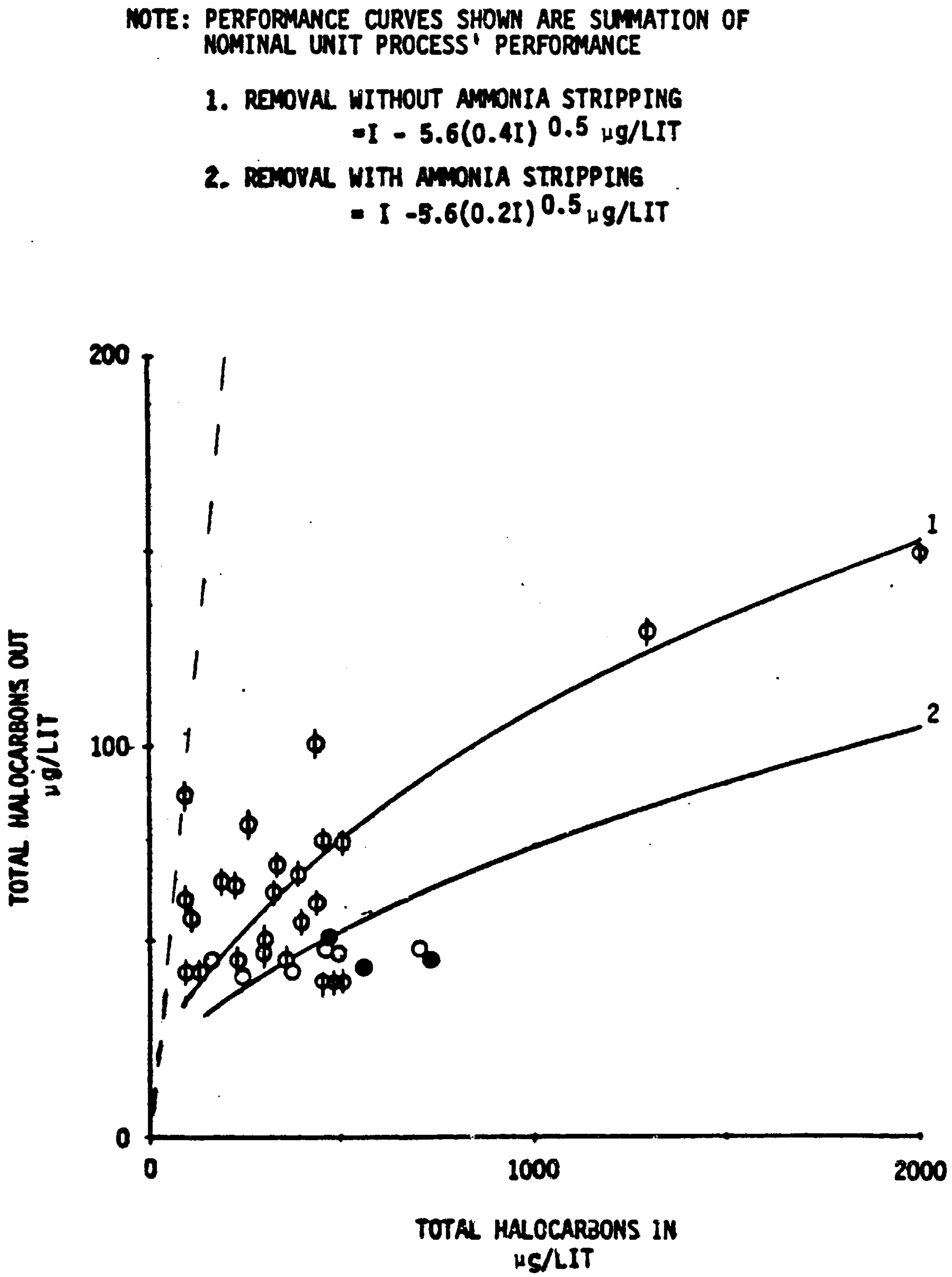


FILTRATION/CARBON ADSORPTION/FILTRATION

NOMINAL REMOVAL = $I - 5.6(0.40I)^{0.5}$ µg/LIT



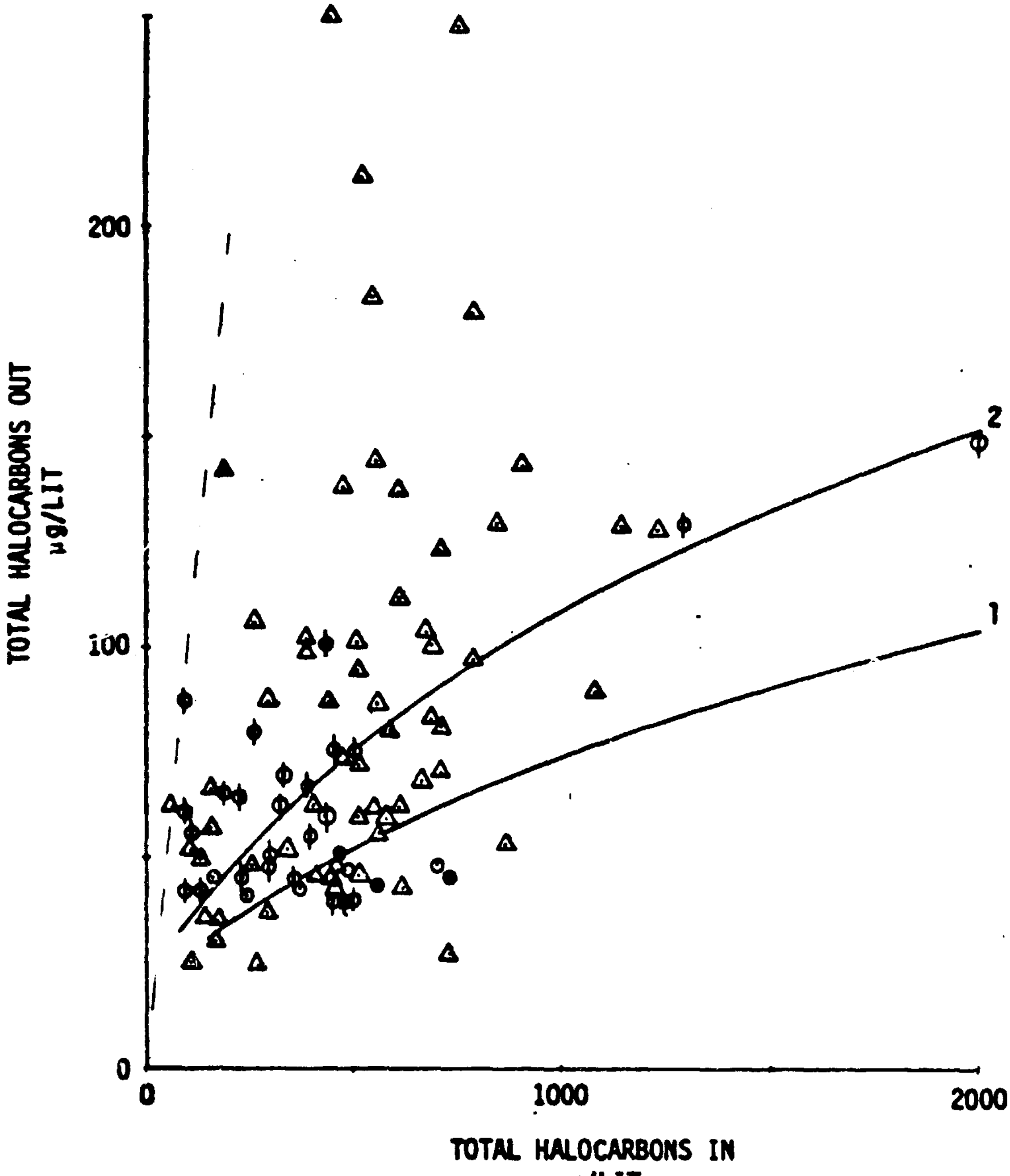
FLOCCULATION/FILTRATION/CARBON ADSORPTION/FILTRATION



RECLAMATION FACILITY

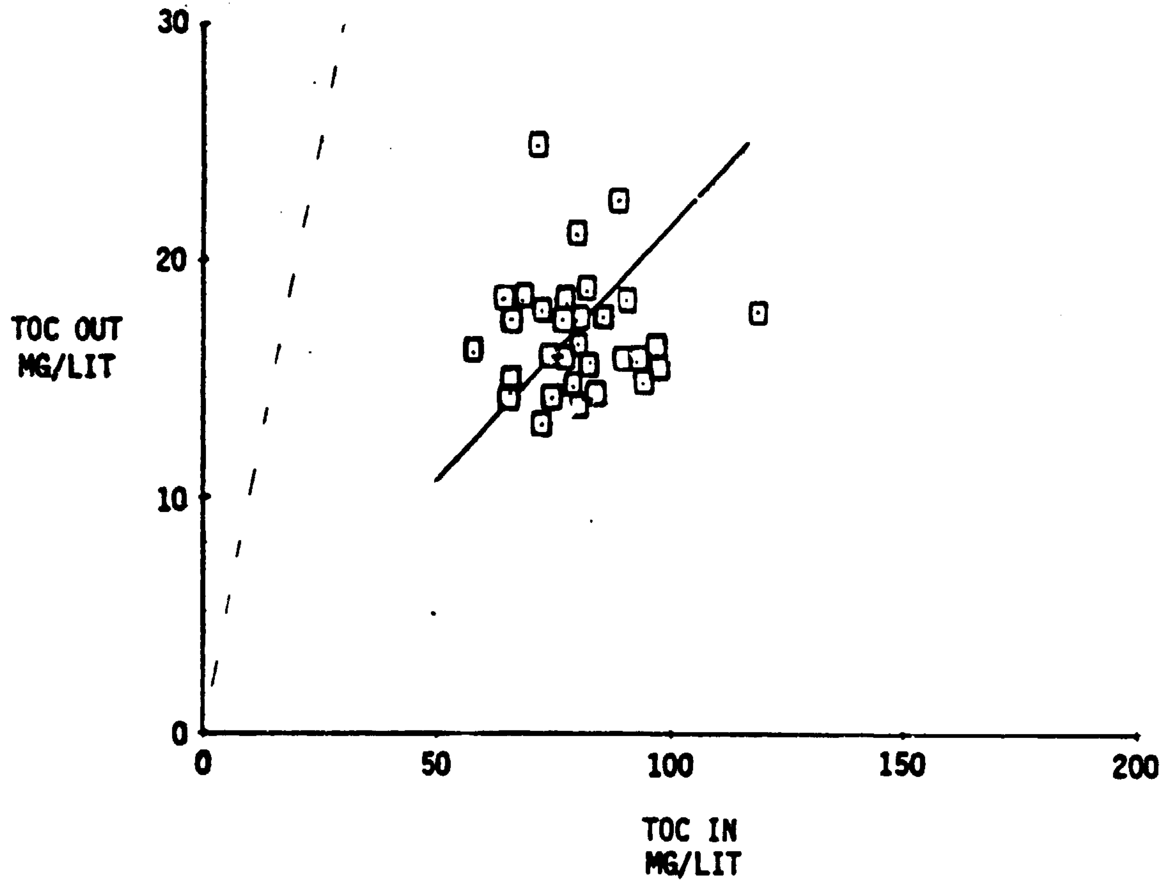
NOTE: PERFORMANCE CURVES SHOWN ARE SUMMATION OF NOMINAL UNIT PROCESS' PERFORMANCE.

1. NOMINAL REMOVAL WITH FLOCCULATION & AMMONIA STRIPPING $= I - 5.6(0.19I)^{0.5}$ µg/LIT
2. NOMINAL REMOVAL WITHOUT FLOCCULATION OR WITH FLOCCULATION, WITHOUT AMMONIA STRIPPING $= I - 5.6(0.40I)^{0.5}$ µg/LIT



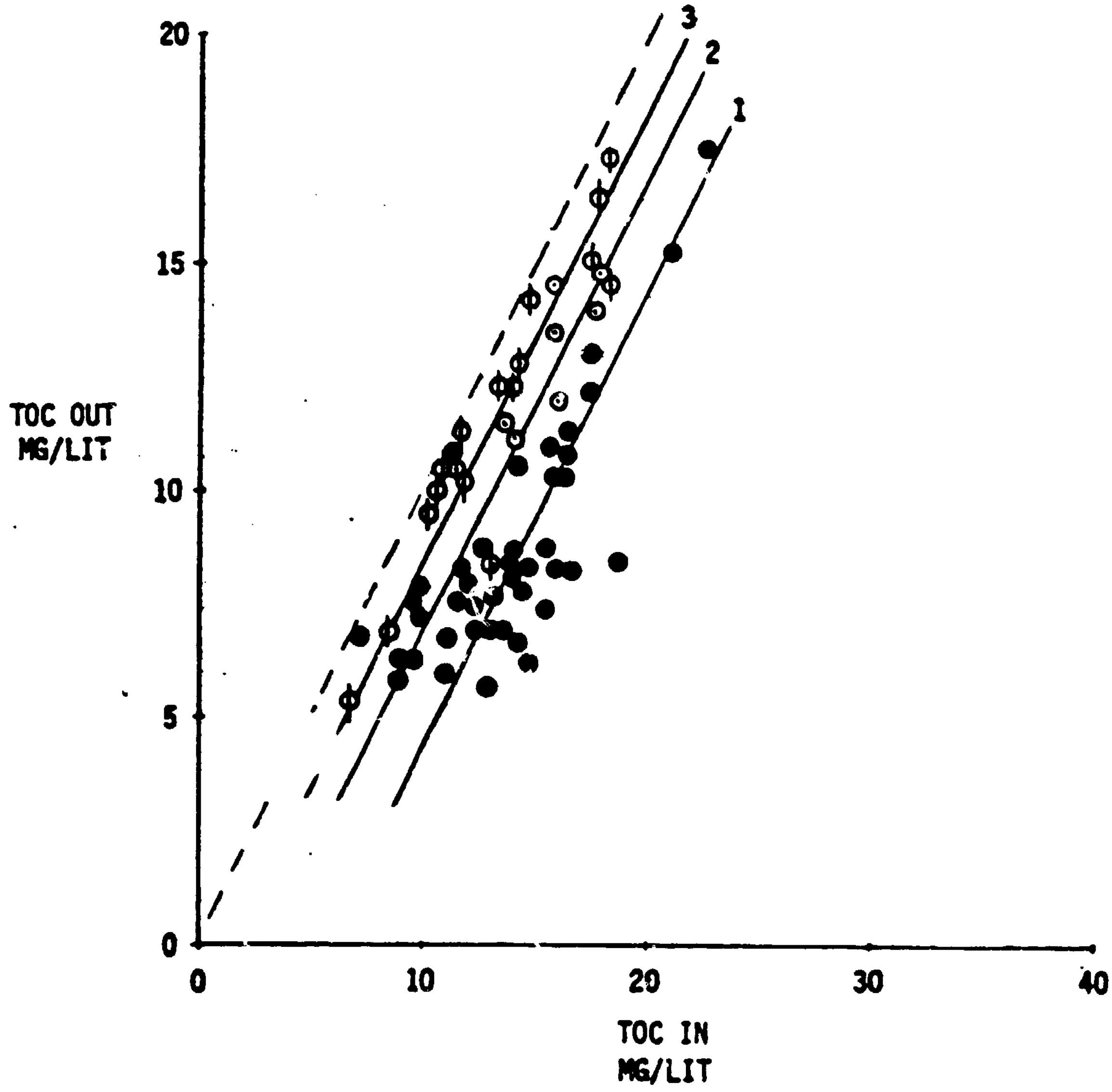
ACTIVATED SLUDGE/CHLORINATION

NOMINAL REMOVAL-78%



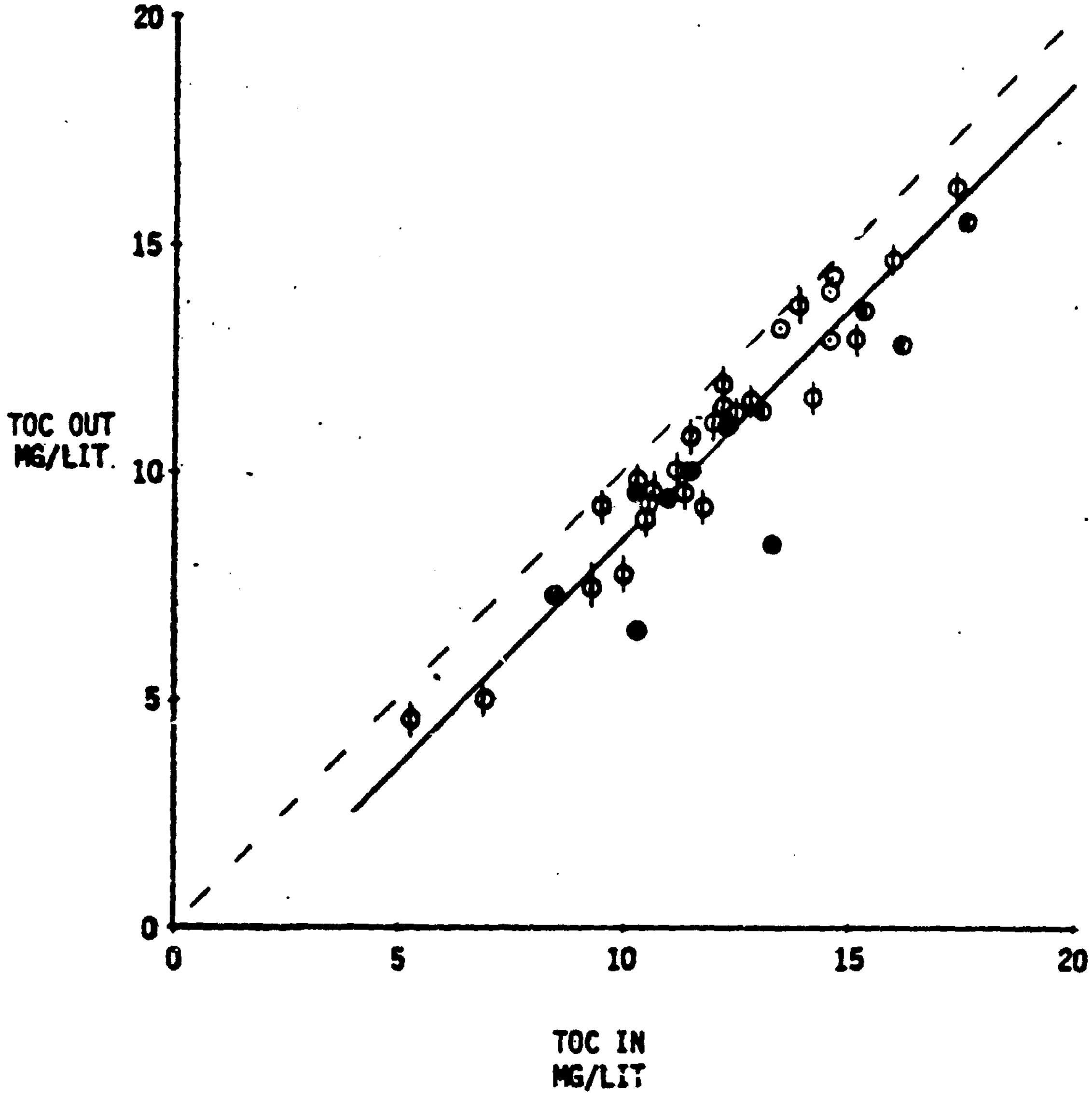
FLOCCULATION/AMMONIA STRIPPING

1. 5.5 MG/LIT REMOVAL @ pH 11 WITH AMMONIA STRIPPING
2. 3.0 MG/LIT REMOVAL @ pH 9.5 WITH AMMONIA STRIPPING
3. 1.5 MG/LIT REMOVAL @ pH 9.5 WITHOUT AMMONIA STRIPPING



FILTRATION/OZONATION

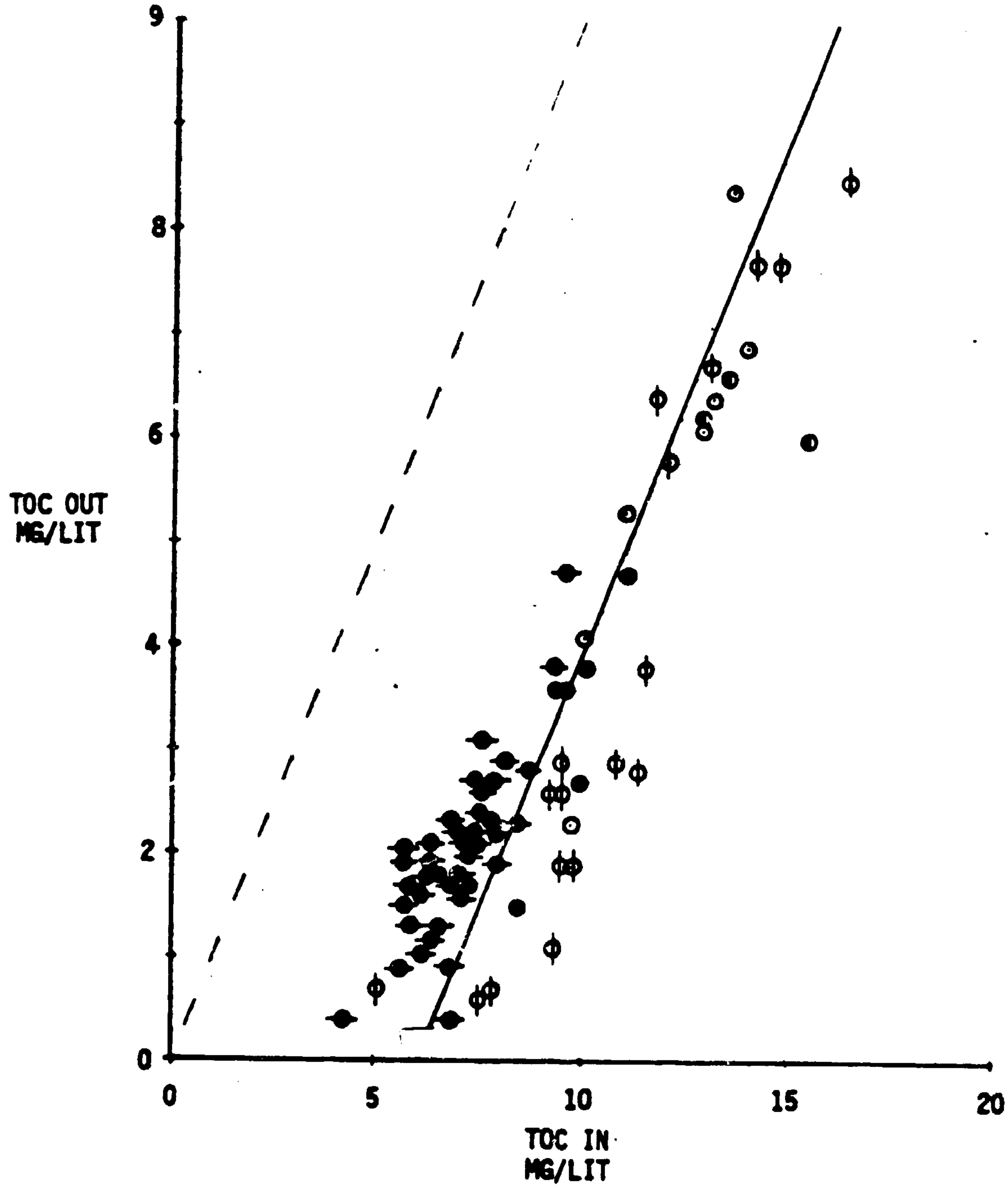
NOMINAL REMOVAL = 15% MG/LIT



CARBON ADSORPTION

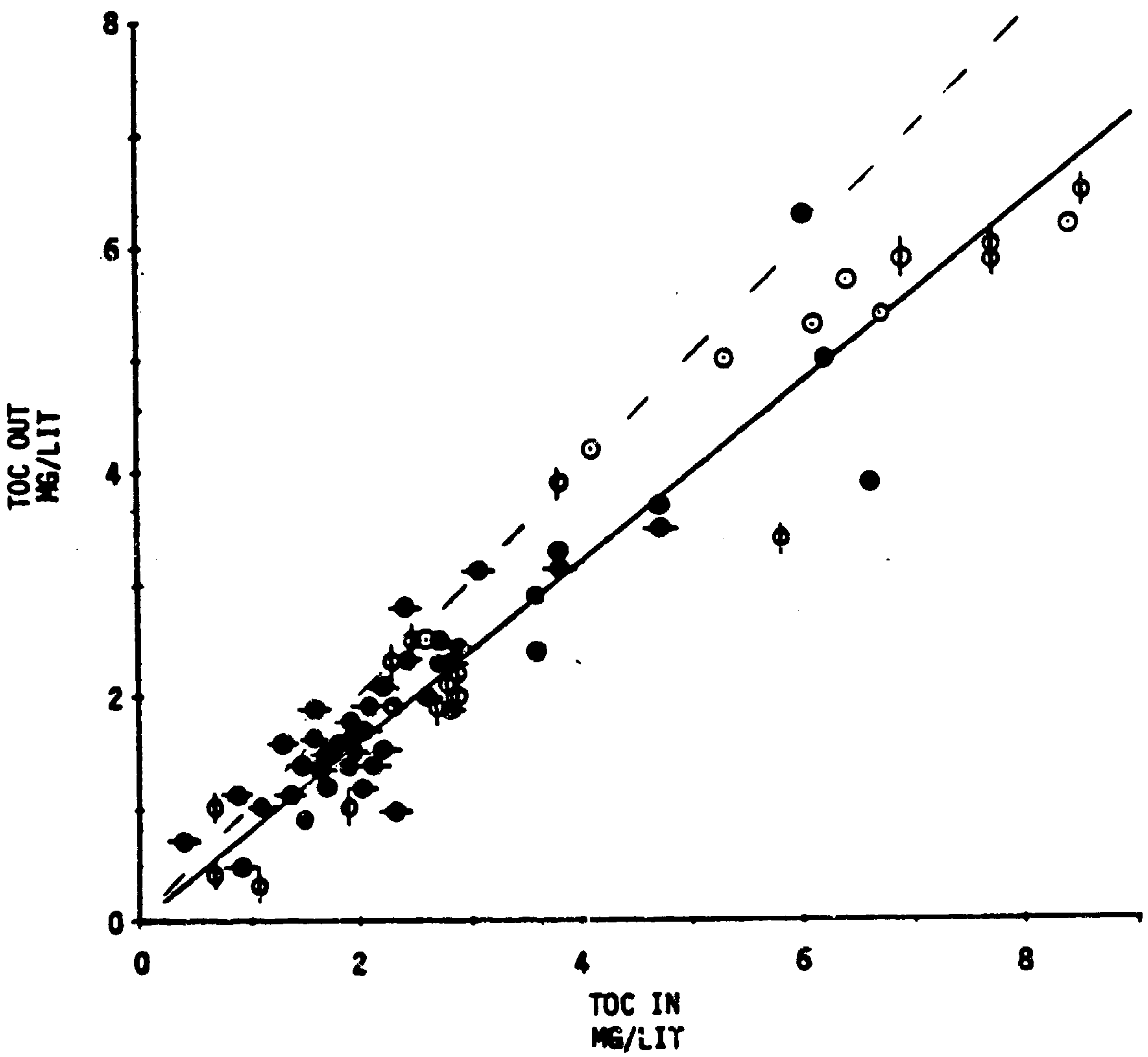
NOMINAL REMOVAL = 6 MG/LIT

NOTE: ADSORPTION PERFORMANCE IS DEPENDENT ON OPERATING HISTORY.



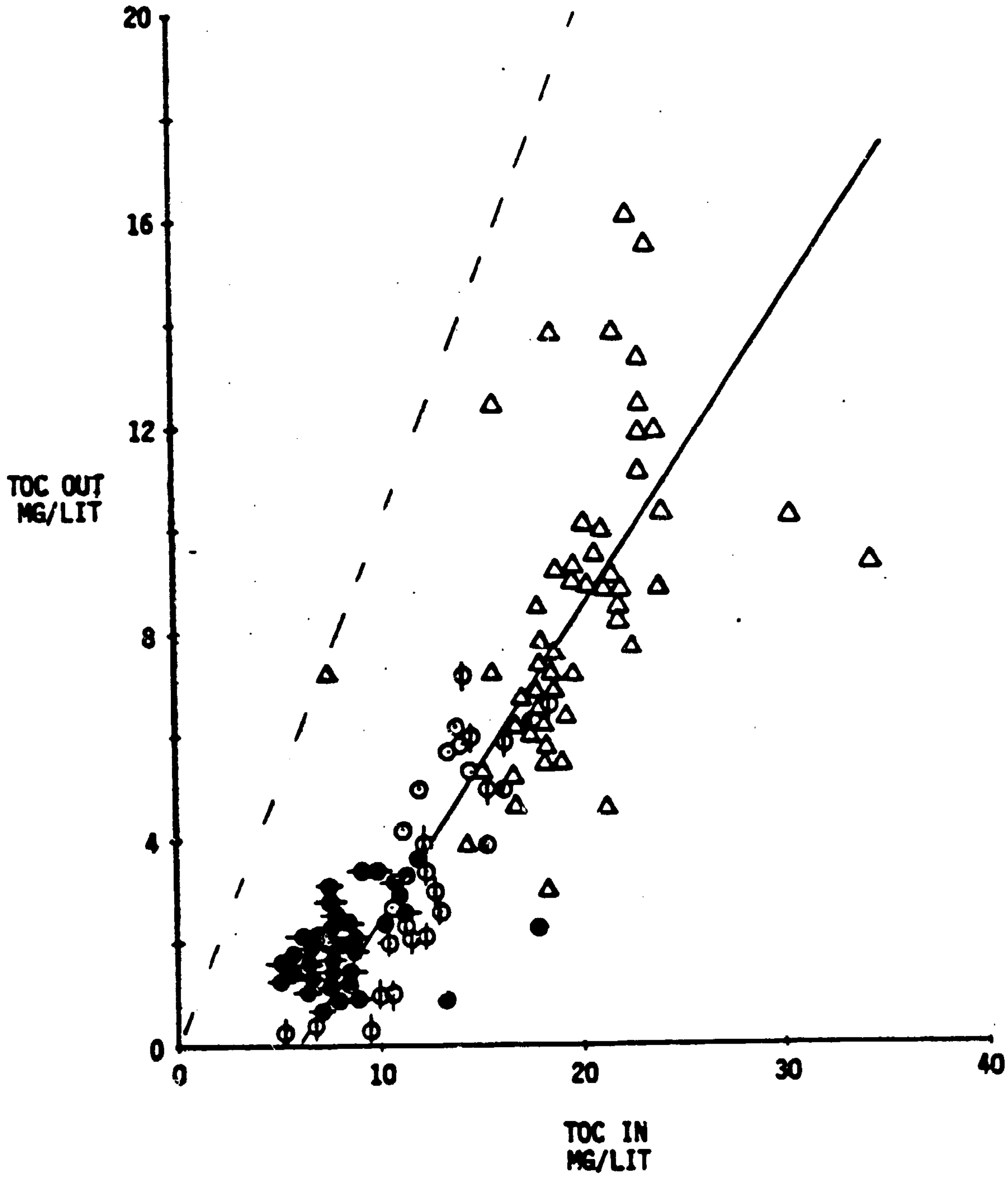
FILTRATION/CHLORINATION

NOMINAL REMOVAL = 15%



FILTRATION/CARBON ADSORPTION/FILTRATION

NOMINAL REMOVAL = I - [(0.85I-6)0.85



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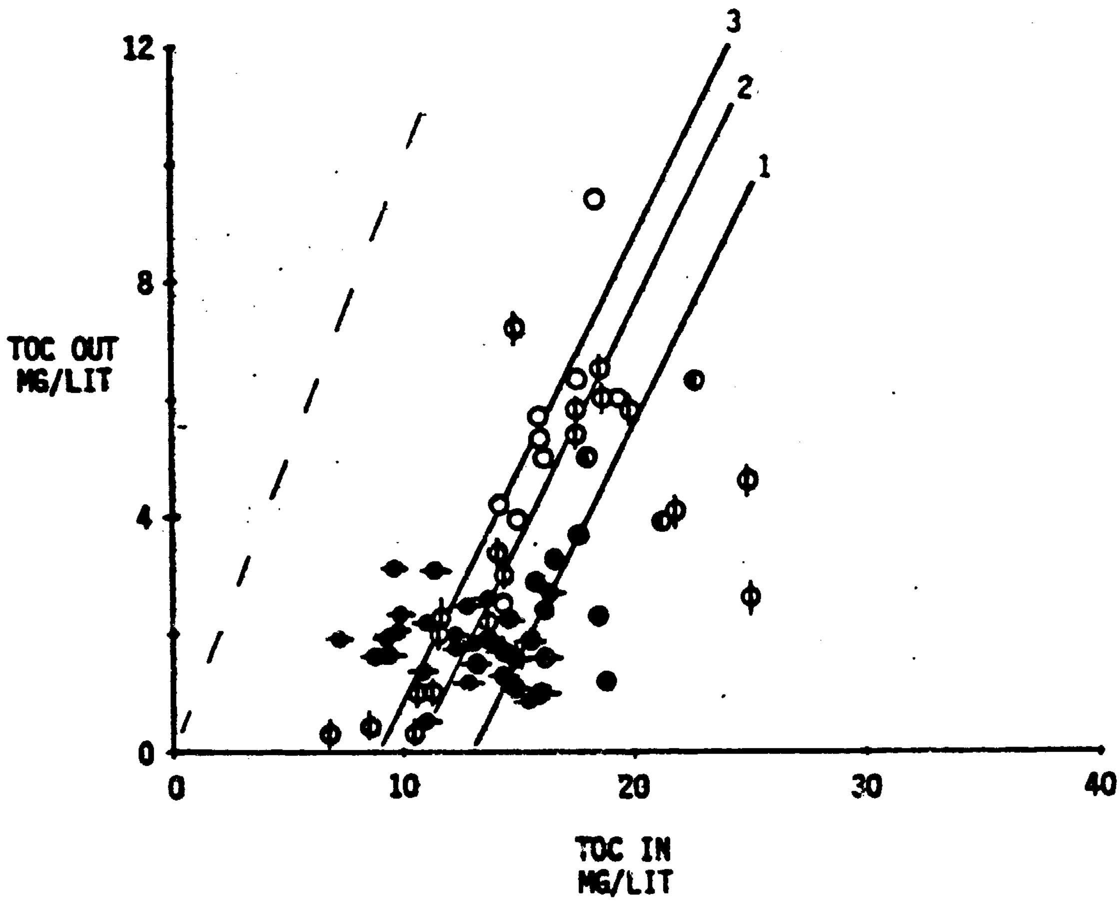
FLOCCULATION/FILTRATION/CARBON ADSORPTION/FILTRATION

NOTE: PERFORMANCE CURVES SHOWN ARE SUMMATION OF NOMINAL UNIT PROCESS' PERFORMANCE.

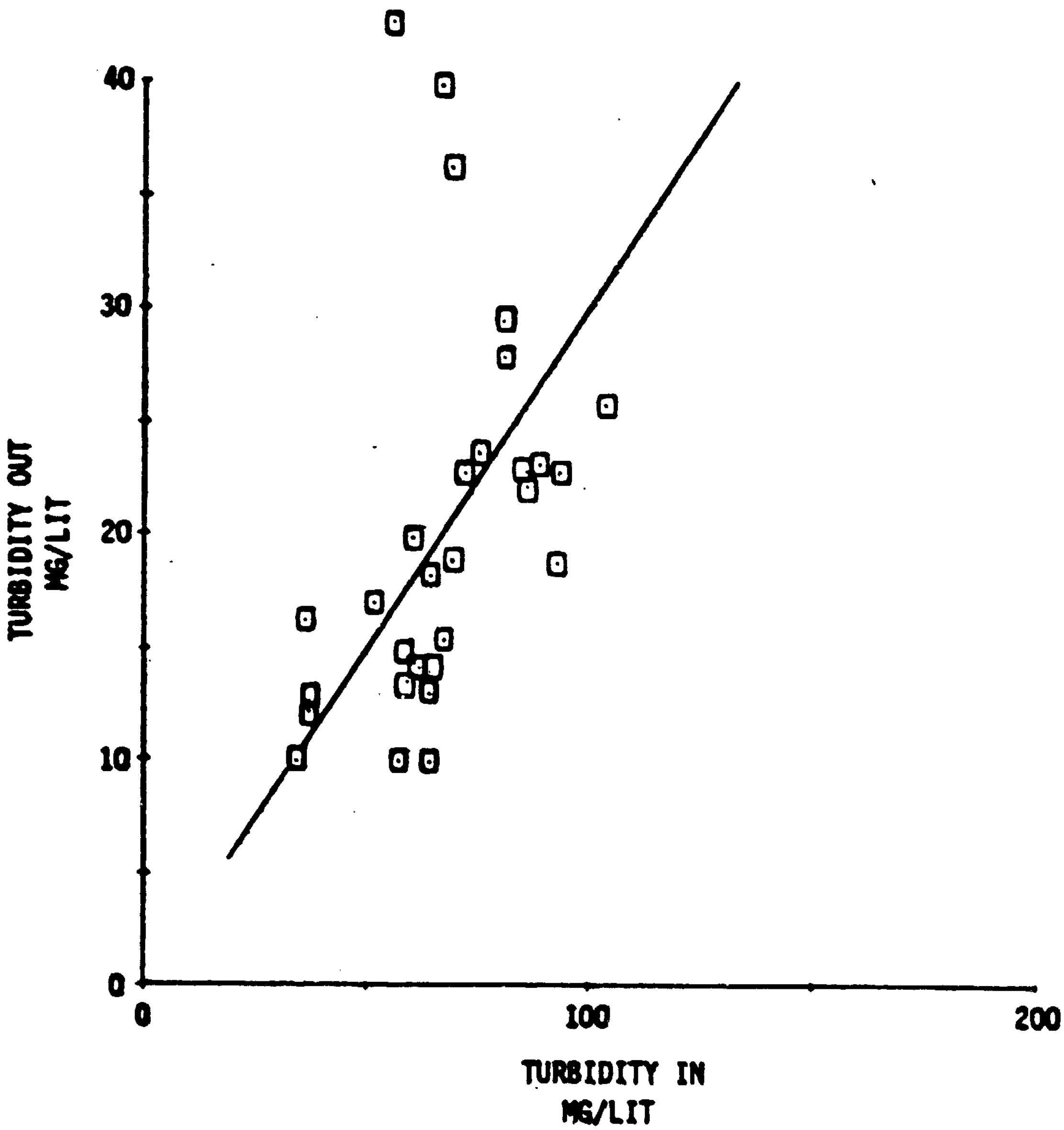
1. NOMINAL REMOVAL @ pH 11 WITH AMMONIA STRIPPING
   =I-(I-13.0) 0.8 MG/LIT
2. NOMINAL REMOVAL @ pH 9.5 WITH AMMONIA STRIPPING
   =I-(I-10.5) 0.8 MG/LIT
3. NOMINAL REMOVAL @ pH 9.5 WITHOUT AMMONIA STRIPPING
   =I-(I-9.0) 0.8 MG/LIT



C-3

ACTIVATED SLUDGE/CHLORINATION

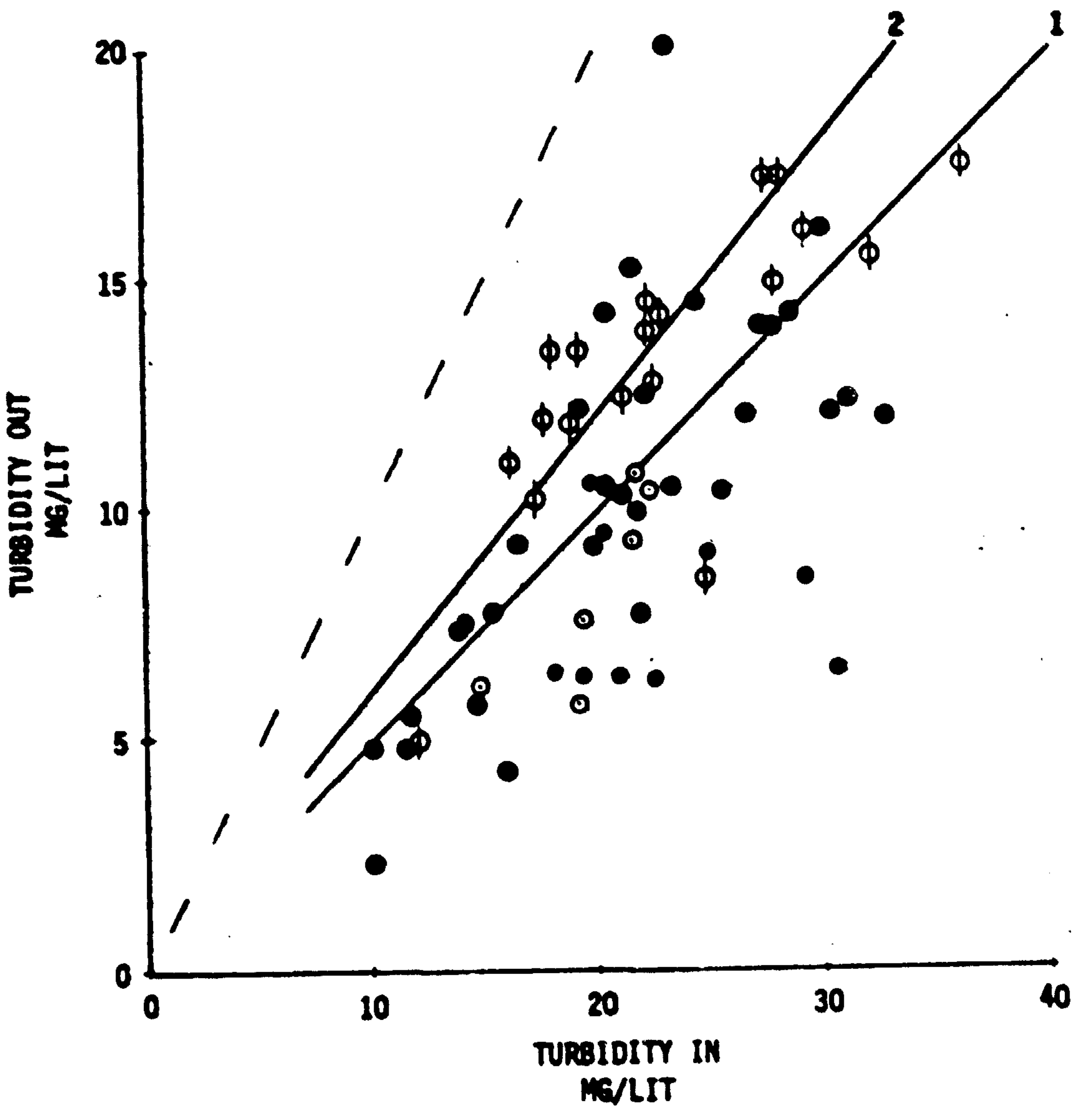
NOMINAL REMOVAL = 70%



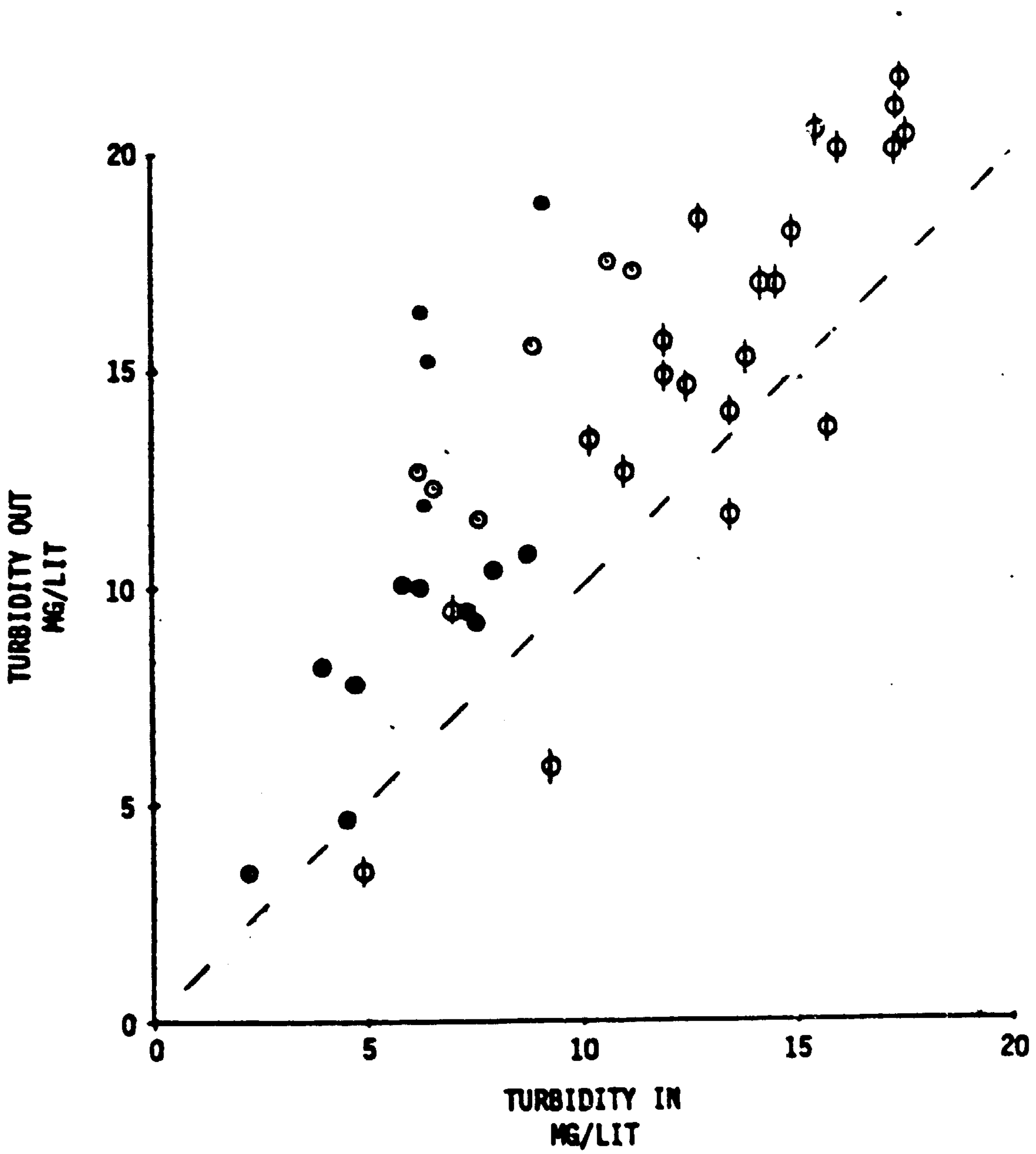
FLOCCULATION/AMMONIA STRIPPING

1. 50% REMOVAL

2. 40% REMOVAL WITHOUT AMMONIA STRIPPING

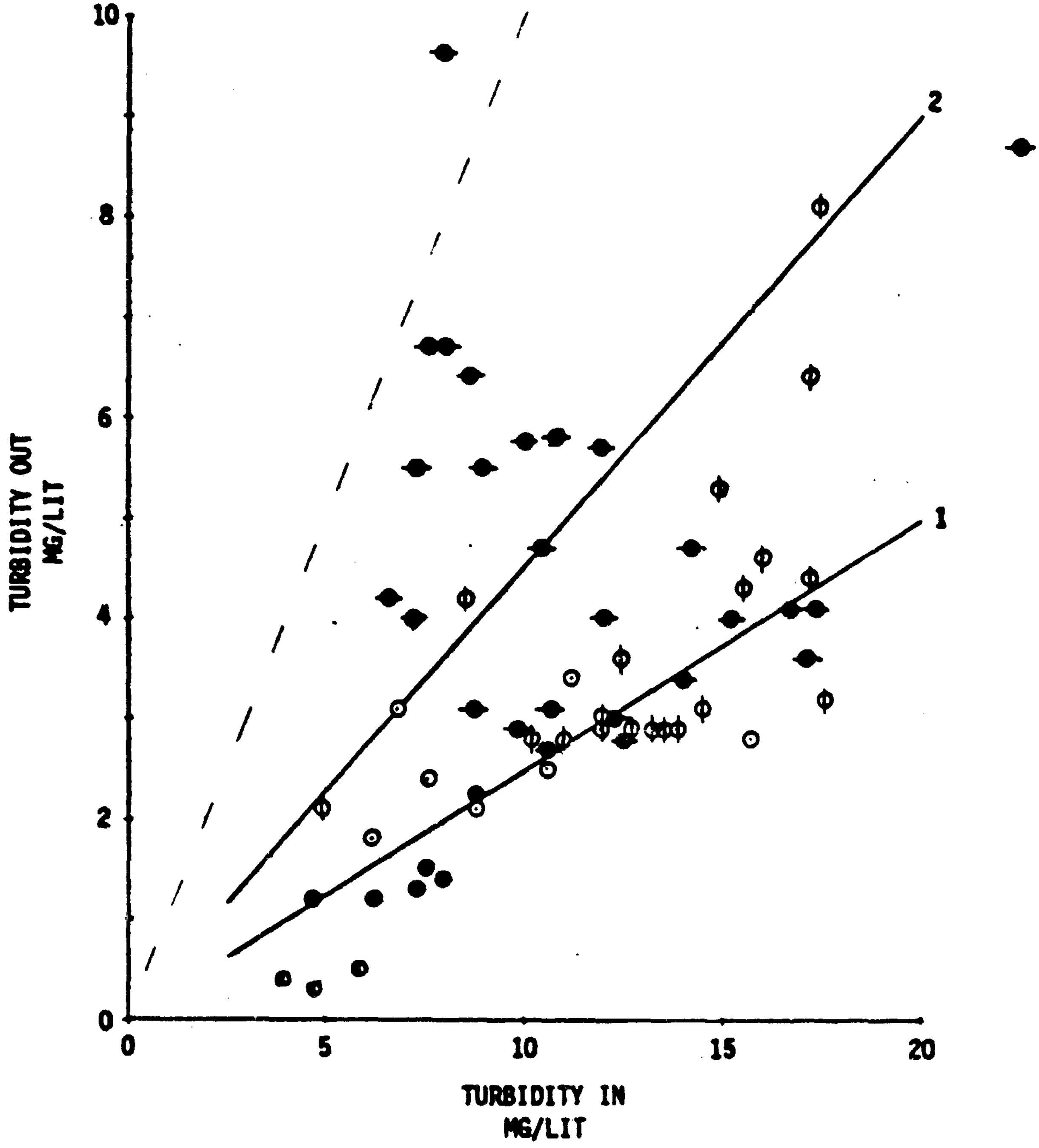


FILTRATION/OZONATION

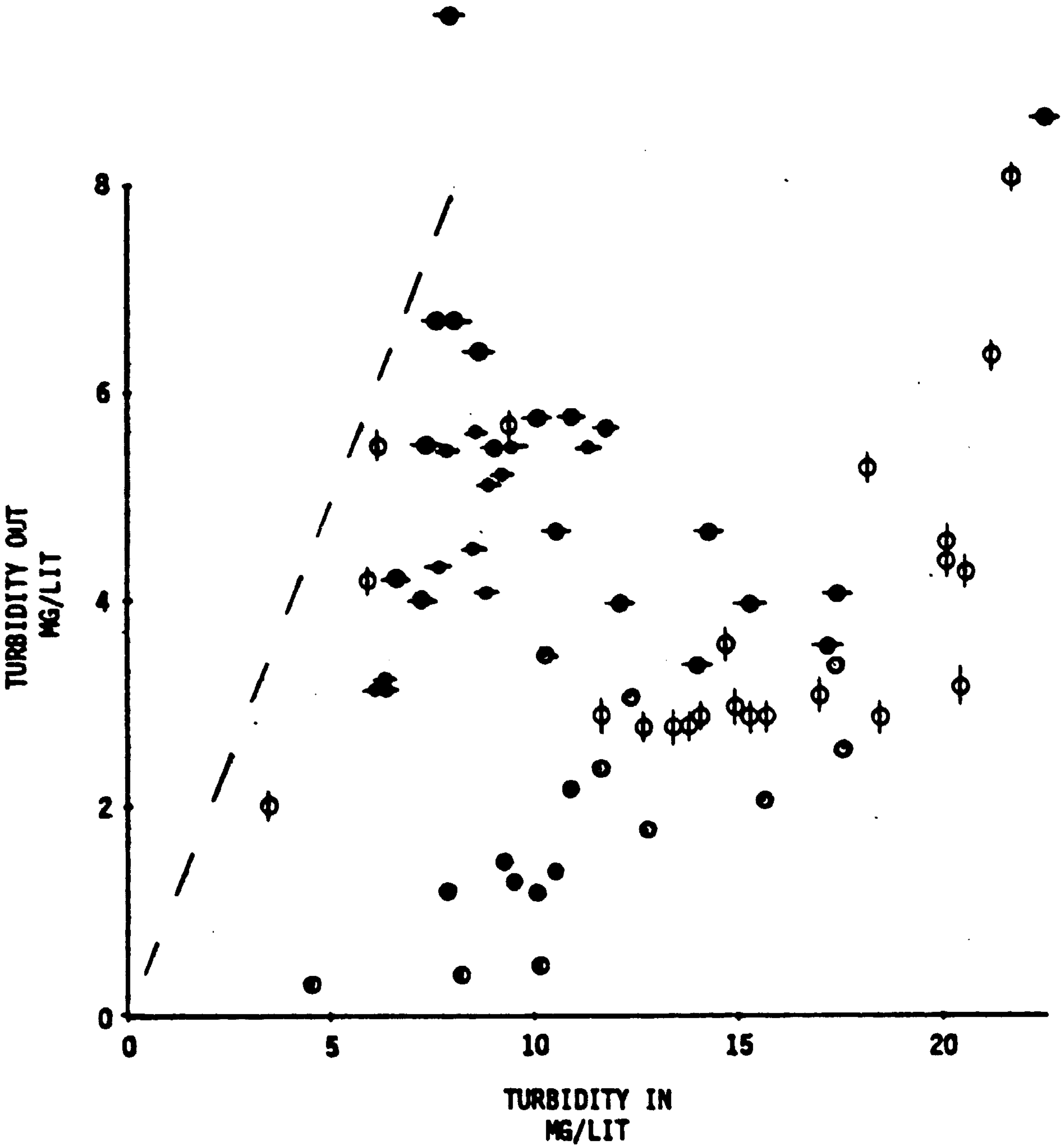


FILTRATION/OZONATION/CARBON ADSORPTION

1. 75% REMOVAL
2. 55% REMOVAL WITHOUT FILTRATION/OZONATION

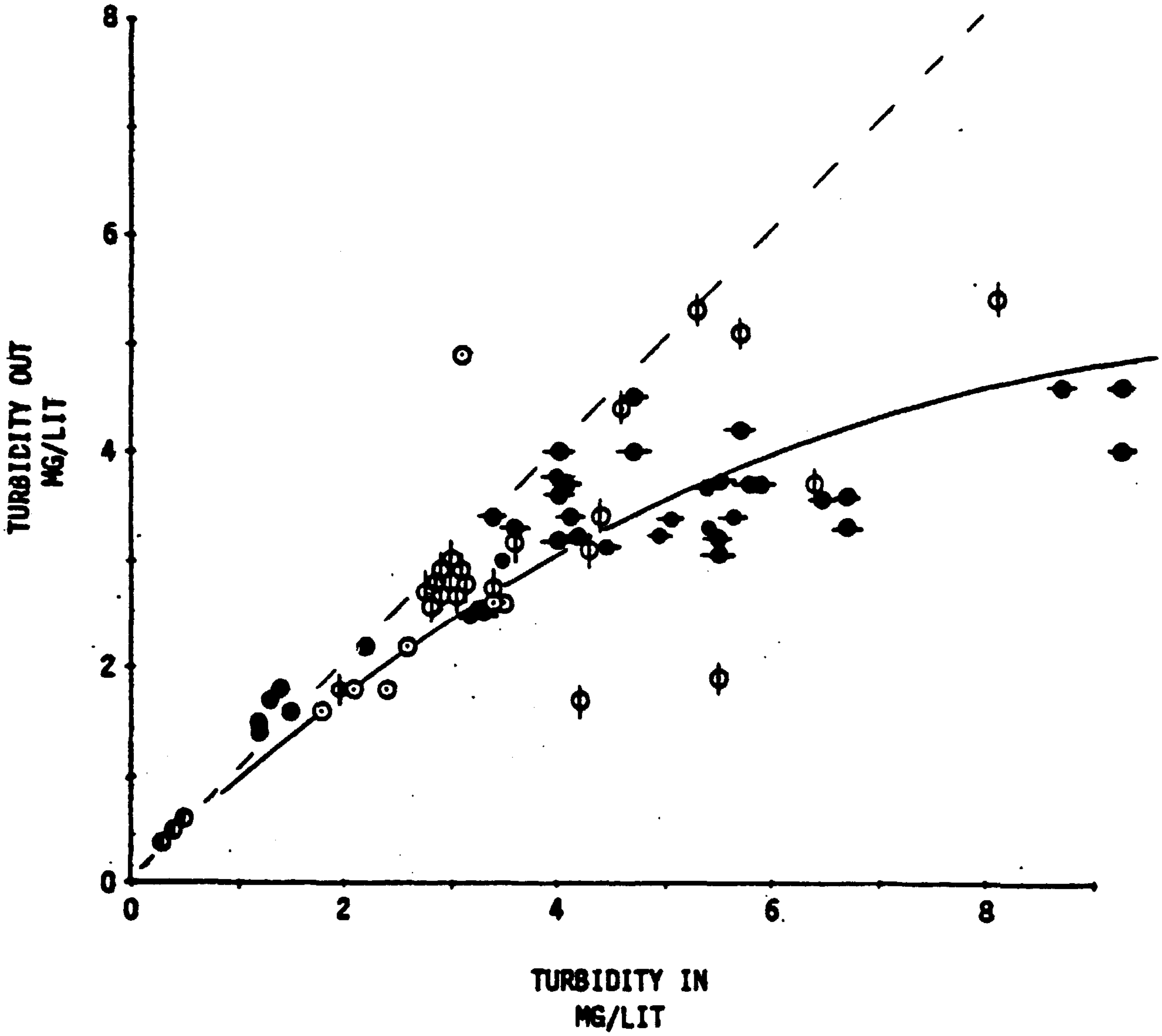


CARBON ADSORPTION



FILTRATION/CHLORINATION

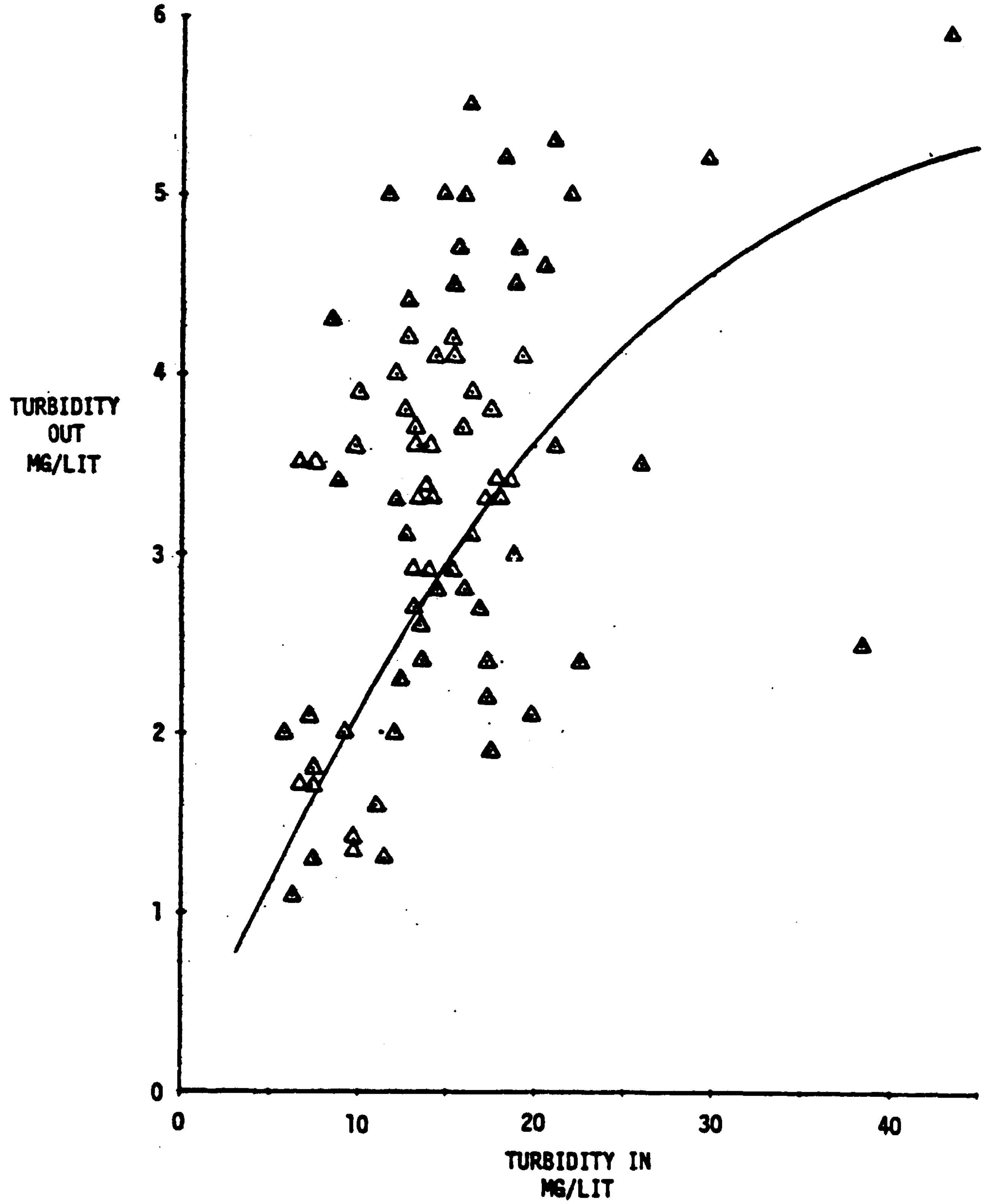
$$\text{REMOVAL} = I(1-e^{-I/15})\ \text{MG/LIT}$$



FILTRATION/CARBON ADSORPTION/FILTRATION

NOMINAL REMOVAL $= I(1-.25e^{-I/60})$ MG/LIT

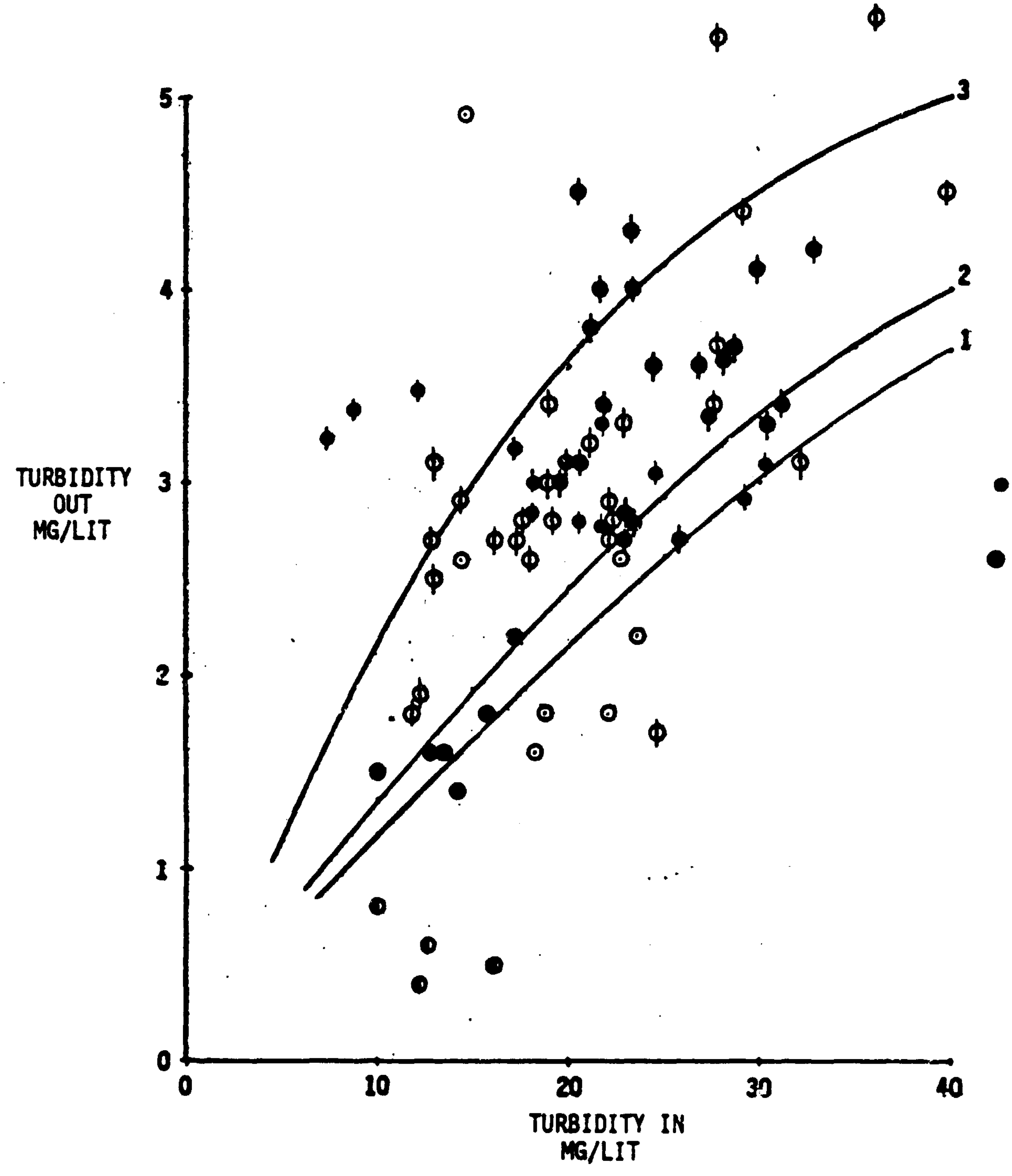
NOTE: PERFORMANCE CURVE SHOWN IS SUMMATION OF UNIT PROCESS PROCESS'PERFORMANCE



FLOCCULATION/FILTRATION/CARBON ADSORPTION/FILTRATION

NOTE: PERFORMANCE CURVES SHOWN ARE SUMMATION OF NOMINAL UNIT PROCESS' PERFROMANCE.

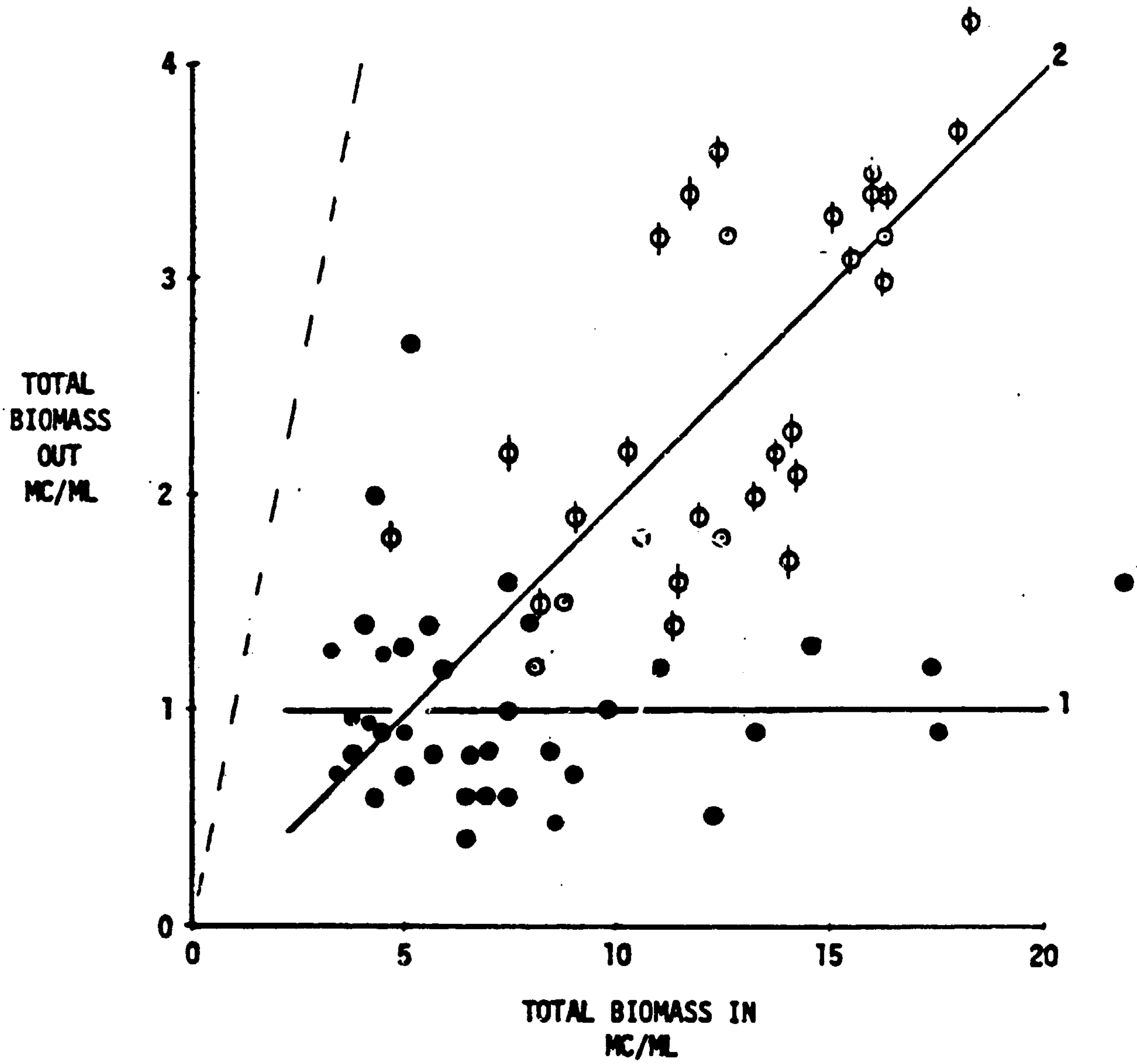
1. NOMINAL REMOVAL = $I(1 - .13e^{-I/20})$ MG/LIT
2. NOMINAL REMOVAL WITHOUT AMMONIA STRIPPING = $I(1 - .15e^{-I/100})$ MG/LIT
3. NOMINAL REMOVAL WITHOUT FILTRATION/OZONATION = $I(1 - .23e^{-I/67})$ MG/LIT



FLOCCULATION

1. NOMINAL REMOVAL AT PH 11 = (I-1.0) MC/ML

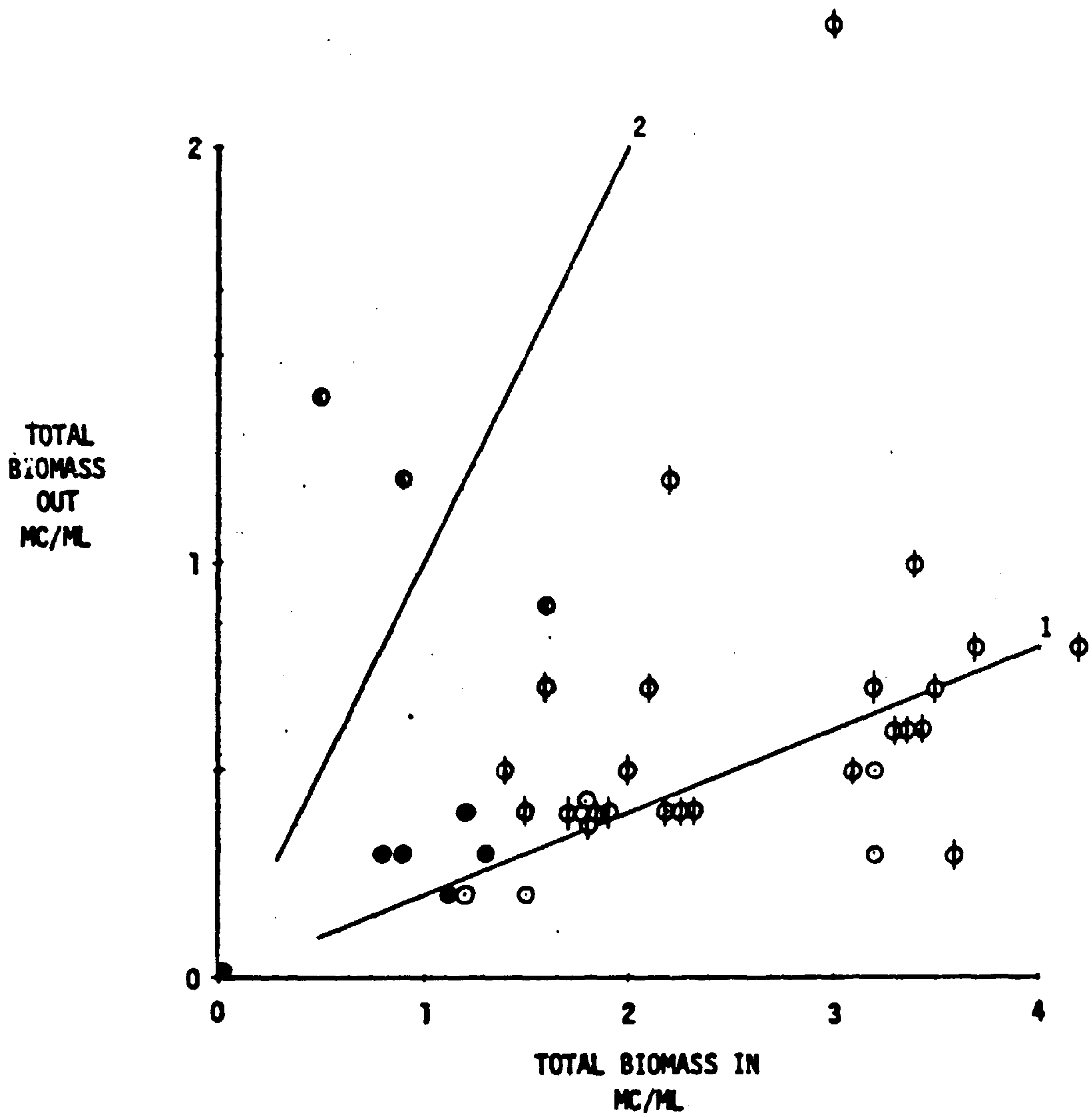
2. NOMINAL REMOVAL AT PH 9.5 = 80%



FILTRATION/OZONATION

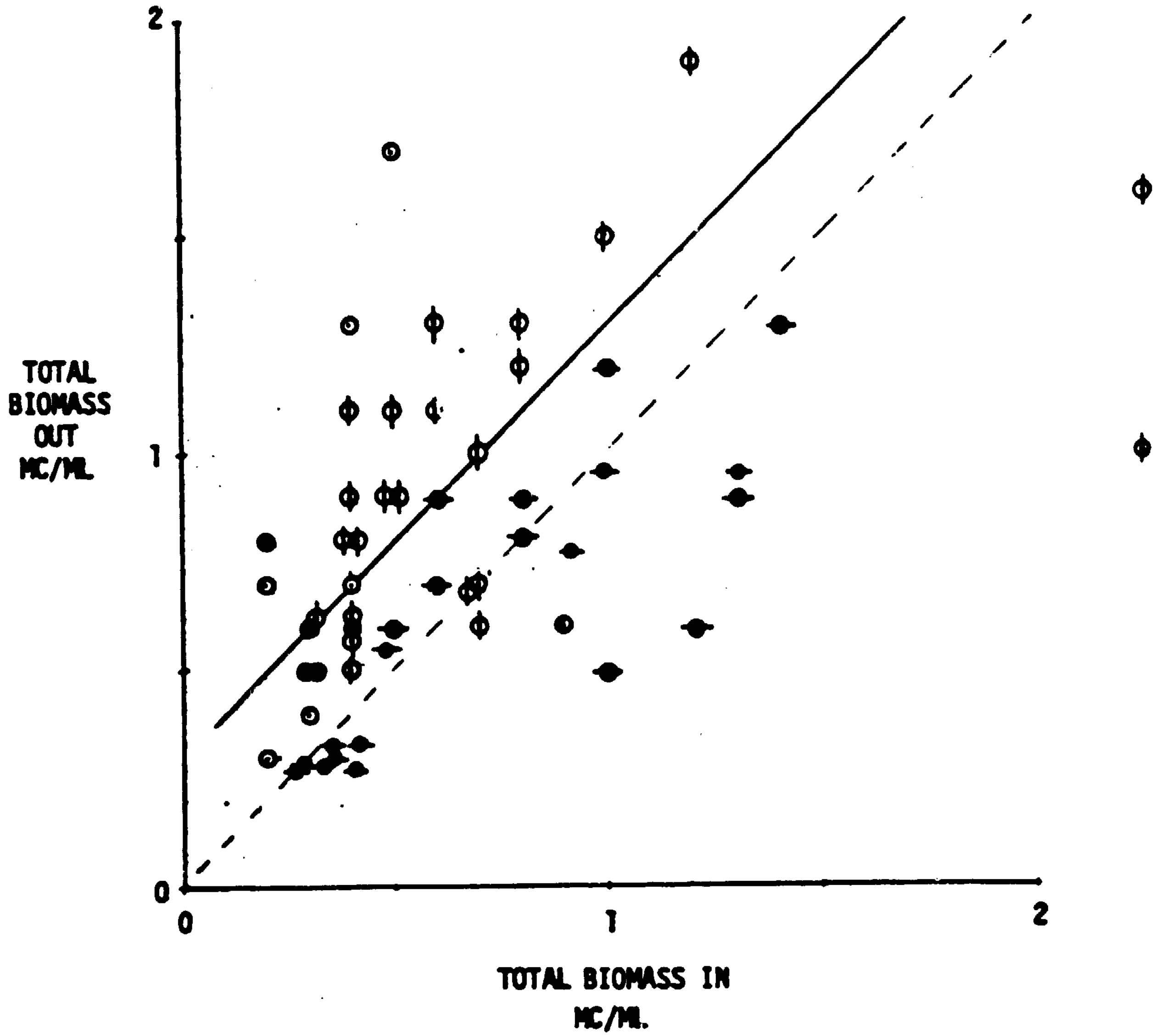
1. NOMINAL REMOVAL = 80%

2. NOMINAL REMOVAL WITHOUT OZONATION = 0



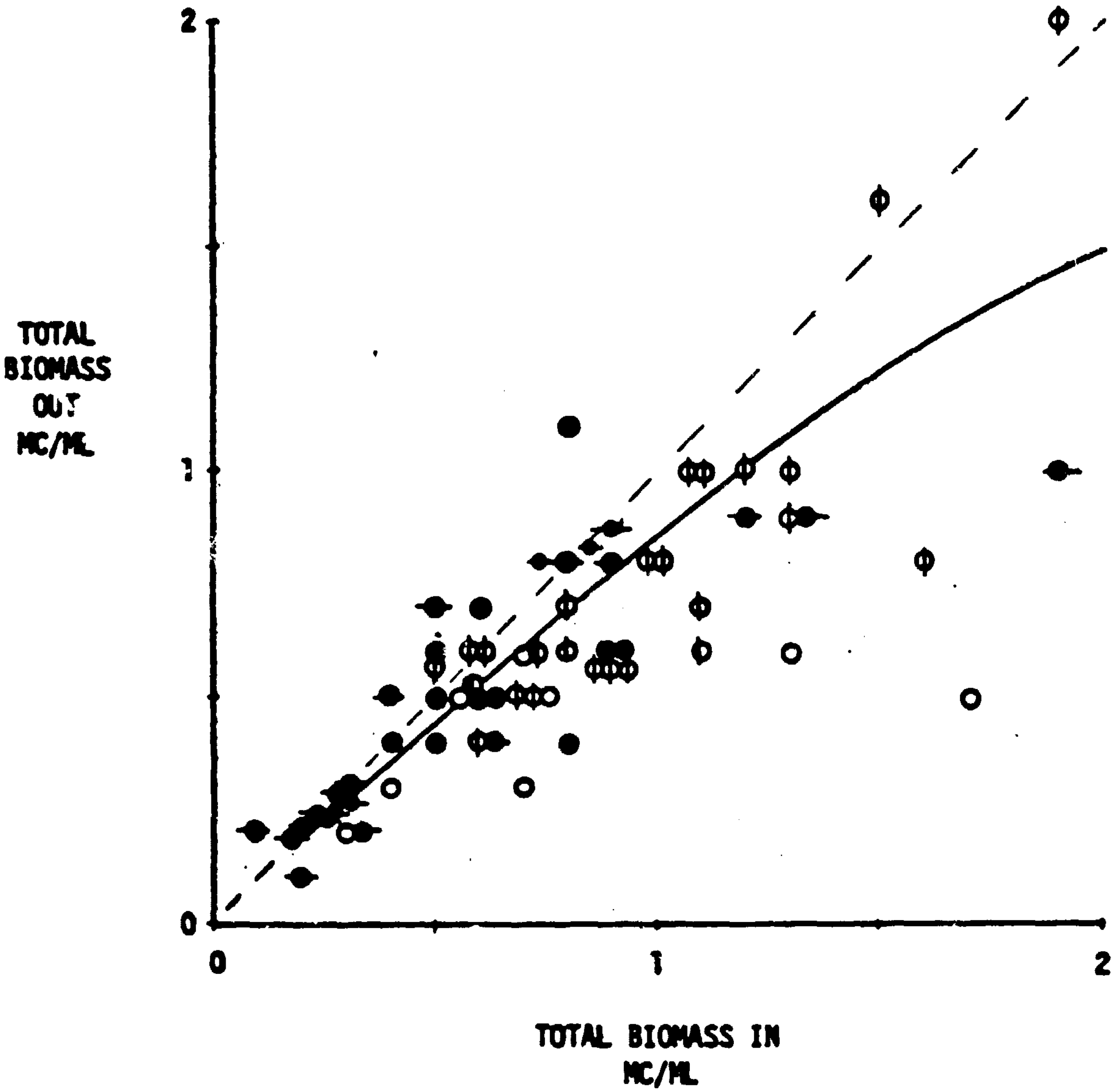
CARBON ADSORPTION

NOMINAL ADDITION = 0.3 MC/ML



FILTRATION/CHLORINATION

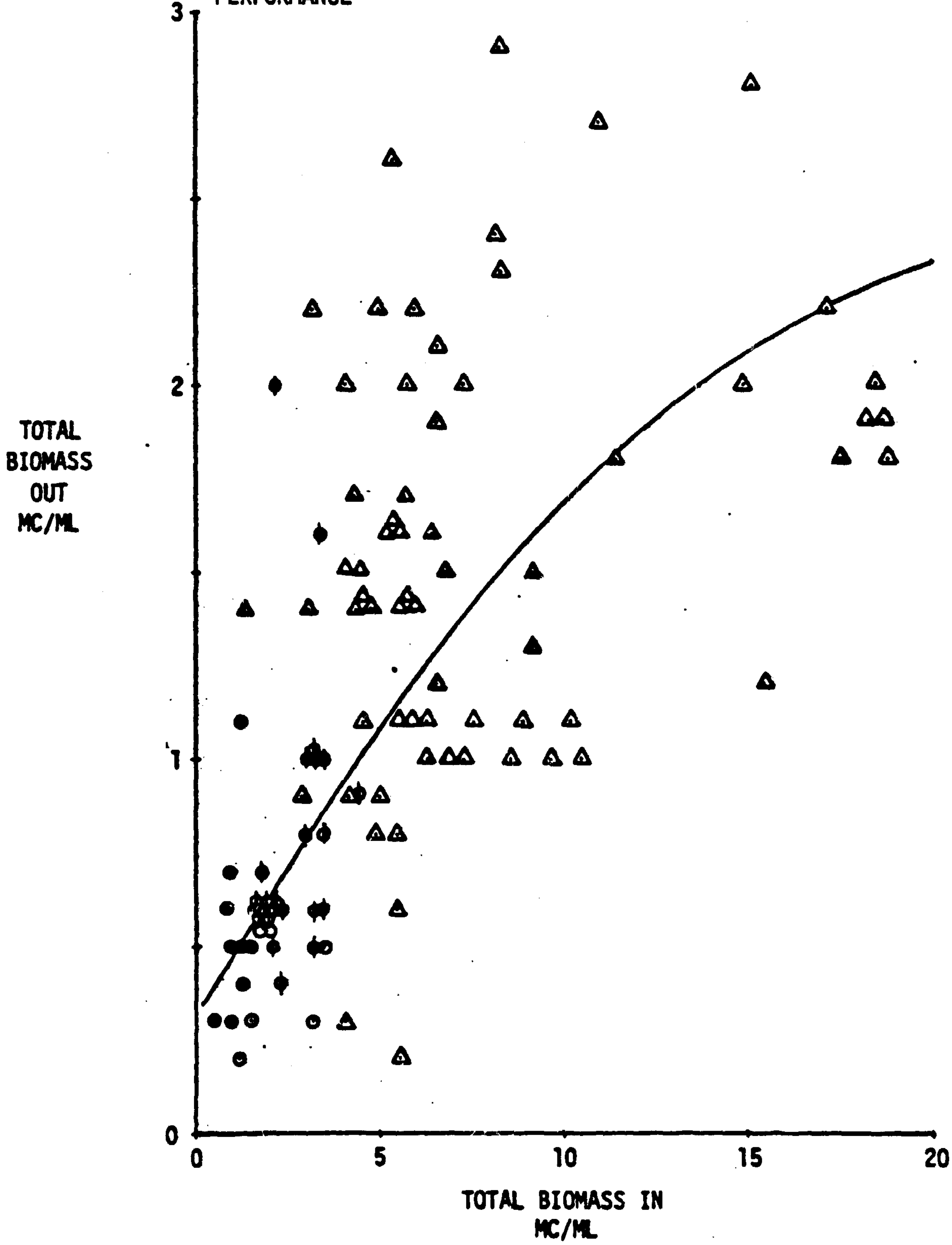
NOMINAL REMOVAL $=I(1-e^{-I/7})$ MC/ML



FILTRATION/CARBON ADSORPTION/FILTRATION

$$\text{NOMINAL REMOVAL} = \left[I - (0.2I + 0.3)e^{-\left(\frac{0.2I+.3}{7}\right)}\right] \text{MC/ML}$$

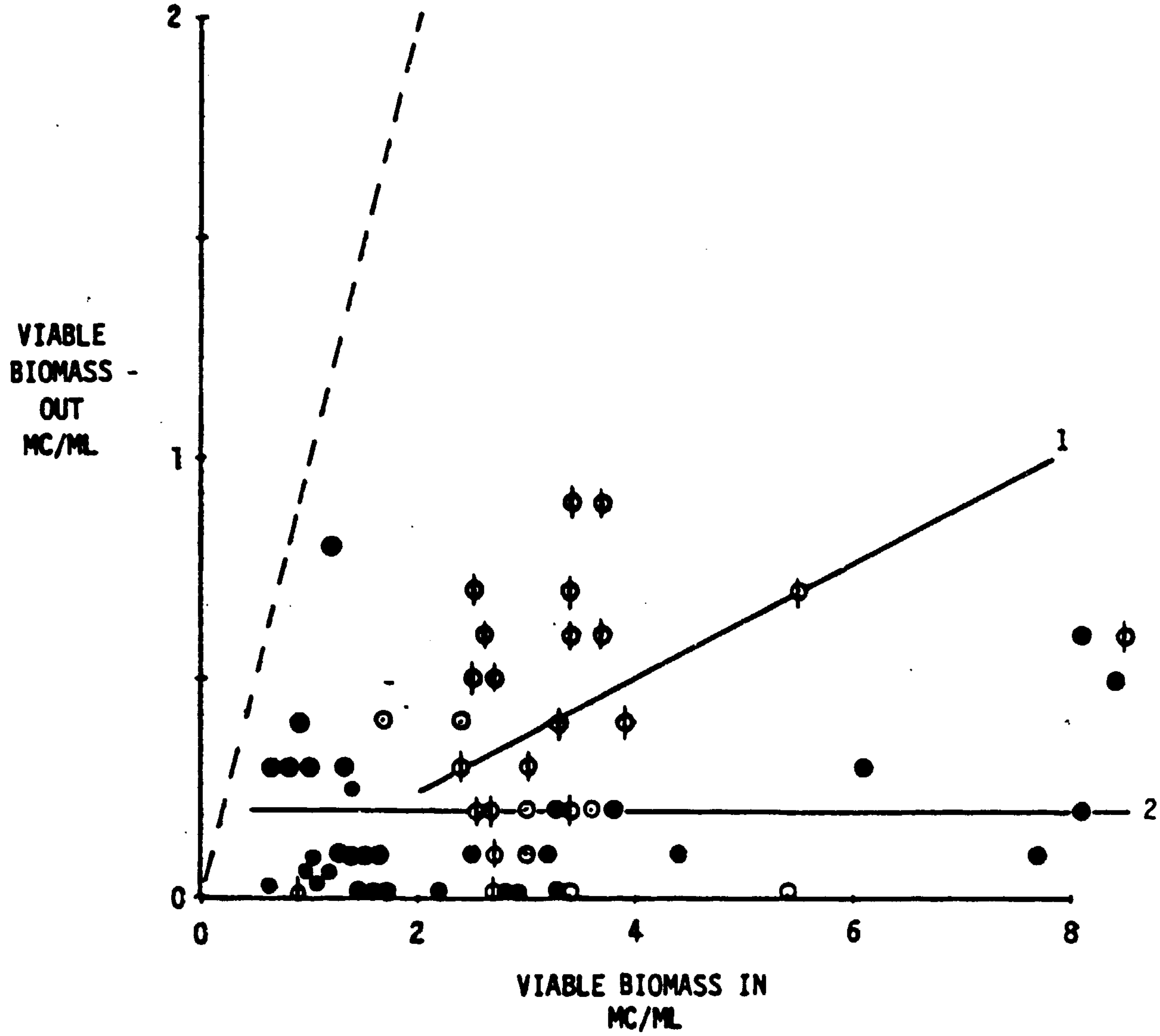
NOTE: PERFORMANCE CURVE SHOWN IS SUMMATION OF UNIT PROCESS' PERFORMANCE



FLOCCULATION

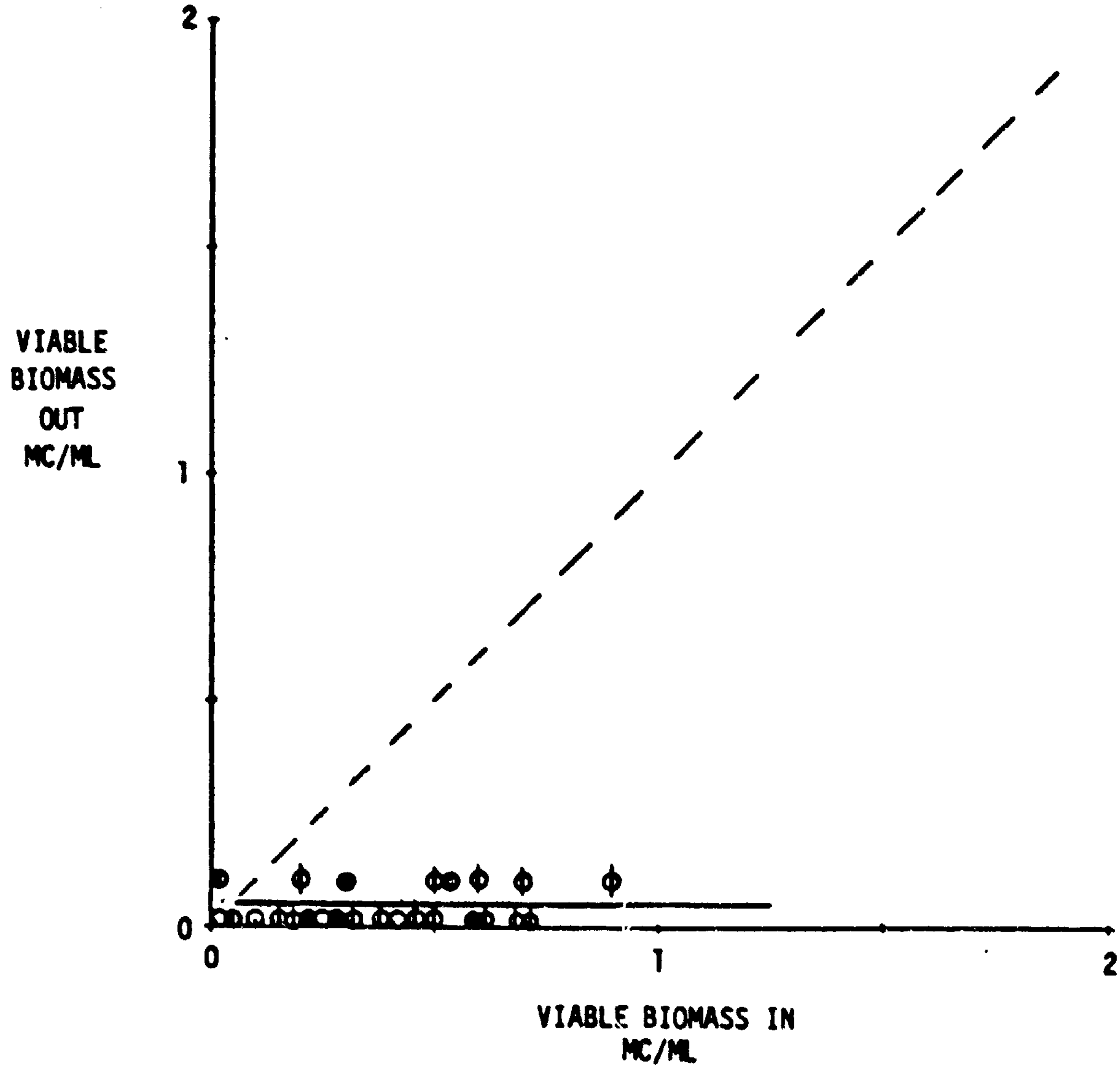
1. NOMINAL REMOVAL = 88% WITHOUT AMMONIA STRIPPING

2. NOMINAL REMOVAL = (I-0.2) MC/ML WITH AMMONIA STRIPPING



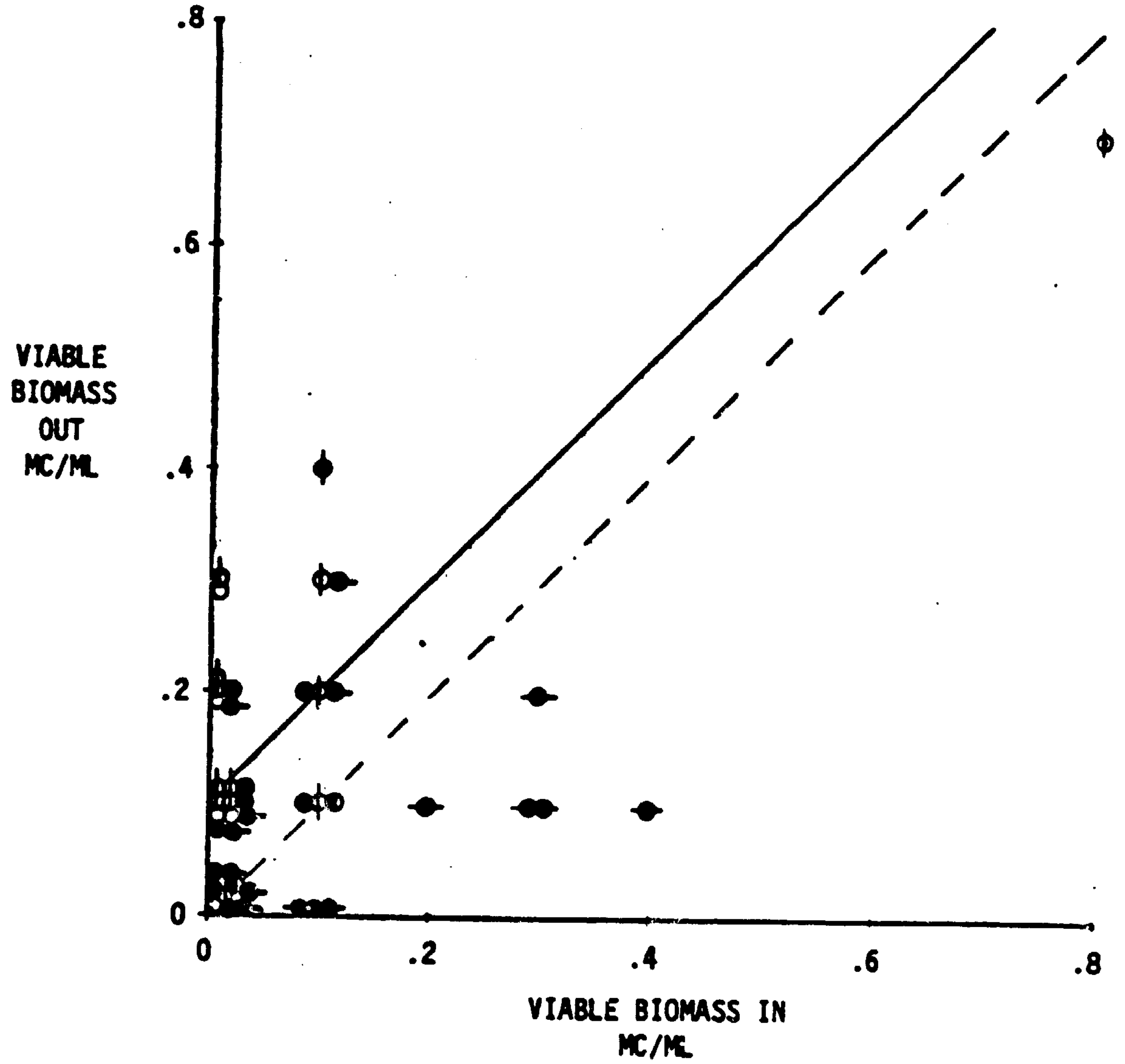
FILTERATION/OZONATION

NOMINAL REMOVAL =(I-0.05) MC/ML



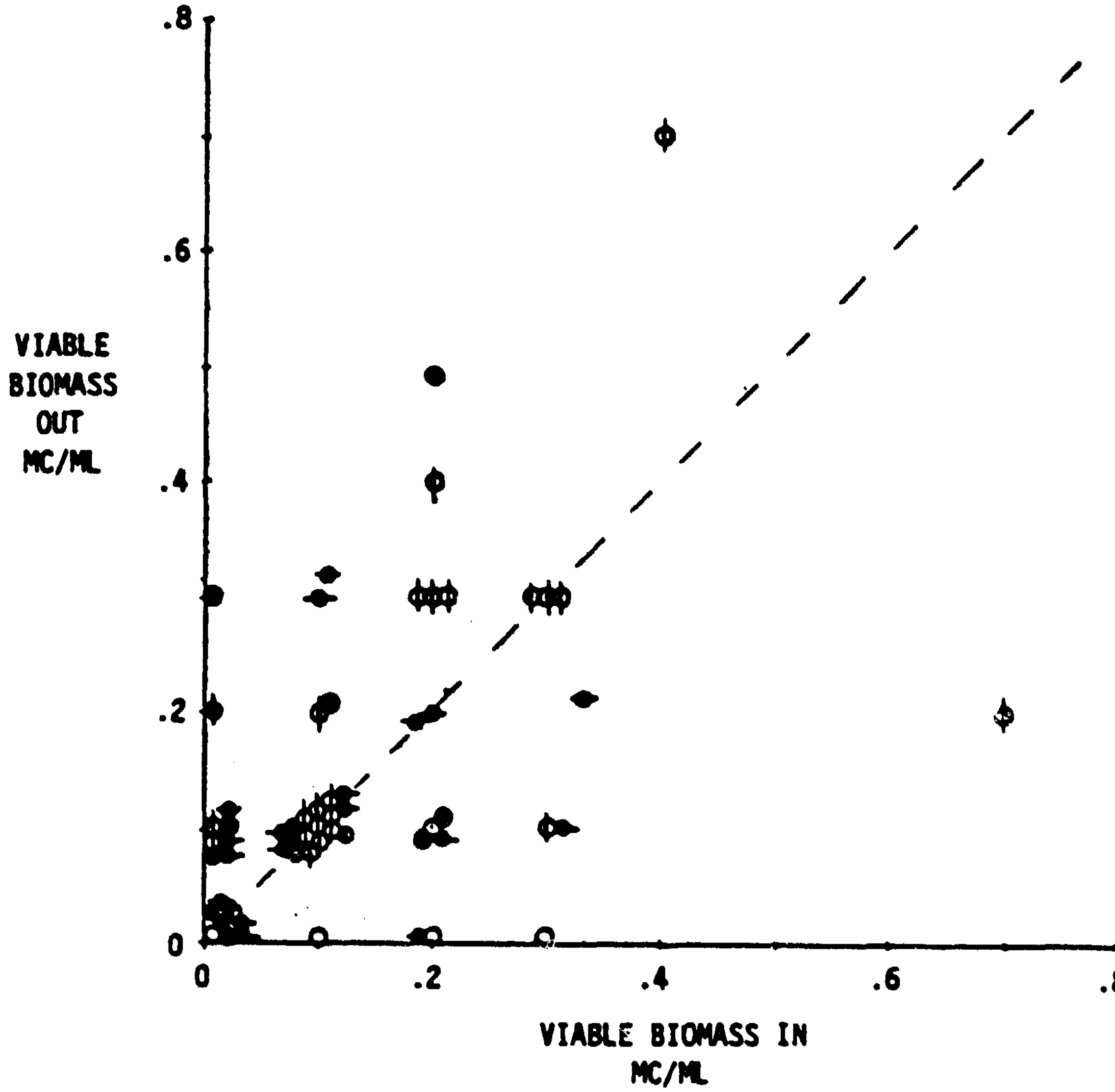
CARBON ADSORPTION

NOMINAL ADDITION = 0.1 MC/ML



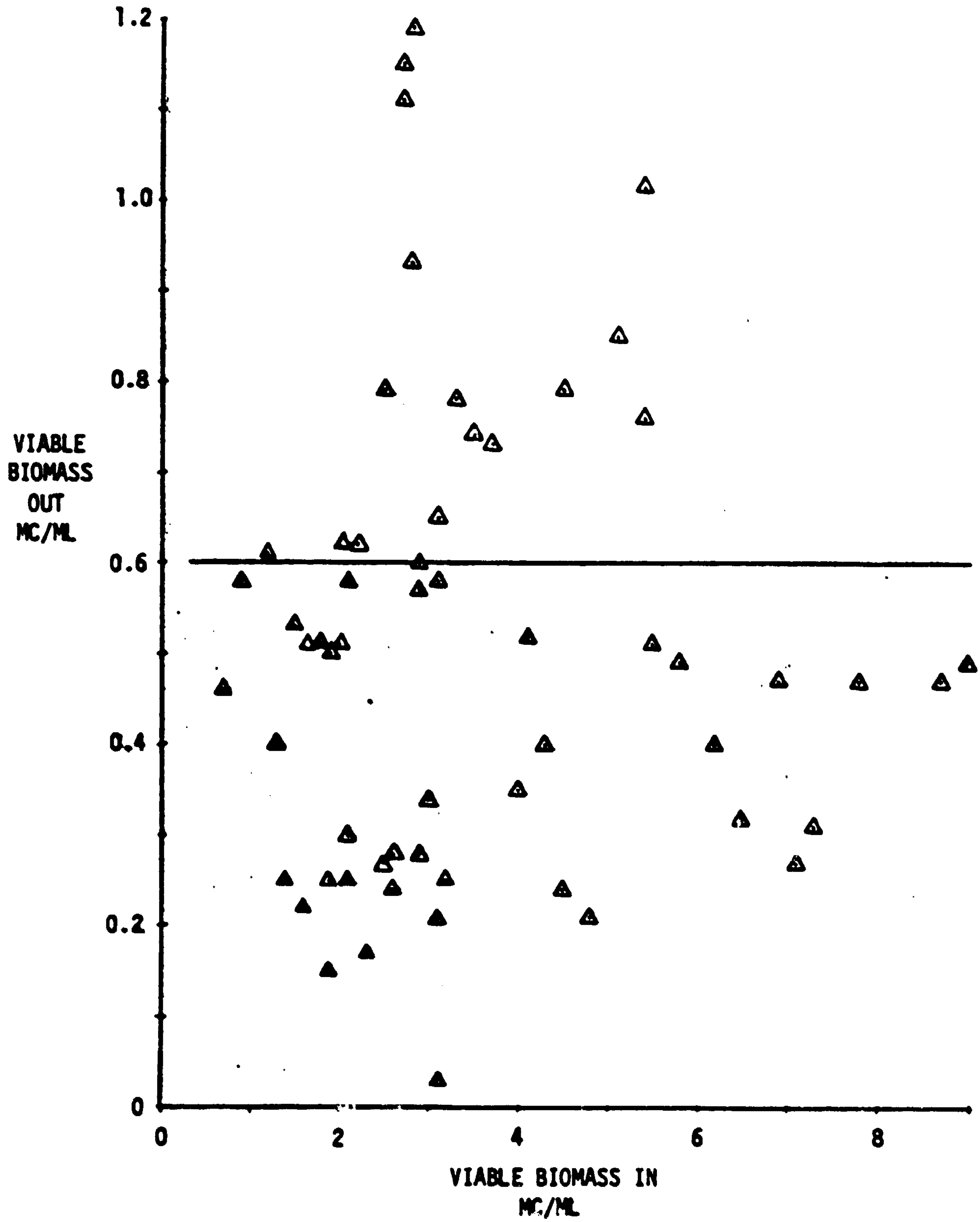
FILTERATION/CHLORINATION

NOMINAL REMOVAL = 0



FILTRATION/CARBON ADSORPTION/FILTRATION

NOMINAL REMOVAL =(I-0.6) MC/ML



APPENDIX B

MONTHLY AVERAGES FOR PART I OF THE TEST PERIOD

JANUARY 1978 TO SEPTEMBER 1979

APRIL AVERAGES

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → (1 MGD) → FLOCCULATION AMMONIA STRIPPING * RECARBONATION → FILTRATION OZONATION → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

Parameter	Units	Primary	Activated Sludge Chlorine Contact % Removal	1 MGD	Flocculation Ammonia Stripping * Recarbonation % Removal		Filtration Ozonation % Removal		Granular Activated Carbon % Removal		Filtration Chlorination % Removal	Effluent	Daily Removal, % Recla-mation	Daily Removal, % Total
TOTAL BIOMASS	MC/ML	29.2	-	11.8	78	2.6	77	0.6	-83	1.1	38	0.8	93	97
VIABLE BIOMASS	MC/ML	5.6	-	3.5	89	0.4	75	0.1	-100	0.2	0	0.2	94	96
COLIFORM	#/100 ML	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBIDITY	MG/LIT	55.5	66	19.0	32	13.0	-14	14.8	73	3.9	23	3.1	84	95
TOTAL RESIDUAL CHLORINE	MG/LIT	0	-	8.0	26	5.9	11	5.3	96	0.3	-	2.2	-	-
TOTAL ORGANIC CARBON	MG/LIT	77.0	82	14.1	14	12.1	10	11.0	57	4.7	27	3.4	76	94
TOTAL OXYGEN DEMAND	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL HALO-CARBONS	µG/LIT	990.1	68	312.6	47	166.7	25	125.6	46	67.6	12	59.4	81	94
PHENOL	µG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
AMMONIA (As N)	MG/LIT	28.5	28	20.6	5	19.5	0	19.5	11	17.4	-1	17.7	14	38
NITRATE/NITRITE (As N)	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.3	4	7.0	-8	7.5	-2	7.6	2	7.5	2	7.3	-	-
CONDUCTIVITY	µMHO/CM	1480.5	0	1486.3	-2	1522.7	-1	1533.1	0	1530.8	-2	1575.6	-6	-6
HARDNESS	MG/LIT	-	-	303.2	2	297.0	-2	301.5	29	213.8	-50	321.1	-6	-
SODIUM	MG/LIT	91.9	-19	109.0	18	89.4	2	87.4	1	86.3	-10	95.2	13	-4
CHLORIDE	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
DISSOLVED OXYGEN	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-

* AERATOR OUT OF SERVICE

APRIL AVERAGES (1σ TOTAL VARIATION)

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → 1 MGD → FLOCCULATION AMMONIA STRIPPING* RECARBONATION → FILTRATION OZONATION → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

Parameter	Units	After Primary	Activated Sludge / Chlorine Contact % Removal	1 MGD	Flocculation / Ammonia Stripping* / Recarbonation % Removal		Filtration / Ozonation % Removal		Granular Activated Carbon % Removal		Filtration / Chlorination % Removal	Effluent	Daily Removal, % Reclamation	Daily Removal, % Total
TOTAL BIOMASS	MC/ML	29.2 (14)	-	11.8 (13)	78 (20)	2.6 (3.2)	69 (58)	0.8 (3.4)	-38 (52)	1.1 (3.4)	38 (40)	0.8 (1.6)	93 (14)	97
VIABLE BIOMASS	MC/ML	6.6 (13)	-	3.5 (5.6)	78 (76)	0.8 (3.8)	24	0.6 (4.8)	32	0.4 (3.5)	14	0.3 (0.9)	90 (32)	94
COLIFORM	#/100 ML	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBIDITY	MG/LIT	55.6 (21)	66 (24)	19.0 (19)	32 (35)	13.0 (8.3)	-14 (36)	14.8 (11)	73 (45)	3.9 (4.1)	23 (42)	3.1 (1.8)	84 (15)	95 (2)
TOTAL RESIDUAL CHLORINE	MG/LIT	0 (0)	-	8.0 (4.4)	26 (7)	5.9 (1.7)	11 (9)	5.3 (1.9)	96 (3)	0.3 (0.1)	-	2.2 (1.3)	-	-
TOTAL ORGANIC CARBON	MG/LIT	77.0 (36)	82 (15)	14.1 (9)	14 (24)	12.1 (6.2)	10 (20)	11.8 (7.0)	67 (89)	4.7 (16.4)	27	3.4 (5.4)	76 (40)	94 (6)
TOTAL OXYGEN DEMAND	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL HALOCARBONS	μG/LIT	990.1 (1700)	68 (47)	312.5 (400)	47 (42)	166.7 (170)	25 (23)	125.6 (110)	46 (58)	[illegible].6 (56)	12 (28)	59.4 (41)	81 (38)	91 (21)
PHENOL	μG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
AMMONIA (As N)	MG/LIT	28.5 (12)	28 (26)	20.6 (11)	5 (20)	19.6 (10)	0 (24)	19.5 (10)	11 (15)	17.4 (10)	-1 (60)	17.7 (16)	14 (30)	39 (32)
NITRATE/NITRITE (As N)	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.3	4	7.0	-8	7.5	-2	7.6	2	7.5	2	7.3	-	-
CONDUCTIVITY	μMHO/CM	1480.5	0	1486.3	-2	1[illegible]2.7	-1	1533.1	0	1530.8	-2	1575.6	-6	-6
HARDNESS	MG/LIT	-	-	303.2	2	297.0	-2	301.5	29	213.8	-50	321.1	-6	-
SODIUM	MG/LIT	91.9	-19	109.0	18	89.4	2	87.4	1	86.3	-10	96.2	13	-4
CHLORIDE	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
DISSOLVED OXYGEN	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-

* AERATOR OUT OF SERVICE

MAY AVERAGES

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → (1 MGD) → FLOCCULATION AMMONIA STRIPPING RECARBONATION → FILTRATION OZONATION → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

Parameter	Units	Primary	Activated Sludge Chlorine Contact % Removal	1 MGD	Flocculation Ammonia Stripping Recarbonation % Removal		Filtration Ozonation % Removal		Granular Activated Carbon % Removal		Filtration Chlorination % Removal	Effluent	Daily Removal, % Reclamation	Daily Removal, % Total
TOTAL BIOMASS	MC/ML	21.1	-	11.8	91	1.1	64	0.4	-30	0.5	24	0.4	96	98
VIABLE BIOMASS	MC/ML	2.3	-	5.3	95	0.3	63	0.1	-88	0.2	7	0.2	97	93
COLIFORM	#/100 ML	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBIDITY	MG/LIT	66.5	67	21.7	60	8.7	-25	10.9	81	2.0	-27	2.6	88	96
TOTAL RESIDUAL CHLORINE	MG/LIT	0	-	8.4	48	4.4	26	3.3	92	0.3	-	2.5	-	-
TOTAL ORGANIC CARBON	MG/LIT	77.4	79	16.7	32	11.3	1	11.2	58	4.7	52	2.2	87	97
TOTAL OXYGEN DEMAND	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL HALO-CARBONS	µG/LIT	1250.2	64	455.2	75	112.8						104.2	77	92
PHENOL	µG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
AMMONIA (As N)	MG/LIT	29.8	19	24.2	23	18.6	-1	18.8	16	15.8	2	15.5	36	48
[illegible]ATE/NITRITE (As N)	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.2	3	7.0	-14	7.9	0	7.9	5	7.5	0	7.5	-	-
CONDUCTIVITY	µMHO/CM	1448.0	2	1416.5	3	1375.8	-3	1421.9	-1	1429.7	5	1351.2	5	7
HARDNESS	MG/LIT	-	-	213.8	21	169.6	-11	187.7	26	136.9	-37	189.8	-	-
SODIUM	MG/LIT	142.0	5	135.5	-1	136.9	-3	140.5	0	140.7	6	131.9	3	7
CHLORIDE	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
DISSOLVED OXYGEN	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-

MAY AVERAGES

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → 1 MGD → FLOCCULATION AMMONIA STRIPPING RECARBONATION → FILTRATION OZONATION → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

		Primary effluent	Activated Sludge Chlorine Contact % Removal	1 MGD	Flocculation Ammonia Stripping Recarbonation % Removal		Filtration Ozonation % Removal		Granular Activated Carbon % Removal		Filtration Chlorination % Removal	Effluent	Daily Removal, % Reclamation	Daily Removal, % Total
TOTAL BIOMASS	MC/ML	21.1	-	11.8	91	1.1	64	0.4	-30	0.5	24	0.4	96	98
VIABLE BIOMASS	MC/ML	2.3	-	5.3	96	0.3	63	0.1	-88	0.2	7	0.2	97	93
COLIFORM	#/100 ML	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBIDITY	MG/LIT	66.5	67	21.7	60	8.7	-25	10.9	81	2.0	-27	2.6	88	96
TOTAL RESIDUAL CHLORINE	MG/LIT	0	-	8.4	48	4.4	26	3.3	92	0.3	-	2.5	-	-
TOTAL ORGANIC CARBON	MG/LIT	77.4	79	16.7	32	11.3	1	11.2	58	4.7	52	2.2	87	97
TOTAL OXYGEN DEMAND	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL HALO-CARBONS	µG/LIT	1250.2	64	455.2	75	112.8						104.2	77	92
PHENOL	µG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
AMMONIA (As N)	MG/LIT	29.8	19	24.2	23	18.6	-1	18.8	16	15.8	2	15.5	36	48
NITRATE/NITRITE (As N)	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.2	3	7.0	-14	7.9	0	7.9	5	7.5	0	7.5	-	-
CONDUCTIVITY	µMHO/CM	1448.0	2	1416.5	3	1375.8	-3	1421.9	-1	1429.7	5	1351.2	5	7
HARDNESS	MG/LIT	-	-	213.8	21	169.6	-11	187.7	26	138.9	-37	189.8	-	-
SODIUM	MG/LIT	142.0	5	135.5	-1	136.9	-3	140.5	0	140.7	6	131.[illegible]	3	7
CHLORIDE	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
DISSOLVED OXYGEN	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-

MAY AVERAGES (1σ TOTAL VARIATION)

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → (1 MGD) → FLOCCULATION AMMONIA STRIPPING RECARBONATION → FILTRATION OZONATION → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

		Primary	Activated Sludge Chlorine Contact % Removal	1 MGD	Flocculation Ammonia Stripping Recarbonation % Removal		Filtration Ozonation % Removal		Granular Activated Carbon % Removal		Filtration Chlorination % Removal	Effluent	Daily Removal, Reclamation	Daily Removal, Total
TOTAL BIOMASS	MG/ML	21.1 (10)	-	11.8 (9.6)	91 (17)	1.1 (1.8)	64 (46)	0.4 (0.9)	-30 (40)	0.5 (1.0)	24 (27)	0.4 (0.8)	96 (12)	98
VIABLE BIOMASS	MG/ML	2.3 (4.2)	-	5.3 (7.0)	95 (22)	3.3 (0.3)	63 (200)	0.1 (0.2)	-88	0.2 (0.2)	7	0.2 (0.3)	97 (9)	93
COLIFORM	#/100 ML	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBIDITY	MG/LIT	66.5 (46)	67 (23)	21.7 (25)	60 (20)	8.7 (8.2)	-25 (60)	10.9 (8.8)	81 (16)	2.0 (2.3)	-27 (42)	2.6 (2.0)	88 (12)	96 (4)
TOTAL RESIDUAL CHLORINE	MG/LIT	0 (0)	-	8.4 (5.1)	48 (20)	4.4 (2.2)	26 (36)	3.3 (2.4)	92 (11)	0.3 (0.1)	-	2.5	-	-
TOTAL ORGANIC CARBON	MG/LIT	77.4 (46)	79 (17)	16.7 (9.4)	32 (30)	11.3 (8.6)	1 (24)	11.2 (7.0)	58 (22)	4.7 (5.0)	52 (28)	2.2 (3.2)	87 (20)	97 (4)
TOTAL OXYGEN DEMAND	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL HALO-CARBONS	μG/LIT	1250.2 (1000)	64 (39)	455.2 (280)	75 (38)	112.6 (120)	51 (33)					104.2 (116)	77 (17)	92 (13)
PHENOL	μG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
AMMONIA (As N)	MG/LIT	29.8 (12)	19 (23)	24.2 (10)	23 (20)	18.6 (8.8)	-1 (16)	18.8 (9.6)	16 (14)	15.8 (9.0)	2 (26)	15.5 (8.6)	36 (22)	46 (22)
NITRATE /NITRITE (As N)	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	7.2	3	7.0	-14	7.9	0	7.9	5	7.5	0	7.5	-	-
CONDUCTIVITY	μMHO/CM	1448.0	2	1416.5	3	1375.8	-3	1421.9	-1	1429.7	5	1361.2	6	7
HARDNESS	MG/LIT	-	-	213.8	21	140.6	-11	187.7	28	138.9	-37	180.8	-	-
SODIUM	MG/LIT	142.0	6	136.5	-1	136.9	-3	140.5	0	140.7	6	131.9	3	7
CHLORIDE	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
DISSOLVED OXYGEN	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-

JUNE AVERAGES

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → 1 MGD → FLOCCULATION AMMONIA STRIPPING RECARBONATION → FILTRATION OZONATION (OUT OF SERVICE) → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

Parameter	Units	After Primary	Activated Sludge Chlorine Contact % Removal	After Activated Sludge (1 MGD)	Flocculation Ammonia Stripping Recarbonation % Removal	After Flocculation	Filtration Ozonation (Out of Service) % Removal	After Filtration Ozonation	Granular Activated Carbon % Removal	After Granular Activated Carbon	Filtration Chlorination % Removal	Effluent	Daily Removal/% Reclamation	Daily Removal/% Total
TOTAL BIOMASS	MC/ML	-	-	5.4	87	0.7	-	-	11	0.6	10	0.6	89	-
VIABLE BIOMASS	MC/ML	-	-	1.3	82	0.2	-	-	17	0.2	21	0.2	88	-
COLIFORM	#/100 ML	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBIDITY	MG/LIT	-	-	25.8	57	11.1	-	-	46	6.0	39	3.7	86	-
TOTAL RESIDUAL CHLORINE	MG/LIT	-	-	11.2	51	5.4	-	-	89	0.6	-353	2.6	77	-
TOTAL ORGANIC CARBON	MG/LIT	-	-	12.2	38	7.6	-	-	71	2.2	10	2.0	84	-
TOTAL OXYGEN DEMAND	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL HALO-CARBONS	µG/LIT	-	-	554.4	79	116.9	-	-	-	-	-	92.6	83	-
PHENOL	µG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
AMMONIA (As N)	MG/LIT	-	-	21.6	8	19.9	-	-	7	18.4	10	16.6	23	-
NITRATE/NITRITE (As N)	MG/LIT	-	-	1.8	-50	2.7	-	-	-156	6.9	5	6.5	-264	-
pH	pH	-	-	6.9	-20	8.3	-	-	4	7.9	5	7.5	-8	-
CONDUCTIVITY	µMHO/CM	-	-	1258.1	7	1175.9	-	-	0	1171.5	-3	1208.3	4	-
HARDNESS	MG/LIT	-	-	166.7	22	129.2	-	-	-6	137.0	-14	156.5	6	-
SODIUM	MG/LIT	-	-	132.7	15	112.6	-	-	4	108.3	-9	118.4	11	-
CHLORIDE	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
DISSOLVED OXYGEN	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-

JULY AVERAGES

INFLUENT 15-50 MGD → PRIMARY → ACTIVATED SLUDGE CHLORINE CONTACT → 1 MGD → FLOCCULATION AMMONIA STRIPPING RECARBONATION → FILTRATION OZONATION → GRANULAR ACTIVATED CARBON → FILTRATION CHLORINATION → EFFLUENT

Parameter	Units	Primary	Activated Sludge Chlorine Contact % Removal	1 MGD	Flocculation Ammonia Stripping Recarbonation % Removal		Filtration Ozonation % Removal		Granular Activated Carbon % Removal		Filtration Chlorination % Removal	Effluent	Daily Reclamation Removal/%	Total Removal/%
TOTAL BIOMASS	MC/ML	-	-	6.3	89	0.6	-	-	9	0.5	-28	0.7	98	-
VIABLE BIOMASS	MC/ML	-	-	1.6	94	0.1	-	-	-15	0.1	-79	0.2	88	-
COLIFORM	#/100 ML	-	-	-	-	-	-	-	-	-	-	-	-	-
TURBIDITY	MG/LIT	-	-	20.7	58	8.6	-	-	43	4.9	31	3.3	84	-
TOTAL RESIDUAL CHLORINE	MG/LIT	-	-	8.3	31	5.7	-	-	88	0.7	-379	3.2	61	-
TOTAL ORGANIC CARBON	MG/LIT	-	-	11.9	44	6.6	-	-	72	1.8	13	1.6	87	-
TOTAL OXYGEN DEMAND	MG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL HALOCARBONS	µG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
PHENOL	µG/LIT	-	-	-	-	-	-	-	-	-	-	-	-	-
AMMONIA (As N)	MG/LIT	-	-	24.0	25	18.0	-	-	18	14.7	3	14.3	40	-
NITRATE/NITRITE (As N)	MG/LIT	-	-	3.2	-22	3.9	-	-	-88	7.3	-6	7.8	-143	-
pH	pH	-	-	6.9	-25	8.7	-	-	8	8.0	4	7.7	-10	-
CONDUCTIVITY	µMHO/CM	-	-	1159.3	0	1157.9	-	-	-1	1172.0	-1	1180.5	-2	-
HARDNESS	MG/LIT	-	-	170.0	17	141.3	-	-	-31	184.8	-12	207.7	-21	-
SODIUM	MG/LIT	-	-	122.7	8	113.4	-	-	1	111.8	-2	113.8	7	-
CHLORIDE	MG/LIT	-	-	231.4	-10	254.2	-	-	-3	261.7	7	244.4	-6	-
DISSOLVED OXYGEN	MG/LIT	-	-	3.7	-74	6.6	-	-	30	4.5	82	0.8	78	-

RECLAMATION PLANT INFLUENT CHARACTERISTICS
AVERAGE MONTHLY VALUES

MONTH	BOD, MG/LIT *	COD, MG/LIT *	TOC, MG/LIT	SUSPENDED * SOLIDS, MG/LIT	TURBIDITY MG/LIT	TOTAL BIOMASS MC/ML	VIABLE BIOMASS MC/ML	TOTAL HALOCARBONS μg/LIT	AMMONIA* MG/LIT	AMMONIA MG/LIT
JANUARY '78	12.3			24.6	25.6				21.2	
FEBRUARY	10.2		23.2	18.6	11.6				24.7	20.4
MARCH	25.2	52	24.8	19.3	13.9			1046.0	26.5	19.2
APRIL	9.7		30.0	17.3	21.6			528.0	27.1	24.3
MAY	12.3			17.8	27.7	4.5		563.0	24.6	23.9
JUNE	18.4			19.4					27.6	
JULY	12.5			19					29.2	
AUGUST	12		12.9	18	10.6	11.5		452.8	25.1	19.7
SEPTEMBER	12		16.7	16	12.5	12.2		420.9	25.4	20.0
OCTOBER	17			22					31.9	
NOVEMBER	28		25.4	21	23.9	10.4	3.7	301.5	33.6	22.7
DECEMBER	20		19.3	15	17.9	5.8	3.1	868.1	31.0	21.2
JANUARY '79	23	39	18.1	15.1	15.2	5.5	3.4	824.6	29.9	20.1
FEBRUARY	10	37	20.1	13	11.9	8.2	5.8	470.0	23.6	21.7
MARCH	20	43	21.4	15	19.4	8.8	3.8	730.5	25.4	22.0
APRIL	17.2	37	14.1	12.6	19.0	11.8	3.5	312.5		20.6
MAY	21	33	16.7	10	21.7	11.8	5.3	455.2		24.2
JUNE	18	32	12.2	10	25.8	5.4	1.3	554.4	21.6	21.6
JULY	18	33	11.9	14	20.7	5.3	1.6	-	14.5	24.0

* PALO ALTO REGIONAL WATER QUALITY CONTROL FACILITY LABORATORY MEASUREMENTS FROM 24 HOUR COMPOSITE SAMPLES.

RECLAMATION PLANT PERFORMANCE SUMMARY
AVERAGE MONTHLY VALUES ± 1σ

MONTH	FLOW, MGD	BOD, MG/LIT * EFFLUENT	BOD, MG/LIT * % REMOVED	COD, MG/LIT * EFFLUENT	COD, MG/LIT * % REMOVED	TOC, MG/LIT EFFLUENT	TOC, MG/LIT % REMOVED	TOTAL HALOCARBONS MG/LIT EFFLUENT	TOTAL HALOCARBONS MG/LIT % REMOVED
JANUARY '78				7.0	87	31.4	55 ± 12		
FEBRUARY	0.4					26.4			
MARCH	0.4	2.8	89	10.3	83			295	92
APRIL	0.6			14.0	69	19.1	36 ± 16	211	79
MAY	0.6			15.8	61			149	69
JUNE	0.6								
JULY	0.6								
AUGUST	0.6					6.0	54 ± 11	149.3	67 ± 96
SEPTEMBER	0.2					6.7	60 ± 12	121.1	71 ± 29
OCTOBER	0								
NOVEMBER	0.4					10.0	61 ± 11		
DECEMBER	0.44	5.4	73	5.5		5.6	71 ± 5	40.7	95 ± 9
JANUARY '79	0.42	7.7	67	10.5	73	6.5	64 ± 7	94.7	89 ± 9
FEBRUARY	0.45	8.8	12	24	35	9.2	55 ± 19	89.2	81 ± 18
MARCH	0.68	4.6	80	11.4	74	7.8	64 ± 15	164.4	77 ± 23
APRIL	1.0	4.1	76	5.3	86	3.4	76 ± 20	59.4	81 ± 19
MAY	1.0	8.6	59	5.7	83	2.2	87 ± 10	105.5	77 ± 17
JUNE	1.0	5.6	69	3.8	88	2.0	84 ± 7	92.6	83 ± 37
JULY	1.0	2.6	86	-	-	1.6	87 ± 8	-	-

* PALO ALTO REGIONAL WATER QUALITY CONTROL FACILITY LABORATORY MEASUREMENTS FROM 24 HOUR COMPOSITE SAMPLES.

RECLAMATION PLANT PERFORMANCE SUMMARY
AVERAGE MONTHLY VALUES ± 1σ

MONTH	FLOW, MGD	TURBIDITY, NTU* EFFLUENT	TURBIDITY, NTU* % REMOVED	TURBIDITY, MG/LIT EFFLUENT	TURBIDITY, MG/LIT % REMOVED	TOTAL BIOMASS, NC/ML EFFLUENT	TOTAL BIOMASS, NC/ML % REMOVED	VIABLE BIOMASS, NC/ML EFFLUENT	VIABLE BIOMASS, NC/ML % REMOVED	AMMONIA * MG/LIT	AMMONIA MG/LIT	AMMONIA % REMOVED
JANUARY '78		1.1	85	3.9	85 ± 55							
FEBRUARY	0.4			4.8	59 ± 43						15.6	24 ± 34
MARCH	0.4	1.1	83	4.0	71 ± 12					20.2	14.9	22 ± 150
APRIL	0.6	1.0	85	4.2	81 ± 4	1.3		1.0		21.1	19.0	22 ± 7
MAY	0.6			8.1	71 ± 18	1.3	71 ± 19	1.1	84 ± 27	20.4	20.4	15 ± 7
JUNE	0.6											
JULY	0.6											
AUGUST	0.6			2.4	77 ± 8	1.8	84 ± 7	1.7	86 ± 46		14.8	25 ± 17
SEPTEMBER	0.2			2.7	78 ± 6	1.3	90 ± 36	1.1	85 ± 36		8.0	60 ± 17
OCTOBER	0											
NOVEMBER	0.4			3.7	85 ± 32	1.1	90 ± 7	0.4	90 ± 9		18.4	19 ± 6
DECEMBER	0.44			4.6	74 ± 8	1.8	68 ± 13	1.1	66 ± 39		19.5	8 ± 13
JANUARY '79	0 12	0.88	89	3.4	78 ± 6	1.8	66 ± 16	0.6	83 ± 20	27.0	15.5	23 ± 16
FEBRUARY	0.45	0.9	86	3.0	75 ± 18	1.2	85 ± 15	1.1	81 ± 17	23.9	15.6	28 ± 103
MARCH	0.68	0.74	92	2.5	87 ± 7	1.0	89 ± 8	0.4	89 ± 5	24.7	19.0	14 ± 15
APRIL	1.0	0.5	92	3.1	84 ± 8	0.8	93 ± 7	0.3	90 ± 16		17.7	14 ± 15
MAY	1.0	0.25	95	2.6	88 ± 6	0.4	96 ± 6	0.2	97 ± 5		15.5	36 ± 11
JUNE	1.0	0.26	95	3.7	86 ± 3	0.6	89 ± 6	0.2	88 ± 11	21.0	16.6	23 ± 14
JULY	1.0	0.26	95	3.3	84 ± 11	0.7	88 ± 15	0.2	88 ± 52	14.2	14.3	40 ± 11

* PALO ALTO REGIONAL WATER QUALITY CONTROL FACILITY LABORATORY MEASUREMENTS FROM 24 HOUR COMPOSITE SAMPLES.

APPENDIX C

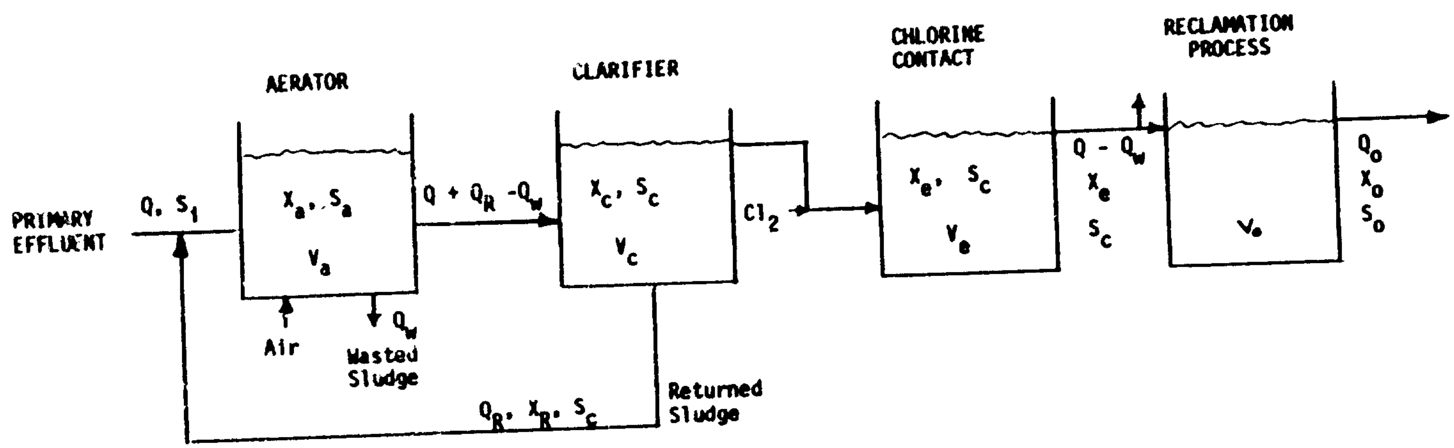
MATH MODEL

OF

SOLIDS & NON-VOLATILE ORGANICS

IN EFFLUENT FROM

ACTIVATED SLUDGE PROCESS



WASTEWATER TREATMENT PROCESS SCHEMATIC

EQUATIONS FOR CALCULATING SOLIDS AND ORGANICS CONCENTRATIONS IN EFFLUENT FROM ACTIVATED SLUDGE PROCESS

HOURLY CHANGE IN RETURN SOLIDS

$$\bar{X}_R = \frac{T_s - \bar{X}_a V_a}{Q_{R/24}}$$

HOURLY CHANGE IN AERATOR SOLIDS WITH HOURLY FLOW VARIATION

$$\bar{X}_a = \bar{X}_a' + \left[\frac{YQ(S_i - S_c) + Q_R \bar{X}_R}{Q + Q_R} - \bar{X}_a'\right]\left[1 - e^{-\left(\frac{Q+Q_R}{V_a}\right)}\right]$$

SOLIDS IN CLARIFIER EFFLUENT

$$X_c = \bar{X}_a K e^{-\frac{\Delta t_c}{Y}}$$

SOLIDS IN FINAL EFFLUENT

$$X_e = X_c K e^{\frac{-\Delta t_e}{Y}}$$

WHERE, DETENTION TIME, Δt_c

FOR PLUG FLOW

$$\Delta t_c = \frac{V_c}{\int_0^{V_c} \frac{d}{dt}(Q - Q_w)}$$

FOR MIXED FLOW

$$\overline{\Delta t}_c = \overline{\Delta t}_c' + \left[\frac{V_c}{(Q - Q_w)} - \overline{\Delta t}_c'\right]\left[1 - e^{-\left(\frac{Q - Q_w}{V_c}\right)}\right]$$

FOR $\overline{\Delta t}_e$ REPLACE V_c WITH V_e IN ABOVE EQUATION

HOURLY CHANGE IN EFFLUENT TOC WITH HOURLY LOAD VARIATION

$$S_c = \bar{S}_i\left[\frac{m}{\overline{\Delta t}_a} - b\right]$$

$$\bar{S}_i = \bar{S}_i' + \left[S_i - \bar{S}_i'\right]\left[1 - e^{-\left(\frac{Q + Q_R}{V_a}\right)}\right]$$

$$\overline{\Delta t}_a = \overline{\Delta t}_a' + \left[\frac{V_a}{Q + Q_R} - \overline{\Delta t}_a'\right]\left[1 - e^{-\left(\frac{Q + Q_R}{V_a}\right)}\right]$$

WHERE THE FOLLOWING VALUES APPLY TO THE PALO ALTO REGIONAL WATER QUALITY CONTROL PLANT

V_a = 7.2 MGAL

V_c = 4.3 MGAL

V_E = 0.738 MGAL

Q_R = 15 MGD

Q_w = 1.64 MGD

T_s = 45,700 x 10^6 MG

$S_i - S_c$ = 50 TO 100 mg/LIT, TOC

Q = 15 TO 50 MGD

Y = 0.6 MG/MG BOD (REFERENCE 17) $\simeq$ 0.6 MG/MG TOC

APPENDIX D

STATISTICAL ANALYSIS COEFFICIENTS

FOR TEST PART II

APPENDIX D

STATISTICAL ANALYSIS COEFFICIENTS

FOR TEST PART II

This section contains the results of statistical analyses on the WMS data. Included are (1) the slope, intercept, and chi square for the lognormal data distribution model, and (2) slope, intercept, and correlation coefficients for process output as a function of input for linear, parabolic, and logarithmic regression models.

LOG-NORMAL DISTRIBUTION: SEP 3, 1980 TO SEP 30, 1980

SAMPLE SOURCE	MONTHLY AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE		LOG(Y)=F(Z) INTERCEPT		CHI SQUARE	SAMPLE SIZE
TETRACHLOROETHYLENE								
1	3.5	2.0	0.2879E	0	0.4924E	0	27.0000	18
2	3.2	2.2	0.3207E	0	0.4405E	0	8.1429	14
3	4.9	0.8	0.7044E	-1	0.6884E	0	2.3333	6
4	3.8	2.0	0.2918E	0	0.5265E	0	9.5714	14
5	3.7	2.0	0.2847E	0	0.5082E	0	5.2857	14
6	3.3	2.1	0.2946E	0	0.4625E	0	6.2353	17
METHYLENE CHLORIDE								
1	21.8	17.6	0.3239E	0	0.1224E	1	2.5556	18
2	10.7	6.3	0.2498E	0	0.9629E	0	1.0000	14
3	18.5	8.6	0.2639E	0	0.1211E	1	4.0000	6
4	14.7	6.5	0.2335E	0	0.1116E	1	4.5714	14
5	12.6	8.6	0.3205E	0	0.1001E	1	1.0000	14
6	11.7	6.3	0.2718E	0	0.9995E	0	0.9412	17
CHLOROFORM								
1	12.0	3.6	0.1239E	0	0.1062E	1	0.8889	18
2	22.5	18.2	0.2626E	0	0.1263E	1	8.1429	14
3	13.3	4.2	0.1183E	0	0.1110E	1	5.6667	6
4	16.2	11.1	0.2413E	0	0.1137E	1	8.1429	14
5	21.0	6.6	0.1364E	0	0.1303E	1	6.7143	14
6	24.2	7.5	0.1345E	0	0.1364E	1	2.7059	17
1,1,1-TRICHLOROETHANE								
1	1.6	0.9	0.2030E	0	0.1774E	0	8.1111	18
2	0.8	0.3	0.5686E	-1	0.2541E	-1	24.5714	14
3	0.5	0.0	0.0000E	0	0.0000E	0	24.0000	6
4	0.4	0.1	0.0000E	0	0.0000E	0	56.0000	14
5	3.2	1.0	0.1684E	0	0.4833E	0	15.2857	14
6	3.5	0.9	0.1206E	0	0.5298E	0	15.6471	17
BROMODICHLOROMETHANE								
1	15.3	6.8	0.2251E	0	0.1137E	1	5.8889	18
2	24.4	14.2	0.2335E	0	0.1328E	1	8.8571	14
3	19.4	6.3	0.1338E	0	0.1269E	1	0.6667	6
4	21.1	9.0	0.1644E	0	0.1294E	1	3.8571	14
5	20.2	5.3	0.1505E	0	0.1285E	1	3.1429	14
6	20.1	7.0	0.2367E	0	0.1260E	1	17.4118	17

EOF..

LOG-NORMAL DISTRIBUTION: SEP 3, 1980 TO SEP 30, 1980

SAMPLE SOURCE	MONTHLY AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE	INTERCEPT	CHI SQUARE	SAMPLE SIZE
TRICHLOROETHYLENE						
1	1.7	0.9	0.1930E 0	0.1833E 0	3.1111	18
2	1.0	0.3	0.7301E -1	0.4955E -1	6.0000	14
3	0.9	0.3	0.6559E -1	0.3128E -1	4.0000	6
4	0.7	0.2	0.1534E -1	0.6028E -2	38.8571	14
5	1.7	0.3	0.7605E -1	0.2226E 0	2.4286	14
6	1.8	0.3	0.6430E -1	0.2621E 0	1.5294	17
DIBROMOCHLOROMETHANE						
1	8.9	5.3	0.2952E 0	0.8086E 0	1.4444	18
2	13.4	7.6	0.2366E 0	0.1067E 1	6.7143	14
3	10.3	5.5	0.2121E 0	0.9662E 0	0.6667	6
4	13.7	7.3	0.2413E 0	0.1078E 1	0.2857	14
5	9.3	2.3	0.1063E 0	0.9550E 0	4.5714	14
6	13.4	3.9	0.1348E 0	0.1109E 1	4.4706	17
BROMOFORM						
4	0.1	0.3	0.1521E -1	0.4065E -2	46.7143	14
TRIHALOMETHANES						
1	36.3	14.9	0.1880E 0	0.1524E 1	8.1111	18
2	60.4	37.7	0.2171E 0	0.1722E 1	8.8571	14
3	43.0	15.7	0.1425E 0	0.1612E 1	0.6667	6
4	51.1	25.4	0.1912E 0	0.1667E 1	0.2857	14
5	50.4	11.1	0.9698E -1	0.1693E 1	4.5714	14
6	57.8	9.8	0.7596E -1	0.1756E 1	3.2941	17
TOTAL HALOCARBONS						
1	64.8	18.9	0.1326E 0	0.1793E 1	1.4444	18
2	76.1	34.3	0.1625E 0	0.1850E 1	3.1429	14
3	67.9	18.1	0.1168E 0	0.1819E 1	2.3333	6
4	70.7	23.8	0.1335E 0	0.1829E 1	1.7143	14
5	71.6	9.7	0.5948E -1	0.1851E 1	0.2857	14
6	78.2	11.3	0.6472E -1	0.1889E 1	1.5294	17

EOF..

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3, 1980 TO SEP 30, 1980

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 2

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	-0.0053	1.0276	0.7142	0.9211	14
2.	METHYLENE CHLORIDE	7.3039	0.1985	5.5127	0.3402	16
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	-10.5012	2.5546	14.2211	0.5685	16
6.	1,1,1-TRICHLOROETHANE	0.5719	0.1755	0.2802	0.5256	16
7.	BROMODICHLOROMETHANE	11.0713	0.7395	12.1173	0.4427	16
8.	TRICHLOROETHYLENE	0.5403	0.3087	0.1931	0.8220	16
9.	DIBROMOCHLOROMETHANE	0.0894	0.5119	6.4290	0.4864	16
10.	BROMOFORM	0.0472	-0.1046	0.0649	0.9733	6
11.	TRIHALOMETHANES	24.5236	0.0770	32.3069	0.4402	16
12.	TOTAL HALOCARBONS	64.1609	0.1626	31.4403	0.3309	16

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.2633	1.3493	-0.0575	0.7026	0.9237
2.	METHYLENE CHLORIDE	4.1567	0.6159	-0.0098	5.3975	0.3970
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	36.3777	-4.4606	0.2424	13.7551	0.6057
6.	1,1,1-TRICHLOROETHANE	0.0004	0.9866	-0.2117	0.2502	0.6503
7.	BROMODICHLOROMETHANE	40.5544	-4.0770	0.1379	11.4300	0.5326
8.	TRICHLOROETHYLENE	0.3153	0.5797	-0.0636	0.1877	0.8327
9.	DIBROMOCHLOROMETHANE	23.0442	-2.4709	0.1191	6.0244	0.5742
10.	BROMOFORM	0.0494	-0.2153	0.4531	0.0640	0.9733
11.	TRIHALOMETHANES	204.9743	-0.4732	0.1000	29.6396	0.5751
12.	TOTAL HALOCARBONS	107.1273	-4.3741	0.0303	30.6693	0.3912

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.1553	1.2270	0.2923	0.8595
2.	METHYLENE CHLORIDE	0.4414	0.4626	0.2013	0.5637
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-0.1944	1.3306	0.1920	0.7549
6.	1,1,1-TRICHLOROETHANE	-0.1500	0.3001	0.1234	0.6645
7.	BROMODICHLOROMETHANE	0.5590	0.6403	0.1050	0.6556
8.	TRICHLOROETHYLENE	-0.0052	0.5217	0.0759	0.8320
9.	DIBROMOCHLOROMETHANE	0.6165	0.4720	0.1934	0.6376
10.	BROMOFORM	-1.5453	0.2502	0.7440	0.8875
11.	TRIHALOMETHANES	0.7312	0.6204	0.1765	0.6663
12.	TOTAL HALOCARBONS	1.4753	0.2064	0.1403	0.5207

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3, 1980 TO SEP 30, 1980

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 3

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL. NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	1.7101	0.7099	0.3969	0.7044	8
2.	METHYLENE CHLORIDE	25.6407	-0.2044	11.0371	0.2916	8
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	8
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	8
5.	CHLOROFORM	5.0540	0.6630	3.1039	0.3667	8
6.	1,1,1-TRICHLOROETHANE	0.3173	0.1045	0.1047	0.6925	8
7.	BROMODICHLOROMETHANE	0.2096	1.0344	4.1727	0.7544	7
8.	TRICHLOROETHYLENE	0.3762	0.2651	0.0930	0.9340	8
9.	DIBROMOCHLOROMETHANE	5.4002	0.6647	4.9273	0.5133	8
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0000	8
11.	TRIHALOMETHANES	2.7011	1.0101	0.2680	0.7700	8
12.	TOTAL HALOCARBONS	63.5411	0.0607	16.4995	0.0656	8

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL. NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	2.5636	0.3195	0.0435	0.3960	0.7055
2.	METHYLENE CHLORIDE	27.0611	-0.4777	0.0044	11.0170	0.2970
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	59.0091	-0.9989	0.4200	2.9451	0.5094
6.	1,1,1-TRICHLOROETHANE	0.2854	0.1444	-0.0097	0.1045	0.6936
7.	BROMODICHLOROMETHANE	33.2003	-3.2055	0.1279	3.5050	0.8257
8.	TRICHLOROETHYLENE	0.4329	0.2056	0.0120	0.0934	0.9347
9.	DIBROMOCHLOROMETHANE	17.6994	-1.6060	0.0891	4.7274	0.5675
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0000	0.0000
11.	TRIHALOMETHANES	89.4935	-3.6054	0.0572	5.2451	0.9174
12.	TOTAL HALOCARBONS	66.2010	-0.0416	0.0009	16.4986	0.0664

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL. NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.2770	0.6314	0.0368	0.7712
2.	METHYLENE CHLORIDE	1.4021	-0.1440	0.2639	0.3250
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.6590	0.4123	0.0900	0.3347
6.	1,1,1-TRICHLOROETHANE	-0.3072	0.3017	0.0769	0.7634
7.	BROMODICHLOROMETHANE	0.2704	0.7052	0.0961	0.7067
8.	TRICHLOROETHYLENE	-0.2046	0.5664	0.0419	0.9376
9.	DIBROMOCHLOROMETHANE	0.5221	0.5303	0.1076	0.4760
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0000
11.	TRIHALOMETHANES	0.5001	0.6995	0.0005	0.5052
12.	TOTAL HALOCARBONS	1.7290	0.0404	0.1076	0.1360

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3, 1980 TO SEP 30, 1980

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 4

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL. NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	0.7240	0.9170	0.6016	0.9261	13
2.	METHYLENE CHLORIDE	11.9390	0.1974	5.9706	0.3436	15
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	-7.5730	1.9074	0.2007	0.6259	15
6.	1,1,1-TRICHLOROETHANE	0.3005	0.0203	0.1117	0.3201	15
7.	BROMODICHLOROMETHANE	17.0459	0.1741	0.7111	0.1217	16
8.	TRICHLOROETHYLENE	0.4244	0.1709	0.0959	0.8590	16
9.	DIBROMOCHLOROMETHANE	11.9606	0.1034	6.9163	0.0725	16
10.	BROMOFORM	0.3000	-1.3522	0.3995	0.3650	6
11.	TRIHALOMETHANES	37.6200	0.2600	24.5619	0.1416	16
12.	TOTAL HALOCARBONS	71.5516	-0.0000	25.1705	0.0601	16

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.2490	1.4104	-0.0059	0.5701	0.9339
2.	METHYLENE CHLORIDE	9.6272	0.4925	-0.0068	5.9273	0.3649
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	22.6449	-2.5968	0.1541	7.0780	0.6630
6.	1,1,1-TRICHLOROETHANE	0.3453	0.0780	-0.0131	0.1115	0.3340
7.	BROMODICHLOROMETHANE	52.4306	-4.4730	0.1331	7.0094	0.4563
8.	TRICHLOROETHYLENE	0.4064	0.2006	-0.0051	0.0959	0.0600
9.	DIBROMOCHLOROMETHANE	15.2009	-0.5420	0.0258	6.0991	0.1000
10.	BROMOFORM	0.3447	-3.0151	6.9416	0.3906	0.3710
11.	TRIHALOMETHANES	176.6369	-6.9424	0.0032	22.4000	0.4293
12.	TOTAL HALOCARBONS	214.1011	-5.3332	0.0443	23.0599	0.3244

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.1020	1.2365	0.1110	0.9677
2.	METHYLENE CHLORIDE	0.0066	0.2005	0.2091	0.3603
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-0.2637	1.2961	0.1007	0.6314
6.	1,1,1-TRICHLOROETHANE	-0.4047	0.1410	0.1071	0.3432
7.	BROMODICHLOROMETHANE	1.1932	0.0592	0.1693	0.2129
8.	TRICHLOROETHYLENE	-0.2246	0.4106	0.0601	0.0337
9.	DIBROMOCHLOROMETHANE	0.9629	0.0940	0.2310	0.2666
10.	BROMOFORM	-1.0066	-0.2345	0.0201	0.5193
11.	TRIHALOMETHANES	1.5922	0.0220	0.2092	0.2409
12.	TOTAL HALOCARBONS	2.0972	-0.1756	0.1006	0.2206

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3, 1980 TO SEP 30, 1980

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	1.2096	0.7442	0.9736	0.7740	13
2.	METHYLENE CHLORIDE	7.5962	0.3025	7.3864	0.3847	16
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	6.0647	1.2200	4.9020	0.6575	15
6.	1,1,1-TRICHLOROETHANE	3.1592	0.0713	0.8724	0.1465	16
7.	BROMODICHLOROMETHANE	13.8779	0.3989	4.1870	0.5421	16
8.	TRICHLOROETHYLENE	1.5019	0.1037	0.2700	0.4839	16
9.	DIBROMOCHLOROMETHANE	8.5901	0.0040	2.0740	0.4345	16
10.	BROMOFORM	0.0020	0.1614	0.0000	1.0000	2
11.	TRIHALOMETHANES	29.6752	0.5283	9.1079	0.6843	16
12.	TOTAL HALOCARBONS	57.6578	0.2163	8.8952	0.5449	16

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	1.2695	0.7623	-0.0030	0.9736	0.7740
2.	METHYLENE CHLORIDE	10.3133	-0.0578	0.0084	7.3227	0.4033
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	10.1066	0.6272	0.0207	4.8918	0.6593
6.	1,1,1-TRICHLOROETHANE	3.8727	-0.9415	0.2643	0.8581	0.2310
7.	BROMODICHLOROMETHANE	12.6160	0.5646	-0.0047	4.1855	0.5420
8.	TRICHLOROETHYLENE	1.3130	0.3313	-0.0534	0.2673	0.4993
9.	DIBROMOCHLOROMETHANE	11.1539	-0.4266	0.0284	2.0380	0.4655
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0130	1.0111
11.	TRIHALOMETHANES	29.7285	0.5255	0.0000	9.1079	0.6843
12.	TOTAL HALOCARBONS	-6.5184	2.5840	-0.0200	8.1206	0.6435

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.1692	0.7616	0.1136	0.8693
2.	METHYLENE CHLORIDE	0.6090	0.3480	0.2836	0.3980
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.5675	0.6867	0.1097	0.5918
6.	1,1,1-TRICHLOROETHANE	0.4830	0.0662	0.1534	0.2539
7.	BROMODICHLOROMETHANE	0.8227	0.3969	0.1212	0.5390
8.	TRICHLOROETHYLENE	0.1917	0.1424	0.0854	0.4911
9.	DIBROMOCHLOROMETHANE	0.8807	0.0870	0.0972	0.4849
10.	BROMOFORM	-1.0403	0.6896	0.0000	1.0000
11.	TRIHALOMETHANES	1.0151	0.4303	0.0843	0.6901
12.	TOTAL HALOCARBONS	1.5057	0.1928	0.0547	0.5871

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3. 1980 TO SEP 30. 1980

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	-0.0076	0.9757	0.0072	0.0722	14
2.	METHYLENE CHLORIDE	10.6397	0.0519	6.2019	0.0049	16
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1.2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	12.3011	0.7540	5.4056	0.5037	16
6.	1.1.1-TRICHLOROETHANE	3.5730	-0.1115	0.0223	0.1673	16
7.	BROMODICHLOROMETHANE	19.9201	0.1170	4.0332	0.4466	16
8.	TRICHLOROETHYLENE	1.9047	-0.0501	0.2925	0.1527	16
9.	DIBROMOCHLOROMETHANE	12.3005	0.0225	4.0001	0.1290	16
10.	BROMOFORM	0.2420	-2.6727	0.0619	0.9000	3
11.	TRIHALOMETHANES	51.8370	0.1126	10.0929	0.1430	16
12.	TOTAL HALOCARBONS	85.2053	-0.1500	12.2909	0.2142	16

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.2104	1.2305	-0.0470	0.0011	0.8741
2.	METHYLENE CHLORIDE	11.6885	-0.0076	0.0033	6.2707	0.1036
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1.2-DICHLOROETHYLENE	0.0006	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	21.0030	-0.5482	0.0450	5.3639	0.5150
6.	1.1.1-TRICHLOROETHANE	5.3970	-2.7004	0.6756	0.7170	0.5100
7.	BROMODICHLOROMETHANE	17.6954	0.4110	-0.0084	4.0258	0.4499
8.	TRICHLOROETHYLENE	1.0414	0.0263	-0.0173	0.2923	0.1506
9.	DIBROMOCHLOROMETHANE	8.3565	0.0107	-0.0315	3.9639	0.1954
10.	BROMOFORM	0.6606	-30.5320	256.1277	0.0000	1.0000
11.	TRIHALOMETHANES	55.5942	-0.0021	0.0022	10.0895	0.1451
12.	TOTAL HALOCARBONS	139.5964	-2.1575	0.0170	11.0995	0.3251

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.1527	1.1982	0.1700	0.9429
2.	METHYLENE CHLORIDE	0.0139	0.1541	0.2648	0.3263
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1.2-DICHLOROETHYLENE	0.0000	0.0090	0.0000	0.0000
5.	CHLOROFORM	0.8760	0.4117	0.1141	0.5147
6.	1.1.1-TRICHLOROETHANE	0.5309	-0.1006	0.1135	0.3071
7.	BROMODICHLOROMETHANE	1.2170	0.0972	0.0796	0.4053
8.	TRICHLOROETHYLENE	0.2630	-0.0509	0.0711	0.1712
9.	DIBROMOCHLOROMETHANE	1.6242	0.0532	0.1446	0.2709
10.	BROMOFORM	-4.2520	-1.9939	0.0165	0.9997
11.	TRIHALOMETHANES	1.6090	0.0038	0.0079	0.1900
12.	TOTAL HALOCARBONS	2.1021	-0.1207	0.0723	0.2664

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3, 1980 TO SEP 30, 1980

FROM SAMPLE SOURCE 2 TO SAMPLE SOURCE 3

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	2.3183	0.5244	0.4747	0.6784	8
2.	METHYLENE CHLORIDE	20.8605	-0.0196	11.5376	0.0114	8
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	4.1122	0.5622	1.4243	0.9893	8
6.	1,1,1-TRICHLOROETHANE	0.2100	0.3847	0.0978	0.7386	8
7.	BROMODICHLOROMETHANE	2.3490	0.7279	3.2504	0.8594	7
8.	TRICHLOROETHYLENE	0.0126	0.8022	0.0650	0.9681	8
9.	DIBROMOCHLOROMETHANE	1.5730	0.8480	2.3854	0.9096	8
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0000	0
11.	TRIHALOMETHANES	6.7533	0.7098	5.7966	0.8981	8
12.	TOTAL HALOCARBONS	29.5924	0.5786	13.5811	0.5784	8

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	16.3789	-5.2388	0.5741	0.3419	0.8453
2.	METHYLENE CHLORIDE	34.9632	-2.4557	0.0800	10.6766	0.3792
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	19.5421	-1.1476	0.0411	1.0515	0.9516
6.	1,1,1-TRICHLOROETHANE	0.2754	0.2385	0.0743	0.0976	0.7398
7.	BROMODICHLOROMETHANE	26.0396	-1.4305	0.0449	2.8117	0.8968
8.	TRICHLOROETHYLENE	0.2056	0.4651	0.1361	0.0642	0.9697
9.	DIBROMOCHLOROMETHANE	1.1091	0.9298	-0.0028	2.3838	0.9097
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0000	0.0000
11.	TRIHALOMETHANES	40.6906	-0.5597	0.0104	5.2003	0.9189
12.	TOTAL HALOCARBONS	113.4089	-1.8083	0.0157	12.7843	0.6342

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.3604	0.4745	0.0464	0.5961
2.	METHYLENE CHLORIDE	1.2299	0.0089	0.2686	0.2711
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.3395	0.6469	0.0521	0.8413
6.	1,1,1-TRICHLOROETHANE	-0.2270	0.6400	0.0808	0.7340
7.	BROMODICHLOROMETHANE	0.1881	0.7979	0.0797	0.8096
8.	TRICHLOROETHYLENE	-0.0890	0.9665	0.0346	0.9578
9.	DIBROMOCHLOROMETHANE	0.1805	0.8185	0.1090	0.8595
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0000
11.	TRIHALOMETHANES	0.2901	0.7844	0.0660	0.8396
12.	TOTAL HALOCARBONS	0.8633	0.5263	0.0941	0.4986

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3. 1980 TO SEP 30. 1980

FROM SAMPLE SOURCE 3 TO SAMPLE SOURCE 4

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	-1.0734	1.2210	0.1189	0.9959	8
2.	METHYLENE CHLORIDE	12.1293	0.2895	4.5235	0.7510	8
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1.2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	-0.6456	0.9898	1.2466	0.9597	8
6.	1.1.1-TRICHLOROETHANE	0.2202	0.3732	0.0473	0.7781	8
7.	BROMODICHLOROMETHANE	1.0032	0.8527	0.9636	0.9872	7
8.	TRICHLOROETHYLENE	0.1541	0.6901	0.1187	0.8455	8
9.	DIBROMOCHLOROMETHANE	-1.6398	1.2013	1.1834	0.9850	8
10.	BROMOFORM	0.0000	0.0000	0.3598	0.4139	1
11.	TRIHALOMETHANES	7.3510	0.8442	9.5283	0.8007	8
12.	TOTAL HALOCARBONS	26.1681	0.5862	11.5445	0.6446	8

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	2.8961	-0.0950	0.1343	0.1014	0.9977
2.	METHYLENE CHLORIDE	6.4783	0.9024	-0.0125	4.1224	0.7993
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1.2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-19.0453	3.4731	-0.0766	1.0667	0.9706
6.	1.1.1-TRICHLOROETHANE	0.5524	-0.0738	1.0926	0.0395	0.8515
7.	BROMODICHLOROMETHANE	5.7154	0.3696	0.0114	0.8750	0.9895
8.	TRICHLOROETHYLENE	-0.3566	1.7005	-0.5362	0.1:22	0.8632
9.	DIBROMOCHLOROMETHANE	2.8014	0.3876	0.0298	0.9967	0.9899
10.	BROMOFORM	0.0000	0.0000	0 0000	0.3598	0.4139
11.	TRIHALOMETHANES	20.2384	0.2762	0.0056	9.4808	0.8026
12.	TOTAL HALOCARBONS	151.0085	-3.2522	0.0278	9.8786	0.7568

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.1378	1.1991	0.0112	0.9970
2.	METHYLENE CHLORIDE	0.7818	0.3638	0.1235	0.7167
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1.2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-0.1508	1.1085	0.0459	0.9536
6.	1.1.1-TRICHLOROETHANE	-0.2655	0.4875	0.0573	0.6655
7.	BROMODICHLOROMETHANE	0.0892	0.8908	0.0293	0.9814
8.	TRICHLOROETHYLENE	-0.0730	0.8695	0.0612	0.8624
9.	DIBROMOCHLOROMETHANE	-0.1010	1.1097	0.0488	0.9818
10.	BROMOFORM	0.0000	0.0000	0.4439	1.0321
11.	TRIHALOMETHANES	0.1948	0.8810	0.0957	0.0170
12.	TOTAL HALOCARBONS	0.8451	0.5297	0.0768	0.6168

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3, 1980 TO SEP 30, 1980

FROM SAMPLE SOURCE 4 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	-0.1953	1.0054	0.6083	0.8954	13
2.	METHYLENE CHLORIDE	2.0341	0.7004	6.6711	0.5665	15
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	15.4012	0.3426	5.2079	0.5853	14
6.	1,1,1-TRICHLOROETHANE	1.8723	3.2207	0.0170	0.4361	15
7.	BROMODICHLOROMETHANE	17.0238	0.1293	4.7155	0.3235	16
8.	TRICHLOROETHYLENE	1.1923	0.6671	0.2560	0.5541	16
9.	DIBROMOCHLOROMETHANE	7.9301	0.1146	1.9595	0.5253	16
10.	BROMOFORM	-0.0935	14.1360	0.0000	1.0000	2
11.	TRIHALOMETHANES	42.6913	0.1543	10.9053	0.4076	16
12.	TOTAL HALOCARBONS	70.7004	0.0000	9.6317	0.4191	16

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.0746	0.9240	0.0112	0.6070	0.8956
2.	METHYLENE CHLORIDE	4.4064	0.3342	0.0122	6.6421	0.5717
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	12.9985	0.6359	-0.0060	5.1814	0.5910
6.	1,1,1-TRICHLOROETHANE	2.2583	1.4590	1.0094	0.8165	0.4373
7.	BROMODICHLOROMETHANE	21.6702	-0.2386	0.0070	4.6769	0.3453
8.	TRICHLOROETHYLENE	-1.3090	7.3799	-4.2210	0.2074	0.7403
9.	DIBROMOCHLOROMETHANE	6.3314	0.3005	-0.0006	1.9238	0.5496
10.	BROMOFORM	0.0000	0.0000	0.0000	0.0130	1.0111
11.	TRIHALOMETHANES	47.5377	-0.0416	0.0016	10.8551	0.4947
12.	TOTAL HALOCARBONS	71.5861	-0.0250	0.0002	9.6305	0.4194

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.1447	1.1044	0.0744	0.9581
2.	METHYLENE CHLORIDE	0.2031	0.7150	0.2550	0.5537
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.9563	0.3046	0.1107	0.5855
6.	1,1,1-TRICHLOROETHANE	0.7125	0.5033	0.1437	0.4781
7.	BROMODICHLOROMETHANE	1.1581	0.1123	0.1365	0.3164
8.	TRICHLOROETHYLENE	0.2025	0.4353	0.0776	0.6115
9.	DIBROMOCHLOROMETHANE	0.7873	0.1669	0.0906	0.5785
10.	BROMOFORM	19.4776	10.0060	0.0000	1.0000
11.	TRIHALOMETHANES	1.4633	0.1377	0.1004	0.5066
12.	TOTAL HALOCARBONS	1.0592	-0.0075	0.0602	0.4530

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR SEP 3, 1980 TO SEP 30, 1980

FROM SAMPLE SOURCE 5 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	0.2370	0.8472	1.1274	0.7763	15
2.	METHYLENE CHLORIDE	5.4775	0.5076	4.5263	0.6729	17
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	5.4030	0.7470	3.0206	0.9131	16
6.	1,1,1-TRICHLOROETHANE	1.3072	6.6241	0.5600	0.7240	17
7.	BROMODICHLOROMETHANE	23.0625	-0.0986	5.3662	0.2114	17
8.	TRICHLOROETHYLENE	1.6201	0.1004	0.2014	0.2045	17
9.	DIBROMOCHLOROMETHANE	7.0567	0.5541	3.2026	0.5793	17
10.	BROMOFORM	0.0066	0.0081	0.0000	1.0000	2
11.	TRIHALOMETHANES	46.2144	0.1889	9.9447	0.3857	17
12.	TOTAL HALOCARBONS	66.4100	0.1345	12.0324	0.2206	17

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.4063	1.4125	-0.0029	1.0935	0.7913
2.	METHYLENE CHLORIDE	4.5402	0.6896	-0.0059	4.5100	0.6757
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-0.3762	1.2190	-0.0083	2.0700	0.9214
6.	1,1,1-TRICHLOROETHANE	2.2323	-0.0567	0.1115	0.5516	0.7432
7.	BROMODICHLOROMETHANE	1.0264	1.9546	-0.0438	3.8824	0.7071
8.	TRICHLOROETHYLENE	0.0713	0.0342	-0.1553	0.2669	0.3715
9.	DIBROMOCHLOROMETHANE	-7.0511	2.0099	-0.0740	2.6185	0.7590
10.	BROMOFORM	0.0000	0.0000	0.0000	0.1062	0.4816
11.	TRIHALOMETHANES	21.6770	0.9379	-0.0047	9.2447	0.5142
12.	TOTAL HALOCARBONS	62.3975	0.2240	-0.0004	12.0291	0.2210

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.4479	1.5966	0.1766	0.9362
2.	METHYLENE CHLORIDE	0.4735	0.5380	0.1902	0.7143
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.2420	0.8177	0.0547	0.9255
6.	1,1,1-TRICHLOROETHANE	0.2956	0.4433	0.0916	0.6229
7.	BROMODICHLOROMETHANE	1.4539	-0.1171	0.1471	0.1202
8.	TRICHLOROETHYLENE	0.2107	0.1073	0.0662	0.3277
9.	DIBROMOCHLOROMETHANE	0.4216	0.6696	0.1100	0.6650
10.	BROMOFORM	-1.3039	0.4490	0.0000	1.0000
11.	TRIHALOMETHANES	1.2743	0.2743	0.0770	0.4590
12.	TOTAL HALOCARBONS	1.5440	0.1707	0.0710	0.2546

LOG-NORMAL DISTRIBUTION: SEP 3, 1980 TO FEB 28, 1981

SAMPLE SOURCE	AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE		LOG(Y)=F(Z) INTERCEPT		CHI SQUARE	SAMPLE SIZE
TOTAL BIOMASS								
1	2.0	1.1	0.3113E	0	0.2206E	0	11.8144	97
2	0.2	0.1	0.2601E	0	-0.8346E	0	1.1379	58
3	0.7	0.5	0.3149E	0	-0.2938E	0	3.5663	83
4	0.3	0.3	0.2845E	0	-0.5782E	0	0.5556	90
5	0.3	0.2	0.2731E	0	-0.6544E	0	6.3158	95
6	0.3	0.4	0.2975E	0	-0.6705E	0	6.0870	115
VIABLE BIOMASS								
1	0.6	0.5	0.4343E	0	-0.3701E	0	32.6667	99
2	0.0	0.0	0.3448E	0	-0.1698E	1	5.2759	58
3	0.2	0.2	0.4553E	0	-0.8758E	0	6.4762	84
4	0.1	0.1	0.4671E	0	-0.1127E	1	3.4506	91
5	0.1	0.1	0.4719E	0	-0.1238E	1	1.4624	93
6	0.1	0.4	0.4335E	0	-0.1167E	1	6.0690	116
RES CHLORINE								
1	4.0	1.9	0.2464E	0	0.5473E	0	5.5385	91
2	1.5	1.0	0.3388E	0	0.4781E	-1	0.6377	69
3	1.2	1.1	0.3129E	0	-0.3173E	-1	7.1282	78
4	0.9	0.8	0.3433E	0	-0.1495E	0	1.9080	87
5	0.3	0.5	0.3356E	0	-0.7382E	0	81.3627	91
6	2.0	1.2	0.3085E	0	0.2194E	0	11.8654	104
TURBIDITY-SI02								
1	13.9	5.2	0.1746E	0	0.1109E	[illegible]	5.9123	114
2	11.4	10.0	0.2234E	0	0.9805E	[illegible]	9.1795	78
3	6.2	3.9	0.2149E	0	0.7294E	0	20.0612	98
4	9.3	3.5	0.1776E	0	0.9353E	0	7.6364	110
5	5.7	4.0	0.1805E	0	0.7077E	0	22.1982	111
6	4.7	1.8	0.1480E	0	0.6437E	0	6.2029	138
DIS OXYGEN								
1	6.2	1.8	0.1578E	0	0.7657E	0	38.5439	114
2	6.7	1.3	0.8404E	-1	0.8208E	0	7.7692	78
3	6.6	1.6	0.1079E	0	0.8089E	0	8.0202	99
4	6.9	1.6	0.9945E	-1	0.8301E	0	3.9091	110
5	6.3	1.4	0.9677E	-1	0.7897E	0	10.7679	112
6	6.2	1.6	0.1213E	0	0.7760E	0	18.5217	138

EOF..

LOG-NORMAL DISTRIBUTION: SEP 3, 1980 TO FEB 28, 1981

SAMPLE SOURCE	AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE	LOG(Y)=F(Z) INTERCEPT	CHI SQUARE	SAMPLE SIZE
AMMONIA						
1	5.1	10.2	0.4780E 0	0.3761E 0	12.1136	88
2	5.9	12.7	0.5348E 0	0.3245E 0	9.2281	57
3	5.1	12.1	0.5726E 0	0.2350E 0	9.1316	76
4	4.6	13.5	0.5400E 0	0.2077E 0	16.2222	81
5	4.3	12.6	0.5916E 0	0.9275E -1	18.9722	72
6	4.2	12.8	0.5163E 0	0.1283E 0	23.5670	97
PH						
1	5.6	0.5	0.3182E -1	0.7471E 0	14.0000	115
2	7.4	1.0	0.5853E -1	0.8656E 0	0.4615	78
3	6.0	0.7	0.4688E -1	0.7768E 0	18.5000	100
4	6.3	0.8	0.4913E -1	0.7959E 0	5.5455	110
5	6.2	0.6	0.4117E -1	0.7936E 0	6.9558	113
6	6.1	0.5	0.3425E -1	0.7825E 0	6.3478	138
TOT ORG CARBON						
1	9.7	2.4	0.1108E 0	0.9753E 0	10.7708	96
2	6.8	2.1	0.1377E 0	0.8107E 0	12.8824	68
3	7.2	3.0	0.1536E 0	0.8293E 0	13.7531	81
4	6.8	2.0	0.1278E 0	0.8145E 0	15.2222	90
5	4.2	1.6	0.1448E 0	0.5945E 0	1.2527	91
6	3.7	1.4	0.1306E 0	0.5524E 0	8.8113	106
CONDUCTIVITY						
1	1234.4	62.6	0.2145E -1	0.3091E 1	2.4348	115
2	1287.1	85.3	0.2715E -1	0.3109E 1	12.3846	78
3	1296.1	53.2	0.1837E -1	0.3112E 1	2.5000	100
4	1303.8	60.4	0.2045E -1	0.3115E 1	3.9091	110
5	1316.9	64.9	0.2156E -1	0.3119E 1	5.6283	113
6	1313.3	65.5	0.2200E -1	0.3118E 1	11.3478	138
HARDNESS						
1	327.2	338.3	0.2237E 0	0.2430E 1	11.8750	80
2	253.5	102.3	0.1415E 0	0.2379E 1	1.2647	68
3	280.4	254.1	0.1782E 0	0.2396E 1	5.2791	86
4	249.8	70.7	0.1259E 0	0.2380E 1	2.5263	95
5	236.9	69.2	0.1315E 0	0.2355E 1	3.5306	98
6	390.2	306.5	0.2368E 0	0.2514E 1	11.9551	89
SODIUM						
1	158.7	12.6	0.3403E -1	0.2199E 1	3.4815	108
2	154.8	13.9	0.3757E -1	0.2188E 1	4.3947	76
3	154.1	10.7	0.2968E -1	0.2187E 1	4.1505	93
4	155.8	12.3	0.3364E -1	0.2191E 1	6.8544	103
5	154.1	11.2	0.3112E -1	0.2187E 1	1.0962	104
6	153.7	13.4	0.3650E -1	0.2185E 1	8.0000	130

EOF..

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 2

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.1723	0.0040	0.1184	0.0560	56
2.	VIABLE BIOMASS	MIL C/ML	0.0325	-0.0041	0.0363	0.0368	57
5.	RES CHLORINE	MG/L	0.8776	0.1345	0.9308	0.2636	66
6.	TURBIDITY-SIO2	MG/L	-2.2082	1.0335	5.5174	0.6508	73
7.	DIS OXYGEN	MG/L	2.1952	0.7251	0.7302	0.8255	73
10.	AMMONIA	MG/L	-0.8645	1.0049	3.1823	0.9700	54
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0
12.	PH	PH	6.3576	0.1949	0.9033	0.1181	73
13.	TOT ORG CARBON	MG/L	2.8803	0.3952	1.7597	0.5354	64
14.	CONDUCTIVITY	MMMHO/CM	356.2761	0.7546	71.3212	0.4821	73
15.	TEMPERATURE#1	DEG F	33.7940	0.5293	1.0906	0.7552	73
16.	HARDNESS	MG/L	200.1208	0.0502	117.4959	0.1869	45
17.	SODIUM	MG/L	39.5770	0.7301	10.1351	0.6792	71
20.	AMBIENT TEMP	DEG F	15.9998	0.7821	0.9391	0.8237	81

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.0739	0.0979	-0.0170	0.1117	0.3352
2.	VIABLE BIOMASS	MIL C/ML	0.0169	0.0628	-0.0521	0.0356	0.1911
5.	RES CHLORINE	MG/L	0.2534	0.4420	-0.0310	0.9092	0.3350
6.	TURBIDITY-SIO2	MG/L	12.6343	-1.4599	0.0919	4.8211	0.7483
7.	DIS OXYGEN	MG/L	6.6462	-0.7201	0.1113	0.6432	0.8677
10.	AMMONIA	MG/L	-0.4301	0.8452	0.0034	3.1105	0.9706
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	-19.6378	8.4544	-0.6385	0.8100	0.4549
13.	TOT ORG CARBON	MG/L	3.4184	0.2907	0.0047	1.7582	0.5365
14.	CONDUCTIVITY	MMMHO/CM	2399.9630	-2.5323	0.0013	71.1629	0.4856
15.	TEMPERATURE#1	DEG F	-262.8664	8.3916	-0.0519	0.5652	0.9423
16.	HARDNESS	MG/L	235.5657	0.0703	-0.0000	117.4644	0.1865
17.	SODIUM	MG/L	-340.0337	5.4264	-0.0144	9.5244	0.7241
20.	AMBIENT TEMP	DEG F	196.9927	-4.1842	0.0340	0.9283	0.8281

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.8367	0.0797	0.2437	0.2709
2.	VIABLE BIOMASS	MIL C/ML	-1.6619	0.0892	0.3423	0.4601
5.	RES CHLORINE	MG/L	-0.1701	0.3857	0.3172	0.4284
6.	TURBIDITY-SIO2	MG/L	0.1226	0.7926	0.1491	0.7400
7.	DIS OXYGEN	MG/L	0.3537	0.5961	0.0523	0.7694
10.	AMMONIA	MG/L	-0.1033	0.9115	0.2969	0.8986
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	0.7282	0.1807	0.0523	0.1305
13.	TOT ORG CARBON	MG/L	0.1808	0.6448	0.1122	0.6083
14.	CONDUCTIVITY	MMMHO/CM	0.9678	0.6927	0.0221	0.4928
15.	TEMPERATURE#1	DEG F	0.7944	0.5719	0.0063	0.7774
16.	HARDNESS	MG/L	2.0835	0.1216	0.1566	0.2536
17.	SODIUM	MG/L	0.5145	0.7619	0.0262	0.7086
20.	AMBIENT TEMP	DEG F	0.4138	0.7782	0.0056	0.8222

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REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 3

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.1079	0.3042	0.4513	0.5157	81
2.	VIABLE BIOMASS	MIL C/ML	0.0825	0.2571	0.2231	0.2947	82
5.	RES CHLORINE	MG/L	0.3698	0.1848	0.7693	0.3902	76
6.	TURBIDITY-SIO2	MG/L	5.7518	0.0331	3.9211	0.0431	96
7.	DIS OXYGEN	MG/L	2.3082	0.6901	1.0738	0.7532	97
10.	AMMONIA	MG/L	-0.5690	1.0432	4.2268	0.9378	78
11.	NITRATE	MG/L	0.0000	0.0000			
12.	PH	PH	4.1767	0.3283	0.7100	0.2069	98
13.	TOT ORG CARBON	MG/L	0.4026	0.6978	2.3660	0.6034	78
14.	CONDUCTIVITY	MMHO/CM	666.5134	0.5103	43.0356	0.5933	98
15.	TEMPERATURE#1	DEG F	27.0565	0.6194	1.1958	0.7961	97
16.	HARDNESS	MG/L	255.5196	0.0720	282.9058	0.0918	67
17.	SODIUM	MG/L	43.3488	0.7076	6.6844	0.7815	91
20.	AMBIENT TEMP	DEG F	2.9844	0.9613	0.6664	0.9281	100

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.1583	0.2442	0.0153	0.4510	0.5164
2.	VIABLE BIOMASS	MIL C/ML	0.1020	0.1678	0.0768	0.2229	0.2968
5.	RES CHLORINE	MG/L	1.0888	-0.2138	0.0467	0.7836	0.4560
6.	TURBIDITY-SIO2	MG/L	1.1641	0.6788	-0.0205	3.8867	0.1388
7.	DIS OXYGEN	MG/L	3.9938	0.0605	0.0532	1.0525	0.7644
10.	AMMONIA	MG/L	1.5910	0.1198	0.0195	3.5892	0.9353
11.	NITRATE	MG/L	0.0000	0.0000	0.0000		
12.	PH	PH	-9.6293	4.7598	-0.3487	0.6752	0.3666
13.	TOT ORG CARBON	MG/L	7.1088	-0.5878	0.0578	2.2183	0.6641
14.	CONDUCTIVITY	MMHO/CM	2246.0800	-2.0911	0.0011	42.3331	0.6108
15.	TEMPERATURE#1	DEG F	-182.6000	6.3138	-0.0386	0.8843	0.8981
16.	HARDNESS	MG/L	281.0149	-0.0331	0.0000	282.6165	0.1022
17.	SODIUM	MG/L	-119.2061	2.7285	-0.0062	6.5421	0.7919
20.	AMBIENT TEMP	DEG F	-119.5005	4.3275	-0.0231	0.6606	0.9294

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.4000	0.6161	0.2432	0.6550
2.	VIABLE BIOMASS	MIL C/ML	-0.6220	0.5948	0.3591	0.6495
5.	RES CHLORINE	MG/L	-0.3201	0.4408	0.2708	0.5462
6.	TURBIDITY-SIO2	MG/L	0.6655	0.0598	0.2135	0.2602
7.	DIS OXYGEN	MG/L	0.3620	0.5755	0.0677	0.7827
10.	AMMONIA	MG/L	-0.0567	0.8090	0.3051	0.8464
11.	NITRATE	MG/L	0.0600	0.0000		
12.	PH	PH	0.4911	0.3822	0.0454	0.2681
13.	TOT ORG CARBON	MG/L	0.0409	0.8111	0.1169	0.6434
14.	CONDUCTIVITY	MMHO/CM	1.7026	0.4561	0.0189	0.5573
15.	TEMPERATURE#1	DEG F	0.6382	0.6553	0.0071	0.8117
16.	HARDNESS	MG/L	1.8394	0.2224	0.1818	0.4058
17.	SODIUM	MG/L	0.5817	0.7318	0.0182	0.7893
20.	AMBIENT TEMP	DEG F	0.0917	0.9513	0.0039	0.9201

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 8

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.2205	0.0555	0.2631	0.2326	98
2.	VIABLE BIOMASS	MIL C/ML	0.0613	0.1169	0.1411	0.2369	91
5.	RES CHLORINE	MG/L	0.2908	0.[illegible]404	0.5000	0.4446	86
6.	TURBIDITY-SIO2	MG/L	1.7286	0.5318	1.9104	0.8173	107
7.	DIS OXYGEN	MG/L	2.6516	0.6935	1.0570	0.7501	107
10.	AMMONIA	MG/L	-1.0612	1.0684	7.4770	0.8347	79
11.	NITRATE	MG/L	0.0000	0.0000			
12.	PH	PH	2.7040	0.6380	0.7086	0.3870	108
13.	TOT ORG CARBON	MG/L	1.7679	0.5133	1.5220	0.6404	89
14.	CONDUCTIVITY	MMHO/CM	699.6009	0.4897	51.1653	0.5160	108
15.	TEMPERATURE#1	DEG F	25.5023	0.6406	1.2035	0.7914	106
16.	HARDNESS	MG/L	215.3553	0.0902	63.4912	0.4557	69
17.	SODIUM	MG/L	34.9676	0.7655	8.2540	0.7453	101
20.	AMBIENT TEMP	DEG F	14.1213	0.8103	0.8903	0.8466	116

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.0917	0.1866	-0.0293	0.2581	0.3003
2.	VIABLE BIOMASS	MIL C/ML	0.0444	0.1852	-0.0534	0.1409	0.2412
5.	RES CHLORINE	MG/L	-0.2020	0.3944	-0.0256	0.5589	0.5069
6.	TURBIDITY-SIO2	MG/L	-0.2582	0.8368	-0.0103	1.8039	0.8228
7.	DIS OXYGEN	MG/L	8.9204	-0.1498	0.0718	1.0188	0.7705
10.	AMMONIA	MG/L	3.2914	-0.7325	0.0383	3.9875	0.8975
11.	NITRATE	MG/L	0.0000	0.0000	0.0000		
12.	PH	PH	-6.2027	3.5043	-0.2263	0.6910	0.4270
13.	TOT ORG CARBON	MG/L	4.5195	-0.0156	0.0238	1.4682	0.6608
14.	CONDUCTIVITY	MMHO/CM	1428.3480	-0.6975	0.0005	51.0433	0.5194
15.	TEMPERATURE#1	DEG F	-176.7576	6.1265	-0.0371	0.9589	0.8734
16.	HARDNESS	MG/L	187.7379	0.2057	-0.0009	61.9280	0.4962
17.	SODIUM	MG/L	-134.2183	2.8652	-0.0065	8.1327	0.7540
20.	AMBIENT TEMP	DEG F	18.3300	0.6944	0.0008	0.8903	0.8466

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.6539	0.3462	0.2611	0.4935
2.	VIABLE BIOMASS	MIL C/ML	-0.9346	0.3328	0.4103	0.6186
5.	RES CHLORINE	MG/L	-0.5263	0.6540	0.2941	0.5732
6.	TURBIDITY-SIO2	MG/L	-0.0266	0.8589	0.0901	0.8639
7.	DIS OXYGEN	MG/L	0.4226	0.5289	0.0658	0.7553
10.	AMMONIA	MG/L	-0.0558	0.7367	0.3808	0.8317
11.	NITRATE	MG/L	0.0000	0.0000		
12.	PH	PH	0.3204	0.6352	0.0444	0.4272
13.	TOT ORG CARBON	MG/L	0.0768	0.7550	0.0948	0.6781
14.	CONDUCTIVITY	MMHO/CM	1.7960	0.4267	0.0171	0.4807
15.	TEMPERATURE#1	DEG F	0.6126	0.4698	0.0071	0.7981
16.	HARDNESS	MG/L	1.7997	0.2345	0.1136	0.4606
17.	SODIUM	MG/L	0.4762	0.7806	0.0221	0.7545
20.	AMBIENT TEMP	DEG F	0.3891	0.7920	0.0053	0.8293

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.1675	0.0533	0.1941	0.2962	90
2.	VIABLE BIOMASS	MIL C/ML	0.0222	0.1532	0.1317	0.3301	90
5.	RES CHLORINE	MG/L	0.3441	-0.0201	0.3044	0.1295	85
6.	TURBIDITY-SIO2	MG/L	3.3918	0.1374	2.3541	0.3284	107
7.	DIS OXYGEN	MG/L	3.0606	0.5335	1.0376	0.6664	107
10.	AMMONIA	MG/L	-1.2794	0.9814	6.2969	0.8648	79
12.	PH	PH	2.2465	0.7067	0.4857	0.5595	107
13.	TOT ORG CARBON	MG/L	1.1331	0.2999	1.4431	0.4383	87
14.	CONDUCTIVITY	MMHO/CM	721.9695	0.4855	54.1132	0.4951	107
16.	HARDNESS	MG/L	217.8330	0.0665	65.1014	0.3455	78
17.	SODIUM	MG/L	43.7508	0.7005	7.2635	0.7609	101

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.0038	0.1387	-0.0165	0.1932	0.3387
2.	VIABLE BIOMASS	MIL C/ML	0.0202	0.1489	0.0065	0.1317	0.3302
5.	RES CHLORINE	MG/L	0.6911	-0.1886	0.0169	0.3698	0.2998
6.	TURBIDITY-SIO2	MG/L	2.3653	0.2942	-0.0053	2.3522	0.3311
7.	DIS OXYGEN	MG/L	4.4187	0.0274	0.0430	1.0236	0.6778
10.	AMMONIA	MG/L	2.7493	-0.6875	0.0352	4.7852	0.9254
12.	PH	PH	-5.3227	3.1385	-0.1916	0.4716	0.5934
13.	TOT ORG CARBON	MG/L	8.0260	-0.9603	0.0540	1.2990	0.5877
14.	CONDUCTIVITY	MMHO/CM	1841.6540	-1.3530	0.0008	53.8423	0.5027
16.	HARDNESS	MG/L	208.0233	0.1410	-0.0000	64.4771	0.3690
17.	SODIUM	MG/L	-207.1806	3.8175	-0.0096	6.9521	0.7838

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.7185	0.3331	0.2373	0.4927
2.	VIABLE BIOMASS	MIL C/ML	-1.0031	0.4975	0.0208	0.6052
5.	RES CHLORINE	MG/L	-0.6931	-0.2696	0.2970	0.6136
6.	TURBIDITY-SIO2	MG/L	0.3123	0.3427	0.1426	0.5193
7.	DIS OXYGEN	MG/L	0.4463	0.4497	0.0727	0.6651
10.	AMMONIA	MG/L	-0.2108	0.7820	0.4439	0.8295
12.	PH	PH	0.2705	0.6968	0.0310	0.5951
13.	TOT ORG CARBON	MG/L	0.1984	0.3960	0.1383	0.3145
14.	CONDUCTIVITY	MMHO/CM	1.8587	0.4095	0.0179	0.4521
16.	HARDNESS	MG/L	1.9335	0.1754	0.1241	0.3200
17.	SODIUM	MG/L	0.5796	0.7318	0.0197	0.7739

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.2141	0.0408	0.4035	0.1124	92
2.	VIABLF BIOMASS	MIL C/ML	0.1577	-0.0368	0.3941	0.0291	93
5.	RES CHLORINE	MG/L	1.7591	0.0312	1.0366	0.1402	87
6.	TURBIDITY-SIO2	MG/L	4.4161	0.0015	1.4865	0.1627	109
7.	DIS OXYGEN	MG/L	2.6872	0.5467	1.1081	0.6637	109
10.	AMMONIA	MG/L	-1.0724	1.0158	4.6096	0.8964	75
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0
12.	PH	PH	4.0657	0.3535	0.4493	0.3327	110
13.	TOT ORG CARBON	MG/L	1.5039	0.2310	1.3211	0.3777	87
14.	CONDUCTIVITY	MMHO/CM	351.0430	0.6210	56.2356	0.5751	110
15.	TEMPERATURE#1	DEG F	30.3830	0.5749	1.1896	0.7644	109
16.	HARDNESS	MG/L	175.3407	0.6246	238.5027	0.7105	56
17.	SODIUM	MG/L	49.4441	0.6430	8.4651	0.6913	104
20.	AMBIENT TEMP	DEG F	20.7091	0.7181	1.0064	0.7813	119

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.1043	0.1523	-0.0216	0.4032	0.1547
2.	VIABLE BIOMASS	MIL C/ML	0.1501	-0.0222	-0.0113	0.3941	0.0294
5.	RES CHLORINE	MG/L	1.2779	0.2694	-0.0242	1.0254	0.2019
6.	TURBIDITY-SIO2	MG/L	2.1270	0.3504	-0.0117	1.4407	0.2923
7.	DIS OXYGEN	MG/L	4.2649	-0.0540	0.0517	1.0877	0.6789
10.	AMMONIA	MG/L	-0.2070	0.6453	0.0040	4.5430	0.8993
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	-8.6666	4.0506	-0.3335	0.4266	0.5146
13.	TOT ORG CARBON	MG/L	7.3310	-0.8341	0.0456	1.2102	0.5297
14.	CONDUCTIVITY	MMHO/CM	-3142.5810	6.6745	-0.0025	53.3058	0.6314
15.	TEMPERATURE#1	DEG F	-129.0141	4.9116	-0.0294	1.0343	0.8310
16.	HARDNESS	MG/L	-37.9160	1.5098	-0.0004	208.3962	0.7941
17.	SODIUM	MG/L	-279.7527	4.7522	-0.0126	8.0106	0.7297
20.	AMBIENT TEMP	DEG F	151.2825	-2.8758	0.0247	1.0012	0.7837

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.6996	0.2620	0.2500	0.4833
2.	VIABLE BIOMASS	MIL C/ML	-1.0099	0.3956	0.3897	0.6575
5.	RES CHLORINE	MG/L	0.0674	0.2346	0.2836	0.3904
6.	TURBIDITY-SIO2	MG/L	0.4964	0.1155	0.1318	0.3497
7.	DIS OXYGEN	MG/L	0.4104	0.4661	0.0880	0.6431
10.	AMMONIA	MG/L	-0.1634	0.8047	0.3558	0.8683
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	0.4867	0.3927	0.0308	0.3939
13.	TOT ORG CARBON	MG/L	0.2524	0.3075	0.1325	0.2588
14.	CONDUCTIVITY	MMHO/CM	1.3144	0.5839	0.0180	0.5659
15.	TEMPERATURE#1	DEG F	0.7571	0.5917	0.0071	0.7642
16.	HARDNESS	MG/L	0.9152	0.6520	0.1956	0.6922
17.	SODIUM	MG/L	0.6393	0.7043	0.0234	0.7036
20.	AMBIENT TEMP	DEG F	0.5609	0.6998	0.0060	0.7618

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 2 TO SAMPLE SOURCE 3

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.0747	2.5795	0.2918	0.7426	47
2.	VIABLE BIOMASS	MIL C/ML	0.1743	0.9792	0.2624	0.1437	48
5.	RES CHLORINE	MG/L	0.2978	0.5855	0.6600	0.6591	55
6.	TURBIDITY-SIO2	MG/L	3.3510	0.1298	3.6318	0.2960	63
7.	DIS OXYGEN	MG/L	0.3504	0.9243	1.0272	0.7760	63
10.	AMMONIA	MG/L	0.8076	0.9614	6.6715	0.8950	47
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0
12.	PH	PH	3.6599	0.2072	0.4542	0.6054	63
13.	TOT ORG CARBON	MG/L	2.9437	0.7249	2.9859	0.4438	55
14.	CONDUCTIVITY	MMHO/CM	215.7639	0.3488	33.4419	0.7859	63
15.	TEMPERATURE#1	DEG F	2.7849	0.9414	0.5338	0.9575	63
16.	HARDNESS	MG/L	-280.1863	2.3370	170.4198	0.8351	55
17.	SODIUM	MG/L	15.3843	0.9017	4.3892	0.9159	61
20.	AMBIENT TEMP	DEG F	7.6624	0.8982	0.8972	0.8596	71

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.1139	2.1929	0.6771	0.2908	0.7429
2.	VIABLE BIOMASS	MIL C/ML	0.1024	5.2319	-27.1097	0.2582	0.2271
5.	RES CHLORINE	MG/L	-0.3683	1.4981	-0.2172	0.6015	0.7282
6.	TURBIDITY-SIO2	MG/L	4.2327	0.2798	-0.0029	3.6106	0.3070
7.	DIS OXYGEN	MG/L	-1.5239	1.4663	-0.0376	1.0223	0.7793
10.	AMMONIA	MG/L	-0.7458	1.7595	-0.0162	6.4574	0.9020
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	15.7422	-2.9827	0.2186	0.4241	0.6692
13.	TOT ORG CARBON	MG/L	-0.0182	1.4642	-0.0465	2.9541	0.5002
14.	CONDUCTIVITY	MMHO/CM	-4484.1210	11.3550	-0.0041	29.2025	0.8418
15.	TEMPERATURE#1	DEG F	-44.9141	2.2907	-0.0093	0.5330	0.9576
16.	HARDNESS	MG/L	887.8701	-1.9134	0.0050	88.0167	0.9625
17.	SODIUM	MG/L	-93.8915	2.2998	-0.0044	4.3402	0.9178
20.	AMBIENT TEMP	DEG F	-429.6624	12.8040	-0.0818	0.8435	0.8771

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.2982	0.8082	0.2081	0.7557
2.	VIABLE BIOMASS	MIL C/ML	0.0501	0.5793	0.4050	0.6096
5.	RES CHLORINE	MG/L	-0.1108	0.8666	0.1657	0.8629
6.	TURBIDITY-SIO2	MG/L	0.5280	0.2491	0.2099	0.2371
7.	DIS OXYGEN	MG/L	-0.0165	1.0028	0.0545	0.8504
10.	AMMONIA	MG/L	0.0756	0.9101	0.2357	0.9293
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	0.4704	0.3349	0.0314	0.6353
13.	TOT ORG CARBON	MG/L	0.2848	0.7416	0.1304	0.4461
14.	CONDUCTIVITY	MMHO/CM	0.4502	0.8575	0.0113	0.7908
15.	TEMPERATURE#1	DEG F	0.0755	0.9594	0.0032	0.9540
16.	HARDNESS	MG/L	0.1481	0.9613	0.1258	0.7602
17.	SODIUM	MG/L	0.2142	0.9024	0.0121	0.9146
20.	AMBIENT TEMP	DEG F	0.2052	0.8986	0.0052	0.8556

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 3 TO SAMPLE SOURCE 4

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.1401	0.2948	0.2301	0.5595	81
2.	VIABLE BIOMASS	MIL C/ML	0.0789	0.2250	0.1802	0.3589	82
5.	RES CHLORINE	MG/L	0.1965	0.6753	0.3023	0.8532	76
6.	TURBIDITY-SIO2	MG/L	9.0953	0.0885	3.2310	0.1500	97
7.	DIS OXYGEN	MG/L	1.2560	0.8644	0.8901	0.8447	98
10.	AMMONIA	MG/L	-0.5591	1.0620	5.8978	0.9199	74
11.	NITRATE	MG/L	0.0000	0.0000			
12.	PH	PH	0.8304	0.9010	0.3208	0.8981	98
13.	TOT ORG CARBON	MG/L	3.0664	0.5192	1.3800	0.7449	78
14.	CONDUCTIVITY	MMMHO/CM	131.9837	0.9020	15.6259	0.9506	98
15.	TEMPERATURE#1	DEG F	0.1711	0.9957	0.6897	0.9363	96
16.	HARDNESS	MG/L	234.7607	0.0368	69.1733	0.1492	84
17.	SODIUM	MG/L	18.6466	0.8765	4.6809	0.8986	91
20.	AMBIENT TEMP	DEG F	5.8445	0.9206	0.5308	0.9548	107

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.0272	0.7885	-0.1887	0.2128	0.6419
2.	VIABLE BIOMASS	MIL C/ML	0.0396	0.5230	-0.2494	0.1361	0.4161
5.	RES CHLORINE	MG/L	-0.2546	1.4231	-0.1941	0.2329	0.9349
6.	TURBIDITY-SIO2	MG/L	10.8727	-0.3025	0.0195	3.2085	0.1899
7.	DIS OXYGEN	MG/L	-3.6401	2.3235	-0.1025	0.7762	0.8844
10.	AMMONIA	MG/L	2.1283	-0.1897	0.0217	3.2457	0.9728
11.	NITRATE	MG/L	0.0000	0.0000	0.0000		
12.	PH	PH	1.3449	0.7472	0.0112	0.3206	0.8982
13.	TOT ORG CARBON	MG/L	0.6953	1.0383	-0.0228	1.3072	0.7750
14.	CONDUCTIVITY	MMMHO/CM	1402.9480	-1.2193	0.0008	15.1171	0.9538
15.	TEMPERATURE#1	DEG F	6.0165	0.8315	0.0012	0.6897	0.9363
16.	HARDNESS	MG/L	18.6468	0.9875	-0.0004	35.7406	0.8596
17.	SODIUM	MG/L	171.4216	-1.0727	0.0062	4.6101	0.9018
20.	AMBIENT TEMP	DEG F	-210.5481	6.8493	-0.0406	0.5010	0.9603

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.3797	0.6713	0.1818	0.7768
2.	VIABLE BIOMASS	MIL C/ML	-0.5608	0.6590	0.3627	0.7092
5.	RES CHLORINE	MG/L	-0.0791	0.9990	0.1328	0.9196
6.	TURBIDITY-SIO2	MG/L	0.9073	0.0711	0.1480	0.1183
7.	DIS OXYGEN	MG/L	0.1361	0.8608	0.0475	0.8905
10.	AMMONIA	MG/L	-0.0048	0.8716	0.2734	0.9251
11.	NITRATE	MG/L	0.0000	0.0000		
12.	PH	PH	0.1149	0.8734	0.0215	0.8872
13.	TOT ORG CARBON	MG/L	0.2008	0.7380	0.0715	0.8840
14.	CONDUCTIVITY	MMMHO/CM	0.3673	0.8825	0.0054	0.9415
15.	TEMPERATURE#1	DEG F	0.0224	0.9875	0.0043	0.9248
16.	HARDNESS	MG/L	1.3800	0.4127	0.1022	0.5965
17.	SODIUM	MG/L	0.2721	0.8751	0.0134	0.8941
20.	AMBIENT TEMP	DEG F	0.1749	0.9043	0.0031	0.9375

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REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 4 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	0.0911	0.3343	0.1281	0.7498	89
2.	VIABLE BIOMASS	MIL C/ML	0.9369	0.5051	0.1007	0.5929	89
5.	RES CHLORINE	MG/L	0.2585	0.0041	0.3883	0.0791	44
6.	TURBIDITY-SIO2	MG/L	2.4321	0.3472	3.8029	0.2900	107
7.	DIS OXYGEN	MG/L	1.0374	0.7629	0.6553	0.8767	107
10.	AMMONIA	MG/L	0.4035	0.7359	6.8408	0.8358	72
12.	PH	PH	2.3510	0.[illegible]987	0.3716	0.7782	107
13.	TOT ORG CARBON	MG/L	0.7118	0.4972	1.2986	0.5460	86
14.	CONDUCTIVITY	MMMHO/CM	136.3891	0.9077	32.7114	0.8583	107
15.	TEMPERATURE#1	DEG F	8.1073	0.8885	1.1601	0.8282	105
16.	HARDNESS	MG/L	51.0987	0.7309	45.7176	0.7412	89
17.	SODIUM	MG/L	21.4730	0.8504	4.2222	0.9269	101
20.	AMBIENT TEMP	DEG F	2.3121	0.9667	0.4370	0.9691	118

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.0308	1.1515	-0.4489	0.1100	0.8229
2.	VIABLE BIOMASS	MIL C/ML	0.0010	1.0368	-0.8410	0.0958	0.6430
5.	RES CHLORINE	MG/L	0.2660	-0.0147	0.0077	0.3882	0.0796
6.	TURBIDITY-SIO2	MG/L	1.2510	0.6289	-0.0148	3.7976	0.2948
7.	DIS OXYGEN	MG/L	-1.7095	1.5424	-0.0526	0.6255	0.8804
10.	AMMONIA	MG/L	0.1697	0.8671	-0.0016	6.8307	0.8365
12.	PH	PH	2.9068	0.4646	0.0096	0.3718	0.7784
13.	TOT ORG CARBON	MG/L	0.0566	0.6602	-0.0092	1.2966	0.5877
14.	CONDUCTIVITY	MMMHO/CM	1232.6410	-0.7736	0.0006	32.5023	0.8603
15.	TEMPERATURE#1	DEG F	106.0780	-1.9256	0.0198	1.1575	0.8291
16.	HARDNESS	MG/L	109.8118	0.3301	0.0008	45.4899	0.7442
17.	SODIUM	MG/L	-161.6827	3.1419	-0.0071	3.9950	0.9348
20.	AMBIENT TEMP	DEG F	-154.3120	5.2545	-0.029[illegible]	0.4[illegible]80	0.9717

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.2106	0.7604	0.1333	0.8684
2.	VIABLE BIOMASS	MIL C/ML	-0.4260	0.7177	0.3087	0.8082
5.	RES CHLORINE	MG/L	-0.7409	0.0840	0.3033	0.5715
6.	TURBIDITY-SIO2	MG/L	0.2450	0.4910	0.1543	0.5502
7.	DIS OXYGEN	MG/L	0.0737	0.8642	0.0438	0.8900
10.	AMMONIA	MG/L	-0.1882	0.9704	0.3589	0.8927
12.	PH	PH	0.3071	0.6091	0.0246	0.7764
13.	TOT ORG CARBON	MG/L	-0.0380	0.7636	0.1168	0.5953
14.	CONDUCTIVITY	MMMHO/CM	0.3201	0.8989	6.0110	0.8587
15.	TEMPERATURE#1	DEG F	0.2200	0.8818	0.0049	0.8281
16.	HARDNESS	MG/L	0.5401	0.7601	0.0907	0.7226
17.	SODIUM	MG/L	0.2759	0.8719	0.0115	0.9291
20.	AMBIENT TEMP	DEG F	0.0720	0.9610	0.0026	0.9596

REGRESSION ANALYSIS FOR SEP 3, 1980 TO FEB 28, 1981

FROM SAMPLE SOURCE 5 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	[illegible]	0.4320	0.3934	0.2268	94
2.	VIABLE BIOMASS	MIL C/ML	0.1074	0.2506	0.3941	0.0890	92
5.	RES CHLORINE	MG/L	1.9532	0.0259	1.0713	0.9577	89
6.	TURBIDITY-SIO2	MG/L	3.4335	0.1791	1.3494	0.4829	110
7.	DIS OXYGEN	MG/L	0.1704	0.9252	0.7030	0.8770	111
10.	AMMONIA	MG/L	-0.3298	1.4023	2.4786	0.9740	67
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0
12.	PH	PH	1.4046	0.7479	0.2750	0.8554	112
13.	TOT ORG CARBON	MG/L	1.7470	0.5023	1.1844	0.5668	88
14.	CONDUCTIVITY	MMMHO/CM	143.0083	0.8906	38.1038	0.8286	112
16.	HARDNESS	MG/L	-220.7516	2.6320	242.0330	0.5677	68
17.	SODIUM	MG/L	20.1280	0.3681	6.5169	0.8301	104

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.0757	1.0230	-0.5991	0.3920	0.2485
2.	VIABLE BIOMASS	MIL C/ML	0.8659	1.0403	-1.3746	0.3923	0.1296
5.	RES CHLORINE	MG/L	2.0543	-0.6497	0.3356	1.0694	0.0823
6.	TURBIDITY-SIO2	MG/L	2.6222	0.3713	-0.0059	1.3364	0.5195
7.	DIS OXYGEN	MG/L	0.0090	0.9764	-0.0039	0.7029	0.8770
10.	AMMONIA	MG/L	-0.5175	1.5220	-0.0029	2.4623	0.9743
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	4.8220	-0.2802	0.0763	0.2719	0.8589
13.	TOT ORG CARBON	MG/L	1.2146	0.7123	-0.0170	1.1793	0.5722
14.	CONDUCTIVITY	MMMHO/CM	3305.6240	-3.9109	0.0018	36.4631	0.8444
16.	HARDNESS	MG/L	78[illegible].9370	-6.1214	0.0175	233.4415	0.6798
17.	SODIUM	MG/L	29.5108	0.7481	0.0004	6.5166	0.8301

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	-0.2602	0.6149	0.2082	0.7095
2.	VIABLE BIOMASS	MIL C/ML	-0.4511	0.5756	0.3203	0.7062
5.	RES CHLORINE	MG/L	0.1410	-0.1023	0.2856	0.3184
6.	TURBIDITY-SIO2	MG/L	0.3059	0.4530	0.1085	0.6490
7.	DIS OXYGEN	MG/L	-0.0124	0.9850	0.0581	0.8594
10.	AMMONIA	MG/L	0.0757	0.7944	0.3201	0.8872
11.	NITRATE	MG/L	0.0000	0.0000	0.0000	0.0000
12.	PH	PH	0.1822	0.7559	0.0184	0.8532
13.	TOT ORG CARBON	MG/L	0.2019	0.6080	0.1053	0.6440
14.	CONDUCTIVITY	MMMHO/CM	0.3759	0.8793	0.0140	0.7946
16.	HARDNESS	MG/L	0.3415	0.9240	0.2028	0.5875
17.	SODIUM	MG/L	0.2830	0.8703	0.0187	0.8204

EOF..

LOG-NORMAL DISTRIBUTION: APR 1, 1979 TO APR 30, 1979

SAMPLE SOURCE	MONTHLY AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE	INTERCEPT	CHI SQUARE	SAMPLE SIZE
TETRACHLOROETHYLENE						
0	156.7	111.9	0.4879E 0	0.2010E 1	9.0000	20
1	68.8	60.1	0.4057E 0	0.1713E 1	12.5000	20
3	31.9	18.5	0.3781E 0	0.1389E 1	8.8000	25
4	17.0	10.9	0.3791E 0	0.1108E 1	4.8182	22
5	6.2	7.0	0.3913E 0	0.6049E 0	1.1429	21
6	6.7	9.3	0.4536E 0	0.5601E 0	4.0000	26
METHYLENE CHLORIDE						
0	228.7	199.9	0.4197E 0	0.2200E 1	1.5000	20
1	25.5	41.7	0.5803E 0	0.1020E 1	2.5000	20
3	16.0	21.6	0.5787E 0	0.8609E 0	1.6000	25
4	13.7	19.9	0.5703E 0	0.7921E 0	0.7273	22
5	22.2	7.0	0.1608E 0	0.1322E 1	4.4762	21
6	21.7	6.3	0.1344E 0	0.1318E 1	2.0769	26
1,2-DICHLOROETHYLENE						
0	24.2	78.2	0.7286E 0	0.2363E 0	62.0000	20
1	41.6	186.2	0.6531E 0	0.1460E 0	70.5000	20
4	10.1	47.3	0.5002E 0	0.1066E 0	78.4546	22
5	0.1	0.3	0.1458E -1	0.3182E -2	74.4762	21
CHLOROFORM						
0	31.6	14.9	0.2344E 0	0.1447E 1	2.5000	20
1	25.1	5.5	0.9458E -1	0.1389E 1	6.5000	20
3	18.6	5.1	0.1174E 0	0.1255E 1	4.0000	25
4	17.4	3.7	0.9395E -1	0.1232E 1	3.4545	22
5	5.6	4.8	0.3020E 0	0.6399E 0	4.9524	21
6	5.8	3.8	0.2426E 0	0.6939E 0	5.5385	26
1,1,1-TRICHLOROETHANE						
0	175.9	197.8	0.1056E 1	0.1618E 1	3.0000	20
1	51.0	43.6	0.7834E 0	0.1338E 1	10.0000	20
3	10.6	10.6	0.6103E 0	0.7298E 0	9.2000	25
4	6.3	5.2	0.4555E 0	0.6383E 0	4.8182	22
5	0.8	0.7	0.1049E 0	0.7844E -1	21.6191	21
6	2.2	7.7	0.3138E 0	0.1007E 0	20.5385	26
BROMODICHLOROMETHANE						
0	2.9	0.9	0.1321E 0	0.4501E 0	5.0000	20
1	4.0	1.2	0.1599E 0	0.5733E 0	12.5000	20
3	3.1	1.2	0.1533E 0	0.4642E 0	5.2000	25
4	2.8	0.6	0.1013E 0	0.4377E 0	0.7273	22
5	0.7	0.6	0.9816E -1	0.3760E -1	30.1905	21
6	1.3	1.3	0.1856E 0	0.9150E -1	10.5385	26

EOF..

LOG-NORMAL DISTRIBUTION. APR 1, 1979 TO APR 30, 1979

SAMPLE SOURCE	MONTHLY AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE		LOG(Y)=F(Z) INTERCEPT		CHI SQUARE	SAMPLE SIZE
TRICHLOROETHYLENE								
0	74.6	40.3	0.2861E	0	0.1795E	1	6.5000	20
1	26.5	20.3	0.3141E	0	0.1318E	1	4.0000	20
3	12.4	8.2	0.3053E	0	0.9986E	0	2.0000	25
4	8.2	5.2	0.2955E	0	0.8269E	0	11.6364	22
5	2.2	2.7	0.3206E	0	0.1968E	0	14.9524	21
6	2.3	3.3	0.3412F	0	0.1820E	0	29.7692	26
DIBROMOCHLOROMETHANE								
0	0.2	0.3	0.8250E	-2	0.1845E	-2	70.5000	20
1	1.5	0.4	0.1091E	0	0.1728E	0	5.5000	20
3	1.4	0.5	0.1107E	0	0.1560E	0	6.4000	25
4	1.4	0.2	0.6690E	-1	0.1565E	0	1.6364	22
5	0.7	0.2	0.1907E	-1	0.5612E	-2	65.9048	21
6	0.9	0.4	0.9349E	-1	0.2422E	-1	33.6154	26
BROMOFORM								
0	3.4	2.4	0.2745E	0	0.4404E	0	1.5000	20
1	1.7	0.6	0.1264E	0	0.2218E	0	2.0000	20
3	5.0	15.3	0.3494E	0	0.3242E	0	29.6000	25
4	1.9	0.5	0.1114E	0	0.2695E	0	3.9091	22
5	1.1	0.4	0.7839E	-1	0.8151E	-1	3.0476	21
6	1.5	1.7	0.2061E	0	0.1161E	0	4.0000	26
TRIHALOMETHANES								
0	38.1	16.1	0.1801E	0	0.1546E	1	1.5000	20
1	32.2	6.1	0.8311E	-1	0.1501E	1	3.5000	20
3	28.1	18.3	0.1610E	0	0.1409E	1	5.2000	25
4	23.6	4.1	0.7798E	-1	0.1366E	1	0.2727	22
5	8.1	5.6	0.2318E	0	0.8410E	0	7.8095	21
6	9.5	6.5	0.2043E	0	0.9188E	0	8.2308	26
TOTAL HALOCARBONS								
0	698.2	490.1	0.3872E	0	0.2708E	1	2.5000	20
1	245.6	194.7	0.3286E	0	0.2281E	1	6.5000	20
3	99.0	49.6	0.2332E	0	0.1940E	1	4.4000	25
4	78.9	48.7	0.2329E	0	0.1836E	1	6.1818	22
5	39.5	12.8	0.1279E	0	0.1578E	1	1.6190	21
6	42.3	24.2	0.1741E	0	0.1584E	1	9.0000	26

EOF..

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 0 TO SAMPLE SOURCE 1

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	13.6005	0.3566	16.1634	0.9293	20
2.	METHYLENE CHLORIDE	6.5537	0.0666	27.7585	0.4299	18
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	22.7212	0.0381	5.6183	0.2126	20
6.	1,1,1-TRICHLOROETHANE	24.2778	0.1816	22.0835	0.0676	16
7.	BROMODICHLOROMETHANE	2.6789	0.4420	1.1396	0.4220	19
8.	TRICHLOROETHYLENE	-1.5580	0.3784	12.9699	0.7696	20
9.	DIBROMOCHLOROMETHANE	1.6950	0.1010	0.3407	0.6398	10
10.	BROMOFORM	1.6768	-0.0001	0.6193	0.0972	20
11.	TRIHALOMETHANES	29.0771	0.0478	6.4470	0.2290	20
12.	TOTAL HALOCARBONS	76.1909	0.1969	6[illegible].6910	0.7930	20

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	13.6590	0.3551	0.0000	16.1634	0.9293
2.	METHYLENE CHLORIDE	21.0051	-0.0545	0.0001	26.5809	0.5021
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	29.8387	-0.4586	0.0071	5.3893	0.3485
6.	1,1,1-TRICHLOROETHANE	16.3032	0.2868	-0.0002	21.1365	0.0796
7.	BROMODICHLOROMETHANE	3.3421	0.0080	0.0645	1.1380	0.4240
8.	TRICHLOROETHYLENE	11.6621	-0.1151	0.0033	12.0919	0.8035
9.	DIBROMOCHLOROMETHANE	0.1379	6.1002	-4.3886	0.2733	0.7874
10.	BROMOFORM	1.5239	3.0892	-0.0087	0.6164	0.1369
11.	TRIHALOMETHANES	43.6637	-0.7292	0.0089	6.1011	0.3895
12.	TOTAL HALOCARBONS	37.9430	0.3453	-0.0000	63.2845	0.8160

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.0942	0.0053	0.1531	0.9491
2.	METHYLENE CHLORIDE	-0.8254	0.8274	0.4444	0.7248
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	1.3809	-0.0095	0.1005	0.0870
6.	1,1,1-TRICHLOROETHANE	-0.8243	0.7934	0.1824	0.9124
7.	BROMODICHLOROMETHANE	0.3875	0.4167	0.1514	0.3475
8.	TRICHLOROETHYLENE	-0.3515	0.9312	0.1586	0.8783
9.	DIBROMOCHLOROMETHANE	0.2642	0.0058	0.0799	0.6638
10.	BROMOFORM	0.1411	0.1128	0.1780	0.2021
11.	TRIHALOMETHANES	1.4463	0.8220	0.0921	0.1095
12.	TOTAL HALOCARBONS	0.3556	0.6970	0.1640	0.8560

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 3

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	7.3943	0.3142	11.5381	0.7604	23
2.	METHYLENE CHLORIDE	4.9045	0.4017	14.7889	0.7533	19
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	7.4191	0.4587	4.2044	0.5433	23
6.	1,1,1-TRICHLOROETHANE	3.8898	0.1897	3.9397	0.8966	18
7.	BROMODICHLOROMETHANE	0.6949	0.6354	0.9500	0.6017	22
8.	TRICHLOROETHYLENE	4.0121	0.2957	3.6229	0.8484	23
9.	DIBROMOCHLOROMETHANE	1.3025	0.1721	0.4386	0.1984	23
10.	BROMOFORM	25.4070	-11.5563	14.5494	0.4038	22
11.	TRIHALOMETHANES	28.6898	-0.0125	18.7022	0.0252	23
12.	TOTAL HALOCARBONS	28.0740	0.3366	32.1783	0.7598	23

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	3.1346	0.5008	-0.0013	11.2477	0.7741
2.	METHYLENE CHLORIDE	0.5157	0.0820	0.0023	14.2038	0.7723
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	20.1573	-0.6449	0.0225	4.1337	0.5645
6.	1,1,1-TRICHLOROETHANE	2.9632	0.2321	-0.0003	3.9082	0.8983
7.	BROMODICHLOROMETHANE	-0.1707	1.1004	-0.0594	0.9498	0.6107
8.	TRICHLOROETHYLENE	1.3669	0.4881	-0.0022	3.3218	0.8744
9.	DIBROMOCHLOROMETHANE	1.6485	-0.3114	0.1574	0.4370	0.2075
10.	BROMOFORM	75.3304	-71.0035	16.0699	12.3877	0.6271
11.	TRIHALOMETHANES	27.1036	0.0825	-0.0015	18.7028	0.0255
12.	TOTAL HALOCARBONS	45.2072	0.0991	0.0006	31.6906	0.7674

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.1302	0.8599	0.1004	0.9202
2.	METHYLENE CHLORIDE	-0.1047	0.9239	0.3355	0.8547
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.4746	0.5674	0.0960	0.5537
6.	1,1,1-TRICHLOROETHANE	-0.0263	0.6873	0.1113	0.9338
7.	BROMODICHLOROMETHANE	-0.0062	0.8430	0.0919	0.8134
8.	TRICHLOROETHYLENE	-0.0459	0.7890	0.1550	0.8789
9.	DIBROMOCHLOROMETHANE	0.1625	0.1180	0.0951	0.1550
10.	BROMOFORM	0.5537	-0.9368	0.3257	0.7420
11.	TRIHALOMETHANES	0.9563	0.3042	0.1639	0.2765
12.	TOTAL HALOCARBONS	0.5666	0.6129	0.1531	0.8894

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 4

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
[illegible].	[illegible]OROETHYLENE	2.1575	0.1096	4.9222	0.8537	22
[illegible].	[illegible]LENE CHLORIDE	4.8291	0.3698	13.8972	0.7492	19
[illegible]	[illegible]ARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	4.3469	0.5223	2.2221	0.7960	22
6.	1,1,1-TRICHLOROETHANE	3.0052	0.0843	2.1206	0.8776	18
7.	BROMODICHLOROMETHANE	1.2289	0.4262	0.2858	0.8815	21
8.	TRICHLOROETHYLENE	1.0771	0.2225	1.8605	0.9184	22
9.	DIBROMOCHLOROMETHANE	1.2644	0.1581	0.1412	0.5128	22
10.	BROMOFORM	1.3432	0.3086	0.2975	0.6800	21
11.	TRIHALOMETHANES	7.6276	0.4993	2.6491	0.7708	22
12.	TOTAL HALOCARBONS	40.4344	0.1004	44.4500	0.4024	22

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.1493	0.2784	-0.0006	4.7600	0.8640
2.	METHYLENE CHLORIDE	7.4123	0.1411	0.0016	13.6242	0.7605
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-1.7201	1.0281	-0.0100	2.2056	0.7994
6.	1,1,1-TRICHLOROETHANE	2.0724	0.1270	-0.0003	2.0606	0.8840
7.	BROMODICHLOROMETHANE	1.1140	0.4808	-0.0079	0.2853	0.8819
8.	TRICHLOROETHYLENE	0.8902	0.2911	-0.0008	1.7920	0.9245
9.	DIBROMOCHLOROMETHANE	1.4691	-0.1285	0.0933	0.1394	0.5301
10.	BROMOFORM	1.0607	0.7161	-0.0982	0.2945	0.6880
11.	TRIHALOMETHANES	1.2309	0.9186	-0.0066	2.6336	0.7739
12.	TOTAL HALOCARBONS	7.0110	0.6401	-0.0011	43.1337	0.4594

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.3409	0.8286	0.1434	0.9440
2.	METHYLENE CHLORIDE	-0.2261	0.9287	0.3523	0.8365
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.1779	0.7593	0.0557	0.8078
6.	1,1,1-TRICHLOROETHANE	-0.0749	0.5614	0.1050	0.9182
7.	BROMODICHLOROMETHANE	0.1619	0.5123	0.0425	0.8875
8.	TRICHLOROETHYLENE	-0.3121	0.8484	0.1107	0.9315
9.	DIBROMOCHLOROMETHANE	0.1534	0.1324	0.0420	0.4599
10.	BROMOFORM	0.2303	0.3125	0.0653	0.6595
11.	TRIHALOMETHANES	0.3420	0.6841	0.0487	0.7870
12.	TOTAL HALOCARBONS	0.5403	0.5721	0.1684	0.7441

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GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1. 1979 TO APR 30. 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	2.3298	0.0351	5.6711	0.3073	21
2.	METHYLENE CHLORIDE	23.0529	-0.0415	5.4097	0.3254	19
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	5.2824	-0.0343	2.5104	0.3271	21
6.	1,1,1-TRICHLOROETHANE	1.2286	-0.0018	0.5854	0.4125	16
7.	BROMODICHLOROMETHANE	0.7039	0.0161	0.3117	0.2027	14
8.	TRICHLOROETHYLENE	1.2702	0.0146	1.0925	0.3260	21
9.	DIBROMOCHLOROMETHANE	0.6947	0.0046	0.1510	0.4091	21
10.	BROMOFORM	0.6033	0.3422	0.5050	0.5730	21
11.	TRIHALOMETHANES	7.5024	-0.0210	2.9221	0.4009	21
12.	TOTAL HALOCARBONS	30.6494	-0.0072	10.7663	0.2533	21

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.0772	0.1365	-0.0007	5.4063	0.3905
2.	METHYLENE CHLORIDE	25.4473	-0.1906	0.0011	5.0091	0.4569
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-12.2740	1.4175	-0.0286	2.3070	0.4383
6.	1,1,1-TRICHLOROETHANE	1.2961	-0.0047	0.0000	0.5845	0.4150
7.	BROMODICHLOROMETHANE	0.4756	0.1456	-0.0163	0.3090	0.3009
8.	TRICHLOROETHYLENE	0.7120	0.0540	-0.0004	1.0704	0.3572
9.	DIBROMOCHLOROMETHANE	0.5764	0.1573	-0.0467	0.1515	0.4916
10.	BROMOFORM	0.3359	0.6630	-0.0072	0.5034	0.5770
11.	TRIHALOMETHANES	-16.5540	1.5343	-0.0241	2.7424	0.5603
12.	TOTAL HALOCARBONS	27.7277	0.1507	-0.0004	10.1197	0.4161

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.5400	0.6233	0.2449	0.8460
2.	METHYLENE CHLORIDE	1.4126	-0.0685	0.1243	0.3100
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.3107	0.1958	0.2523	0.4945
6.	1,1,1-TRICHLOROETHANE	0.1569	-0.1316	0.3670	0.4946
7.	BROMODICHLOROMETHANE	-0.1937	0.0652	0.2059	0.4033
8.	TRICHLOROETHYLENE	-0.2409	0.2660	0.2435	0.7374
9.	DIBROMOCHLOROMETHANE	-0.1753	0.0528	0.1075	0.4907
10.	[illegible]	-0.0025	0.4068	0.2196	0.6509
11.	TRIHALOMETHANES	0.5562	0.1662	0.1676	0.5903
12.	TOTAL HALOCARBONS	1.5969	-0.0187	0.1103	0.3830

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	2.4539	0.0128	3.3844	0.6793	23
2.	METHYLENE CHLORIDE	22.8559	-0.0254	4.2509	0.2716	20
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	4.8694	-0.0212	1.8337	0.5440	23
6.	1,1,1-TRICHLOROETHANE	1.0139	-0.0025	0.5193	0.9137	17
7.	BROMODICHLOROMETHANE	0.1900	0.1994	0.3613	0.6813	22
8.	TRICHLOROETHYLENE	0.9077	0.0069	0.9284	0.7567	23
9.	DIBROMOCHLOROMETHANE	0.7209	0.0903	0.1647	0.3415	22
10.	BROMOFORM	0.2122	0.5198	0.3925	0.7123	22
11.	TRIHALOMETHANES	7.1661	0.0012	2.3460	0.6259	23
12.	TOTAL HALOCARBONS	35.0175	-0.0040	7.8541	0.6634	23

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	1.8169	0.0407	-0.0002	3.3625	0.6844
2.	METHYLENE CHLORIDE	23.6000	-0.0964	0.0005	4.1643	0.3333
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.9557	0.3179	-0.0069	1.9185	0.5546
6.	1,1,1-TRICHLOROETHANE	1.0638	-0.0046	0.0000	0.5187	0.9139
7.	BROMODICHLOROMETHANE	0.4087	0.0843	0.0145	0.3600	0.6841
8.	TRICHLOROETHYLENE	0.5796	0.0300	-0.0003	0.9027	0.7674
9.	DIBROMOCHLOROMETHANE	0.6700	0.1504	-0.0195	0.1646	0.3425
10.	BROMOFORM	0.7541	-0.1266	0.1747	0.3836	0.7276
11.	TRIHALOMETHANES	-1.8974	0.6851	-0.0096	2.3056	0.6423
12.	TOTAL HALOCARBONS	28.9400	0.0843	-0.0002	7.5746	0.6923

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.2760	0.3906	0.2789	0.8554
2.	METHYLENE CHLORIDE	1.3510	-0.0141	0.0852	0.1008
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.6842	-0.0622	0.1958	0.5946
6.	1,1,1-TRICHLOROETHANE	0.0186	-0.1324	0.3869	0.7970
7.	BROMODICHLOROMETHANE	-0.4015	0.6254	0.1513	0.7340
8.	TRICHLOROETHYLENE	-0.2363	0.1609	0.1869	0.8896
9.	DIBROMOCHLOROMETHANE	-0.0956	0.1328	0.0754	0.4206
10.	BROMOFORM	-0.1225	0.5909	0.1781	0.6805
11.	TRIHALOMETHANES	0.2215	0.4091	0.1792	0.6803
12.	TOTAL HALOCARBONS	1.5376	-0.0061	0.0928	0.6988

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 3 TO SAMPLE SOURCE 4

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	-0.1740	0.5781	2.5754	0.9710	24
2.	METHYLENE CHLORIDE	0.0235	0.8289	6.9791	0.9369	21
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	10.0151	0.3791	3.1964	0.5117	24
6.	1,1,1-TRICHLOROETHANE	1.1112	0.4550	0.8798	0.9808	10
7.	BROMODICHLOROMETHANE	0.7811	0.6911	0.3150	0.8645	23
8.	TRICHLOROETHYLENE	0.7034	0.5791	1.6494	0.9446	24
9.	DIBROMOCHLOROMETHANE	0.7761	0.4809	0.1690	0.6903	24
10.	BROMOFORM	1.9460	-0.0047	0.4524	0.2334	23
11.	TRIHALOMETHANES	23.1097	-0.0009	4.2570	0.0039	24
12.	TOTAL HALOCARBONS	40.4151	0.2921	44.4632	0.3176	24

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.8220	0.4697	0.0016	2.5020	0.9726
2.	METHYLENE CHLORIDE	1.6947	0.6137	0.0028	6.7243	0.9416
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-12.5998	2.7862	-0.0597	2.5766	0.7214
6.	1,1,1-TRICHLOROETHANE	0.2686	0.5940	-0.0043	0.8311	0.9822
7.	BROMODICHLOROMETHANE	0.9682	0.5585	0.0220	0.3151	0.8652
8.	TRICHLOROETHYLENE	0.2296	0.6600	-0.0025	1.6333	0.9457
9.	DIBROMOCHLOROMETHANE	0.8287	0.3636	0.0536	0.1686	0.6910
10.	BROMOFORM	0.5046	0.8131	-0.0102	0.3806	0.5752
11.	TRIHALOMETHANES	4.6842	0.9515	-0.0073	3.2003	0.6596
12.	TOTAL HALOCARBONS	40.9806	0.2800	0.0001	44.4628	0.3176

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.1852	0.9555	0.0497	0.9932
2.	METHYLENE CHLORIDE	-0.0137	0.9385	0.1369	0.9747
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.6163	0.4828	0.0774	0.5904
6.	1,1,1-TRICHLOROETHANE	-0.0592	0.8220	0.0442	0.9860
7.	BROMODICHLOROMETHANE	0.1524	0.6344	0.0585	0.8160
8.	TRICHLOROETHYLENE	-0.0799	0.8955	0.0611	0.9793
9.	DIBROMOCHLOROMETHANE	0.1198	0.2903	0.0592	0.6786
10.	BROMOFORM	0.2716	-0.0080	0.1189	0.0395
11.	TRIHALOMETHANES	1.2038	0.1084	0.0802	0.2298
12.	TOTAL HALOCARBONS	0.6542	0.6061	0.1801	0.6737

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 4 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	-1.4173	0.4476	4.7209	0.7079	23
2.	METHYLENE CHLORIDE	23.0903	-0.0917	6.1572	0.2940	20
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	1.6930	0.2243	4.4280	0.1955	23
6.	1,1,1-TRICHLOROETHANE	1.0962	0.0010	0.5094	0.3905	16
7.	BROMODICHLOROMETHANE	1.3650	-0.1534	0.4636	0.2442	16
8.	TRICHLOROETHYLENE	0.2046	0.2401	2.1901	0.4005	23
9.	DIBROMOCHLOROMETHANE	1.1506	-0.2919	0.1606	0.4600	23
10.	BROMOFORM	0.6796	0.2700	0.5941	0.5140	22
11.	TRIHALOMETHANES	5.4341	0.1171	5.1635	0.1105	23
12.	TOTAL HALOCARBONS	37.6770	0.0159	12.1117	0.1026	23

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.4030	0.1513	0.0077	4.5670	0.7300
2.	METHYLENE CHLORIDE	25.8769	-0.5131	0.0059	5.3525	0.5560
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	21.1113	-2.1065	0.0666	4.3677	0.2535
6.	1,1,1-TRICHLOROETHANE	1.8619	-0.2263	0.0134	0.5549	0.5045
7.	BROMODICHLOROMETHANE	2.0666	-0.6914	0.0964	0.4606	0.2682
8.	TRICHLOROETHYLENE	-0.1530	0.3343	-0.0044	2.1927	0.4924
9.	DIBROMOCHLOROMETHANE	2.9389	-3.1170	1.0725	0.1484	0.6243
10.	BROMOFORM	2.4070	-1.7719	0.5657	0.5762	0.5556
11.	TRIHALOMETHANES	14.4303	-0.6874	0.0174	5.1530	0.1333
12.	TOTAL HALOCARBONS	35.3212	0.0670	-0.0002	12.0043	0.1225

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.38[illegible]	0.8834	0.2094	0.8906
2.	METHYLENE CHLORIDE	1.4195	-0.1246	0.1359	0.4915
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-0.0013	0.5213	0.2974	0.3233
6.	1,1,1-TRICHLOROETHANE	0.0017	-0.0789	0.3705	0.4797
7.	BROMODICHLOROMETHANE	0.0573	-0.3469	0.2361	0.2242
8.	TRICHLOROETHYLENE	-0.3192	0.5910	0.2694	0.6918
9.	DIBROMOCHLOROMETHANE	-0.0714	-0.4970	0.1090	0.4045
10.	BROMOFORM	-0.0404	0.2616	0.2294	0.5790
11.	TRIHALOMETHANES	0.3524	0.3660	-0.2157	0.3697
12.	TOTAL HALOCARBONS	1.5146	0.0316	0.1200	0.2391

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 5 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	1.7099	0.5418	5.6570	0.5610	24
2.	METHYLENE CHLORIDE	11.9355	0.4096	4.3069	0.6155	24
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	3.1761	0.2719	2.4711	0.5199	23
6.	1,1,1-TRICHLOROETHANE	-2.1733	2.7576	1.1714	0.9920	17
7.	BROMODICHLOROMETHANE	-0.0094	1.2046	0.6043	0.8907	17
8.	TRICHLOROETHYLENE	0.5514	0.5903	2.6570	0.5026	24
9.	DIBROMOCHLOROMETHANE	-0.0150	1.1604	0.2435	0.8287	23
10.	BROMOFORM	-0.0690	0.9470	0.5426	0.9503	23
11.	TRIHALOMETHANES	3.6005	0.5823	5.9174	0.4695	24
12.	TOTAL HALOCARBONS	-2.7754	1.0022	10.9517	0.5905	24

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.6687	1.3797	-0.0312	5.4255	0.6007
2.	METHYLENE CHLORIDE	25.1221	-0.0766	0.0321	3.9030	0.6845
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-5.2619	1.3699	-0.0516	1.9371	0.7427
6.	1,1,1-TRICHLOROETHANE	0.0464	0.4996	0.1443	0.2612	0.9996
7.	BROMODICHLOROMETHANE	1.2473	-0.6322	0.3409	0.4140	0.9614
8.	TRICHLOROETHYLENE	-2.3631	3.3160	-0.2744	2.1292	0.7211
9.	DIBROMOCHLOROMETHANE	1.2067	-1.4070	1.1115	0.1437	0.9439
10.	BROMOFORM	0.0597	0.0150	0.0960	0.3004	0.9759
11.	TRIHALOMETHANES	-5.6317	2.5382	-0.0724	5.1823	0.6341
12.	TOTAL HALOCARBONS	-36.6500	2.6330	-0.0159	10.6339	0.6006

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.0240	0.8387	0.2390	0.8999
2.	METHYLENE CHLORIDE	0.8501	0.3746	0.0821	0.5646
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	0.2946	0.4982	0.1641	0.7743
6.	1,1,1-TRICHLOROETHANE	-0.1230	1.1735	0.1877	0.9647
7.	BROMODICHLOROMETHANE	0.0687	0.4900	0.2092	0.6063
8.	TRICHLOROETHYLENE	-0.0023	0.7722	0.2290	0.8537
9.	DIBROMOCHLOROMETHANE	0.0045	0.5633	0.0981	0.6424
10.	BROMOFORM	-0.0203	0.7449	0.1513	0.8521
11.	TRIHALOMETHANES	0.2755	0.6766	0.1885	0.6937
12.	TOTAL HALOCARBONS	0.1109	0.9141	0.1210	0.7196

LOG-NORMAL DISTRIBUTION: APR 1, 1979 TO APR 30, 1979

SAMPLE SOURCE	MONTHLY AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE		LOG(Y)=F(Z) INTERCEPT		CHI SQUARE	SAMPLE SIZE
TOTAL BIOMASS								
0	30.6	3.8	0.5677E	-1	0.1482E	1	23.3750	16
1	14.3	3.4	0.1188E	0	0.1141E	1	2.0000	25
3	5.6	3.1	0.1880E	0	0.6986E	0	7.3793	29
4	2.4	0.6	0.9200E	-1	0.3665E	0	23.6154	26
5	2.7	0.9	0.9868E	-1	0.4171E	0	8.8000	25
6	2.5	0.7	0.9035E	-1	0.3877E	0	23.9310	29
VIABLE BIOMASS								
0	5.9	6.4	0.7849E	0	0.4564E	0	8.8333	12
1	3.4	1.8	0.2029E	0	0.4880E	0	3.6000	25
3	1.6	2.1	0.5040E	0	-0.1115E	0	3.4286	28
4	1.5	4.3	0.8480E	0	-0.8321E	0	4.3636	22
5	0.9	2.7	0.5299E	0	-0.6716E	0	14.3333	24
6	0.4	0.8	0.4038E	0	-0.6624E	0	3.3333	30
RES CHLORINE								
0	0.1	0.0	0.8260E	-3	-0.1000E	1	32.0000	8
1	10.2	4.7	0.1544E	0	0.9793E	0	9.5714	14
3	6.0	3.1	0.4940E	0	0.6594E	0	15.2857	14
4	5.2	0.9	0.8556E	-1	0.7045E	0	2.1667	12
5	1.1	2.3	0.4824E	0	-0.3690E	0	35.0769	13
6	2.3	0.8	0.3725E	0	0.2819E	0	16.6667	15
TURBIDITY-SIO2								
0	49.3	15.3	0.3475E	0	0.1632E	1	49.8261	23
1	21.2	11.0	0.2263E	0	0.1274E	1	2.0769	26
3	12.3	4.2	0.2505E	0	0.1044E	1	29.0000	30
4	13.7	6.1	0.2960E	0	0.1065E	1	19.8519	27
5	4.3	3.1	0.2128E	0	0.5766E	0	9.0000	26
6	3.1	1.0	0.1423E	0	0.4670E	0	3.3333	30
TOT ORG CARBON								
0	54.1	17.1	0.1275E	0	0.1714E	1	11.5000	20
1	14.6	5.9	0.1394E	0	0.1140E	1	6.0000	24
3	13.2	7.0	0.1858E	0	0.1081E	1	2.8000	25
4	11.9	6.4	0.1689E	0	0.1038E	1	2.4348	23
5	5.1	4.9	0.4773E	0	0.5051E	0	0.5833	24
6	5.1	5.1	0.4514E	0	0.5136E	0	0.5385	26

EOF..

LOG-NORMAL DISTRIBUTION: APR 1, 1979 TO APR 30, 1979

SAMPLE SOURCE	MONTHLY AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE		INTERCEPT		CHI SQUARE	SAMPLE SIZE
AMMONIA								
0	27.9	4.4	0.6925E	-1	0.1440E	1	2.8696	23
1	19.2	4.3	0.9988E	-1	0.1273E	1	7.4615	26
3	19.9	4.7	0.1104E	0	0.1285E	1	3.6667	30
4	19.4	5.4	0.1340E	0	0.1269E	1	8.0000	25
5	17.5	5.0	0.1346E	0	0.1225E	1	9.6000	25
6	17.1	4.8	0.1295E	0	0.1214E	1	3.6667	30
PH								
0	7.2	0.3	0.1722E	-1	0.8563E	0	6.3478	23
1	7.0	0.3	0.1629E	-1	0.8469E	0	4.7692	26
3	7.3	0.3	0.1847E	-1	0.8649E	0	3.6667	30
4	7.6	0.2	0.1173E	-1	0.8794E	0	6.5185	27
5	7.4	0.3	0.1565E	-1	0.8699E	0	4.7692	26
6	7.2	0.2	0.1451E	-1	0.8583E	0	4.3333	30
CONDUCTIVITY								
0	1471.4	73.5	0.2215E	-1	0.3167E	1	2.4348	23
1	1466.0	69.2	0.2035E	-1	0.3166E	1	5.9231	26
3	1525.4	49.6	0.1445E	-1	0.3183E	1	8.3333	30
4	1537.3	64.8	0.1820E	-1	0.3186E	1	3.5556	27
5	1541.8	65.5	0.1845E	-1	0.3188E	1	2.8462	26
6	1562.5	73.0	0.2019E	-1	0.3193E	1	6.3333	30
HARDNESS								
0	36.2	16.9	0.2186E	0	0.1512E	1	0.8750	16
1	425.5	264.0	0.2301E	0	0.2565E	1	2.5000	20
3	279.5	84.7	0.1231E	0	0.2429E	1	0.1667	24
4	300.4	94.1	0.1317E	0	0.2458E	1	2.5714	21
5	218.6	73.3	0.1251E	0	0.2321E	1	2.0000	20
6	307.0	85.4	0.1182E	0	0.2471E	1	6.8333	24

EOF..

REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 0 TO SAMPLE SOURCE 1

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	6.5642	0.2642	3.8829	0.2582	14
2.	VIABLE BIOMASS	MIL C/ML	4.8504	-0.0833	2.1870	0.4379	10
5.	RES CHLORINE	MG/L	8.7811	0.0000	0.7818	0.8794	8
6.	TURBIDITY-SIO2	MG/L	9.9550	0.2480	10.9109	0.3429	21
9.	TOT ORG CARBON	MG/L	10.7391	0.0842	5.9630	0.2527	20
10.	AMMONIA	MG/L	9.0887	0.3858	4.2156	0.3723	21
12.	PH	PH	3.5481	0.4847	0.2403	0.4982	21
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000	0
14.	CONDUCTIVITY	MMMHO/CM	1050.6140	0.2880	47.9738	0.4256	21
16.	HARDNESS	MG/L	77.2443	9.2559	228.1157	0.5690	14
17.	SODIUM	MG/L	25.0089	0.7623	9.7510	3.8765	21

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	130.5209	-8.4044	0.1487	3.6378	0.4251
2.	VIABLE BIOMASS	MIL C/ML	4.2134	0.1228	-0.0078	2.1550	0.4639
5.	RES CHLORINE	MG/L	8.7811	0.0000	0.0000	0.7818	0.8794
6.	TURBIDITY-SIO2	MG/L	8.4333	0.3351	-0.0010	10.8997	0.3455
9.	TOT ORG CARBON	MG/L	7.7837	0.1887	-0.0008	5.9593	0.2549
10.	AMMONIA	MG/L	-8.2391	1.6550	-0.0227	4.1856	0.3884
12.	PH	PH	-30.8204	10.0400	-0.6631	0.2261	0.5780
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
14.	CONDUCTIVITY	MMMHO/CM	10767.4400	-13.2115	0.0047	39.7095	0.6625
16.	HARDNESS	MG/L	-62.0267	17.4877	-0.0994	225.9348	0.5801
17.	SODIUM	MG/L	24.5229	0.7788	-0.0001	9.7503	0.9765

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.4991	0.4368	0.1386	0.1627
2.	VIABLE BIOMASS	MIL C/ML	0.5688	-0.0187	0.2187	0.2195
5.	RES CHLORINE	MG/L				
6.	TURBIDITY-SIO2	MG/L	0.6498	0.3921	0.1924	0.6007
9.	TOT ORG CARBON	MG/L	0.4867	0.3918	0.1338	0.3444
10.	AMMONIA	MG/L	0.5383	0.5188	0.0985	0.3331
12.	PH	PH	0.4175	0.5013	0.0146	0.5083
13	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000
14.	CONDUCTIVITY	MMMHO/CM	2.3402	0.2615	0.0141	0.3987
16.	HARDNESS	MG/L	1.6019	0.6234	0.1936	0.6405
17.	SODIUM	MG/L	0.9933	0.4992	0.0572	0.8911

REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 3

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	3.3430	0.0874	1.4879	0.5586	25
2.	VIABLE BIOMASS	MIL C/ML	0.3298	0.1526	1.4017	0.4579	23
5.	RES CHLORINE	MG/L	1.6131	0.8895	0.5868	0.7188	12
6.	TURBIDITY-SIO2	MG/L	6.6513	0.2639	3.3534	0.6462	26
9.	TOT ORG CARBON	MG/L	-2.7798	1.0950	2.9308	0.9079	24
10.	AMMONIA	MG/L	1.3432	0.9323	2.1068	0.8852	26
12.	PH	PH	4.0190	0.4827	0.2050	0.5878	26
13.	TOT ORG CARBON	MG/L	0.0000	0.0000			
14.	CONDUCTIVITY	MMMHO/CM	781.2891	0.5063	38.8259	0.6634	26
16.	HARDNESS	MG/L	186.0314	0.2609	42.1757	0.8545	20
17.	SODIUM	MG/L	5.5744	0.8723	6.5898	0.9544	26

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	4.5214	-0.0994	0.0069	1.4851	0.5609
2.	VIABLE BIOMASS	MIL C/ML	-1.2665	0.9166	-0.0733	1.3779	0.4861
5.	RES CHLORINE	MG/L	-9.5261	3.1930	-0.1616	0.5220	0.7440
6.	TURBIDITY-SIO2	MG/L	0.8685	0.7494	-0.0080	2.8465	0.7618
9.	TOT ORG CARBON	MG/L	5.8906	0.1242	0.0223	2.6303	0.9266
10.	AMMONIA	MG/L	-7.9944	1.9241	-0.0251	2.0338	0.8935
12.	PH	PH	9.6816	-1.1183	0.1130	0.2047	0.5896
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	-4240.3360	7.3229	-0.0023	35.3925	0.7312
16.	HARDNESS	MG/L	196.4859	0.2132	0.0000	42.1078	0.8550
17.	SODIUM	MG/L	13.9686	0.6963	0.0009	6.4879	0.9558

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.3067	0.2949	0.1171	0.6740
2.	VIABLE BIOMASS	MIL C/ML	-0.7506	0.9139	0.3430	0.8209
5.	RES CHLORINE	MG/L	0.0499	0.7642	0.0439	0.7284
6.	TURBIDITY-SIO2	MG/L	-0.1160	0.9029	0.1703	0.7740
9.	TOT ORG CARBON	MG/L	-0.1568	1.0838	0.1120	0.8087
10.	AMMONIA	MG/L	0.0272	0.9779	0.0479	0.9006
12.	PH	PH	0.4770	0.4638	0.0122	0.5801
13.	TOT ORG CARBON	MG/L	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	1.6072	0.4976	0.0109	0.6751
16.	HARDNESS	MG/L	1.4465	0.3948	0.0598	0.8316
17.	SODIUM	MG/L	0.1406	0.9130	0.0403	0.9446

REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 4

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	1.8380	0.0265	0.3862	0.3859	24
2.	VIABLE BIOMASS	MIL C/ML	2.2026	-0.1636	4.3792	0.0704	20
5.	RES CHLORINE	MG/L	-0.8772	0.7158	0.5363	0.8032	12
6.	TURBIDITY-SIO2	MG/L	6.9656	0.3402	4.2803	0.6551	25
9.	TOT ORG CARBON	MG/L	-1.3786	0.8975	3.3424	0.8446	23
10.	AMMONIA	MG/L	1.1453	0.9215	2.7227	0.8338	23
12.	PH	PH	5.8548	0.2435	0.1913	0.3151	25
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000	0
14.	CONDUCTIVITY	MMMHO/CM	553.2649	0.6677	37.6827	0.7463	25
16.	HARDNESS	MG/L	189.8890	0.2341	68.5445	0.6699	19
17.	SODIUM	MG/L	10.0335	0.8232	10.4907	0.8249	25

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	2.8246	-0.1273	0.0058	0.3784	0.4279
2.	VIABLE BIOMASS	MIL C/ML	0.2988	0.7930	-0.0940	4.3628	0.1113
5.	RES CHLORINE	MG/L	1.0455	0.2492	0.0279	0.5356	0.8038
6.	TURBIDITY-SIO2	MG/L	-2.3901	1.1068	-0.0124	3.2801	0.8153
9.	TOT ORG CARBON	MG/L	13.0369	-0.7083	0.0368	2.5856	0.9131
10.	AMMONIA	MG/L	-10.4850	2.1577	-0.0312	2.6279	0.8462
12.	PH	PH	39.1935	-9.1771	0.6646	0.1779	0.4702
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
14.	CONDUCTIVITY	MMMHO/CM	-3137.0260	5.7205	-0.0017	36.2035	0.7688
16.	HARDNESS	MG/L	169.9953	0.3246	-0.0000	68.3870	0.6718
17.	SODIUM	MG/L	48.7336	-0.1132	0.0058	9.8897	0.8462

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.2077	0.1215	0.0616	0.4716
2.	VIABLE BIOMASS	MIL C/ML	-1.0195	0.2221	0.8317	0.7968
5.	RES CHLORINE	MG/L	-0.3951	1.1925	0.0520	0.7748
6.	TURBIDITY-SIO2	MG/L	-0.1939	1.0062	0.1724	0.7923
9.	TOT ORG CARBON	MG/L	0.1177	0.8040	0.1224	0.6907
10.	AMMONIA	MG/L	-0.0298	1.0127	0.0752	0.8194
12.	PH	PH	0.6929	0.2195	0.0111	0.3084
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000
14.	CONDUCTIVITY	MMMHO/CM	1.1618	0.6391	0.0105	0.7[illegible]
16.	HARDNESS	MG/L	1.8945	0.3695	0.0961	0.6852
17.	SODIUM	MG/L	0.1641	0.8995	0.0660	0.8413

REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	2.2167	0.0216	0.2994	0.5217	23
2.	VIABLE BIOMASS	MIL C/ML	0.5772	0.0467	2.5703	0.0602	23
5.	RES CHLORINE	MG/L	0.3930	-0.0136	0.0374	0.9989	11
6.	TURBIDITY-SIO2	MG/L	-0.7085	0.2328	1.8161	0.8141	24
9.	TOT ORG CARBON	MG/L	-0.7940	0.3658	2.8268	0.6224	22
10.	AMMONIA	MG/L	2.0925	0.7741	2.7142	0.7877	23
12.	PH	PH	3.0646	0.6145	0.1909	0.6511	24
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000	0
14.	CONDUCTIVITY	MMMHO/CM	509.6621	0.7013	36.9547	0.7733	24
16.	HARDNESS	MG/L	155.7979	0.0961	27.6299	0.7601	18
17.	SODIUM	MG/L	10.9695	0.8009	10.7789	0.8154	24

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	3.1408	-0.1243	0.0058	0.2902	0.5626
2.	VIABLE BIOMASS	MIL C/ML	-1.0417	0.9186	-0.0949	2.5428	0.1574
5.	RES CHLORINE	MG/L	1.5570	-0.2971	0.0170	0.0333	0.9992
6.	TURBIDITY-SIO2	MG/L	3.9642	-0.1527	0.0062	1.1584	0.9289
9.	TOT ORG CARBON	MG/L	-0.3872	0.3204	0.0010	2.8261	0.6226
10.	AMMONIA	MG/L	-8.8655	1.9388	-0.0294	2.6299	0.8023
12.	PH	PH	6.1831	-0.2665	0.0621	0.1908	0.6516
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000	0.0000
14.	CONDUCTIVITY	MMMHO/CM	-2753.1370	5.1679	-0.0015	35.6451	0.7899
16.	HARDNESS	MG/L	169.0051	0.0369	0.0000	27.4604	0.7635
17.	SODIUM	MG/L	33.5860	0.1874	0.0038	10.5266	0.8248

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.2744	0.1095	0.0892	0.5633
2.	VIABLE BIOMASS	MIL C/ML	-0.7399	0.0270	0.4581	0.8257
5.	RES CHLORINE	MG/L	-0.1395	-0.4561	0.0619	0.9947
6.	TURBIDITY-SIO2	MG/L	-0.2507	0.6411	0.1599	0.7011
9.	TOT ORG CARBON	MG/L	-1.2575	1.5629	0.2778	0.7133
10.	AMMONIA	MG/L	-0.0111	0.9623	0.0793	0.7920
12.	PH	PH	0.3715	0.5865	0.0113	0.6499
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000	0.0000
14.	CONDUCTIVITY	MMMHO/CM	1.0670	0.6695	0.0102	0.7793
16.	HARDNESS	MG/L	1.7095	0.2247	0.0643	0.7425
17.	SODIUM	MG/L	0.0625	0.9481	0.0728	0.8353

REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 1 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	2.4286	0.0057	0.7544	0.0261	25
2.	VIABLE BIOMASS	MIL C/ML	6.5551	-0.0354	0.8045	0.0831	25
5.	RES CHLORINE	MG/L	1.0010	0.1767	0.5307	0.4555	12
6.	TURBIDITY-SIO2	MG/L	2.1193	0.0499	0.8998	0.5176	26
9.	TOT ORG CARBON	MG/L	-0.7105	0.3246	2.4291	0.6689	24
10.	AMMONIA	MG/L	2.9179	0.7134	3.4269	0.6664	26
12.	PH	PH	4.4236	0.3916	0.1563	0.5766	26
13.	TOT ORG CARBON	MG/L	0.0000	0.0000			
14.	CONDUCTIVITY	MMMHO/CM	462.6919	0.7392	37.0176	0.8193	26
16.	HARDNESS	MG/L	213.9470	0.1758	64.7749	0.6015	20
17.	SODIUM	MG/L	4.6733	0.8464	13.1874	0.8393	26

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	2.3784	0.0136	-0.0003	0.7544	0.0266
2.	VIABLE BIOMASS	MIL C/ML	0.3801	0.0550	-0.0092	0.8076	0.0956
5.	RES CHLORINE	MG/L	2.6574	-0.2253	0.0240	0.5301	0.4572
6.	TURBIDITY-SIO2	MG/L	1.8429	0.0731	-0.0004	0.8958	0.5238
9.	TOT ORG CARBON	MG/L	-3.4259	0.6286	-0.0070	2.3951	0.6803
10.	AMMONIA	MG/L	-13.6726	2.4756	-0.0446	3.2848	0.6995
12.	PH	PH	-15.3731	5.9846	-0.3950	0.1504	0.6155
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	-1345.3860	3.1935	-0.0008	36.5685	0.8232
16.	HARDNESS	MG/L	235.4631	0.0775	0.0000	64.5876	0.6046
17.	SODIUM	MG/L	-10.1003	1.1563	-0.0015	13.0300	0.8435

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.3298	0.0241	0.0950	0.1275
2.	VIABLE BIOMASS	MIL C/ML	-0.7432	0.1417	0.4289	0.5506
5.	RES CHLORINE	MG/L	-0.1612	0.5910	0.1019	0.3660
6.	TURBIDITY-SIO2	MG/L	0.0235	0.3571	0.1213	0.5506
9.	TOT ORG CARBON	MG/L	-1.7363	1.9194	0.3056	0.7697
10.	AMMONIA	MG/L	0.0329	0.9194	0.0898	0.7250
12.	PH	PH	0.5235	0.3925	0.0095	0.5827
13.	TOT ORG CARBON	MG/L	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	0.9669	0.7019	0.0102	0.8232
16.	HARDNESS	MG/L	1.7220	0.2823	0.0893	0.6457
17.	SODIUM	MG/L	-1.6722	1.8126	0.1706	0.8042

REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 3 TO SAMPLE SOURCE 4

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	1.4825	0.1814	0.4308	0.6894	26
2.	VIABLE BIOMASS	MIL C/ML	2.1965	-0.3403	4.3135	0.1642	20
5.	RES CHLORINE	MG/L	-1.1561	1.0997	0.3923	0.9001	12
6.	TURBIDITY-SIO2	MG/L	-0.8133	1.1865	3.0353	0.8597	27
9.	TOT ORG CARBON	MG/L	1.0620	0.8187	2.1861	0.9367	23
10.	AMMONIA	MG/L	-0.2101	1.0079	2.1912	0.9094	25
12.	PH	PH	4.5456	0.4101	0.1694	0.5302	27
13.	TOT ORG CARBON	MG/L	0.0000	0.0000			
14.	CONDUCTIVITY	MMMHO/CM	-69.2825	1.0552	35.2253	0.8527	27
16.	HARDNESS	MG/L	86.1121	0.7481	67.1118	0.6826	21
17.	SODIUM	MG/L	-0.2174	0.9954	6.6542	0.9288	27

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	1.9323	0.0279	0.0105	0.4264	0.6971
2.	VIABLE BIOMASS	MIL C/ML	3.9831	-3.5435	0.4621	4.1490	0.3159
5.	RES CHLORINE	MG/L	-3.5428	1.9964	-0.0824	0.3896	0.9016
6.	TURBIDITY-SIO2	MG/L	1.1836	0.6664	0.0260	2.9837	0.8648
9.	TOT ORG CARBON	MG/L	5.6462	0.2713	0.0117	1.8998	0.9526
10.	AMMONIA	MG/L	-4.2357	1.4497	-0.0114	2.1763	0.9106
12.	PH	PH	96.3222	-24.7216	1.7181	0.1040	0.8538
13.	TOT ORG CARBON	MG/L	0.0009	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	-3380.8910	5.4029	-0.0018	34.7280	0.8378
16.	HARDNESS	MG/L	351.8313	-0.9942	0.0026	63.0509	0.7271
17.	SODIUM	MG/L	6.7226	0.8115	0.0012	6.6173	0.9292

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.1063	0.3920	0.0669	0.6761
2.	VIABLE BIOMASS	MIL C/ML	-0.8075	0.1437	0.8633	0.7604
5.	RES CHLORINE	MG/L	-0.2526	1.2684	0.0310	0.9264
6.	TURBIDITY-SIO2	MG/L	0.0802	0.9904	0.1386	0.8861
9.	TOT ORG CARBON	MG/L	0.2258	0.7542	0.0832	0.8707
10.	AMMONIA	MG/L	-0.0668	1.0479	0.0585	0.8975
12.	PH	PH	0.5451	0.3848	0.0099	0.5135
13.	TOT ORG CARBON	MG/L	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	-0.2084	1.0668	0.0096	0.8542
16.	HARDNESS	MG/L	0.8481	0.6599	0.1022	0.6178
17.	SODIUM	MG/L	-0.0941	1.0463	0.0362	0.9512

GAS CHROMATOGRAPH REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 4 TO SAMPLE SOURCE 5

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TETRACHLOROETHYLENE	-1.4173	0.4476	4.7209	0.7079	23
2.	METHYLENE CHLORIDE	23.0903	-0.0917	6.1572	0.2948	20
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0
5.	CHLOROFORM	1.6930	0.2243	4.4280	0.1955	23
6.	1,1,1-TRICHLOROETHANE	1.0962	0.0010	0.5894	0.3985	16
7.	BROMODICHLOROMETHANE	1.3650	-0.1534	0.4636	0.2442	16
8.	TRICHLOROETHYLENE	0.2046	0.2401	2.1981	0.4885	23
9.	DIBROMOCHLOROMETHANE	1.1586	-0.2919	0.1686	0.4608	23
10.	BROMOFORM	0.6796	0.2700	0.5941	0.5140	22
11.	TRIHALOMETHANES	5.4341	0.1171	5.1635	0.1185	23
12.	TOTAL HALOCARBONS	37.6770	0.0159	12.1117	0.1026	23

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CAL NO.	COMPOUND	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	0.4830	0.1513	0.0077	4.5678	0.7300
2.	METHYLENE CHLORIDE	25.8769	-0.5131	0.0059	5.3525	0.5568
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	21.1113	-2.1065	0.0666	4.3677	0.2535
6.	1,1,1-TRICHLOROETHANE	1.8619	-0.2263	0.0134	0.5549	0.5045
7.	BROMODICHLOROMETHANE	2.0666	-0.6914	0.0964	0.4686	0.2682
8.	TRICHLOROETHYLENE	-0.1530	0.3343	-0.0044	2.1927	0.4924
9.	DIBROMOCHLOROMETHANE	2.9389	-3.1178	1.0725	0.1484	0.6243
10.	BROMOFORM	2.4070	-1.7719	0.5657	0.5762	0.5556
11.	TRIHALOMETHANES	14.4303	-0.6874	0.0174	5.1538	0.1333
12.	TOTAL HALOCARBONS	35.3212	0.0678	-0.0002	12.0843	0.1225

LOGARITHMIC CURVE FIT RESULTS (LOG[Y]=A0 +A1*LOG[X])

CAL NO.	COMPOUND	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TETRACHLOROETHYLENE	-0.3851	0.8834	0.2094	0.8906
2.	METHYLENE CHLORIDE	1.4199	-0.1246	0.1359	0.4915
3.	CARBON TETRACHLORIDE	0.0000	0.0000	0.0000	0.0000
4.	1,2-DICHLOROETHYLENE	0.0000	0.0000	0.0000	0.0000
5.	CHLOROFORM	-0.0013	0.5213	0.2974	0.3233
6.	1,1,1-TRICHLOROETHANE	0.0017	-0.0789	0.3705	0.4797
7.	BROMODICHLOROMETHANE	0.0573	-0.3469	0.2361	0.2242
8.	TRICHLOROETHYLENE	-0.3192	0.5910	0.2694	0.6918
9.	DIBROMOCHLOROMETHANE	-0.0714	-0.4978	0.1098	0.4845
10.	BROMOFORM	-0.0404	0.2616	0.2294	0.5790
11.	TRIHALOMETHANES	0.3524	0.3660	-0.2157	0.3697
12.	TOTAL HALOCARBONS	1.5146	0.0316	0.1200	0.2391

REGRESSION ANALYSIS FOR APR 1, 1979 TO APR 30, 1979

FROM SAMPLE SOURCE 5 TO SAMPLE SOURCE 6

LINEAR CURVE FIT RESULTS (Y=A0 + A1*X)

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.	SAMPLE SIZE
1.	TOTAL BIOMASS	MIL C/ML	2.3367	0.0635	0.7519	0.0734	25
2.	VIABLE BIOMASS	MIL C/ML	0.4752	-0.0357	0.8203	0.1221	24
5.	RES CHLORINE	MG/L	2.6216	-0.1379	0.4649	0.6191	12
6.	TURBIDITY-SIO2	MG/L	2.2284	0.2031	0.8870	0.5688	26
9.	TOT ORG CARBON	MG/L	0.2702	0.8203	2.9208	0.8031	23
10.	AMMONIA	MG/L	2.8271	0.7911	2.6146	0.8298	25
12.	PH	PH	2.8453	0.5864	0.1193	0.7927	26
13.	TOT ORG CARBON	MG/L	0.0000	0.0000			
14.	CONDUCTIVITY	MMMHO/CM	18.9414	0.9921	8.3014	0.9920	26
16.	HARDNESS	MG/L	88.3779	0.9619	49.6581	0.8124	20
17.	SODIUM	MG/L	-16.2852	1.1733	5.0115	0.9735	26

PARABOLIC CURVE FIT RESULTS (Y=A0 + A1*X + A2*X**2)

CHA NO.	SENSOR	UNITS	A0	A1	A2	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.2835	1.2166	-0.1315	0.7384	0.2019
2.	VIABLE BIOMASS	MIL C/ML	0.4939	-0.1099	0.0060	0.8193	0.1314
5.	RES CHLORINE	MG/L	3.8472	-4.7053	0.5389	0.4349	0.6784
6.	TURBIDITY-SIO2	MG/L	0.6361	0.7716	-0.0313	0.7454	0.7227
9.	TOT ORG CARBON	MG/L	2.1875	0.0606	0.0416	2.6564	0.8805
10.	AMMONIA	MG/L	1.3610	0.9711	-0.0051	2.6093	0.8306
12.	PH	PH	-53.7068	15.8589	-1.0298	0.0818	0.9085
13.	TOT ORG CARBON	MG/L	0.0000	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	-130.5771	1.1849	-0.0001	8.2946	0.9920
16.	HARDNESS	MG/L	-215.3998	3.3954	-0.0043	39.5101	0.8859
17.	SODIUM	MG/L	-28.2577	1.5076	-0.0022	4.7545	0.9761

LOGARITHMIC CURVE FIT RESULTS (LOG(Y)=A0 +A1*LOG(X))

CHA NO.	SENSOR	UNITS	A0	A1	STANDARD ERROR	CORR. COEFF.
1.	TOTAL BIOMASS	MIL C/ML	0.3878	0.1901	0.0930	0.2305
2.	VIABLE BIOMASS	MIL C/ML	-0.7790	-0.1638	0.4275	0.5608
5.	RES CHLORINE	MG/L	0.3133	-0.1627	0.0805	0.6665
6.	TURBIDITY-SIO2	MG/L	0.1936	0.4786	0.1119	0.6720
9.	TOT ORG CARBON	MG/L	0.0599	0.7195	0.3391	0.7357
10.	AMMONIA	MG/L	0.1730	0.8417	0.0684	0.8587
12.	PH	PH	0.3170	0.6205	0.0071	0.8059
13.	TOT ORG CARBON	MG/L	0.0000	0.0000		
14.	CONDUCTIVITY	MMMHO/CM	0.0072	0.9983	0.0023	1.0019
16.	HARDNESS	MG/L	0.5872	0.8064	0.0627	0.8526
17.	SODIUM	MG/L	-2.1592	2.1096	0.0767	0.9629

LOG-NORMAL DISTRIBUTION: SEP 3, 1980 TO FEB 28, 1981

	AVERAGE	ONE SIGMA	LOG(Y)=F(Z) SLOPE	INTERCEPT	CHI SQUARE	SAMPLE SIZE
FLASH MIX PH						
	10.8	0.9	0.4223E -1	0.1032E 1	291.7720	149
PLANT FLOW						
	1.4	0.3	0.1010E 0	0.1385E 0	189.0946	148
SLUDGE DENSITY						
	0.9	0.9	0.3121E 0	-0.1451E 0	36.5369	149
SLUDGE PUMP						
	738.4	139.7	0.2065E 0	0.2849E 1	212.8979	147
LIME FEED VL.						
	73.1	237.2	0.5289E 0	0.1444E 1	63.7471	87

EOF..

APPENDIX E

STANFORD/WMS DATA FOR ORGANIC REMOVAL BY GAC

This section contains data relative to the performance of activated carbon with age for removal of TOC and trace organics.

PERFORMANCE OF GRANULAR ACTIVATED CARBON
FOR REMOVAL OF TOC

I- Influent Concentration, mg/l; O- Effluent Concentration, mg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		NMS DATA GAC			NMS DATA PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	6.44	1.46	0.227	0.92	0.143	5.56	0.863	2.65	.411	10.2	5.9	0.578		6.1
600	7.29	1.46	0.200	1.06	0.145	5.61	0.770	2.71	.372	10.6	5.4	0.509		4.9
900	9.74	1.20	0.123	2.78	0.285	6.68	0.685	3.55	.365	9.3	4.7	0.505		4.7
1240	8.08	2.02	0.250	2.15	0.266	6.86	0.849	3.68	.455	9.5	4.3	0.453		3.6
1500	10.80	3.31	0.306	2.45	0.227	6.15	0.569	3.97	.368	11.2	4.8	0.429		5.0
1835														
2090	6.52	2.81	0.431	2.50	0.383	8.98	1.377	4.76	.731					
2430	6.21	2.71	0.436	2.69	0.433	4.92	0.792	3.44	.554					
3235	9.87	5.67	0.574			8.20	0.831							
3660	9.25	4.67	0.505	5.12	0.554	6.52	0.705	5.44	.588					
4125	12.60	7.19	0.571	6.46	0.513	8.27	0.656	7.31	.580					
4465	11.90	7.08	0.595	6.61	0.555	10.50	0.882	8.06	.678					
4800														
5225	7.92	6.46	0.816	5.32	0.672	7.33	0.926	6.37	.804					
5525	8.61	6.38	0.741	7.18	0.834	7.24	0.841	6.93	.805					
6000	8.64	5.75	0.666	5.01	0.580	7.88	0.912	6.21	.719	9.3	6.3	0.677	15.1	6.0
6300	8.02	4.84	0.603	5.82	0.726	7.00	0.873	5.89	.734	8.8	5.9	0.670	18.0	5.7
6600		4.27		5.02						7.4	7.1	0.959	12.5	5.1
6900	6.77	7.15	1.056	5.83	0.861	6.82	1.007	6.6	.975	6.6	5.9	0.894	11.4	5.4
7100	9.15	5.54	0.605	5.28	0.577	7.41	0.810	6.08	.664	10.9	3.5	0.321	10.8	4.5
7820	8.93	5.05	0.566	5.44	0.609	5.69	0.637	5.39	.604	9.0	6.1	0.678	10.5	4.6
8400	8.24	4.33	0.525	5.07	0.615	6.17	0.749	5.19	.630	6.7	4.0	0.597	8.7	3.7
8820	6.73	4.11	0.611	4.22	0.627	4.97	0.738	4.43	.659	6.7	3.7	0.552	8.9	3.3
9400	7.14	4.80	0.672	6.04	0.846	4.91	0.688	5.25	.735	6.8	3.6	0.529	9.8	3.8

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF CHLOROFORM

I- Influent Concentration, µg/l; O- Effluent Concentration, µg/l; O/I- Fractional Concentration

BED VOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		WMS DATA				
										GAC			PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	11.24	0.20	0.018	0.32	0.026	12.13	1.079	4.1	0.375					
600	12.06	0.82	0.068	0.26	0.022	12.88	1.068	4.7	0.386	15.8	9.2	0.582		
900	14.58	0.41	0.028	1.13	0.078	15.16	1.041	5.6	0.382	19.5	9.6	0.492		
1200	17.57	0.86	0.049	1.90	0.108	18.12	1.031	7.0	0.396					
1500	22.11	2.79	0.126	6.42	0.290	19.79	0.895	9.7	0.437	20.7	11.1	0.536		
1835	16.56	4.68	0.283	11.43	0.690	17.26	1.042	11.1	0.007					
2090	9.21	4.80	0.521	5.86	0.636	11.50	1.249	7.4	0.802					
2430	10.21	10.23	1.002	8.78	0.860	9.34	0.915	9.5	0.926					
3235	11.69	8.13	0.695			13.85	1.185							
3660	12.67	21.17	1.671	30.75	2.427	15.59	1.230	22.5	1.776	23.2	28.7	1.237		29.1
4125	4.98	16.02	3.217	14.18	2.847	7.93	1.592	12.71	2.552	16.9	28.2	1.669		27.5
4465	6.24	12.05	1.931	9.62	1.542	5.27	0.845	9.0	1.439	16.3	23.1	1.417		19.8
4800	3.82	6.99	1.830	6.63	1.736					16.5	20.8	1.261		20.4
5225	6.93	13.15	1.898	12.69	1.831					16.1	20.7	1.286	18.4	24.8
5525	4.42	15.60	3.529	15.49	3.505									
5825	10.33	15.54	1.504	14.28	1.382					12.0	17.6	1.467	14.0	16.3
6105	8.85	15.26	1.724	14.88	1.681					21.0	26.4	1.257	19.6	22.8
6600	4.88	8.44	1.730	7.79	1.596					18.2	19.9	1.093	22.7	20.0
6900	7.45	10.45	1.403	10.54	1.415					16.8	17.3	1.030	21.0	20.1
7100	8.75	15.21	1.738	14.10	1.611									
7820														16.4
8400										17.9	24.7	1.380	12.9	26.1
8820										10.1	19.3	1.911	10.6	2[illegible].0
9400														

PERFORMANCE OF GRANULAR ACTIVATED CARBON
FOR REMOVAL OF T?ICHLOROETHANE

I- Influent Concentration, μg/l; O- Effluent Concentration, μg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		WMS DATA				
										GAC			PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	10.78	0.04	0.004	0.04	0.004	12.27	1.138	4.12	.382					
600	22.02	0.19	0.009	0.04	0.002	19.44	0.883	6.56	.298	10.9	2.1	0.193		
900	24.32	0.00	0.000	0.07	0.003	22.73	0.935			10.6	2.4	0.226		
1240	61.15	0.03	0.000	0.22	0.004	38.55	0.630	12.93	.212					
1500	64.69	0.20	0.003	1.94	0.030	42.21	0.652	14.78	.229	26.4	4.2	0.159		
1835	98.08	0.43	0.004	5.71	0.058	55.34	0.564	20.49	.209					
2090	15.79	0.47	0.030	1.93	0.122	21.74	1.377	8.05	.510					
2430	15.31	3.62	0.236	3.64	0.238	15.09	0.986	7.45	.487					
3235	37.82	5.35	0.141			0.17	1.133							
3650	31.32	21.60	0.690	36.45	1.164	37.70	1.204	31.92	1.019	63.5	19.9	0.313		15.9
4125	5.01	17.62	3.517	16.04	3.202	15.60	3.114	16.42	3.277	5.7	13.9	2.439		14.0
4465	9.98	14.28	1.431	12.76	1.279	7.54	0.756	11.53	1.155	13.6	13.3	0.978		12.3
4800	2.46	6.98	2.837	7.37	2.996					5.1	9.0	1.765		9.4
5225	0.23	15.67	68.130	15.38	66.870					1.0	6.1	6.1	4.5	7.5
5525	0.17	19.54	114.941	22.36	131.529									
5825	1.01	15.68	15.525	15.06	14.911					0.8	5.6	7.0	5.2	4.8
6100	0.98	15.66	15.980	16.22	16.551					0.6	6.6	11.0	2.1	7.6
6600	0.42	8.57	20.405	8.06	19.190					0.4	4.9	12.25	1.2	5.4
6900	0.48	8.11	16.896	8.02	16.708					0.6	3.3	5.5	2.0	3.4
7100	5.54	15.59	2.814	13.85	2.500									
7820														5.1
8400										0.4	4.0	10.0	1.5	3.8
8820										0.4	2.7	6.75	1.9	3.2
9400														

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF BROMODICHLOROMETHANE

I- Influent Concentration, μg/l; O- Effluent Concentration, μg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		WMS DATA GAC			WMS DATA PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	[illegible]	0.00	0.000	0.00	0.000	1.70	0.637							
603	[illegible].14	0.00	0.000	0.00	0.000	2.98	0.720			7.6	3.5	0.461		
900	[illegible].51	0.00	0.000	0.01	0.002	3.93	0.713			10.3	4.5	0.437		
1240	4.34	0.00	0.000	0.05	0.012	4.41	1.016							
1580	4.46	0.02	0.004	0.29	0.065	4.39	0.984	1.57	.351	6.1	4.0	0.656		
1835	3.45	0.30	0.087	0.71	0.206	3.70	1.072	1.57	.455					
2090	1.60	0.07	0.044	0.31	0.194	2.07	1.294	.82	.510					
2430	1.87	0.39	0.209	0.47	0.251	1.71	0.914	.86	.458					
3235	1.59	0.54	0.340			2.27	1.428							
3660	2.34	2.21	0.944	3.64	1.556	2.57	1.098	2.81	1.199	8.3	8.0	0.964		8.7
4125	1.82	1.77	0.973	1.57	0.863	1.51	0.830	1.62	.888	7.4	7.7	1.041		8.4
4465	2.06	1.65	0.801	1.51	0.733	1.16	0.563	1.44	.699	7.5	7.1	0.947		6.8
4800	1.77	1.03	0.582	1.19	0.672			1.11	.627	8.8	8.3	0.943		8.3
5225	8.26	2.75	0.333	2.78	0.337			2.77	.335	9.4	8.8	0.936	11.2	9.0
5525	3.68	4.00	1.087	5.06	1.375			4.53	1.231					
6000	11.21	5.81	0.518	6.40	0.571			6.11	.545	7.0	11.1	1.586	8.3	9.7
5300	8.97	5.95	0.663	7.97	0.889			6.96	.776	20.4	12.8	0.627	14.3	14.2
6600	4.63	3.92	0.847	4.83	1.043			4.38	.945	15.7	11.0	0.701	21.0	11.9
6900	6.04	3.82	0.632	4.61	0.763			4.22	.698	12.0	9.6	0.800	17.9	11.6
7100	5.80	8.81	1.519	8.12	1.400			8.46	1.459					
7820														13.7
8400										23.2	22.6	0.974	16.5	20.4
8420										15.7	21.5	1.369	12.7	19.5
9400														

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF TRICHLOROETHYLENE

I- Influent Concentration, μg/l; O- Effluent Concentration, μg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		WMS DATA				
										GAC			PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	3.14	0.00	0.000	0.00	0.000	1.64	0.522							
600	23.24	0.04	0.002	0.00	0.000	4.85	0.209			18.8	2.1	0.112		
900	12.55	0.00	0.000	0.00	0.000	4.94	0.394			9.0	2.2	0.244		
1240	9.72	0.00	0.000	0.03	0.003	6.32	0.650				2.5			
1500	19.02	0.29	0.015	0.75	0.039	7.18	0.377	2.74	.144	11.9	2.1	0.176		
1835	28.27	0.00	0.000	0.12	0.004	8.10	0.287							
2090	8.36	0.00	0.000	0.00	0.000	4.33	0.518							
2430	4.13	0.00	0.000	0.00	0.000	2.96	0.717							
3235	8.00	0.00	0.000			5.60	0.700							
3660	5.93	0.00	0.000	0.00	0.000	4.90	0.826			10.7	2.6	0.243		2.1
4125	1.80	0.30	0.167	0.55	0.306	3.49	1.339	1.45	.804	4.6	2.5	0.543		2.3
4465	3.02	0.26	0.086	0.55	0.182	1.61	0.533	.81	.267	6.6	2.3	0.348		1.8
4800	0.58	0.23	0.397	0.49	0.845			.36	.621	2.3	2.3	1.0		1.9
5225	0.09	0.67	7.444	1.03	11.444			.85	9.444	1.1	1.6	1.455	2.7	1.6
5525	0.10	1.22	12.200	2.40	24.000			1.81	18.1					
6000	0.00	[illegible]		1.95						1.1	1.6	1.455	2.3	1.4
6300	0.00	1.22		2.35						1.0	1.9	1.9	2.0	1.9
6600	0.00	0.73		1.35						0.9	1.7	1.889	1.8	1.6
6900	0.04	0.72	18.000	1.15	28.750			.935	23.375	1.0	1.5	1.5	1.8	1.4
7100	2.32	0.00	0.000	2.61	1.125									
7820														2.1
8400										0.7	1.9	2.714	1.5	2.0
8820										0.7	1.6	2.286	1.9	1.6
9400														

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF DIBROMOCHLOROMETHANE

I- Influent Concentration, μg/l; O- Effluent Concentration, μg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		WMS DATA				
										GAC			PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	1.11	0.00	0.000	0.00	0.000	0.44	0.396							
600	3.37	0.00	0.000	0.00	0.000	0.16	0.344			5.5	1.8	0.327		
900	5.04	0.00	0.000	0.00	0.000	1.79	0.355			8.3	2.8	0.337		
1240	2.85	0.00	0.000	0.00	0.000	2.25	0.789							
1580	2.11	0.00	0.000	0.07	0.033	2.09	0.991			4.2	2.1	0.5		
1835	1.46	0.00	0.000	0.19	0.130	1.85	1.267							
2090	0.63	0.00	0.000	0.13	0.206	1.47	2.333							
2430	0.86	0.08	0.093	0.19	0.221	0.72	0.837	.33	.384					
3235	0.79	0.10	0.127			1.01	1.278							
3660	1.28	0.43	0.336	0.91	0.711	1.09	0.852	.81	.633	3.3	2.0	0.606		9.8
4125	1.35	0.40	0.296	0.43	0.319	0.74	0.549	.52	.388	4.3	2.6	0.605		3.1
4465	1.21	0.42	0.347	0.48	0.397	0.60	0.496	.50	.413	4.9	3.5	0.714		1.7
4800	1.27	0.32	0.252	0.54	0.425			.43	.339	3.8	3.8	1.0		3.0
5225	7.33	1.03	0.141	1.08	0.147			1.06	.144	3.6	2.7	0.75	4.7	2.2
5525	2.95	1.80	0.610	2.22	0.753			2.01	.681					
6000	10.89	2.65	0.243	3.17	0.291			2.91	.267	2.4	5.5	2.292	3.9	3.3
6300	7.69	2.77	0.360	4.52	0.588			3.65	.474	11.7	3.5	0.299	7.2	5.1
6600	4.26	2.12	0.498	3.09	0.725			2.61	.612	6.8	2.6	0.382	9.8	3.7
6900	6.51	2.07	0.318	2.91	0.447			2.49	.382	4.3	2.5	0.581	8.7	3.4
7100	6.28	5.62	0.895	6.79	1.081			6.21	.988					
7820														8.4
8400										16.9	11.8	0.698	11.8	14.6
8820										8.1	8.8	1.086	5.8	11.4
9400														

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF TETRACHLOROETHYLENE

I- Influent Concentration, µg/l; O- Effluent Concentration, µg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		WMS DATA				
										GAC			PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	6.03	0.02	0.003	0.03	0.005	1.32	0.219	.46	.076					
600	13.79	0.19	0.014	0.10	0.007	2.13	0.154	.81	.058	15.6	4.8	0.308		
900	20.19	0.13	0.006	0.07	0.003	2.42	0.120	.87	.043	17.0	4.5	0.265		
1240	37.42	0.04	0.001	0.06	0.002	3.75	0.100	1.28	.034		3.2			
1580	73.81	0.11	0.001	0.40	0.005	5.73	0.078	2.08	.028	47.4	6.4	0.135		
1835	103.85	0.29	0.003	0.17	0.002	10.69	0.103	3.72	.036					
2090	27.72	0.12	0.004	0.11	0.004	6.58	0.237	2.27	.082					
2430	14.13	0.39	0.028	0.23	0.016	4.33	0.306	1.65	.117					
3235	18.96	0.05	0.003			6.06	0.320							
3660	7.70	0.06	0.008	0.27	0.035	4.85	0.630	1.73	.224	11.9	4.9	0.412		3.8
4125	1.65	0.24	0.145	0.32	0.194	4.20	2.545	1.59	.962	4.1	4.0	0.976		4.0
4465	2.66	0.05	0.019	0.15	0.056	1.38	0.519	.53	.198	9.5	4.2	0.442		3.3
4800	0.29	0.07	0.241	0.27	0.931					3.1	3.6	1.161		3.6
5225	0.00	0.11		0.24						2.4	2.9	1.208	2.8	3.0
5525	0.09	0.33	3.667	0.54	6.000									
6000	0.23	0.28	1.217	0.51	2.217					2.6	3.0	1.154	4.4	3.0
6300	0.38	0.30	0.789	0.73	1.921					1.9	2.3	1.211	3.5	2.6
6600	0.39	0.22	0.564	0.46	1.179					1.2	1.7	1.417	1.6	1.9
6900	0.21	0.22	1.048	0.34	1.619					1.4	1.6	1.143	2.3	1.6
7100	2.08	0.89	0.428	1.40	0.673									
7820														1.3
8400										2.5	2.7	1.08	2.1	2.4
8820										4.5	4.2	0.933	4.5	4.0
9400														

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF BROMOFORM

I- Influent Concentration, μg/l; O- Effluent Concentration, μg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON		AVERAGE		WMS DATA				
										GAC			PLANT	
	I	O	O/I	O	O/I	O	O/I	O	O/I	I	O	O/I	I	O
300	0.56	0.02	0.036	0.00	0.000	0.13	0.232							
600	1.99	0.00	0.000	0.00	0.000	0.32	0.161			12.8	10.0	0.781		
900	3.48	0.00	0.000	0.00	0.000	0.73	0.210			19.7	10.3	0.523		
1240	1.44	0.00	0.000	0.00	0.000	1.01	0.701							
1580	0.30	0.00	0.000	0.00	0.000	0.84	2.800			7.6	9.8	1.289		
1835	0.35	0.00	0.000	0.05	0.143	0.71	2.029							
2090	0.14	0.00	0.000	0.03	0.214	0.36	2.571							
2430	0.17	0.74	4.353	0.64	3.765	0.43	2.529	0.60	3.549					
3235	0.39	0.00	0.000			0.46	1.179							
3660	0.55	0.07	0.127	0.22	0.400	0.36	0.655	0.22	0.394	8.5	9.6	1.129		9.8
4125	0.55	0.00	0.000	0.13	0.236	0.34	0.618	0.16	0.285	8.6	8.6	1.0		6.8
4465	0.00	0.00		0.08		0.14		0.07						4.0
4800	0.55	0.11	0.200	0.00	0.000									3.9
5225	2.98	0.22	0.074	0.12	0.040			0.17	0.057	2.9	3.5	1.207	3.0	1.9
5525	1.05	0.34	0.324	0.42	0.400			0.38	0.362					
6000	2.84	0.51	0.180	0.54	0.190			0.53	0.185	0.3	3.8	12.667	2.5	0.4
6300	2.13	0.46	0.216	0.94	0.441			0.70	0.329	1.2	0.0	0	0.6	0.2
6600	1.15	0.36	0.313	0.59	0.513			0.48	0.413	1.0	0.0	0	0.3	0.0
6900	1.77	0.39	0.220	0.55	0.311			0.47	0.266	0.1	0.1	1.0	0.2	0.0
7100	0.23	0.20	0.870	0.25	1.087			0.23	0.978					
7820														0.3
8400										0.1	1.8	18.0	0.0	0.1
8820										0.0	0.0	0	0.1	0.0
9400														

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF ETHYLBENZENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
	I	O	O/I	O	O/I	O	O/I
300	45	115	2.556	70	1.556	85	1.889
600	325	35	0.108	35	0.108	95	0.292
900	125	15	0.120	20	0.160	110	0.880
1240	240	105	0.438	25	0.104	130	0.542
1580	55	35	0.636	45	0.818	250	4.545
1835	90	120	1.333	45	0.500	150	1.667
2090	25	25	1.000	0	0.000	35	1.400
2430	135	25	0.185	0	0.000	20	0.148
3235	60	130	2.167			95	1.583
3660	35	0	0.000	30	0.857	30	0.857
4125	80	35	0.438	0	0.000	45	0.563
4465	75	50	0.667	30	0.400	25	0.333
4800	65	45	0.692	35	0.538		
5225	200	40	0.200	230	1.150		
5525	60			235	3.917		
6000	220	110	0.500	40	0.182		
6300	245	175	0.714	80	0.327		
6600	510	75	0.147	145	0.284		
6900	270	125	0.463	60	0.222		
7100	360	155	0.431	135	0.375		
9400	135	25	0.185	50	0.370		

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF CHLOROBENZENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
	I	O	O/I	O	O/I	O	O/I
300	215	100	0.465	9	0.042	475	2.209
600	885	130	0.147	170	0.192	245	0.277
900	270	25	0.093	45	0.167	535	1.981
1240	1840	295	0.160	100	0.054	390	0.212
1580	1190	180	0.151	120	0.101	1015	0.853
1835	1005	390	0.388	105	0.104	560	0.557
2090	135	100	0.741	40	0.296	200	1.481
2430	730	120	0.164	45	0.062	160	0.219
3235	1550	345	0.223			480	0.310
3660	120	50	0.417	60	0.500	185	1.542
4125	300	125	0.417	125	0.417	270	0.900
4465	295	150	0.508	135	0.458	190	0.644
4800	190	165	0.868	80	0.421		
5225	260	120	0.462	220	0.846		
5525	195			255	1.308		
6000	345	235	0.681	60	0.174		
6300	315	345	1.095	245	0.778		
6600	890	510	0.573	135	0.152		
6900	525	575	1.095	295	0.562		
7100	9405	2050	0.218	580	0.062		
9400	445	230	0.517	385	0.865		

PERFORMANCE OF GRANULAR ACTIVATED CARBON
FOR REMOVAL OF 1, 3 DICHLOROBENZENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	1315	35	0.027	15	0.011	215	0.163
600	1610	50	0.031	20	0.012	190	0.118
900	4945	0	0.000	70	0.014	180	0.036
1240	4095	70	0.017	20	0.005	80	0.020
1580	4015	20	0.005	15	0.004	295	0.073
1835	5930	100	0.017	25	0.004	180	0.030
2090	135	0	0.000	25	0.185	110	0.815
2430	1965	25	0.013	0	0.000	250	0.127
3235	905	0	0.000			215	0.238
3660	445	20	0.045	20	0.045	145	0.326
4125	620	20	0.032	30	0.048	195	0.315
4465	275	15	0.055	50	0.182	160	0.582
4800	165	200	1.212	150	0.909		
5225	1575	75	0.048	250	0.159		
5525	1980			325	0.164		
6000	375	210	0.560	50	0.133		
6300	585	160	0.274	100	0.171		
6600	575	40	0.070	95	0.165		
6900	610	640	1.049	90	0.148		
7100	1183	195	0.165	30	0.025		
9400	130	60	0.462	95	0.731		

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF 1, 4 DICHLOROBENZENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	2010	15	0.007	65	0.032	190	0.095
600	2815	345	0.123	70	0.025	190	0.067
900	5070	0	0	105	0.021	145	0.029
1240	4545	165	0.036	55	0.012	195	0.043
1580	4415	55	0.012	50	0.011	330	0.075
1835	6820	100	0.015	35	0.005	245	0.036
2090	200	40	0.200	30	0.150	205	1.025
2430	3760	30	0.008	40	0.011	470	0.125
3235	2075	15	0.007			365	0.176
3660	1280	0	0	20	0.016	230	0.180
4125	2095	20	0.010	50	0.024	310	0.148
4465	835	0	0	100	0.120	290	0.347
4800	490	199	0.406	340	0.694		
5225	820	210	0.256	175	0.213		
5525	750			320	0.427		
6000	2075	220	0.106	285	0.137		
6300	3025	135	0.045	210	0.069		
6600	3175	445	0.140	210	0.066		
6900	1525	490	0.321	95	0.062		
7100	6344	0	0	240	0.038		
9400	475	20	0.042	45	0.095		

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF 1, 2 DICHLOROBENZENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	2220	30	0.014	30	0.014	260	0.117
600	4800	45	0.009	40	0.008	230	0.048
900	7890	15	0.002	175	0.022	270	0.034
1240	6510	45	0.007	35	0.005	240	0.037
1580	4655	60	0.013	75	0.016	535	0.115
1835	6840	75	0.011	30	0.004	390	0.057
2090	230	25	0.109	60	0.261	225	0.978
2430	2420	45	0.019	50	0.021	480	0.198
3235	1410	25	0.018			410	0.291
3660	1170	15	0.013	55	0.047	270	0.231
4125	3140	55	0.018	100	0.032	365	0.116
4465	1325	25	0.019	125	0.094	330	0.249
4800	590	70	0.119	180	0.305		
5225	430	90	0.209	80	0.186		
5525	325			80	0.246		
6000	1520	40	0.026	95	0.063		
6300	2745	0	0	80	0.029		
6600	3030	155	0.051	70	0.023		
6900	210	235	1.119	50	0.238		
7100	3906	610	0.156	200	0.051		
9400	585	50	0.085	100	0.171		

PERFORMANCE OF GRANULAR ACTIVATED CARBON
FOR REMOVAL OF 1, 2, 4 TRICHLOROBENZENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	17290	625	0.036	610	0.035	1295	0.075
600	12590	85	0.007	50	0.004	655	0.052
900	12160	50	0.004	1010	0.083	550	0.045
1240	16180	95	0.006	50	0.003	365	0.023
1580	18190	105	0.006	70	[illegible]	1060	0.058
1835	44345	105	0.002	60	0.001	705	0.016
2090	220	365	1.659	545	2.477	1080	4.909
2430	7495	60	0.008	195	0.026	1050	0.140
3235	4020	85	0.021			945	0.235
3660	7420	90	0.012	70	0.009	1015	0.137
4125	10660	50	0.005	370	0.035	675	0.063
4465	4685	70	0.015	595	0.127	815	0.174
4800	3105	100	0.032	135	0.043		
5225	1090	95	0.087	155	0.142		
5525	1095			85	0.078		
6000	5440	810	0.149	255	0.047		
6300	4840	65	0.013	165	0.034		
6600	8655	190	0.022	140	0.016		
6900	7840	385	0.049	75	0.010		
7100	7439	75	0.010	190	0.026		
9400	2045	50	0.024	120	0.059		

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF NAPHTHALENE AND 1, 2, 3 TRICHLOROBENZENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fr[illegible]tional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
	I	O	O/I	O	O/I	O	O/I
300	9725	475	0.049	480	0.049	665	0.068
600	7865	75	0.010	115	0.015	435	0.055
900	7320	65	0.009	1095	0.150	435	0.059
1240	4990	70	0.014	245	0.049	380	0.076
1580	3950	150	0.038	140	0.035	635	0.161
1835	7930	35	0.004	20	0.003	405	0.051
2090	1305	260	0.199	1365	1.046	1500	1.149
2430	1880	165	0.088	345	0.184	470	0.250
3235	2335	50	0.021			390	0.167
3660	3560	50	0.014	345	0.097	470	0.132
4125	5845	15	0.003	155	0.027	395	0.068
4465	1335	45	0.034	115	0.086	435	0.326
4800	1460	15	0.010	20	0.014		
5225	235	25	0.106	50	0.213		
5525	250			40	0.160		
6000	680	280	0.412	65	0.096		
6300	530	1280	2.415	40	0.075		
6600	845	250	0.296	20	0.024		
6900	560	1485	2.652	15	0.027		
7100	1124	410	0.365	85	0.076		
7400	2515	35	0.014	20	0.008		

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF HEPTALDEHYDE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
	I	O	O/I	O	O/I	O	O/I
300	40	80	2.000	105	2.625	0	0
600	0	0		0		55	
900	140	40	0.286	75	0.536	0	0
1240	80	0	0	110	1.375	80	1.000
1580	85	75	0.882	65	0.765	435	5.118
1835	160	20	0.125	15	0.094	215	1.344
2090	35	15	0.429	0	0	0	0
2430	205	120	0.585	80	0.390	0	0
3235	40	35	0.875			45	1.125
3660	50	50	1.000	135	2.700	40	0.800
4125	130	115	0.885	135	1.038	55	0.423
4465	0	30		85		0	
4800	240	35	0.146	25	0.104		
5225	1910	50	0.026	265	0.139		
5525	370			345	0.932		
6000	180	190	1.056	75	0.417		
6300	150	220	1.467	130	0.867		
6600	1445	160	0.111	200	0.138		
6930	1530	0	0	140	0.092		
7100	0						
3400	0						

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF P-XYLENE

I- Influent Concentration, g/l; O- Effluent Concentration, g/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
	I	O	O/I	O	O/I	O	O/I
300	80	60	0.750	0	0	115	1.438
600	95	35	0.368	25	0.263	100	1.053
900	60	0	0	0	0	105	1.750
1240	55	95	1.727	0	0	75	1.364
1580	50	30	0.600	30	0.600	220	4.400
1835	75	120	1.600	35	0.467	120	1.600
2030	30	30	1.000	0	0	40	1.333
2430	55	35	0.636	0	0	30	0.545
3235	125	50	0.400			90	0.720
3660	60	0	0	35	0.583	30	0.500
4125	65	30	0.462	35	0.538	50	0.769
4465	35	40	1.143	25	0.714	0	0
4800	85	20	0.235	0	0		
5225	55	0	0	135	2.455		
5525	30			95	3.167		
6000	65	40	0.615	20	0.308		
6300	0	75		45			
6600	0	120		80			
6900	190	70	0.368	65	0.342		
7100				220			
9400	70	55	0.786	80	1.143		

PERFORMANCE OF GRANULAR ACTIVATED CARBON
FOR REMOVAL OF M-XYLENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	155	270	1.742	105	0.677	440	2.839
600	360	105	0.292	90	0.250	295	0.819
900	50	25	0.500	20	0.400	350	7.000
1240	185	390	2.108	25	0.135	235	1.270
1580	90	80	0.889	95	1.056	695	7.722
1835	110	315	2.864	100	0.909	460	4.182
2090	70	65	0.929	15	0.214	125	1.786
2430	135	110	0.815	15	0.111	75	0.556
3235	320	95	0.297			310	0.969
3660	215	55	0.256	100	0.465	105	0.488
4125	180	75	0.417	35	0.194	180	1.000
4465	150	120	0.800	60	0.400	135	0.900
4800	120	40	0.333	25	0.208		
5225	75			275	3.667		
5525	70			185	2.643		
6000	110	60	0.545	35	0.318		
6300	105	95	0.905	100	0.952		
6600	215	65	0.302	175	0.814		
6900	200	80	0.400	115	0.575		
7100	490	665	1.357	500	1.020		
9400	175	65	0.371	125	0.714		

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PERFORMANCE OF GRANULAR ACTIVATED CARBON
FOR REMOVAL OF 2-METHYL NAPHTHALENE

I- Influent Concentration, ng/l; O- Effluent Concentration, ng/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	130	0	0	0	0	0	0
600	75	30	0.400	0	0	50	0.667
900	100	15	0.150	45	0.450	40	0.400
1240	105	40	0.381	165	1.571	225	2.143
1580	130	0	0	0	0	55	0.423
1835	135	30	0.222	20	0.148	90	0.667
2090	0						
2430	365	170	0.466			25	0.068
3235	40						
3660	0						
4125	40						
4465	0						
4800	0						
5225	265			90	0.340		
5525	185						
6000	315	280	0.889	95	0.302		
6300	80	100	1.250	30	0.375		
6600	85	20	0.235	30	0.353		
6900	0	155					
7100	75	105	1.400	25	0.333		
9400	95	40	0.421				

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF 1-METHYL NAPHTHALENE

I- Influent Concentration, ng/l; O- Effluent Concentration, n g/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	80	0	0	0	0	0	0
600	45	30	0.667	0	0	25	0.556
900	90	0	0	55	0.611	60	0.667
1240	120	25	0.208	50	0.417	50	0.417
1580	115	0	0	0	0	110	0.957
1835	70	0	0	0	0	40	0.571
2090	0	0		0		0	
2430	385	170	0.442	0	0	15	0.039
3235	45	0	0			0	0
3660	0	0		0		0	
4125	80	0	0	0	0	0	0
4465	20	0	0	0	0	0	0
4800	0	40		0			
5225	290	0	0	115	0.397		
5525	85			0	0		
6000	365	475	1.301	130	0.356		
6300	80	135	1.688	65	0.813		
6600	160	65	0.406	40	0.250		
6900	0	205		0			
7100	485	355	0.732	65	0.134		
9400	85	15	0.176	0	0		

PERFORMANCE OF GRANULAR ACTIVATED CARBON
FOR REMOVAL OF TOTAL ORGANIC HALOGEN - TOX

I- Influent Concentration, μg/l; O- Effluent Concentration, μg/l; O/I- Fractional Concentration

BEDVOLUMES	I	NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
		O	O/I	O	O/I	O	O/I
300	160.0	50.0	.313	56.9	.355	142.0	.888
600	204.0	35.6	.175	38.0	.186	149.0	.730
900	294.0	113.0	.384	60.2	.205	167.0	.568
1240	263.0	116.0	.441	97.3	.370	172.0	.654
1580	316.0	75.4	.239	133.0	.421	187.0	.592
1835	400.0	38.7	.097	123.0	.308	222.0	.555
2057	276.0	58.4	.212	47.3	.171	139.0	.504
2430	147.0	38.0	.259	59.9	.407	130.0	.884
3235	112.0					158.0	1.411
3660	150.0	70.6	.471	64.6	.431	172.0	1.147
4125	121.0	90.5	.748	105.0	.868	115.0	.950
4465	144.0	102.0	.708	100.0	.694	90.8	.631
4800	105.0	148.0	1.410	111.0	1.057		
5225	147.0	72.3	.492	85.5	.582		
5525	151.0	66.5	.440	83.0	.550		
6000	111.0	66.0	.595	79.3	.714		
6300	93.4	68.1	.729	117.0	1.253		
6600	86.5	91.7	1.060	73.2	.846		
6980	91.1	64.3	.706	76.6	.841		
7100							
9400							

PERFORMANCE OF GRANULAR ACTIVATED CARBON FOR REMOVAL OF PURGABLE ORGANIC HALOGEN - POX

I- Influent Concentration, μg/l; O- Effluent Concentration, μg/l; O/I- Fractional Concentration

BEDVOLUMES		NEW CARBON		REGENERATED CARBON		EXHAUSTED CARBON	
	I	O	O/I	O	O/I	O	O/I
300	98.4	6.2	.063	4.2	.043	75.1	.763
600	129.0	23.1	.179	21.1	.164	112.0	.868
900	187.0	94.1	.503	38.3	.205	116.0	.620
1240	173.0	104.0	.601	93.1	.538	117.0	.676
1580	191.0	5.6	.029	107.0	.560	118.0	.618
1835	210.0	5.6	.027	77.5	.369	139.0	.662
2090	99.2	6.1	.061	3.4	.034	79.8	.795
2430	81.1	13.0	.160	15.5	.191	65.2	.804
3235	33.6					83.7	2.491
3660	93.6	30.1	.322	27.1	.290	40.3	.431
4125	34.0	38.1	1.121	45.6	1.341	46.0	1.353
4465	40.0	33.3	.833	38.8	.970	28.6	.715
4800	23.3	26.7	1.146	31.3	1.343		
5225	30.9	24.9	.806	25.9	.838		
5525	16.4	30.4	1.854	31.9	1.945		
6009	29.8	31.8	1.067	32.0	1.074		
6300	28.0	29.6	1.057	26.4	.943		
6600	22.2	45.4	2.045	23.4	1.054		
6980	19.3	19.4	1.005	18.6	.964		
7100							
9400							

APPENDIX F

PLANT DOWNTIME AND MAINTENANCE LOG

APPENDIX F

PLANT DOWNTIME AND MAINTENANCE LOG

This section contains a chronological listing of equipment problems experienced during Part II of the test period.

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Feb 4 to 7	72 (4)		Calcium carbonate deposits on 24" delivery line from flash mixer to flocculator reduced the flow capacity to 0.7 MGD. The deposits were partially removed by soaking in 36% inhibited hydrochloric acid for 22 hours.		72 *							3650
Feb 17 to 21	91 (4, 5,7)		The softened deposits were later removed by hydroflushing (high pressure water cleaning)	5	75 *	29 *		11 *			44	
Feb 9 to 20			Calcium carbonate deposits on recarbonation mixer turbine caused unbalance and excessive vibration. Deposits were removed.			187 (mixer)						
Feb 9	6 (3)		Computer maintenance	6 *							6	
Feb 10	8 (3)		Computer maintenance	8 *							7	
Feb 23	5 (3)		Computer maintenance	5 *							5	

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Dec 3			Ozonizer repair								50	
Dec 4			Ozonizer repair									
Dec 1 to 9			Water jacket leak in ozonizer				208					
			Computer maintenance	4							25	
Dec 24	9 (4)		Aerator sump pump flush		9 *		9				7	
Dec 28 to 30	40 (3)		Flash mixer clean-up to remove encrusted calcium carbonate		40 *		72					
Jan 1 to 4			Ozonizer down				33					
Jan 5 to 11			Lime system maintenance									14
Jan 12 to 18			Lime system maintenance									22
Jan 19 to 25	5 (2)	5 *	Lime system maintenance Ozonizer system maintenance Influent dye test					52				18
Jan 26 to 31	5 (3)		Lime system maintenance		5 *							14

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Nov 3	5		Power out								9	
Nov 4			Flushed lime slaker and lime slurry feed tank; computer maintenance		3						13	
Nov 5			Computer maintenance Lime system maintenance Recarbonation maintenance								21 24	
Nov 6			Computer maintenance Lime system maintenance Aeration system maintenance									
Nov 6 to 30			Tube failed in ozonizer				552					
Nov 11			Inspect ozonizer								1	
Nov 12			Remove ozonizer dielectric tube and wash unit								8	
Nov 13	14 (4)		Aerator sump pump frozen		14 *						6	
Nov 14	15 (4)		Aerator sump pump frozen		12 *							
Nov 16 to 30			General maintenance								85	
Nov 26	3 (3)			3 *							1	

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Oct 12 to 13			Ozonizer inspected				48				3	
Oct 14	2 (3)		Computer maintenance	2 *			24					
Oct 15							24					
Oct 16	2 (3)		Computer power supply failure	1 *			10					
Oct 20			Tightened stack gas compressor belts			1					4	
Oct 23			Changed oil - lime clarifier reservoir		4						2	
Oct 24	1 (3)		Computer maintenance	1 *								
Oct 27			Computer maintenance								12	
Oct 28			Computer maintenance								11	
Oct 29			Computer maintenance		2						13	
Oct 30			Computer maintenance								9	
Oct 31			Computer maintenance								8	

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Sep 12			Recarbonation system maintenance			10					5	
Sep 15			Calibrated pit probe								2	
Sep 16			Maintenance on furnace controls lockouts; cleaned stack gas filter								2	
Sep 16 to 20			Disassembled ozonizer and cleaned tubes				99				34	
Sep 21			Replaced belt on dewatering screw drive motor								1	
Sep 22			Replaced bolt on dewatering screw								2	
Sep 23	1 (3)		Computer maintenance	1 *								
Sep 25			Repair lime conveyor								10	
Sep 30	2 (2)		Repair lime mixer	2 *							4	
			Computer maintenance									
Oct 2			Lime bin vibrator belts								2	
Oct 8 to 11	1 (4)		Ozonizer out of service; dryer solenoid valve not working		1 *		82					

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Aug 19	4 (3)		Computer maintenance	4 *								
Aug 21			Sludge furnace down		12 5(5)	12 (4) 5					4	
Aug 22			Sludge furnace down		11(5)	11					4	
Aug 26	5 (3)		Computer / new facility interface 1300 - 1900	5 *							4	
Aug 27	5 (3)		Computer maintenance 1200 - 1430	5 *							4	
Aug 28	3 (3)		Computer maintenance 1330 - 1700	3 *								
Aug 29	6 (3)		Computer maintenance 1130 - 1700	6 *								
Sep 2	9 (3)		Computer maintenance 1000 - 1830	9 *								
Sep 8			Computer maintenance								4	
Sep 9			Flushed lime slurry feed tank		14	14 (4)						
Sep 10			Furnace maintenance calibrated pit probe		24	24 (4)					2	
Sep 11			Tightened stack gas compressor belts		11	11 (4) 10					6	

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Jul 26	3 (2)	3 *										
Jul 28	2		Computer maintenance	2 *								
Jul 31	1		Aerator sump pump frozen		3 *						6	
Aug 2	7 (2)	7 *	Aerator sump pump frozen - down 0430 - 1100		7						6	
Aug 5	1 (3)		Computer maintenance	1 *	2							
Aug 6	3 (2)	3 *			1	3	1					
Aug 7			Computer maintenance									4
Aug 8 to 11	91 (4)		Aerator sump pump frozen		91 *							38
Aug 12	18 (4)		Removed and started cleaning aerator sump pump valve. (Modified aerator sump pump implemented 8-12-80 flow pattern through 8-21-80)		18 * 6	6 (4)						9
Aug 13	3 (3)		Computer maintenance	3 *								3
Aug 13 to 20			Repair aerator sump pump and associated valves		192	192 (4)						50

PLANT DOWNTIME AND MAINTENANCE LOG

* Equipment or Process Causing Plant Shutdown
(#) Number of Process Causing Downtime

Date	Plant Shutdown (1)	Influent Unavailable (2)	Problem Description	Computer (3)	Chemical Clarification (4)	Recarbonation (5)	Ozonation (6)	Filters (7)	Carbon Adsorption (8)	Chlorination (9)	Maintenance Manhours	Material $
Jul 1	3 (2)	3 *	Replaced lime slurry feed pump mechanical seal - on line at 1900		19						8	
Jul 2			Computer maintenance								4	
Jul 8	4											
Jul 13	3											
Jul 14	3 (2)	3 *										
Jul 16					8							
Jul 17	20 (2)	20 *	Down 0400 - 2400		1							
Jul 18	8 (2)	8 *										
Jul 21	3 (2)	3 *	Ozonizer maintenance				3				4	
Jul 22			Tightened stack gas compressor belts. Down 1300 - 1400			1					2	
Jul 23	3 (2)	3 *										
Jul 24	13 (4)		Recarbonation maintenance. Aerator sump pump frozen by calcium carbonate deposits		8 (5) 13 *	8					13	
Jul 25					13 (5)	13					6	

APPENDIX G

WMS COSTS

APPENDIX G

WMS COSTS

This section contains operating and maintenance costs incurred by each sensor/subsystem in the WMS during the test period. A list of recommended spares is also included.

Sample Collection and Distribution System

The following expenditures can be expected for 8 months of continuous operation:

1)	50 Stainless Steel Filter Screens	$ 66.00
2)	Pneumatic Cylinder	45.00
3)	Pump Boots	20.00
4)	Pump Parts	66.00
5)	Drive Belts	12.50
6)	Red Valves	62.50
7)	Pressure Transducers	165.00
8)	Red Valves Sleeves (4)	120.00
	Total =	$557.00

Recommended Spares:

1) 50 Stainless Steel Filters (10)
2) Pressure Gages (1)
3) Pump Boots (4)
4) Monyo Pump (1)
5) Drive Belts (2)
6) Red Valves (1)
7) Pressure Transducer (1)
8) Red Valve Sleeves (4)
9) Pneumatic Back Flushing Cylinder (1)

The only major hardware components to fail during the test period were Red Valves, one Monyo pump, and one pneumatic cylinder. As such, it is not yet possible to estimate the life expectancy of the system except to state that it should be at least 4 years.

During the course of the test period, 7 man-hours were spent for scheduled maintenance and 9.75 man-hours for unscheduled maintenance.

Commercial Sensors

Total Organic Carbon

The following expenditures can be expected for 8 months of continuous operation:

1)	Phosphoric Acid	$125.00
2)	Pump Tubing	33.00
3)	Sample Pump	250.00
4)	Persulfate	744.00
5)	U.V. Lamps (3)	540.00
6)	Filters	33.00
	Total =	$1725.00

Recommended Spares:

1) Sample Pump (1)
2) Reagent Pump (1)
3) U.V. Chamber Pump (1)
4) U.V. Lamps (3)
5) Pump Tubing
6) Fiberfax Filter (Mist Filter) (1 lb.)

The overall life of the analyzer has yet to be determined. During the course of the test period 32.0 man-hours were spent on routine maintenance and 11.5 man-hours on unscheduled maintenance.

Hardness Analyzer

The following expenditures can be expected for 8 months of continuous operation:

1)	Bromide Electrodes	$ 175.00
2)	Copper Electrodes	273.00
3)	#113201 Reagent (21.45 Gal.)	1393.00
4)	Pump Tubes (3 sets)	90.00
5)	Calcium Carbonate	7.00
6)	Ammonium Hydroxide	3.00
7)	Hydrochloric Acid	3.00
	Total =	$1946.00

Recommended Spares:

1) Pump Tubes (2 sets)
2) Bromide Electrode (1)
3) Copper Electrode (1)

The overall life of the analyzer has yet to be determined. However, the apparent life expectancy of several of the components has been determined:

1) Electrodes - 6 months
2) Pump Tubes - 3 months
3) Flow Cell - 2 years

During the course of the test period, 67.75 man-hours were spent on routine maintenance and 4.75 man-hours on unscheduled maintenance.

Nitrate Analyzer

The following expenditures can be expected for 8 months of continuous operation:

1)	Phosphoric Acid	$329.00
2)	Marshals Reagent	327.00
3)	Sulfanilamide	198.00
4)	Poppet Valves	30.00
5)	Cadmium	50.00
6)	Potassium Nitrate	8.00
7)	Ammonium Acetate	10.00
8)	Acetic Acid	10.00
	Total =	$962.00

Spares

1) Poppet Valves (4)
2) Metricone Drive w/ Motor (1)
3) Pump Bellows (1)
4) Pump Motor (1)
5) Diaphragms (Air Pump) (2)

The overall life expectancy of the analyzer has yet to be determined. However, the apparent life expectancy of several components has been determined.

1) Metricone - 2 years
2) Pump Motor - 3 years
3) Pump Poppet Valves - 6 months

During the course of the test period, 19.5 man-hours were spent on scheduled maintenance and 22.0 man-hours on unscheduled maintenance.

pH Analyzer

The only operating cost incurred during operation will be $50.00 for standards. It is recommended that a spare electrode be kept on hand. The estimated life expectancy of the electrode is 3 years. During the course of the test period, 2.0 man-hours were spent on routine maintenance and 1.0 man-hour on unscheduled maintenance.

Residual Chlorine Analyzer

The following expenditures can be expected for 8 months of continuous operation:

1)	Redox Electrodes	$150.00
2)	Iodine Electrodes	150.00
3)	#112501 Reagent	456.00
4)	#112502 Reagent	456.00
5)	Residual Chlorine Standard	19.80
6)	Pump Tube Sets (3)	150.00
	Total =	$1381.80

Recommended Spares:

1) Pump Tubes (2 sets)
2) Redox Electrode (1)
3) Iodine Electrode (1)

The overall life expectancy of the analyzer has yet to be determined. However, the apparent life expectancy of several of the components has been determined:

1) Electrodes - 6 months
2) Pump Tubes - 3 months
3) Temperature Controlled Flow Cell - 3 years

During the course of the test period, 50.75 man-hours were spent on routine maintenance and 2.25 man-hours on unscheduled maintenance.

Sodium Analyzer

The following expenditures can be expected for 8 months of continuous operation:

1)	Sodium Electrode (1)	$165.00
2)	Reference Electrode (1)	42.00
3)	Anhydrous Ammonia (1 cyl.)	45.00
4)	Sodium Chloride (3.3 lbs.)	14.52
5)	Reference Electrode Electrolyte	15.00
	Total =	$281.52

Recommended Spares:

1) Sodium Electrode (1)
2) Reference Electrode (1)

The overall life expectancy of the analyzer has yet to be determined. However, the life expectancy of the reference electrode is approximately 1 year.

During the course of the test period, 70.00 man-hours were spent on scheduled maintenance and 13.5 man-hours on unscheduled maintenance.

Temperature Sensor

The following expenditure can be expected for 8 months of continuous operation of the two temperature sensors.

Action Pac electronics module (1) $125.00

The only recommended spare is 1 Action Pac electronics module.

The life expectancy of the sensor has yet to be determined. During the course of the test period, .5 man-hour was spent on scheduled maintenance and .5 on unscheduled maintenance.

Turbidity

The following expenditures can be expected for 8 months of continuous operation of the Sigrist Model UP52-TJ Photometer:

1)	Chart Paper (2 rolls)	$32.00
2)	Light Source (2)	15.00
3)	Glow Lamp (1)	9.50
	Total =	$56.50

Recommended Spares:

1) Chart Paper (1 roll)
2) Light Sources (2)

Since there have been no major component failures in the Sigrist Photometer, the life expectancy has yet to be determined. During the course of the test period, 2.25 man-hours were spent on scheduled maintenance and .25 man-hour on unscheduled maintenance.

Ammonia Analyzer

The following expenditures can be expected for 8 months of continuous operation:

1)	Sodium Hypochlorite	$501.00
2)	Sodium Hydroxide	52.00
3)	Phenol	134.00
4)	Sodium Metaphosphate	7.50
5)	Ammonium Chloride	4.00
6)	Pump Check Valves (4)	60.00
7)	Hydrochloric Acid	30.50
	Total =	$789.00

Recommended Spares:

1) Metricone Drive Unit w/motor (1)
2) Pump Check Valves (4)
3) Glass Flow Cell (1)
4) Spare Pump Motor (1)
5) Pump Bellows (1)
6) Diaphragms (Air Pump) (2)

The overall life expectancy of the analyzer has yet to be determined. However, the apparent life expectancy of several of the components has been determined:

1) Metricone Assembly - 2 years
2) Pump Motor - 3 years
3) Pump Check Valves - 3-6 months

During the course of the test period, 159.75 man-hours were spent on scheduled maintenance and 18.25 man-hours on unscheduled maintenance.

Conductivity

The Beckman conductivity sensor required no consumables and suffered no part failures during the test period.

There are no recommended spares for this sensor.

During the course of the test period, .5 man-hour was spent on scheduled maintenance, and no man-hours on unscheduled maintenance.

Dissolved Oxygen Analyzer

The following expenditures can be expected for 8 months of continuous operation for the Delta Scientific unit:

1) Sodium Sulfite	$ 10.00
2) Cobalt Chloride	8.00
3) Membrane Kit (1)	42.00
4) Electrolyte	15.00
5) D.O. Test Kit	25.00
Total =	$100.00

Recommended Spares:

1) Membrane Kit (3)

The overall life expectancy of the analyzer has yet to be determined. The only significant failure which took place was the electrode. Based on this it appears the electrode's life expectancy is 4 years.

During the course of the test period, 4.0 man-hours were spent on routine maintenance and 0.5 man-hour on unscheduled maintenance.

Chemiluminescence Biosensor

Since the biosensor is a prototype unit unique to the WMS, the major initial material cost figures are presented:

1)	Photometer (1)	$2,000.00
2)	Peristaltic Pumps (2)	1,046.00
3)	Chart Recorder (1)	700.00
4)	Teflon Valves (5)	600.00
5)	Air Solenoid Valves (6)	480.00
6)	Flow Meters (2)	100.00
7)	Tubing and Fittings	200.00
	Total =	$5,126.00

The following expenditures can be expected for 8 months of continuous operation:

1)	5- Amino- 2,3- dihydro- 1,4 - phthalazinediane (12 g)	$ 30.00
2)	Sodium Hydroxide (50%) (1 qt)	7.50
3)	Hydrogen Peroxide (30%) (1 pt)	11.00
4)	Carbon Monoxide (3 cylinders)	173.50
5)	Pump Tubes (4 pks)	10.00
6)	Solenoid Valves (2)	180.00
7)	Valve Bushings (4)	6.00
	Total =	$418.00

Recommended Spares:

1) Photomultiplier Tube (1)
2) Valve Bushings (8)
3) Teflon Valve (1)
4) Solenoid Valve (1)
5) Peristaltic Pump (1)

As there have been no major component failures, the life expectancy of the biosensor has yet to be determined.

During the course of the test period, 77.0 man-hours were spent on scheduled maintenance and 15.0 man-hours on unscheduled maintenance.

Coliform Detector

The estimated material cost for the breadboard detector is $5K.

The following expenditures can be expected for 8 months with one run a day:

1) Media (5.6 lbs)	$ 89.00
2) Platinum Electrodes (3)	255.00
3) Nitric Acid (2 pts)	45.00
4) Pump Tubes (5 pks)	33.50
5) Thermometers (5)	118.00
6) Thermistors (3)	61.00
7) Temperature Control Boards (2)	125.00
8) Electrolyte (6.6 pts)	40.00
Total =	$766.50

Recommended Spares:

1) Thermometers (5)
2) Electrodes (3)
3) Peristaltic Pump (1)
4) Teflon Valves (2)
5) Valve Bushings (10)
6) Valve Port Faces (10)
7) Solenoid Valves (2)

As yet the overall life expectancy of the coliform detector has not been determined. However, the apparent life expectancy of the electrodes appears to be 3 years. The life expectancy of the valve bushings and port faces is also 3 years.

During the course of the test period, 110.00 man-hours were spent on routine maintenance and 100.00 man-hours on unscheduled maintenance.

Gas Chromatograph

The initial cost of the WMS automated GC was $78K.

The following expenditures can be expected for 8 months of continuous operation:

1) Nitrogen Gas (2 cyl)	$130.00
2) Argon-methane Gas (3 cyl)	150.00
3) Chart Paper (4 boxes)	237.00
4) Printer Head (1)	100.00
5) Valve Bushings (2)	50.00
Total =	$667.00

Recommended Spares:

1) Preparative Column Prefilter (1)
2) Bendix Valve Bushings (2)
3) Analytical Column (1)

The useful life of the GC has yet to be determined. The instrumentation should last for many years; however, the analytical and preparative columns may require replacement more often.

During the course of the test period, 51.0 man-hours were spent on routine maintenance and 140.0 man-hours on unscheduled maintenance.

Deionized Water System

The following expenditures can be expected for 8 months of continuous operation:

1) Rogard Filters	$ 130.00
2) Carbon Filters	160.00
3) Ion-Exchange Filters	475.00
4) Reverse Osmosis Cartridge	550.00
5) Pump Impellers (3)	16.50
6) Sodium Hypochlorite	23.00
7) Chlorine Filter	16.00
Total =	$1370.50

Recommended Spares:

1) Pump Impellers (3)
2) Rogard Filters (8)
3) Carbon Filters (4)
4) Ion-Exchange Filters (8)

The useful life of the deionized water system has yet to be determined. The life expectancy of the various filters has varied significantly throughout the test period.

During the course of the test period, 10.0 man-hours were spent on routine maintenance and 3.5 man-hours on unscheduled maintenance.