FINE PORE DIFFUSER FOULING: THE LOS ANGELES STUDIES

by

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DISCLAIMER

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing, and managing research, development, and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs, and regulations of EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

As part of these activities, an EPA cooperative agreement was awarded to the American Society of Civil Engineers (ASCE) in 1985 to evaluate the existing data base on fine pore diffused aeration systems in both clean and process waters, conduct field studies at a number of municipal wastewater treatment facilities employing fine pore aeration, and prepare a comprehensive design manual on the subject. This manual, entitled "Design Manual - Fine Pore Aeration Systems," was completed in September 1989 and is available through EPA's Center for Environmental Research Information, Cincinnati, Ohio 45268 (EPA Report No. EPA/625-1-89/023). The field studies, carried out as contracts under the ASCE cooperative agreement, were designed to produce reliable information on the performance and operational requirements of fine pore devices under process conditions. These studies resulted in 16 separate contractor reports and provided critical input to the design manual. This report summarizes the results of one of the 16 field studies.

E. Timothy Oppelt, Director
Risk Reduction Engineering Laboratory

PREFACE

In 1985, the U.S. Environmental Protection Agency funded Cooperative Research Agreement CR812167 with the American Society of Civil Engineers to evaluate the existing data base on fine pore diffused aeration systems in both clean and process waters, conduct field studies at a number of municipal wastewater treatment facilities employing fine pore diffused aeration, and prepare a comprehensive design manual on the subject. This manual, entitled "Design Manual - Fine Pore Aeration Systems," was published in September 1989 (EPA Report No. EPA/725/1-89/023) and is available from the EPA Center for Environmental Research Information, Cincinnati, OH 45268.

As part of this project, contracts were awarded under the cooperative research agreement to conduct 16 field studies to provide technical input to the Design Manual. Each of these field studies resulted in a contractor report. In addition to quality assurance/quality control (QA/QC) data that may be included in these reports, comprehensive QA/QC information is contained in the Design Manual. A listing of these reports is presented below. All of the reports are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (Telephone: 703-487-4650).

1. "Fine Pore Diffuser System Evaluation for the Green Bay Metropolitan Sewerage District" (EPA/600/R-94/093) by J.J. Marx

2. "Oxygen Transfer Efficiency Surveys at the Jones Island Treatment Plants, 1985-1988" (EPA/600/R-94/094) by R. Warriner

3. "Fine Pore Diffuser Fouling: The Los Angeles Studies" (EPA/600/R-94/095) by M.K. Stenstrom and G. Masutani

4. "Oxygen Transfer Studies at the Madison Metropolitan Sewerage District Facilities" (EPA/600/R-94/096) by W.C. Boyle, A. Craven, W. Danley, and M. Rieth

5. "Long Term Performance Characteristics of Fine Pore Ceramic Diffusers at Monroe, Wisconsin" (EPA/600/R-94/097) by D.T. Redmon, L. Ewing, H. Melcer, and G.V. Ellefson

6. "Case History of Fine Pore Diffuser Retrofit at Ridgewood, New Jersey" (EPA/600/R-94/098) by J.A. Mueller and P.D. Saurer

7. "Oxygen Transfer Efficiency Surveys at the South Shore Wastewater Treatment Plant, 1985-1987" (EPA/600/R-94/099) by R. Warriner

8. "Fine Pore Diffuser Case History for Frankenmuth, Michigan" (EPA/600/R-94/100) by T.A. Allbaugh and S.J. Kang

9. "Off-gas Analysis Results and Fine Pore Retrofit Information for Glastonbury, Connecticut" (EPA/600/R-94/101) by R.G. Gilbert and R.C. Sullivan

10. "Off-Gas Analysis Results and Fine Pore Retrofit Case History for Hartford, Connecticut" (EPA/600/R-94/105) by R.G. Gilbert and R.C. Sullivan

11. "The Measurement and Control of Fouling in Fine Pore Diffuser Systems" (EPA/600/R-94/102) by E.L. Barnhart and M. Collins

12. "Fouling of Fine Pore Diffused Aerators: An Interplant Comparison" (EPA/600/R-94/103) by C.R. Baillod and K. Hopkins

13. "Case History Report on Milwaukee Ceramic Plate Aeration Facilities" (EPA/600/R-94/106) by L.A. Ernest

14. "Survey and Evaluation of Porous Polyethylene Media Fine Bubble Tube and Disk Aerators" (EPA/600/R-94/104) by D.H. Houck

15. "Investigations into Biofouling Phenomena in Fine Pore Aeration Devices" (EPA/600/R-94/107) by W. Jansen, J.W. Costerton, and H. Melcer

16. "Characterization of Clean and Fouled Perforated Membrane Diffusers" (EPA/600/R-94/108) by Ewing Engineering Co.

ABSTRACT

This report describes five fine pore diffuser evaluations conducted at three different wastewater treatment plants located in the greater Los Angeles area. The overall goal of the study was to evaluate the performance of fine pore diffusers using selected cleaning methods for extended periods of time at selected treatment plants.

The major part of this study was conducted at the Whittier Narrows Water Reclamation Plant, which is operated by the Los Angeles County Sanitation Districts. This study evaluated fine pore ceramic disk and dome aeration systems using Hcl acid gas cleaning and a dome aeration systems without acid gas cleaning over a 25-month period. A second study, smaller in scope and effort, was conducted at the Valencia Water Reclamation Plant (also operated by the Districts). This study evaluated fine pore plastic disk diffusers over a 13-month period. A third study, also smaller in scope and effort than the Whittier Narrows study, was conducted at the Terminal Island Wastewater Treatment Plant, operated by the City of Los Angeles. In this study, the performance of two membrane tube diffusers was evaluated over a 12-month period.

This report summarizes the performance of six different aeration systems. The principal indicator of performance was oxygen transfer efficiency, as measured through off-gas analysis. For the Whittier Narrows study, changes in diffuser characteristics are also reported.

The fine pore ceramic disk aeration system that was acid gas cleaned performed better than the ceramic dome systems that were acid gas cleaned as well as the control dome aeration system that received no cleaning. Part of the differences in performance between the disk system and the two dome systems is attributable to mechanical problems with the domes. The cleaned and uncleaned dome systems had comparable transfer efficiencies during the study. Results for plastic disk system showed relatively consistent performance over the 13-month period. The tube systems showed high variability due to operational differences, and one tube system showed significant fouling over a relatively brief period. An important finding of this report is the variability of aeration systems performance during day-to-day changes in plant input and operating modes.

This report was submitted in partial fulfillment of Cooperative Agreement No. CR812167 by the American Society of Civil Engineers under subcontract to the University of California, Los Angeles under the partial sponsorship of the U.S. Environmental Protection Agency. The work reported herein was conducted over the period of 1986-1988.

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ACKNOWLEDGMENTS

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The active participation of the Steering Subcommittee of the ASCE Committee on Oxygen Transfer, chaired by Hugh J. Campbell, Jr. was especially important. Professor H. David Stensel of the University of Washington served as ASCE's project monitor. Mr. Richard C. Brenner of the US EPA's Risk Reduction Engineering Laboratory in Cincinati, Ohio served as the EPA project monitor.

The manufactures cited in this report donated their time and effort to helping us. Mr. Jerry Wren of Sanitaire was especially helpful by providing the acid gas cleaning expertise, and operating the acid control panel during cleaning.

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INTRODUCTION

The increased interest in energy conservation in the late 1970's created a new market for high efficiency, energy conserving aeration systems for wastewater treatment plants. Most of the high efficiency aeration systems are some form of fine bubble (≤ 2 mm mean bubble diameter), subsurface diffusers.

Clean water efficiencies of high efficiency diffuser systems were previously investigated in an EPA sponsored study (Yunt and Hancuff, 1983). This study showed that full floor coverage ceramic grid systems are capable of transferring in clean water in excess of 4.3 kg/kW-hr (7 lb O_2/hp power; unless otherwise noted, power number will always refer to wire power). These rates are more than twice the clean water transfer rates obtained in many alternative aeration systems.

Unfortunately, fine pore diffuser systems have several operational disadvantages which reduce their efficiency. The first effect is reduced process water transfer efficiency due to coalescence and depressed film coefficients caused by surface active agents (surfactants) such as detergents, volatile acids, and biologically produced polymers. This phenomena is not limited to fine pore diffusers but seems to impact them more severely than other aeration systems. The second effect is diffuser fouling and plugging caused by the precipitation of inorganic salts, growth of biological slime on the diffuser surface. The third effect is air side fouling from contaminants in the air supply or from liquid contaminants that find their way into the air distribution system because of mechanical failures. All three phenomena cause problems, such as increased pressure drop across the diffuser or coalescence of bubbles as they leave the surface of the diffusers, with a net result of reducing aeration efficiency.

Prior to initiation of this series of research projects, the suppression of aeration efficiency due to surfactants and other contaminants was empirically known and calculated through a coefficient called an "alpha factor (α)." Alpha factors for fine bubble diffusers have been reviewed (Stenstrom and Gilbert, 1981) and studied in process water (Hwang and Stenstrom, 1985; Doyle and Boyle, 1986) for clean, well maintained diffusers. Prediction and measuring techniques for fine bubble diffusers under these conditions have been developed and verified using near full-scale equipment.

The objective of this research, and its sister projects, is to quantify the decrease in aeration efficiency due to fouling and plugging, and in certain cases, to evaluate cleaning techniques. This report addresses three studies performed in the Los Angeles area by UCLA with cooperation of the Los Angeles County Sanitation Districts (Districts) and Bureau of Sanitation of the City of Los Angeles (City).

These investigations were performed with differing goals and levels of effort. The principal study was conducted at the Whittier Narrows Water Reclamation Plant (WNWRP) in Whittier, California. This plant is operated by the Districts and is one of their "upstream" facilities. It treats a relatively constant flow rate (13 MGD), since the diurnal fluctuations in flow rate are passed onto the "downstream" facility, the Joint Water Pollution Control Plant (JWPCP) at Carson. Waste activated sludge, primary sludge, skimmings, and filter backwash sludge are returned to the trunk sewer for treatment at the JWPCP. A portion of the effluent from Whittier Narrows is used for groundwater recharge. The remaining effluent is discharged to the San

Gabriel River for ocean disposal. Industrial discharge to the plant is closely monitored and controlled through Districts' industrial pretreatment and compliance monitoring program.

The goal of the Whittier Narrows project was to evaluate long term fouling of disk and ceramic dome diffusers, and the effectiveness of a patented, in-situ gas cleaning technique (Schmit, et al. (1983). The study was initiated in April 1986 and continued until July 1988. Two ceramic dome diffuser aeration systems (Norton, now Aercor, 0.19m diameter, 3.8 cm high) and one ceramic disk diffuser aeration system (Sanitaire, 0.23 m diameter, 2.54 cm thick disks) were tested. One ceramic dome system served as a control and was not cleaned. The other two systems were periodically cleaned with HCl gas.

The second investigation was performed at the Districts' Valencia Water Reclamation Plant in Valencia, CA. Valencia is north of Los Angeles and is not part of the network of sewers which connect the upstream plants and JWPCP. The Valencia WRP has sludge handling facilities, and treats a diurnally varying wastewater flow (6.4 MGD for the portion of the plant studied in this project). The industrial pretreatment program is in effect for this plant.

The goal of the Valencia study was to monitor the efficiency of plastic disk diffusers (0.18 m Nokia disks) over a period of time to observe fouling and decline in aeration efficiency. The study was begun in June 1987 and continued until March 1988. One aeration tank which had been baffled into three compartments was monitored. The tank was operated in a step feed mode approaching contact stabilization.

The third study was conducted at the Terminal Island Treatment Plant at Terminal Island, CA. This plant is operated by the City and is not part of a network of plants. It treats a diurnally varying wastewater flow rate (21 MGD) and has a significant wastewater contribution from fish canning (40% mass load) and pretreated petroleum refinery wastewater (15% mass load). The plant has sludge handling facilities, and anaerobic digester supernatant is periodically returned to the plant influent. Three tanks were initially used in this study. Two aeration tanks were retrofitted with membrane diffusers. A third tank, with coarse bubble spiral roll diffusers (Chicago Pump, Discfusers), was used as a control.

The first tank was fitted with a full-floor coverage membrane tube (Parkson-Wyss) diffuser. Two air laterals were bolted to each swing arm and spanned the tank width. Diffusers were installed on each lateral to provide near full-floor coverage. A second tank was used as a control and was equipped with "Discfusers" spargers (Chicago Pump) mounted on swing arms. These diffusers existed prior to the study. The third tank was equipped with membrane diffusers (Aertec AERMAX). These diffusers were installed on each swing arm in lieu of the spargers that were previously installed. The goal of this study was to monitor fouling and aeration efficiency. The study was begun in June 1987 and continued until June 1988.

All three plants were periodically monitored with off-gas (Redmon, et al. 1983) oxygen transfer testing. Diffusers from the Whittier Narrows WRP were occasionally sampled for analysis to determine dynamic wet pressure, bubble release volume, and mass of fouling material. A test header containing four disk diffusers was also installed at the Whittier Narrows WRP.

The next chapter describes each plant. Following chapters describe the experimental procedures, experimental results, and effects of process operation on oxygen transfer. Appendix I shows a sample data sheet used in off-gas testing. Appendix II contains the raw diffuser data for Whittier Narrows. Appendix III contains the process data for each plant, averaged by month and averaged over the entire period of observation. Appendix IV contains the average values of all the off-gas results for all plants. Appendix V contains schematic diagrams of several of the diffusers.

PLANT DESCRIPTIONS

This section provides plant-specific information for each study. Plant operating data for each facility are summarized in Appendix III. Note that several parameters changed during the study due to plant upgrades or operational difficulties. In general every attempt was made to maintain constant plant operation. Figure 1 shows the approximate plant locations.

WHITTIER NARROWS

The Whittier Narrows WRP is a full secondary treatment facility with primary clarification, aeration, secondary clarification, filtration, chlorination and dechlorination. The plant is located 38 km inland from the Pacific Ocean. It is operated by the Los Angeles County Sanitation Districts which operates ten other plants in Los Angeles County.

The topology of the Los Angeles Tank is such that long trunk sewers can be operated without pump stations from the inland areas to the JWPCP in Carson. Wastewater flows by gravity from the Whittier Narrows area over 32 km to JWPCP. As growth has occurred the Districts have added treatment capacity at its up-stream plants such as Whittier Narrows. This fortuitous situation allows growth without increasing the size of the trunk sewers, which currently operate at near capacity, and allows the District to concentrate its solids processing facilities at JWPCP. The upstream plants also help to meet the water reclamation needs of the various communities. The Whittier Narrows, San Jose Creek, Long Beach, Los Coyotes, and Pomona water reclamation plants all operate in this fashion.

In addition to solids handling facility design, the unique sewer arrangement provides additional operation freedom to these upstream plants. For example, the flow rate at the Whittier Narrows WRP is set relatively constant and the plant is less disturbed by the diurnal fluctuations in wastewater flow rate. Furthermore, tank maintenance at the Districts' various WRPs can be performed much more easily since a temporary shortfall in capacity at one plant can be treated by another plant.

The Whittier Narrows WRP provides reclaimed water water for various purposes, including groundwater recharge, which requires the plant to produce better than average secondary effluent. Health Department regulations require the plant to meet a turbidity limit 2 NTU or less, and a total coliform limit of 2.2 MPN or less.

Both the Districts' and the City's storm and sanitary sewers are separated. The impacts of stormwater flow on the Whittier Narrows WRP are small compared to plants with combined sewers. There is additional flow during the rainy season (Winter) and for this reason operational flexibility is more limited during these periods.

The Whittier Narrows plant was the location of an early study comparing ceramic disk diffusers, fine bubble tube diffusers, and jet aerators. The disk system used in this study (tank 1) was installed in December 1980, and was the same as used previously. The disks installed at this plant are 2.5 cm thick and are different than the current Sanitaire disk, which is only 1.9 cm thick. The manufacturer reports that the new disks are otherwise identical to the disks used at Whittier Narrows. Both the tube and jet system were replaced with ceramic dome diffusers at the conclusion of the previous study (Yunt and Stenstrom, 1990). Tanks 2 and 3 were placed in

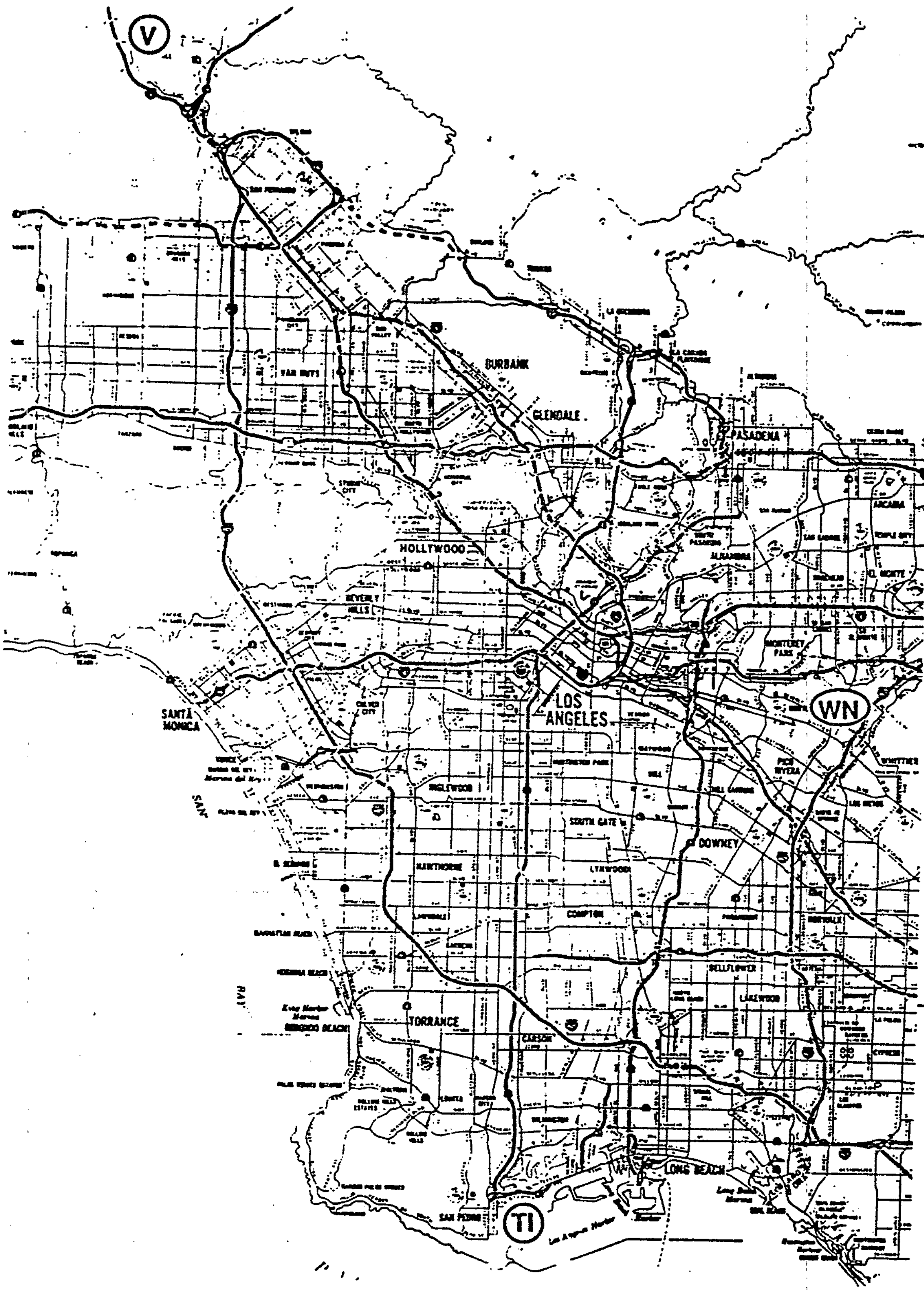

Figure 1 Plant Locations

service in March and May 1982. The disk and domes had a dry permeability rating of 8.2 to 8.8 m^3/hr (14-15 SCFM).

The critical dimensions of the plant are shown in Tables 1 and 2. Figure 2 shows the process flow and Figure 3 shows the aeration system and air piping. The domes in the two Norton tanks were replaced in September and October 1987. The tapering was changed at this time, and the number of domes were reduced in grid 1 and increased in grid 3. The dissolved oxygen concentration (DO) is automatically controlled. DO probes are located at the effluent end of each aeration tank. Changes in air flow rate are affected by changing the blower operation, which simultaneously increases or decreases the air flow to all three aeration tanks.

VALENCIA

The Valencia WRP is located approximately 60 km north of downtown Los Angeles. As indicated previously, it is not part of the network of sewers that connect the upstream plants to JWPCP. It has anaerobic digestion facilities. It has a unique tank geometry relative to other tanks within the District. The tanks are approximately half as long as tanks at other District plants. Each tank at the time of this study contained only two diffuser grids equipped with 0.18 m (7.3") Nokia disks. The disks were nominally 10.2 ± 0.3 mm thick and were composed of sintered polyethleyene. The dry permeability of the disks was 12.3 m^3/hr (21 SCFM). The Districts expanded this plant in 1986 and it was converted to fine pore aeration. Existing baffles were also removed from the aeration tanks. After modification a total of five aeration tanks were in service, with all five operating in single pass mode.

Unfortunately trouble was experienced with the early operation of the expanded and retrofitted plant. Sludge bulking problems occurred. It was concluded that the operational problems were associated with backmixing in the short aeration tanks. The Districts believed that the differential air flow rates through the two grids created a rolling action from the front to back of the tank that destroyed the "plug flow" nature of the tank, creating a more completely mixed plant.

To remedy this problem three of the five tanks were placed in series (serpentine) flow pattern and operated in a step feed mode approaching contact stabilization. Since it was not possible to operate the remaining two tanks in this fashion, they were modified by constructing two wooden baffles across each tank. The tanks were divided into three compartments each, and were also operated in the step feed mode. Plans have been made to further modify the plant and construction of a sixth aeration tank is contemplated.

All tests were conducted in the fourth aeration tank which was one of the single pass tanks. Six hood positions were used. The first position was located in the first compartment in the reaeration zone. The other five hood positions were located in the contact and effluent zones. Tables 3 and 4 show the plant's critical dimensions and diffuser layout. Figure 4 shows the aeration system layout. Grids 1 and 2 have designated half grids 1A/1B and 2A/2B, respectively. Half-grids are served by only one downcomer. The grids are designated this way because the diffuser spacing is different in each half-grid.

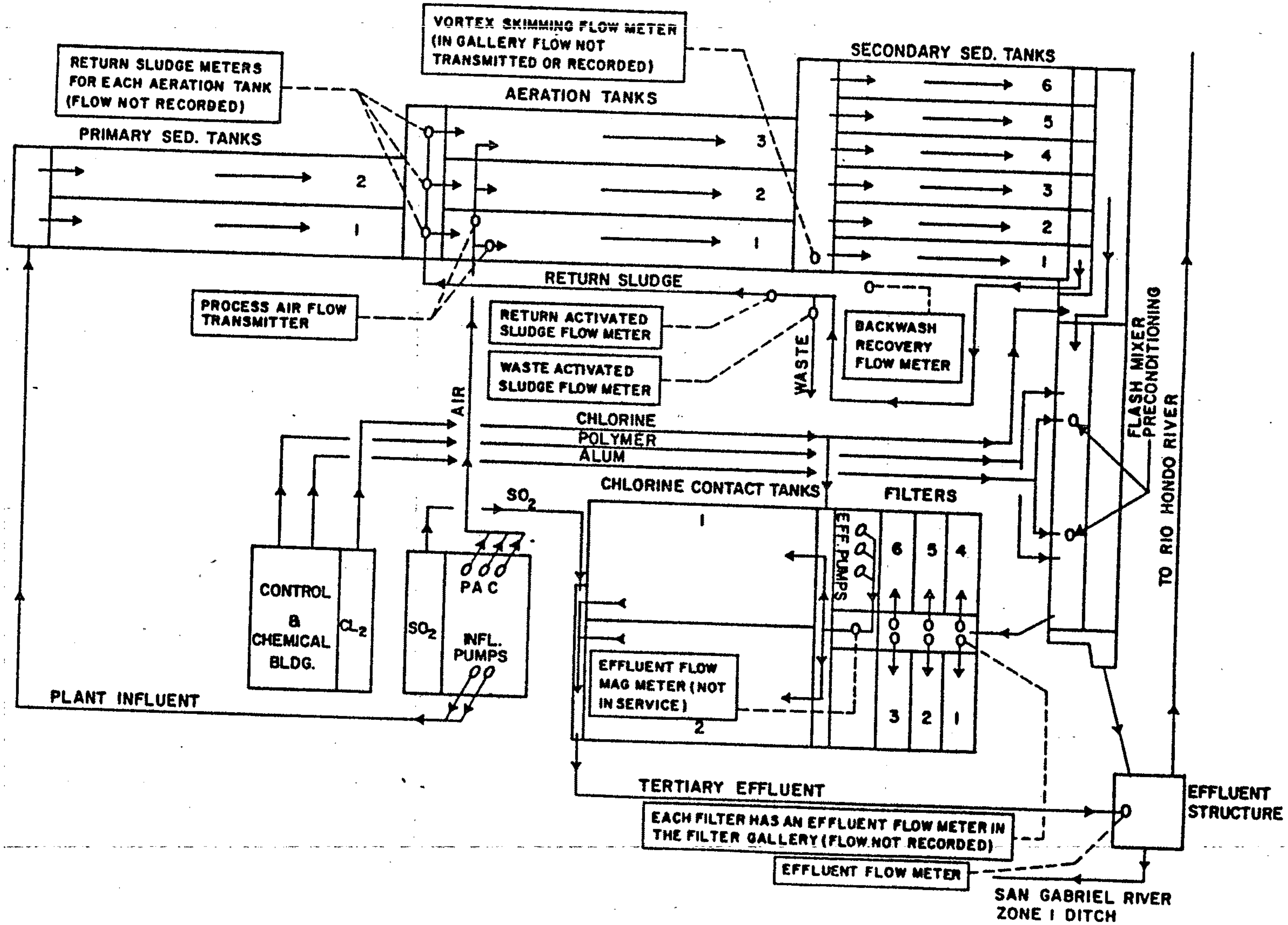

Figure 2 Whittier Narrows WRP Process Flow

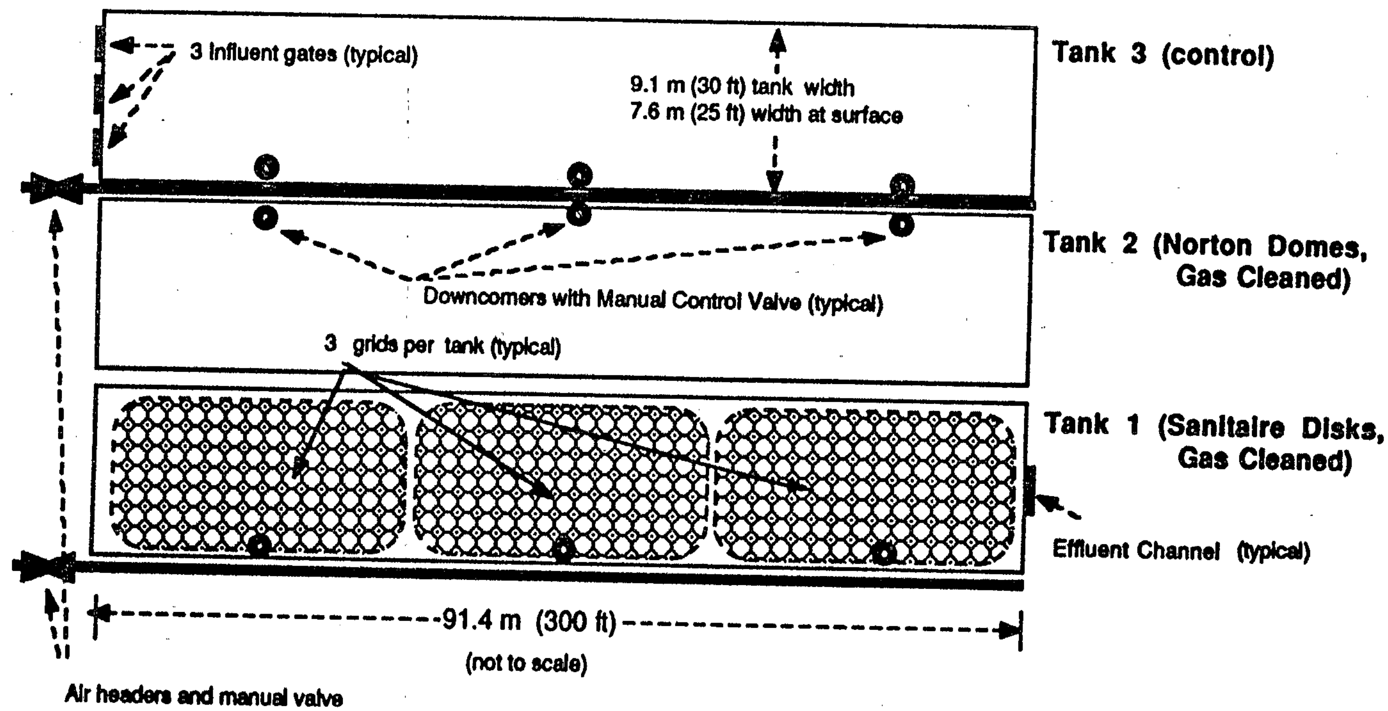

Figure 3 Whittier Narrows WRP Tank Schematic

Table 1. Whittier Narrows Plant Description

	Number	Nominal Size
Primary Clarifiers	2	3.7 sidewater depth (swd) x 6.1 w x 91.4 l meters (12 swd x 20 w x 300 l feet)
Aeration Tanks	3	4.6 swd x 9.1 w x 91.4 l meters (15 swd x 30 w x 300 l feet)
Secondary Clarifiers	6	3.0 swd x 6.1 w x 45.7 l meters (10 swd x 20 w x 150 l feet) (1 clarifier normally used for backwash recovery)
Normal Operation	3	aeration tanks in parallel, conventional activated sludge with tapered aerations. Provisions for step feed and series operation of all 3 tanks
	5	secondary clarifiers
	2	primary clarifiers
Air Filtration	1	two stage, replaceable paper cartridge filters (not functional 4/86 - 9/87)+
Blowers	2	20,400 m^3/hr centrifugal (12,000 SCFM)
	1	9,300 m^3/hr centrifugal (5,500 SCFM)
Diffuser Grids Per Tank	3	Flow control for each grid and each tanks, automatic DO control. 1 probe located at the end of each tank
Design Flow Rate		57 m^3/day (15 MGD)

\+ The air filters had been out of service for an unknown period, perhaps as much as 2 years, prior to the beginning of this study.

Table 2. Whittier Narrows Diffuser Information

Tank	Grid	Description
1 (Sanitaire disks)	1	792 disks (0.23 m or 9 in. diameter) 2.8 disk/m^2 (0.264 disk/ft^2)
	2	774 disks 2.8 disk/m^2 (0.258 disk/ft^2)
	3	460 disks 1.7 disk/m^2 (0.153 disk/ft^2) 900 domes tank 2, 985 tank 3
2 & 3 (Norton domes)	1	prior to 8/21/87, 990 domes 0.18 m (7 in) domes 3.6 domes/m^2 (0.33 dome/ft^2) (0.18 m or 7 in. diameter) after 8/21/87, 836 domes, 3.00 dome/m^2, (0.28 dome/ft^2)
	2	968 domes 3.5 disk/m^2 (0.32 dome/ft^2)
	3	574 domes 2.1 disk/m^2 (0.19 dome/ft^2) after 8/21/87, 728 domes, 2.61 domes/m^2 (0.24 dome/ft^2)
1,2,3	All	3.75 m (12.3 ft) diffuser submergence

Table 3. Valencia Treatment Plant Description

	Number	Nominal Size
Primary Clarifiers	5	3.5 swd x 6.1 w x 19.8 l meters (11.4 swd x 20 w x 65 l feet)
Aeration Tanks	5	4.6 swd x 8.1 w x 41.4 l meters, 3.96 m diffuser submergence (15 swd x 26.5 w x 135 l feet, 13 feet diffuser submergence)
Normal Operation	3	serpentine flow operating as a single contact stabilization process
	2	baffled in three compartments, operating in parallel in contact stabilization model
Secondary Clarifiers	6	3.0 swd x 4.9 w x 41.1 l meters (10 swd x 16 w x 135 l feet)
Air Filtration	2	two-stage replaceable paper cartridge filters
Blowers	2	15,500 m^3/hr Roots centrifugal (9,150 SCFM)
	2	6,100 m^3/hr Sutor-bilt Positive Displacement (3,600 SCFM)
	1	1700 m^3/hr Sutor-built Positive Displacement (1000 SCFM)
Diffuser Grids/Tank	2	flow control for each grid and each tank

Table 4. Valencia Diffuser Layout*

Half–Grid+	Description
1A	343 disk 4.1 disk/m^2 (0.38 disk/ft^2)
1B	288 disks 3.4 disk/m^2 (0.32 disk/ft^2)
2A	262 disks 3.1 disk/m^2 (0.29 disk/ft^2)
2B	205 disks 2.5 disk/m^2 (0.23 disk/ft^2)
Zone	
1	reaeration - 257 disks (257 from grid 1A)
2	contact 466 disks (86 from grid 1A, 288 from grid 1B, 92 from 2A)
3	375 disks (170 from grid 2A, 205 from grid 2B)

* Only Tank 4 tested
\+ One downcomer serves half-grids 1A & 1B, and a second downcomer serves half-grids 2A & 2B.

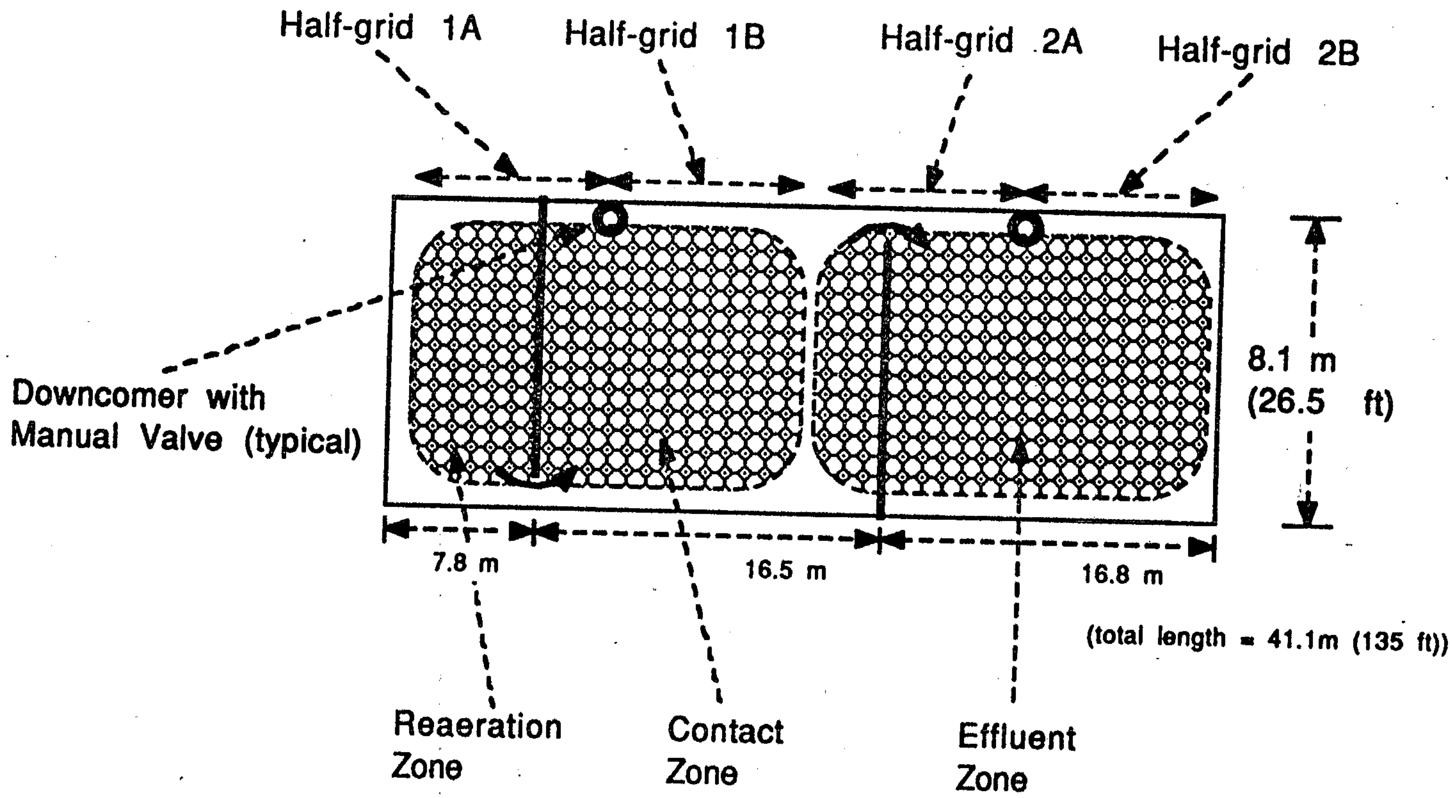

Figure 4 Valencia WRP Tank Schematic

TERMINAL ISLAND

The Terminal Island (TI) study was initiated last among the three studies. It began in June 1987 and continued until July 1988. This study was initially proposed to evaluate a low cost aeration system upgrade. Parkson-Wyss diffusers were to be placed on swing arms. This was the least expensive upgrade alternative for this plant and could serve as a "model" low cost upgrade for other plants using spiral roll, sparged aeration systems.

In early 1988 Parkson changed the design of the aeration system from a simple swing arm installation to a full floor coverage installation. Two headers were attached to the bottom of each swing arm perpendicular to the tank walls. This was a much more expensive installation and was contrary to the goals of the study. Fortunately the plant purchased a second membrane aeration system, which was supplied by Aertec. The system was comprised of 770 AERMAX diffusers which were attached to the swing arms. In this way the initial goal of obtaining an inexpensive fine pore diffuser upgrade was obtained.

Tables 5, 6, and 7 show the critical dimensions of the TI tanks. Figure 5 shows the tank and aeration system. The tanks being tested are numbered 4, 5, and 6 using the plant's terminology. The Parkson-Wyss tank was tank 4 and the AERMAX tank was tank 6. Tank 5 was unmodified and served as a control tank. Tank 5 was equipped with Chicago Pump "Discfusers" in a spiral roll configuration.

The diffuser mounting of both the Parkson-Wyss and AERMAX diffusers were novel. For the Parkson-Wyss, two PVC headers were attached to the ends of a pipe mounted in place of the horizontal diffuser holder on the swing arm. The PVC header was supported from the tank floor by a PVC pipe functioning as a vertical brace. The vertical brace was secured to the floor with a floor flange. It was necessary to compensate for the increased head loss through the diffuser by decreasing its submergence. This was necessary because the plant continued to operate several sparged spiral roll tanks, making it impossible to increase the air system pressure. To increase the elevation of the diffusers a saddle was placed over the PVC header at each location where diffusers were to be located. A vertical nippled extended from the saddle to the tee roughly 0.3 m above the PVC header. Two Parkson-Wyss diffusers were mounted from the tee, perpendicular to the PVC header. The manifolds did not extend completely across the tank floor; a gap was left between the wall and the end of the manifolds to allow maintenance personnel to walk in the tank without having to step over the manifolds. This created non-uniform air flux across the tank and required more careful hood placements, which is discussed later in the report.

To mount the AERMAX diffusers the horizontal sparger tube of the swing arm was removed and rotated 90°. This was facilitated because the particular swing arm design used flanges to connect the horizontal member to the vertical downcomer. After rotation the bosses that were previously used for mounting the spargers were vertical. The lower bosses were plugged and a nipple was inserted into the upper bosses. A tee was fastened to the top of each nipple and two AERMAX diffusers were mounted. One diffuser pointed toward the center of the tank and the other pointed toward the tank wall. A mistake was made in specifying the diffuser length on the tank wall side. In order to not delay the project and avoid the expense of shortening the diffusers, the tees attached to the nipples were rotated so that they were approximately 60° with the wall. This allowed the 0.61 m length diffusers to be used on the inside of the swing

Table 5. Terminal Island Plant Description

	Number	Nominal Size
Primary Clarifiers	6	3.66 swd x 6.1 w x 76.2 l meters (12 swd x 20 w x 250 l feet)
Aeration Tanks	9	4.6 swd x 9.1 w x 91.4 l meters (15 swd x 30 w x 300 l feet)
Normal Operation	3	serpentine operation of 3 each in step feed mode
	2	parallel, conventional operation
	1	aerobic digester
	3	out of service
Secondary Clarifiers	18	3.66 swd x 6.1 w x 45.7 l meters (12 swd x 20 w x 150 l feet)
Air Filtration	3	coarse screens only
Blowers	3	66,300 m^3/hr Roots centrifugal (39,000 SCFM)
Grids per tank	N/A	Diffusers attached to swing arms, 17 per tank
Design flow rate		114,000 m^3/day (30 MGD)

Table 6. Terminal Island - Parkson-Wyss Tank*

Zone	Description
1	6 downcomers+, 0.25 m spacing (10") 530 diffusers
2	6 downcomers, 0.30 m spacing (12") 300 diffusers
3	5 downcomers, 0.46 m spacing (18") 170 diffusers
Total	17 downcomers, 1000 diffusers

* TI Tank 4

\+ Downcomer refers to the vertical part of the old swing arms. Each downcomer is equipped with a plug valve. Approximately 3.6 m (12 ft) diffuser submergence.

Table 7. Terminal Island AERMAX Tank*

Zone	Description
1	9 downcomers+, 0.15 m spacing (6") 270 0.61 m diffusers, 270 0.91 m diffusers
2	5 downcomers, 0.30 m spacing (12") 82 0.61m diffusers, 82 0.91 m diffusers
3	3 downcomers, 0.46 m spacing (18") 32 0.61 m diffusers, 32 0.91 m diffusers
Total	17 downcomers, 770 diffusers

* TI Tank 6.

\+ Downcomer refers to the vertical part of the old swing arms. Each downcomer is equipped with a plug valve. Approximately 4.1 m diffuser submergence.

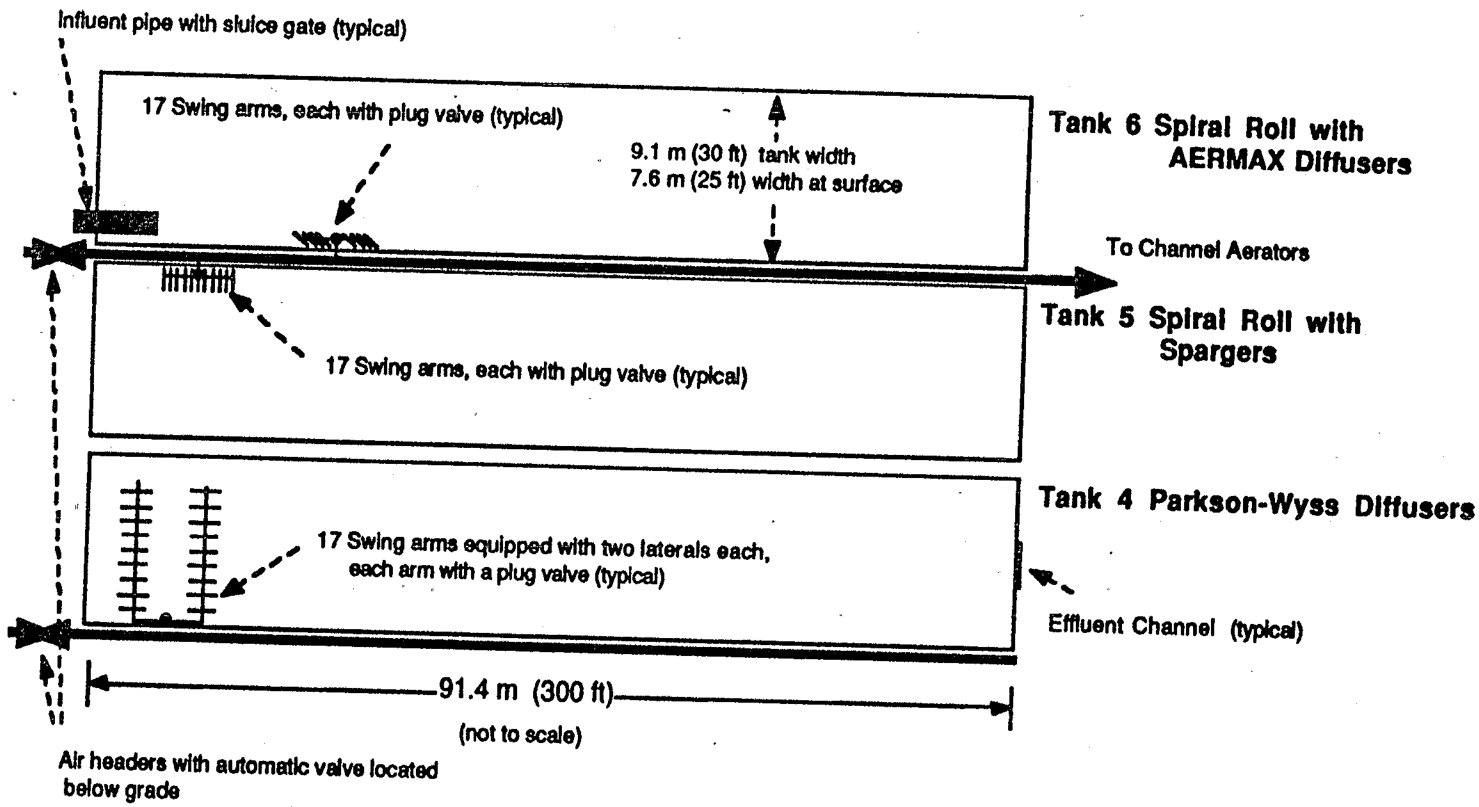

Figure 5 Terminal Island Tank Schematic

arm.

There was very little flow rate control and instrumentation associated with the TI installation, which is consistent with its "low cost" objective. Tank air flow rate was controlled by a single valve for tank 4 and a single valve for tanks 5, 6, and the intrachannel aeration system. Each downcomer retained the plug valve which was installed with the spiral roll sparger system. Using these plug valves it was possible to modulate the flow to each swing arm. However, flow control was very imprecise; a small, almost imperceptible movement in the plug valve would significantly alter the downcomer flow rate. It was intended that all downcomers for both test tanks would always be operated at maximum flow rate; however, this was never practically achieved, and differences in diffuser gas flow rate were detected during off-gas testing. It was not possible to achieve a uniform, tapered gas flow rate.

The two header valves and the blower system were remotely controlled. The operators would turn up the plant air as the load increased during the morning. This increase was detected during the first episode of off-gas testing, and later testing was begun later in the morning to avoid the scatter in aeration rates caused by this flow rate increase.

A large fraction of the TI influent is industrial waste. Approximately 30% of the influent flow is fish cannery wastewater, which accounts for 40% of the plant's BOD loading rate. The waste is seasonal and usually the highest plant loads occur in October. Approximately 25% of the flow and 15% of BOD load is pretreated petroleum refinery effluent. Both industrial waste streams severely impact plant operations from time-to-time. Corrosion is excessive and plant personnel attribute this in part to reduced sulfur compounds in the refinery effluent.

The plant experiences routine foaming problems and sludge settling problems. Antifoam is stocked and frequently used. It is introduced into the primary effluent distribution headers by "cracking" a valve on a plastic storage tank. During the testing antifoam was used. Antifoam has been shown to reduce oxygen transfer rates (Downing, et al. 1960).

Plant operation was changed during the study. At the beginning of the study only five tanks were in service. All five tanks were operated as single aeration systems in conventional mode. Midway through the study the plant manager decided to change operation from conventional to step feed. Therefore tank 5 was removed from service, and tank 3 was returned to service, allowing tanks 1, 2, and 3 to be placed in series (serpentine flow).

This change affected the study in two ways. The return sludges were mixed, which meant that sludge from a conventional system was being mixed with sludge from a step feed system. No impact of this change could be observed on αSOTE. A severe impact on tanks 4 and 6 (the diffuser test tanks) was created by the flow change. More than two months elapsed before the sluice gates controlling the flow to the tanks were readjusted for proper distribution. During this time both tanks 4 and 6 were overloaded. Flow measurements were unavailable to quantify the loading.

Air flow rates in both tanks were increased to account for the overload. The Parkson-Wyss system responded well and air flow rates increased sufficiently to keep positive dissolved oxygen (DO). During this time the air flow rate was 50 to 100% greater than the manufacturer's maximum recommended flow rate. This increased flow was possible in part because tank 4 had its own air header. Increasing flow to this tank did not perturb the other tanks. During the upset (approximately 2 months) the flow rate was temporarily increased to as much as 15 m^3/diff-hr (9 SCFM/diffuser).

The AERMAX tank was operated at a depressed DO concentration during this period. The tank effluent DO was frequently less than 0.5 mg/L. The inability to increase the air flow rate resulted in part because the tank shared its air header with tank 5. The in-channel aeration system was also fed by this air header. It was impossible to increase the air flow rate to the AERMAX tank beyond about 5.1 m^3/diff-hr (3 SCFM/diffusers).

PROCESS DATA

Process data were collected from each plant. Data from the Valencia and Whittier WRPs are stored in a mainframe computer maintained by the Districts. Tapes containing the data were collected twice during the study and converted (SAS, 1982) format at UCLA. Data from TI were stored using PC-DOS spreadsheets. These were collected monthly and converted to SAS format. Appendix III summarizes the process data.

At Whittier Narrows it was necessary to calculate several variables from the raw data provided by the Districts. The Districts calculates two sludge age parameters: mean cell residence time (MCRT), and average mean cell residence time (MCRTA). The Districts believes that total system solids affect the growth kinetics of the treatment system. Therefore, they include the biological solids contained in the secondary clarifiers in their computation of sludge mass. Their procedure assumes that the entire secondary clarifier volume is at the same solids concentration as the effluent from the aeration tanks.

The authors believe that the Districts procedure overestimates the true sludge age, and calculated a solids retention time (SRT) which did not include clarifier solids. The SRT calculated is usually 5 to 10% less than the MCRT calculated by the Districts. This calculation also ignores the effluent suspended solids. The MCRTA calculated by the Districts is "smoothed" by using a three day running average of the mass of solids under aeration and the waste solids mass. The MCRTA does not show the large fluctuations observed in SRT or MCRT.

Food-to-Mass ratios (F/M) were also calculated from the Districts' raw plant data. F/M was calculated on the basis of both primary effluent BOD_5 and COD and mixed liquor volatile suspended solids (MLVSS). Clarifier solids were ignored in these calculations. Generally there were only five BOD_5 analysis per month which is too few to use in this analysis. Therefore, an F/M ratio based on primary effluent COD, which was measured daily, was used in this analysis. It is not the intent of this report to examine the differences between MCRT calculation procedures. Both are provided in the Appendix.

EXPERIMENTAL PROCEDURES

Off-gas testing was performed at all three plants using a Mark IV Aerator Rator purchased from Ewing Engineering. The procedures were similar to those described previously (Redmon, et al. 1983). CO_2 was measured using an absorption cell (Orsat). Sample off-gas was dried with silica gel and water vapor measurements were not performed.

Three hoods were used at Whittier Narrows and Terminal Island. Only one hood was used at Valencia. Three hoods were constructed of PVC pipe prior to the start of all studies and were used at Whittier Narrows until April 1987. After April these three PVC hoods were moved to Terminal Island. Three new hoods constructed from custom formed Fiberglas-epoxy reinforced foam in the spring of 1987. Beginning in May two of these new hoods were used at Whittier Narrows in tanks 2 and 3. An older hood fabricated from Fiberglas pipe was used in tank 1. This hood had been constructed by Districts and UCLA personnel in the previous (Yunt and Stenstrom, 1990).

The hoods were located in each tank in order to sample a representative surface area. The protocol initially adopted by all the contractors associated with the various projects funded in this study required off-gas sampling of at least 2 % of the tank area. For this study approximately 7 to 9 % were sampled at each plant. Figure 6 shows the hood locations at Whittier Narrows. Two locations were used at each point along the tank length. One location was next to the tank wall and the other location was centered between the two tank walls. Three locations were evaluated in testing prior to the initiation of this project were found to be unnecessary. Figure 7 shows the hood locations at Valencia. Two locations per point were used. Figure 8 shows the hood locations for Terminal Island. The nature of the aeration systems required three hood locations at each point in order to obtain a representative sample. A total of sample points along the tank length were used at Terminal Island for all three aeration systems.

The PVC and Fiberglas pipe constructed hoods were 3m long by 0.61 m wide (10 ft x 2 ft). They were equipped with 0.2 m diameter (8 inch) outrigger pontoons for flotation. The ends were also angled so that a tight seal could be made with the tank walls. The Fiberglas-epoxy reinforced foam hoods were slightly larger, measuring 3 m long by 0.71 m wide (10 ft x 28 inches). They were also constructed with angled ends to allow a tight seal with tank walls.

The angled ends were expensive to produce and in retrospect were not necessary to test the ceramic or plastic grid system. For the spiral roll systems they were essential. A small, 2 cm gap between the tank wall and hood can easily reduce recovered gas flow rate by 30% or more in a spiral roll system. Since the spiral roll testing always required three hood positions and flow weight averaging of SOTE, a small gap in the hood position above the swing arm might create 20 to 30% overestimation in oxygen transfer efficiency.

Hoods were connected to the off-gas analyzer with a 4 cm diameter, flexible vacuum cleaner hose. In the case of Whittier Narrows and Terminal Island, the hoods closest to the analyzer were connected with 15 m hoses. For the hood on the tank not adjacent to the analyzer, two 15 m lengths were spliced together to create a 30 m hose.

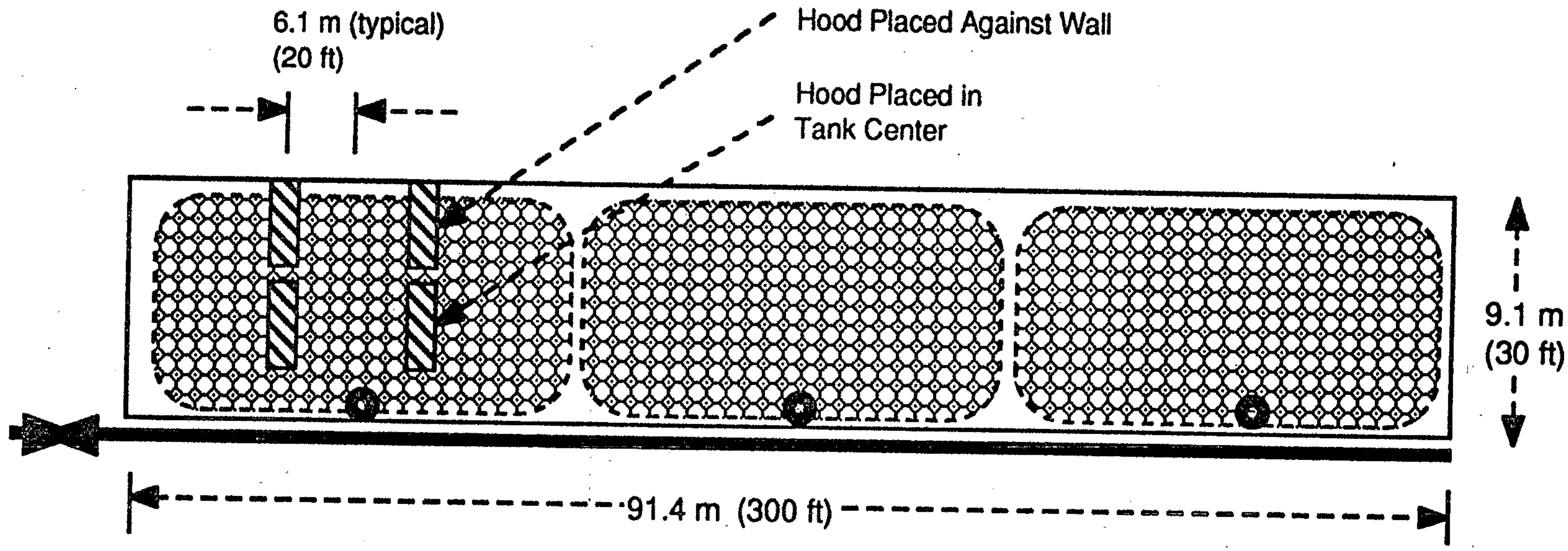

Figure 6 Whittier Narrows Off-gas Hood Locations (4 of 12 shown)

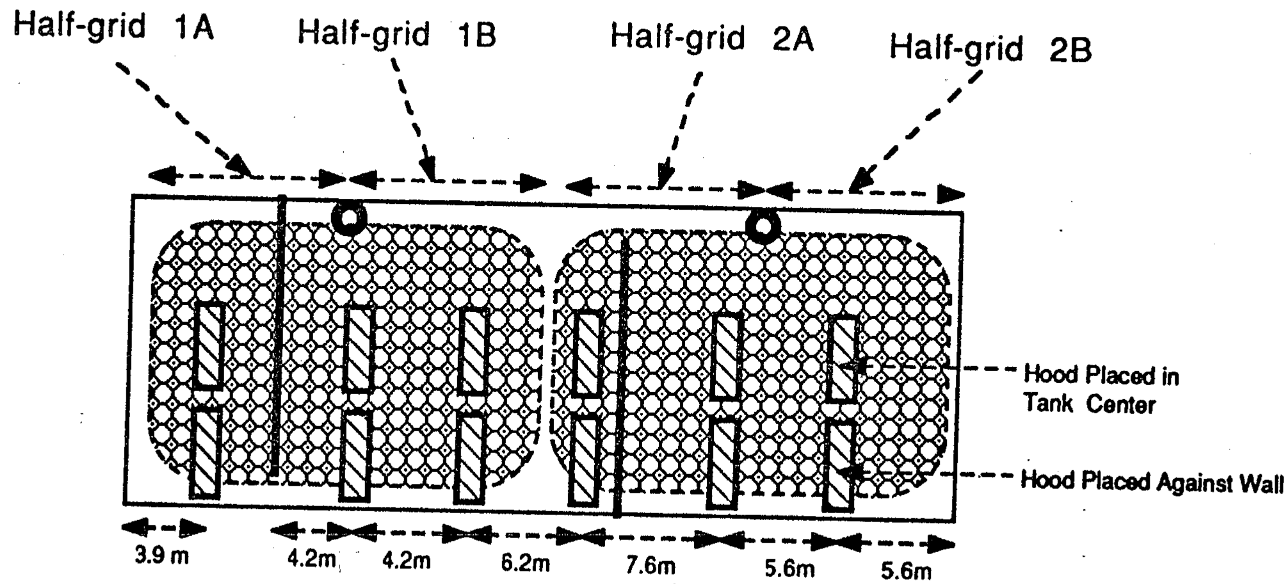

Figure 7 Valencia Off-gas Hood Locations

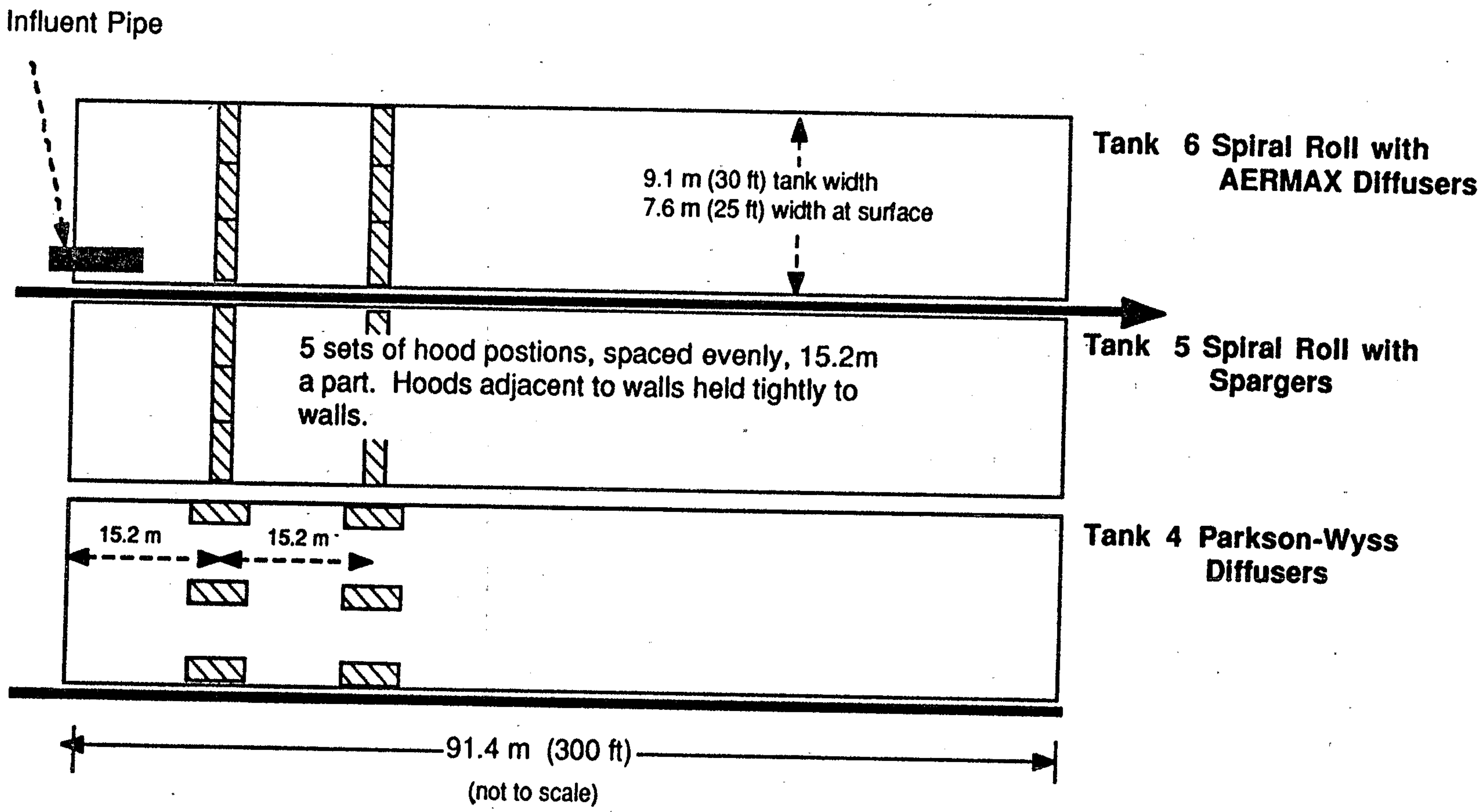

Figure 8 Terminal Island Off-gas Hood Locations

Essentially the same off-gas testing methodology was used at Whittier Narrows and Terminal Island. Testing was begun between 7:00 and 7:30 AM. The hoods were first moved to first tank position. The remaining equipment was then set up. The off-gas analyzer was located between two tanks being tested. At Whittier Narrows, this was always between tanks 2 and 3. Three hoses were used so that all three tanks could be tested from the same analyzer location.

Teams of three people were always used for testing for efficiency and safety reasons. Two people moved hoods, recorded plant data, and collected tank DO and temperature measurements. The other person operated the off-gas analyzer. After the first position in one of the tanks was tested, the analyzer was connected to the hose from another tank. This tank was tested while the team moved the hood at the first tank. In this way there was minimum delay between testing similar positions in each tank.

The testing program was designed this way to minimize experimental errors in testing different tanks because cleaning techniques were being evaluated. For example, tanks 1 and 2 at Whittier were being gas HCl acid gas cleaned and compared with tank 3 which served as a control. Therefore any change in plant operation or load between testing tanks 1 and 3 might be incorrectly attributed to a difference in cleaning technique. This procedure minimized this difference, since the typical elapsed time between testing positions in each tank was only 10 to 20 minutes.

This procedure had the additional advantage in that total testing time was reduced. This occurred because the hood and lines were being flushed when the other tanks were being tested. The gas retention time in the hoods and lines is significant, and in some cases might be as long as 20 minutes. The hood positions opposite the swing arms in the spiral roll tanks were the most problematic in this regard. This hood position typically had 1.7 m^3/hr (1 SCFM) or less air flow rate. The approximate volume of the hood and hose was 0.5 m^3 (17 ft^3). The gas retention time under these circumstances was 17 minutes. After moving a hood to this location, it was necessary to wait until the hood and hose were flushed with fresh off-gas, as indicated by a stable oxygen fraction in the off-gas. Measurements were recorded after the off-gas oxygen mole fraction stabilized.

OFF-GAS TESTING PROCEDURE

The general off-gas testing procedure is summarized in the following steps:

1. Unchain the hoods from their storage positions, attach hoses and manometer tubing, and move them to the first position.

2. Leak check the off-gas analyzer and perform all the set-up procedures as indicated in the instruction manual. Set the Teledyne to read 1.000 using reference gas at the anticipated hood off-gas flow rate. (The Teledyne meter indication was never used; the digital voltmeter was always used).

3. Attach the hose and barometer line to the instrument and begin to balance flux.

4. Continue balancing flux using the hood pressure manometer as an indicator. After the hood pressure is approximately balanced (within ± 5 rotameter units) record the reference gas oxygen content and all other instrument readings.

5. After insuring that the reference reading is approximately constant (± 0.002 volts) switch to the sample cell to off-gas by depressing the 4-way valve.

6. Wait several minutes for the oxygen analyzer to come to a new constant value. During this time collect a sample from the off-gas stream and analyze it for CO_2 mole fraction using the Orsat meter. Also during this time the hood flux was readjusted, if necessary. These adjustments were usually quite small, and did not change cell pressure.

7. After the oxygen analyzer stabilized (± 0.002 volts), record the measurement and return the instrument to reference gas using the 4-way valve.

8. Wait several minutes for the oxygen analyzer to restabilize with reference gas (± 0.002 volts). If this value is not consistent with the previous reference gas reading (generally more than ± 0.005), repeat the entire procedure. If the two reference measurements are consistent, record the measurement. Record all other analyzer measurements. If the hood flux fails to stabilize to within approximately ± 5 rotameter units, continue the procedure until a stable hood flux is obtained.

9. During the time that off-gas measurements are being made, measure the mixed-liquor DO and temperature. In the case of Whittier Narrows, record the plant air flow rate.

Appendix I shows a sample data sheet. In the case of Valencia only one tank was tested. It was necessary to wait a longer time for the off-gas oxygen measurement to stabilize under these circumstances. At Valencia only two people were used for testing; otherwise, the procedures were the same.

At Terminal Island and Whittier Narrows, the hoods were left in the tanks between tests. This facilitated testing and avoided potential hood damage and needless expense associated with removing the hoods and storing them. At Valencia the hood was removed at the end of testing and was returned to the laboratory at UCLA.

Off-gas measurements were analyzed and corrected to standard conditions (20°C, 1 atm barometric pressure, β = 1.0, DO = 0) with the exception of alpha factors. The results were reported as αSOTE (α Standard Oxygen Transfer Efficiency). α factors were calculated for each tank test point (except for the Parkson-Wyss tank) using the clean water data, which are discussed later in this report. Overall αSOTEs and α factors were also calculated. These were always flow-weight averaged; therefore, the positions with the highest air flux had the greatest contribution on the overall average. In all cases a β factor of 0.99 was used.

GAS CLEANING PROCEDURE

The HCl gas cleaning at Whittier Narrows was performed periodically. The experimental design for tanks 1 and 2 called for cleaning of grid 1 every 3 months. Grid 2 was cleaned every 6 months and grid 3 was cleaned every 9 months. Gas cleaning was always performed by Sanitaire personnel who came to Whittier Narrows for this purpose. UCLA and Districts' personnel assisted with cleaning. Districts' personnel always changed air flow rates.

The timing of the gas cleanings were selected somewhat arbitrarily. Initially it was hoped that the rate of increase diffuser pressure loss, as indicated by an increase in dynamic wet pressure (DWP Boyle and Redmon, 1983), or a loss in αSOTE as measured by off-gas analysis, would signal the need for acid gas cleaning. The day-to-day fluctuations in plant operation and their effects on OTE, as well as the poor precision of DWP measurements, made this impossible. Also during the planning phase of the project Sanitaire recommended a change in HCl cleaning philosophy. HCl gas cleaning was no longer envisioned as a method of restoring fouled diffusers, but as a method of preventing diffuser fouling.

Sanitaire provided an HCl control panel which consisted of a rotameter, gas regulator, and stainless steel cylinder attachment and hoses. Figure 9 schematically shows the gas cleaning apparatus for two cylinders. During the study combinations of 1, 2, 3, and 4 cylinders were used (gross weight 900 kg or 2000 lb). The HCl gas lines were always flushed with nitrogen gas after use.

In the first two studies a single 270 Kg (600 lb) cylinder was used (gross weight 90 kg or 2000 lb). This size cylinder was most convenient for gas cleaning but was very inconvenient to lease, load and unload at the plant site, since there was no truck loading platform. After the second cleaning a larger manifold was assembled so that four 27 Kg (60 lb) HCl cylinders were used. The smaller cylinders were easier to lease and transport to the site.

This disadvantage of the smaller cylinders was the reduced gas evaporation rate. HCl liquid at ambient temperature (20°C) has a vapor pressure of 4000 KPascal (600 psig). As vapor is removed from the cylinders additional HCl is evaporated. The latent heat of evaporation causes the cylinder temperature to decrease which reduces the HCl vapor pressure, and reduces gas evaporation rate.

At ambient temperature a single 27 Kg cylinder could produce a flow rate of approximately 34 m^3/hr (20 SCFM). This flow rate quickly declined to less than 7 m^3/hr (4 SCFM) as the HCl temperature dropped. A thick frost formed on the outside of the cylinders. To provide sufficient flow rate with the 27 Kg cylinders it was necessary to manifold 4 cylinders together. Also the cylinders were heated by hosing them with plant effluent. The larger 270 Kg cylinders always provided sufficient HCl flow rate without hosing. The 4 manifolded cylinders were sufficient to produce 34 m^3/hr HCl gas flow rate.

The HCl gas was introduced into the downcomer feeding each diffuser grid. One grid at a time was cleaned. Figure 10 shows the in-tank DWP monitoring apparatus and the HCl injection point. The following description describes the cleaning procedure.

1. The HCl cylinders were delivered to Whittier Narrows on the day prior to testing.

2. At the beginning of the morning shift (7:00 - 7:30 AM) safety equipment, which included a face shield, apron, gloves, and respirator were brought to the cleaning area. The shield, apron and gloves were used by the Sanitaire operator. The respirator was provided by the Districts in the event of an emergency, but was never used.

3. The cylinders were manifolded together, leak checked, and connected to the downcomer with 2.5 cm reinforced tygon tubing.

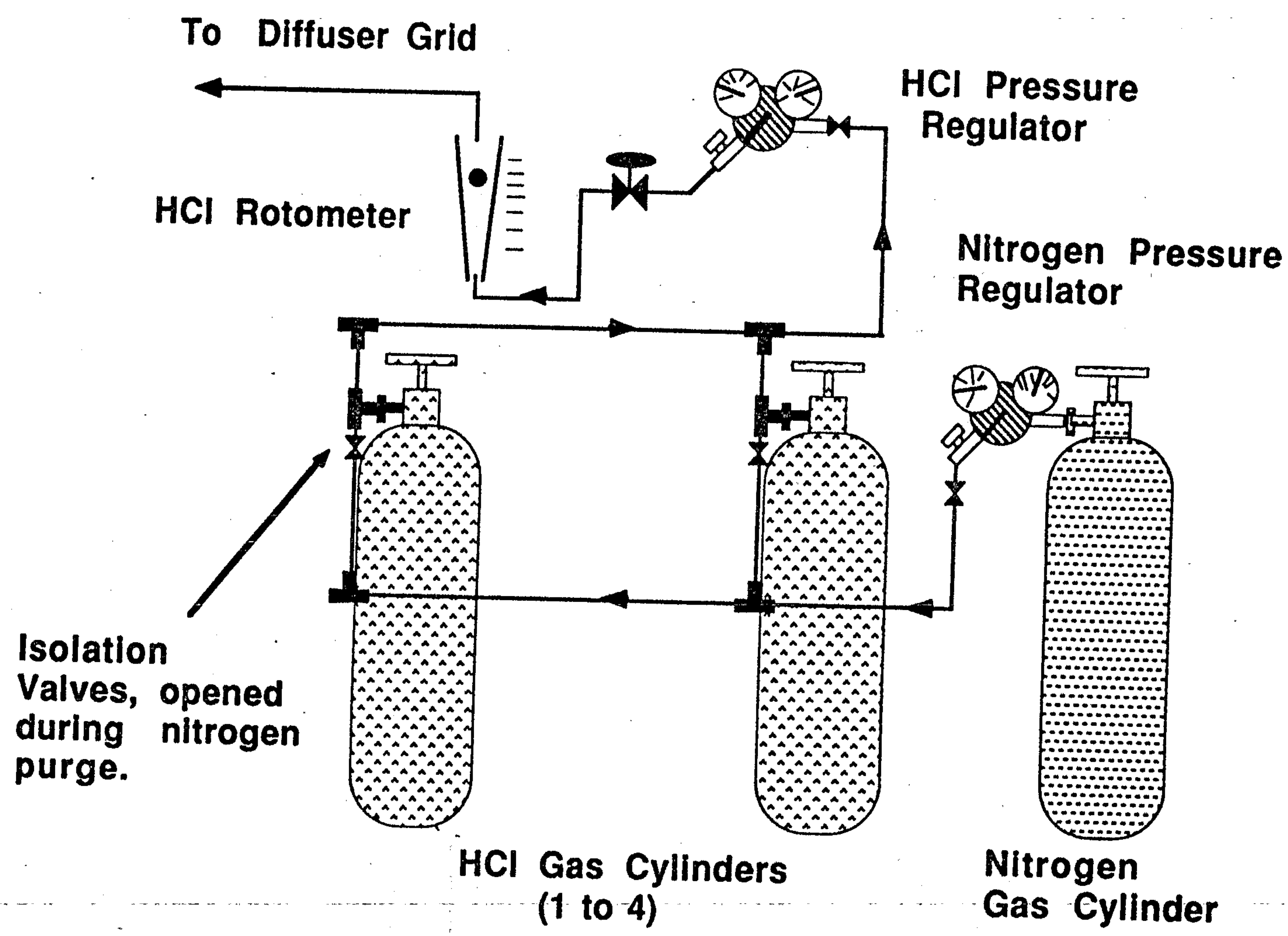

Figure 9 HCl Gas Cleaning Control Panel

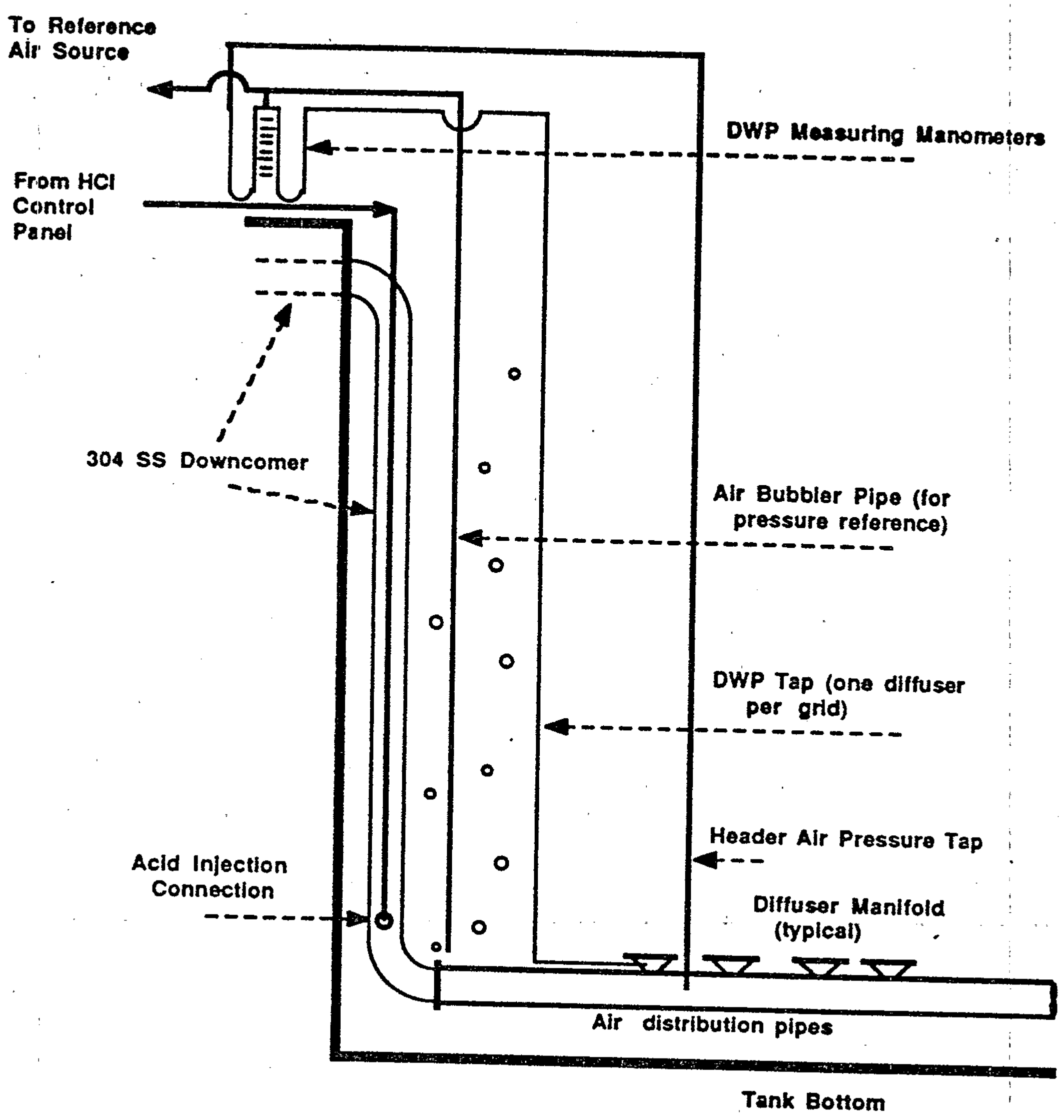

Figure 10 In-Tank DWP Monitoring Apparatus

4. The DWP monitoring equipment was connected to the grid being cleaned and initial measurements were recorded.

5. The air flow rate to the grid being cleaned was increased to 5 m^3/diff-hr (3 SCFM/diffuser) or as high as possible. Generally it was possible to obtain at least 4.3 m^3/hr diffusers. Districts' personnel always controlled the air flow rate. This increase in air flow rate is part of the Sanitaire procedure and is required to insure that the HCl gas permeates through the entire diffuser area; otherwise, the gas may permeate only through the areas in the diffusers with the least resistance. The high air flow rate also insures gas distribution throughout the grid system.

6. The HCl gas was next turned on to a rate of approximately 34 m^3/hr (20 SCFM).

7. As the HCl gas flowed into the diffuser grid, data were recorded every minute. HCl gas flow rate, DWP, and air flow rate were recorded. Usually within 30 seconds of introducing the gas a small decrease in DWP and a small increase in air flow rate were observed.

8. The original Sanitaire protocol required that 45g HCl/diffuser (0.1 lb HCl/diffuser) be used in gas cleaning. This was more than necessary, as observed by a rapid decrease in DWP to a plateau which occurred after only about 11g HCl/diffuser. The cleaning procedure was modified to conserve HCl gas by observing this plateau in DWP. Consequently, only 10 to 25g HCl/diffuser were normally used. In some instances the additional HCl was used to empty the cylinders.

   As the study progressed many of the DWP lines failed. The DWP lines were not renovated prior to the study, and the effect of HCl gas on the lines is unknown. After this happened it was impossible to observe the plateau in DWP; therefore, a known mass of HCl was used, and was determined by integrating the HCl flow rate, and assuming an HCl gas density of 1.22 Kg/m^3 (0.095 lb/ft^3). The mass of HCl was based upon the mass used in previous tests, when the plateau was observed. After cleaning several times, a pattern of HCl use was determined. This allowed all the HCl in the cylinders to be completely used. HCl cleaning was always performed first on tank 1. Tank 2 was cleaned after tank 1. This cleaning sequence was used because it was easier for Districts' personnel to change air flow rates.

LIQUID ACID CLEANING

At the beginning of the Whittier Narrows study in April 1986, all three diffuser tanks were fouled. They had not been cleaned in approximately 18 months. Two off-gas analyses were performed to determine the fouled αSOTE. This αSOTE was considered a worst case efficiency that would result if no diffuser maintenance were practiced. After the second off-gas analysis, each tank was dewatered and cleaned using a liquid acid procedure which has sometimes been called the "modified Milwaukee method."

The liquid acid method is a simple and effective in-situ procedure for cleaning dewatered aeration tanks with ceramic diffusers. To perform the procedure the tank must be dewatered. Immediately after dewatering diffusers can be collected for analysis and foulant characterization. After diffusers are collected the grid system and associated piping are clean using low pressure hoses from the tank top. This hosing cleans the bulk of the slime from the diffusers and makes the tank safer and more convenient for maintenance personnel. After hosing, a solution of 16% hydrochloric acid (conventional muratic acid diluted 1 to 1) acid is sprayed onto the surface of each diffuser. A hand sprayer suitable for acid service can be used for this purpose. The acid solution is allowed to soak the diffusers surface for at least 30 minutes. All maintenance personnel exit from the tank and the air is turned on for at least 10 minutes. Finally, the diffusers are hosed from the top of the tank

Protective equipment (rain gear, face shield, gloves, and HCl gas mask) is worn during this procedure. There is a danger of HCl or H_2S inhalation during this procedure and breathing equipment is required. H_2S may be liberated by the acid if the tank has sludge accumulated on the bottom. Tanks should not be entered by maintenance personnel if there is large sludge accumulation. Care should also be taken with the muratic acid to avoid unnecessarily spraying stainless steel parts.

CLEAN WATER DATA

In order to calculate alpha factors clean water data were collected for the Whittier Narrows, AERTEC and Nokia aeration systems. No clean water tests were performed specifically for this study. Data from previous studies were used. The clean water data were used to calculate α factors.

Whittier Narrows

At Whittier Narrows the Districts performed a field verification clean water test for the Sanitaire disks. This was done in part because their previous clean water ceramic grid system tests had used domes (Yunt and Hancuff, 1983). The test was performed at the Whittier Narrows Plant in grid 1 of tank 1 at 4 m (13 ft) submergence to be consistent with the earlier tests. The entire tank was filled with tap water and grid 1 was isolated from the other grids by a wooden baffle. To prevent hydraulic forces from displacing the baffle it contained a small opening. The opening was sealed during the test but there may have been some interchange of water from grid 1 to grid 2. In spite of this unconventional procedure the test results were reasonably consistent with the manufacturer's and Districts' expectations. Table 8 shows the results of these tests. The tests were extrapolated back to 3.75 m depth (12.3 ft) using a linear correction. These tests were all performed at the diffuser spacing in grid 1, which is 2.8 disc/m^2 (0.264 disk/ft^2).

The diffuser density was less in grids 2 and 3. Therefore, test results for grid 1 are higher than would be expected for grids 2 and 3. The Districts had used literature data for domes at different spacings to estimate SOTE for grids 2 and 3. Sanitaire was consulted and made additional data available. Their predictions are shown in Table 9.

The Sanitaire data were within a few tenths of a percent of the Districts' data for grid 1. Since there was no other source for clean water data for grid 3, and since the Sanitaire data very closely fit the Districts' data, it was used for all analyses concerning Whittier Narrows. Two regressions were used to describe the tabular data, shown in Equation 1 for grids 1 and 2 and Equation 2 for grid 3.

$$\text{SOTE} = 34.92 - 1.813\ \text{QPD} \tag{1}$$

where

QPD = gas flow rate per diffuser (m^3/hr)

$$\text{SOTE} = 28.5 - 1.416\ \text{QPD} \tag{2}$$

The Districts' previous work with ceramic domes and disks had indicated that they were approximately equivalent in clean water efficiency if the number of domes per unit area is increased by 25%. This increase was incorporated in the design of diffuser grids for tanks 2 and 3. For this reason the Sanitaire disk data were also used to estimate the dome efficiency.

Table 8. Whittier Narrows Clean Water Data for Grid 1 of the Ceramic Disk System+

Air flow Rate/Diffuser (m^3/hr)	Submergence (m)	SOTE (%)	Effective depth (m)	SOTE at 3.75 m submergence (%)
1.31	3.93	32.8	1.79	31.8
2.14*	3.92	26.8	1.82	26.1
2.12	3.97	30.6	1.59	29.4
2.12	3.97	31.5	1.97	30.3
2.14	3.97	30.9	1.95	29.6
2.16	3.97	31.0	1.83	29.8
4.20	3.97	27.5	1.55	26.4

* this test was performed first
+ Yunt and Hancuff (1986)

Table 9. Sanitaire's SOTE Estimates for Whittier Narrows

Grid	Gas Flow/Diffuser (m^3/hr)	SOTE at 3.75 m submergence (%)
1 & 2	1.3	33
	1.7	31.5
	2.5	30
	3.4	29
3	1.3	27
	1.7	26
	2.5	24.5
	3.4	24

Valencia

The Districts performed a clean water test of the Nokia plastic disks in their test tank at JWPCP on December 11 and 12, 1985 (Yunt and Handcuff, 1986). These test results are shown in Table 10. The SOTE was modeled by Equation 3:

$$SOTE = 31.3 - 1.875\ QPD \tag{3}$$

Terminal Island - AERMAX

Clean water test results from an independent tester were supplied for the AERMAX system by an AERMAX representative (Anderson 1987). These data were for a wide-band, spiral roll system. The data were collected for one of the manufacturer's other projects. The test report was not inspected and the data were accepted without question. Table 11 shows the clean water SOTEs at 4.1 m (13.5 ft) submergence. No clean water data were available for the Parkson-Wyss system.

Table 10. Nokia Clean Water Oxygen Transfer Efficiency*

Air Flow Rate Per Diffuser (m^3/hr)	SOTE (%)	C^*_∞ (mg/L)
0.66	30.4	10.9
1.32	29.0	10.9
1.31	28.8	10.6
1.32	28.4	10.6
2.61	26.6	10.7

Submergence = 3.96 m (13 ft)
Spacing = 3.66 diffuser/m^2 (0.34/ft^2)

* From Yunt and Hancuff (1986).

Table 11. Aermax Clean Water Efficiency for a Spiral Roll Configuration*

Air Flow/Diffuser (m^3/hr)	SOTE (%)
1.7	28
3.4	22
8.5	18
11.9	16

* From Anderson (1987) (AERTEC Representative)

EXPERIMENTAL RESULTS

This section describes the chronology of testing and the experimental results at each facility. Findings which are specific to each facility are also discussed here. Results which are applicable to all facilities, particularly results which related to process operation (e.g. effect of sludge age on αSOTE) are discussed in the next chapter.

WHITTIER NARROWS

The Whittier Narrows project history is shown in Table 12. Cleanings and off-gas tests are shown along with dome replacement in September and October 1987. The dome replacement was not envisioned at the beginning of the study but were required because of reduced oxygen transfer and gasket leakages.

The periods of operation at Whittier Narrows are summarized in Table 13. At the end of each phase diffusers were collected and analyzed for DWP, BRV, fouling substance mass and composition, and air distribution profiles. All tanks were tested using off-gas analysis.

Two diffusers were collected from each grid of each tank and sent to Professor W.C. Boyle at the University of Wisconsin for analysis. Diffusers were always collected very soon after tank dewatering so that the fouling slimes did not dry out. Next the diffusers were packed in plastic bags and sent overnight freight to Wisconsin.

At Wisconsin dynamic wet pressure, bubble release vacuum, and fouling substance analysis were performed. Fouling substances were weighed on a per unit area of diffuser area basis and both total and non-volatile masses were determined. Later in the study the non-volatile fouling substance was further analyzed to determine acid soluble fraction. Acid soluble residue is only available for the final diffuser stone analysis performed in 1988. The statistical summary of these data is presented in this chapter; the raw data are included in Appendix II. A test header was also installed at Whittier Narrows.

Whittier Narrows Diffuser Analysis Results

Several diffusers which were collected for analysis prior to the initial liquid acid cleaning (6/86) and were later cleaned by hosing or liquid acid cleaning, both in-situ and in the laboratory. It is interesting to note how each technique restores the diffuser parameters. Table 14 shows four diffusers selected from the initial sampling in June 1986 when all three tanks were liquid acid cleaned. The original parameters are shown (before any cleaning), along with parameters after hosing and liquid acid cleaning. Hosing is marginally effective at removing DWP and BRV. Acid cleaning is much more effective; however, new diffuser characteristics (as shown in Table 14) were not obtained. Air side BRVs are also shown in Table 14 for a single dome and disc diffuser. These diffusers are from different grids than the others shown in Table 14.

The combined diffuser analyses, excluding the diffusers which were collected for biofilm analysis, are summarized in Table 15. Five sets of conditions were available for analysis: new diffusers; new domes in service for seven months, with and without HCl gas cleaning; used domes in service 15.5 months after an initial liquid acid cleaning, with and without HCl gas cleaning; used domes and disks in service for 18 months without cleaning, and used disks in

Table 12. Whittier Narrows Project Chronology

Date	Event	Comments
4/28/86	off-gas testing	background testing performed to determine dirty diffuser efficiency
5/12/86	off-gas testing	background testing
5/13-6/19-86	liquid acid cleaning of all three tanks	Diffusers collected for analysis, dome gasket leakage noted
6/20/86	off-gas testing	
7/02/86	off-gas testing	
7/22/86	off-gas testing	hoods were not moved in order to determine diurnal fluctuations in αSOTE
8/01/86	off-gas testing	
8/86	process operation changed	MLSS temporarily reduced in all three tanks
8/21/86	off-gas testing	
8/26-8/27/86	first HCl gas cleaning	grids 1, 2 and 3 cleaned in tanks 1 & 2
9/04/86	off-gas testing	
9/17/86	off-gas testing	
10/17/86	off-gas testing	
10/31/86	off-gas testing	
11/17/86	off-gas testing	
12/9/86	HCl gas cleaning	grid 1 of tanks 1 & 2 cleaned
1/16/87	off-gas testing	
1/30/87	off-gas testing	
2/13/87	off-gas testing	
2/27/87	off-gas testing	
3/13/87	off-gas testing	
3/26-3/27/87	HCl gas cleaning	grids 1, 2 and 3 of tanks 1 & 2 cleaned. Simultaneous off-gas testing performed. Witnessed by W.C. Boyle
4/03/87	off-gas testing	
4/17/87	off-gas testing	
5/22/87	off-gas testing	
6/05/87	off-gas testing	
6/15-6/16/87	HCl gas cleaning	grid 1 of tanks 1 and 2 cleaned
6/19/87	off-gas testing	
7/10/87	off-gas testing	
7/31/87	off-gas testing	
8/31/87	off-gas testing	
9/9/87	domes replaced in tank 3	gasket leakage noted
9/30/87	domes replaced in tank 2	gasket leakage noted
9/30/87	HCl gas cleaning	grid 1 and 2 of tank 1 cleaned
10/9/87	off-gas testing	
11/13/87	off-gas testing	
12/04/87	off-gas testing	
12/24/87	off-gas testing	

Table 12. Whittier Narrows Project Chronology (Continued)

Date	Event	Comments
1/15/88	off-gas testing	
1/26/88	HCl gas cleaning	grid 1 of tank 2 cleaned, grids 1, 2, 3 of tank 1 cleaned
1/29/88	off-gas testing	
2/19/88	off-gas testing	
3/11/88	off-gas testing	
5/88	tanks 2 & 3 manually cleaned using low pressure hosing	gasket leakage noted, broken bolts noted
6/16/88	off-gas testing	
7/88	tank 1 manually cleaned using tank-top hosing	no significant gasket leakage or mechanical problems noted.
8/12/88	off-gas testing	

Table 13. Summary of Whittier Narrows Operation

Period	Description
4/86-6/86	3 tanks operating without cleaning for the previous 18 months
6/86-9/87	2 tanks operating with old domes after liquid acid cleaning, 1 HCl gas cleaned
10/87-5/88	2 tanks operating with new domes, 1 HCl gas cleaned
6/86-6/88	1 tank operating with old disks after liquid acid cleaning, HCl gas cleaned
7/88	disks manually cleaned by tank top hosing

Table 14. Lab and Field Diffuser Cleaning Results for Selected Diffusers at the Beginning of the Whittier Narrows Study

Treatment	Disk 1 (Grid 1, Tank 1)			Disk 2 (Grid 2, Tank 1)			Dome 1 (Grid 3, Tank 2)			Dome 2 (Grid 1, Tank 2)		
	DWP	BRV	DWP/BRV	DWP	BRV	DWP/BRV	DWP	BRV	DWP/BRV	DWP	BRV	DWP/BRV
Before Cleaning	67.8	132	0.51	24.8	155	0.16	22.8	388	0.06	27.7	175	0.16
Lab Hosing	55.6	94.0	0.59	26.1	35.3	0.74	24.8	83.3	0.30	27.4	49.3	0.55
Field Acid Liquid Cleaning	-	-	-	-	-	-	15.7	22.6	0.70	11.7	17.1	0.68
Lab Liquid Acid Cleaning	24.1	31.5	0.77	23.4	24.9	0.93	21.1	36.1	0.58	23.6	35.0	0.67
New Diffuser	17.3	15.9	1.09	-	-	-	14.1	14.7	0.96	-	-	-
Air Side	17.5+	-	-	-	-	-	12.2*	-	-	-	-	

Note: Units in cm. DWP measured at 1.27 m^3/hr-diffuser air flow rate (0.75 SCFM/diffuser). The diffusers at this point had been in service approximately 18 months without cleaning. The disks were originally installed in late 1980 and the domes were installed in early 1981.

\+ Grid 3

* Grid 1

Table 15. Diffuser Analysis Summary

Period in Service (months)+	Number of Observations	Condition prior to service	Condition prior to testing	Tank Number
0	2	new disk & dome*	new disk	-
7	6	new domes	no cleaning	3
7	6	new domes	acid gas cleaning	2
15.5	6	old domes, liquid acid cleaned	no cleaning	3
15.5	6	old domes, liquid acid cleaned	acid gas cleaning	2
18	6	old domes, liquid acid cleaned	no cleaning	2
18	6	old disks, liquid acid cleaned	no cleaning	1
18	8	old domes & disks, liquid acid cleaned	lab cleaned	1 & 2
18	2	old domes &, disks, liquid acid cleaned	in-situ liquid acid cleaned	2
25	6	old disks, liquid acid cleaned	acid gas cleaned	1
25	6	old disks, liquid acid cleaned	acid gas cleaned, lab cleaned	1

* New domes and disks were all purchased in the original installations in 1980 and 1982.

service for 25 months after an initial liquid acid cleaning, with HCl gas cleaning. Additionally, disks and domes were analyzed after in-situ cleaning and after cleaning in the laboratory. The raw data are shown in Appendix II.

An analysis of variance (ANOVA) was performed on the five sets of diffuser conditions to determine the effects of four treatments: length of time in service; cleaning (HCl gas or none); tank number, and grid number. Four dependent variables were examined: DWP at 1.27 m^3/hr/diff (0.75 SCFM/diffuser), BRV, the ratio of DWP at 1.27 m^3/hr to BRV, and mass per unit area of fouling material. SAS (1982) was used to perform the analysis using the SAS ANOVA procedure, which can handle the unbalanced data obtained during the study.

Table 16 shows the results of the ANOVA. The results show that the ratio of DWP to BRV is the most sensitive to the diffuser treatments, followed by BRV, DWP and total mass of fouling material. HCl gas cleaning reduced the accumulation of BRV, DWP and fouling substances. Tank number was significant for BRV and DWP/BRV. Ideally the tank number would not have been significant; however, the unbalanced nature of the experiment (two gas cleaned tanks to one control and no disk control) may contribute to this positive effect. It was included to test for variations in flow rates to the tank and other uncontrolled phenomena. It is interesting to note that the grid number (influent versus middle versus effluent) has the least significant effect. This conclusion is contrary to prevailing opinion which suggests that influent grids foul more rapidly than effluent grids. The mass of total fouling material is less sensitive than other parameters, and this may in part be due to high variability in experimental results, caused by the difficulty of scraping representative samples of fouling material from the diffuser surface.

The diffuser characteristics show that HCl gas cleaning, among other factors, is effective in reducing the accumulation of DWP, BRV and fouling material. Table 17 shows the means of the diffuser data for various conditions. Figures 11 and 12 show the various parameters as a function of time in service.

The air side of the diffusers were also analyzed for BRV. This was of particular interest because the air filters at Whittier Narrows had been out of service during most of the study. Also the blowers at Whittier Narrows withdraw most of their intake from the covered headspace above the primary clarifiers. (The Districts cover their primary clarifiers for odor control, and the practice is common throughout California). There was some speculation that the foul air from the primary clarifiers might be more likely to foul the air side of the diffusers. The six domes collected from the HCl gas cleaned tank 2 in 1987 average 14.2 cm BRV, as compared to 24.5 for the diffusers from tank 3, which received no cleaning. The 14.2 cm BRV is virtually the same as new (a new, unused diffuser would be expected to have the same BRV on both sides), while the 24.5 is significant. At the beginning of the study diffusers from tanks 1 and 2 showed almost no increase in air-side BRV (see Table 14). Therefore, HCl gas cleaning appears to be effective at removing both air and liquid side BRV.

Off-Gas Testing Results

The previous section showed that HCl gas cleaning was effective at preventing the buildup of DWP and BRV on both disks and domes. The other question is whether HCl gas cleaning is effective at maintaining the α factor and αSOTE. In most ways this is the more important performance parameter. For example, an increase of DWP and diffuser orifice loss

Table 16. Results of the Analysis of Variance Diffuser Characteristics

Dependent Variable	Treatments				R^2
	Length of Service (months)	Cleaning Technique	Grid Number	Tank Number	
BRV	+ (10^{-4})	+ (3×10^{-4})	- (0.47)	+(1.4×10^{-3})	0.72
DWP	+ (4×10^{-4})	+ (0.0285)	- (0.83)	- (0.32)	0.49
DWP/BRV	+ (10^{-4})	+ (10^{-4})	+ (10^{-4})	+ (10^{-4})	0.98
Total Fouling Material	+ (0.0149)	+ (0.005)	- (0.40)	- (0.25)	0.48

+ or - indicates acceptance or rejection of the hypothesis that the treatment has a statistically significant impact on the dependent variable. The number in parenthesis indicates the level of significance.

Table 17. Values of Diffuser Data

Means by Grids (all tanks)

Parameter	Grid 1	Grid 2	Grid 3	New
BRV (cm)	58.9	59.7	72.5	12.4
DWP (cm at 1.25 m^3/hr-diffuser)	27.3	26.2	24.6	11.8
BRV/DWP	0.57	0.59	0.59	0.95
Total Fouling Material (mg/cm^2)	10.0	6.7	4.7	0

Means by Cleaning Technique (all grids)

Parameter	HCl Gas Cleaning	No Cleaning
BRV (cm)	46.3	96.3
DWP (cm at 1.25 m^3/hr-diffuser)	24.0	30.1
BRV/DWP	0.59	0.44
Total Fouling Material (mg/cm^2)	6.6	8.2

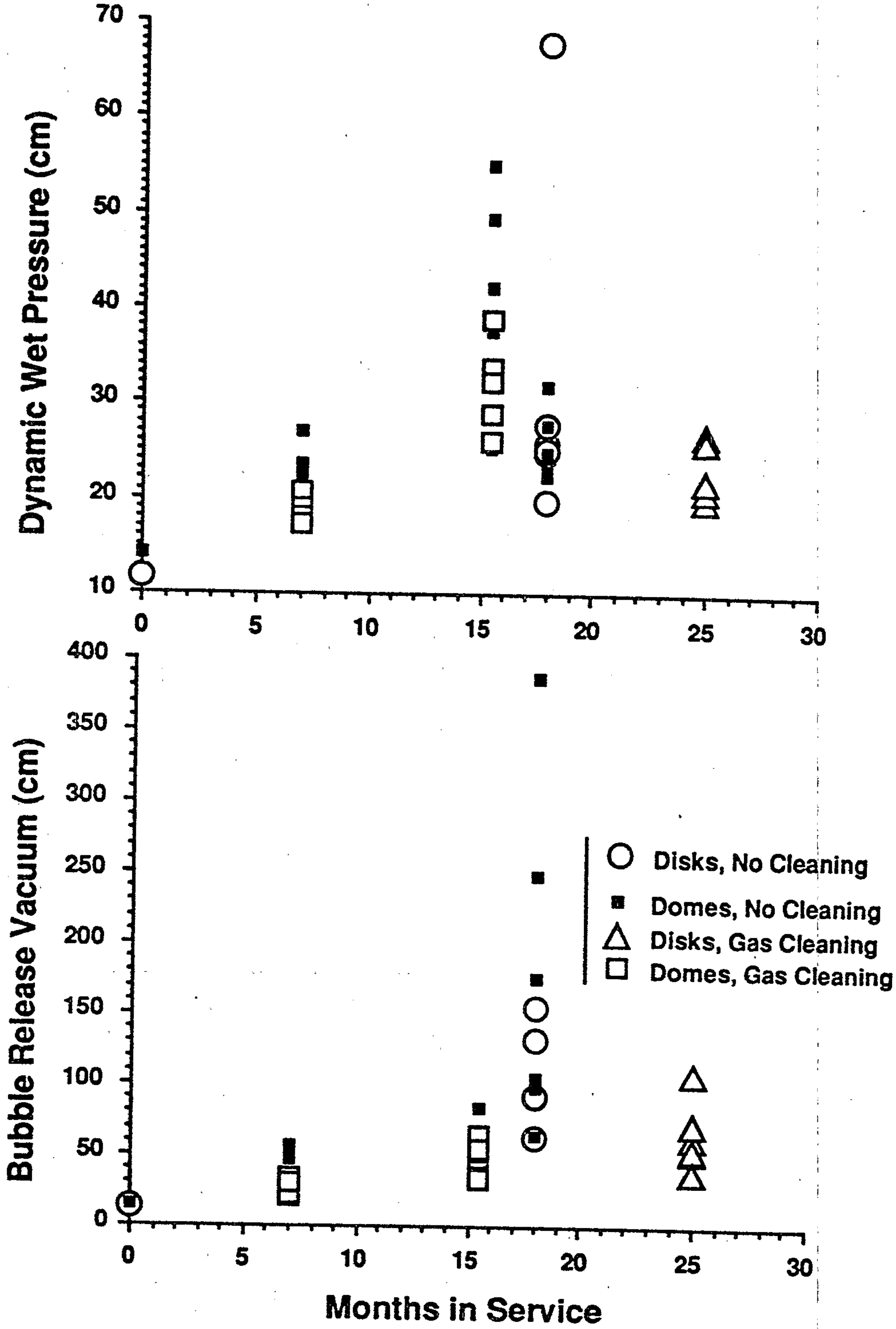

Figure 11 DWP and BRV versus Months in Service

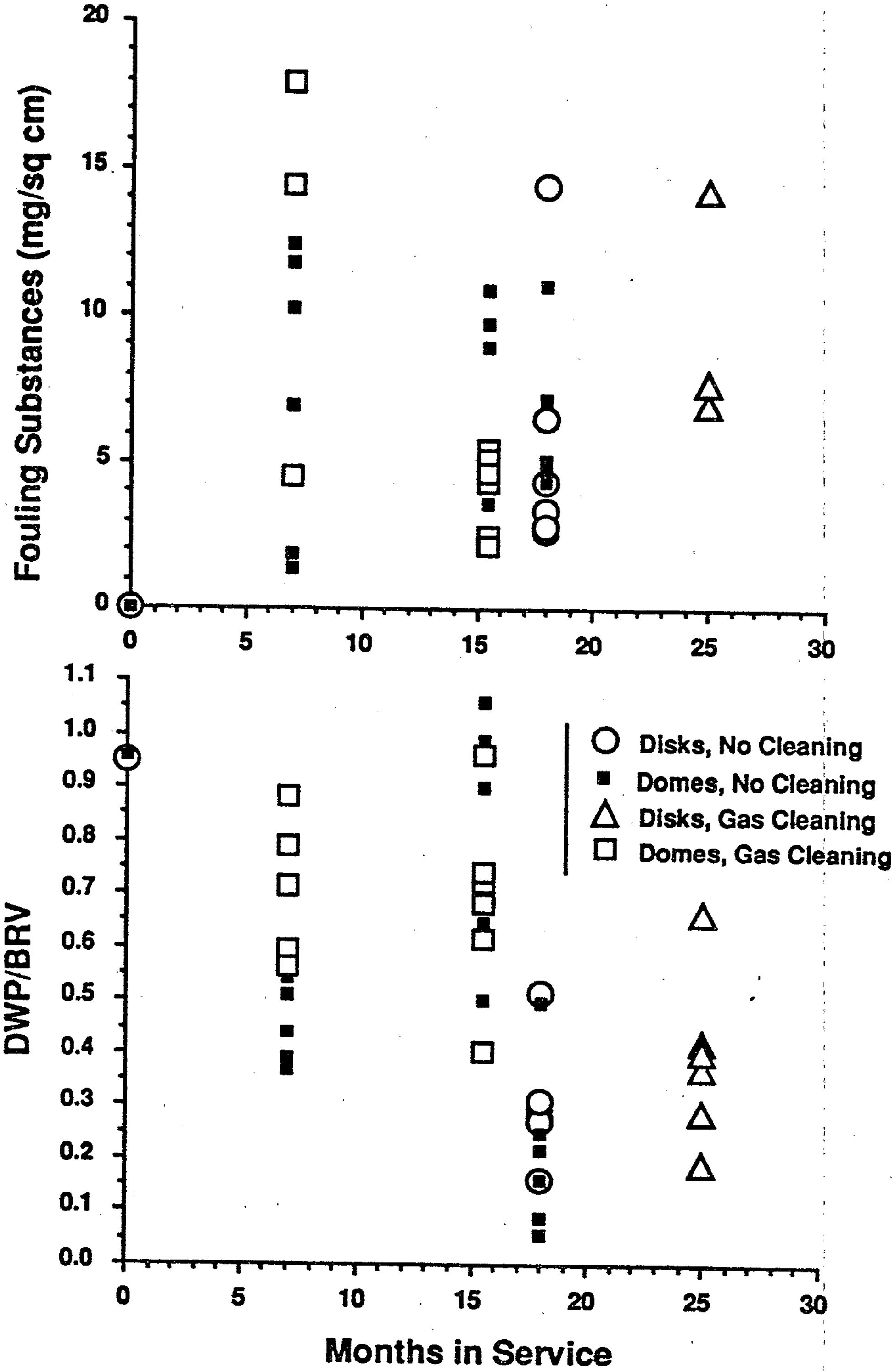

Figure 12 Fouling Substances and BRV/DWP versus Months in Service

from 18 to 64 cm, which is uncommonly large, increases total pressure drop through a diffuser system such as those at Whittier Narrows by approximately 3%, which translates to increased blower energy cost of less than 9%. However, a decrease of 40% in αSOTE due to fouling, which was observed at various times during this study, is an increase in blower energy cost of over 60%. The most significant effect of increased DWP is potential overloading of blower motors, or an increase in total system pressure to beyond a centrifugal blower's surge point.

Figures 13-16 show the overall off-gas efficiency for αSOTE and α factors for all three tanks. There is a very large degree of variability in the day-to-day results, and several obvious increases and decreases due to upset conditions or diffuser modifications. Figure 17 shows the air flux and air flow per diffuser versus time for all three tanks, with interpolations (smooth lines) to better illustrate the data. The interpolations have no statistical significance. The air fluxes generally increased over the life of the study, which was probably in response to declining α factors and αSOTE. Plant load was relatively constant. Figure 18 shows the air fluxes as a function of distance down the tanks. The error bars are standard deviations of all the data collected for that position. Grids 1 and 2 were operated at approximately the same gas flow rate and flux. The flux in grid 3 was significantly less than in grids 1 and 2, and is a result of the tapered aeration strategy.

Figures 19 and 20 show the αSOTE and α factor as a function of tank distance. Again the error bars represent standard deviations of all data collected. The α factor and αSOTE were lowest in grid 1 at hood position 1 and increased to a plateau in grid 3. It is interesting to note that α and αSOTE increased faster in the disk system than in the two dome systems.

The negative horizontal axis values of Figures 13-16 represent the fouled α factors and αSOTE after 18 months of operation without cleaning which was prior to this study. The disk system before cleaning was operating at approximately 8.5 to 9.0% αSOTE while the domes were operating at 6.5 to 7.5% αSOTE. The difference was surprising in view of the similar clean water results discussed previously, and the age of the disk system which was installed 16 months before the dome system was installed. An unknown portion of the difference in efficiency was probably due to gasket leakages at the base of the domes.

Gasket leakage results in much larger bubble size, which appears in the data as reduced αSOTE. Off-gas testing results cannot distinguish between reduced alpha factors or gasket leakage. Both dome tanks appeared to have large bubble diameter in grid 1 at the beginning of the study and this condition existed throughout the study. The bubble patterns in tank 1 usually appeared finer than the bubble patterns in tanks 2 and 3.

The peak in α factor and αSOTE at month zero resulted because of the liquid acid cleaning. After liquid acid cleaning all three tanks improved. The overall, flow weighted average αSOTEs for tanks 1 to 3 was 10.2, 8.7 and 11.2%, respectively. The disk tank continued to demonstrate high αSOTE, increasing 10.2 and 11.4% on July 2 and August 1, 1986, respectively. The αSOTE for tanks 2 and 3 fell to 9.3 percent for tank 2 and remained at 8.4 to 8.8% for tank 3 for this period.

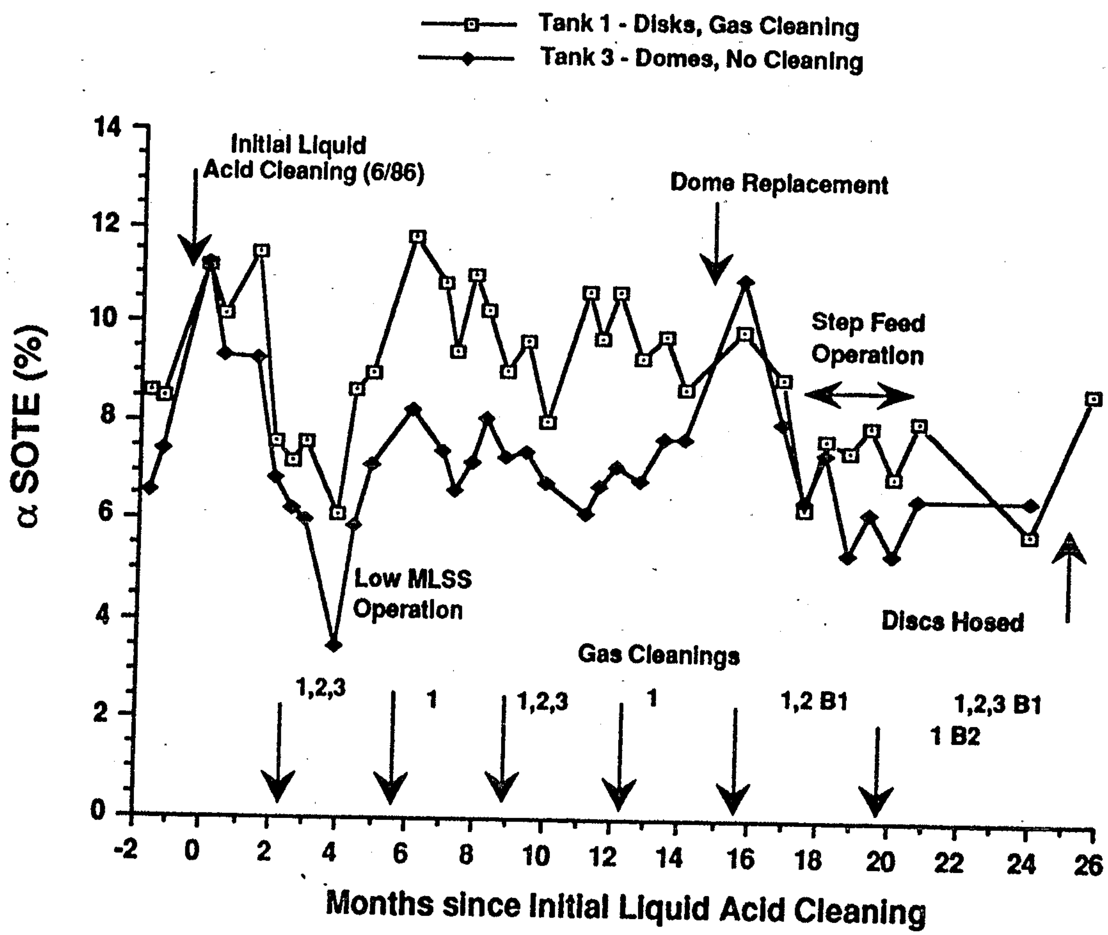

Figure 13 αSOTE versus Time for Tanks 1 and 3 at Whittier Narrows

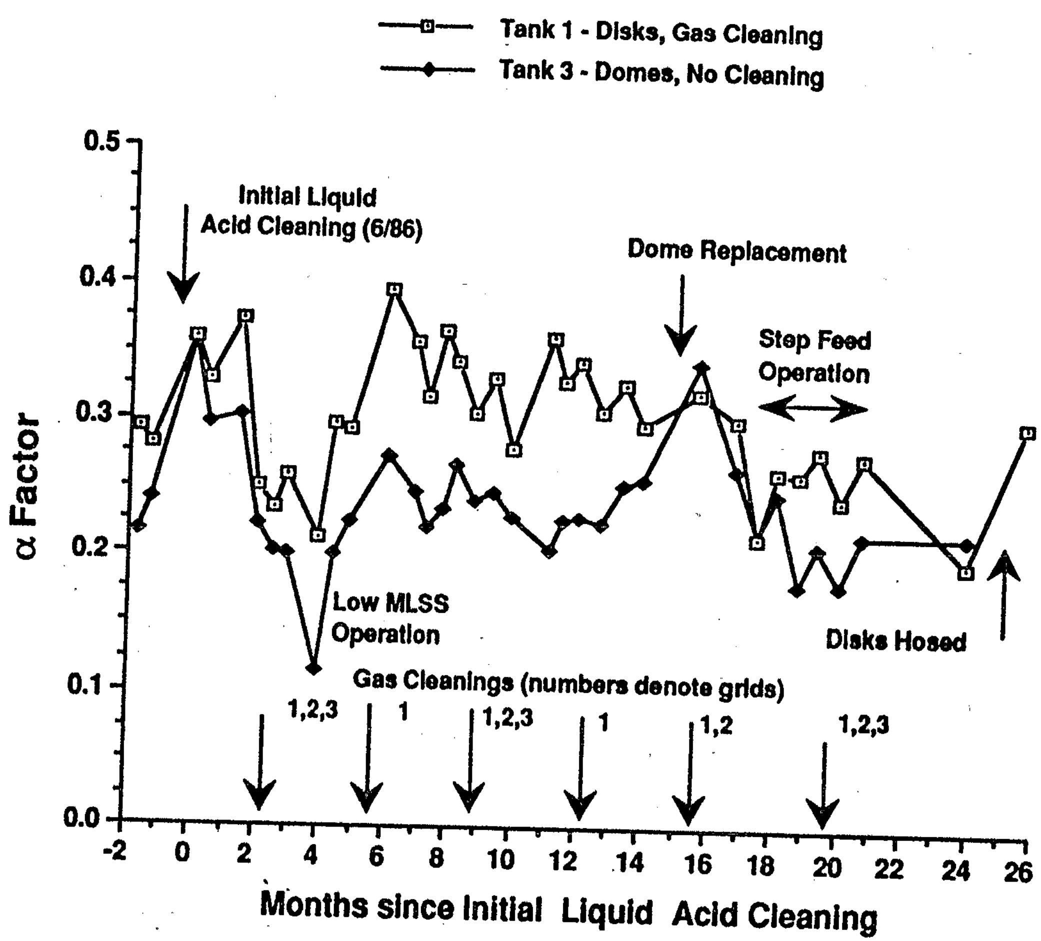

Figure 14 α Factor versus Time for Tanks 1 and 3 at Whittier Narrows

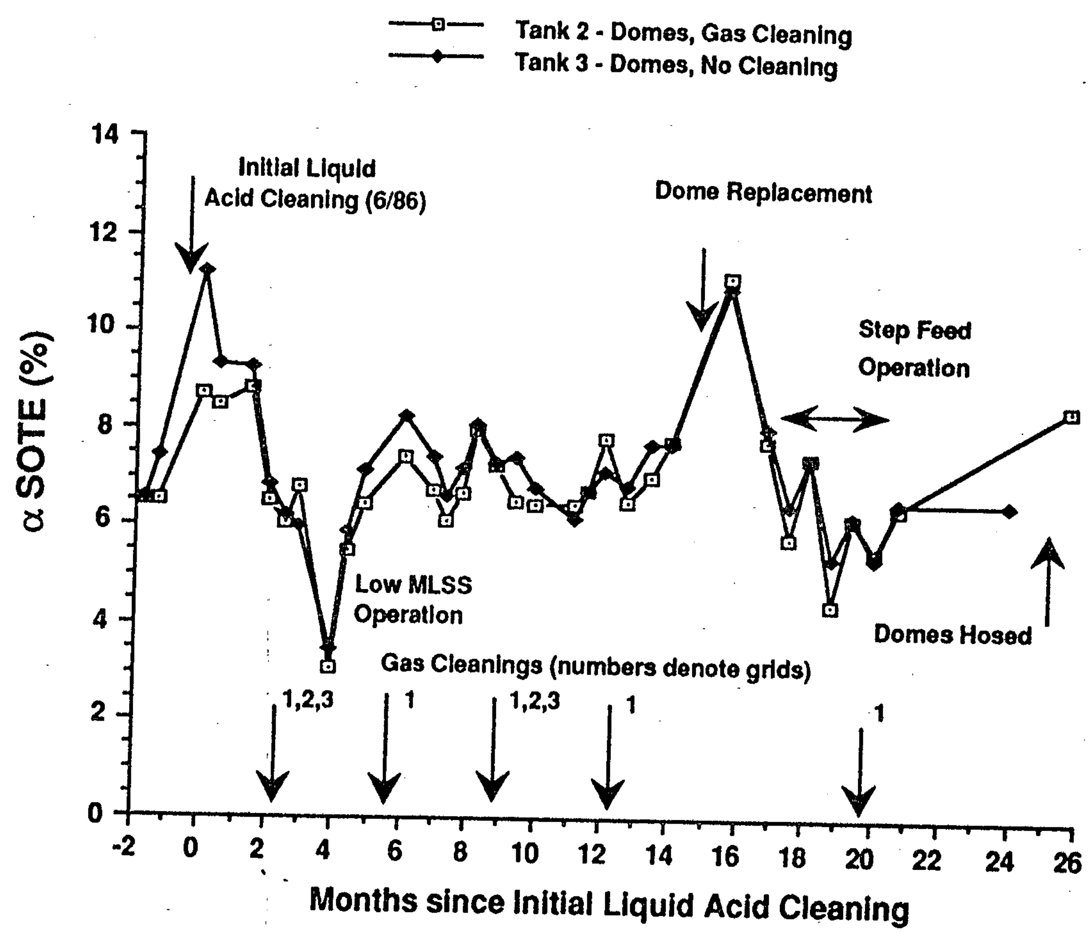

Figure 15 αSOTE versus Time for Tanks 2 and 3 at Whittier Narrows

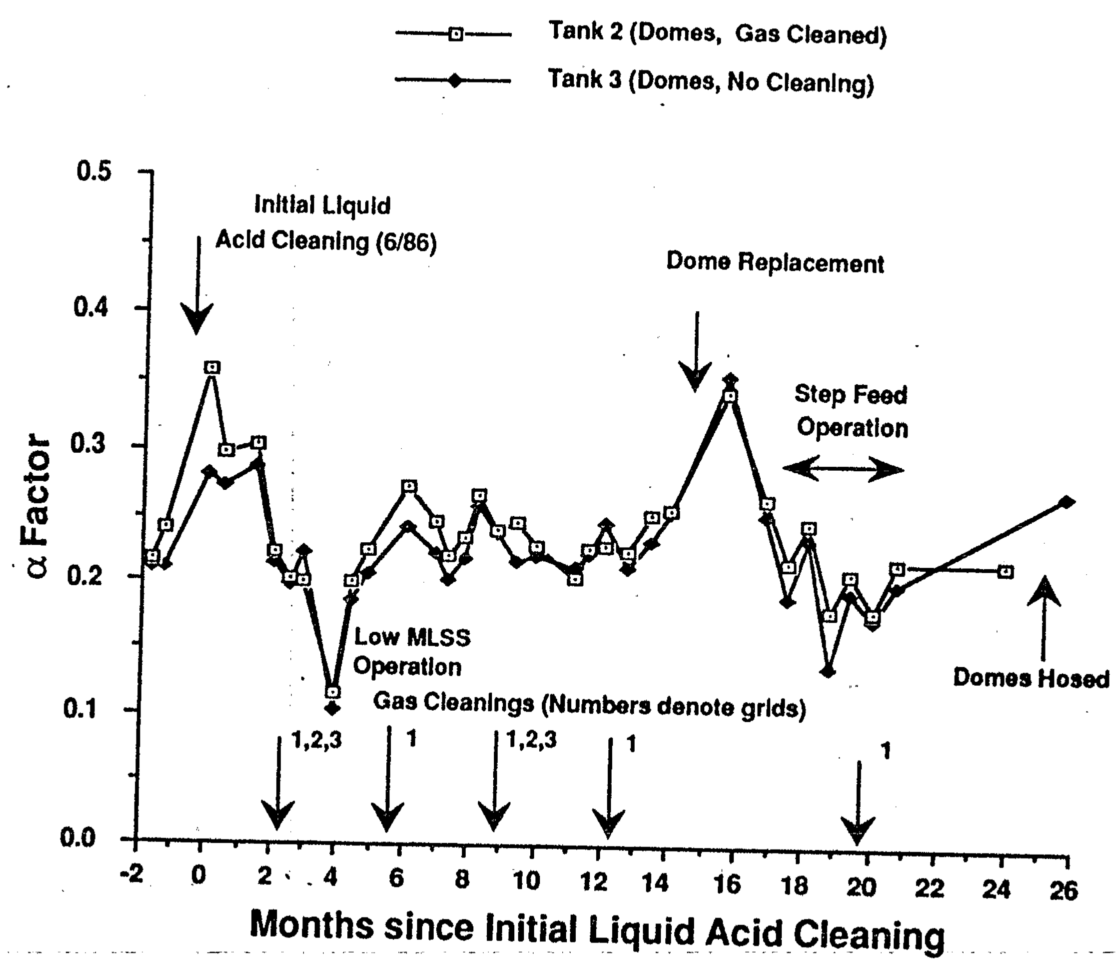

Figure 16 α Factor versus Time for Tanks 2 and 3 at Whittier Narrows

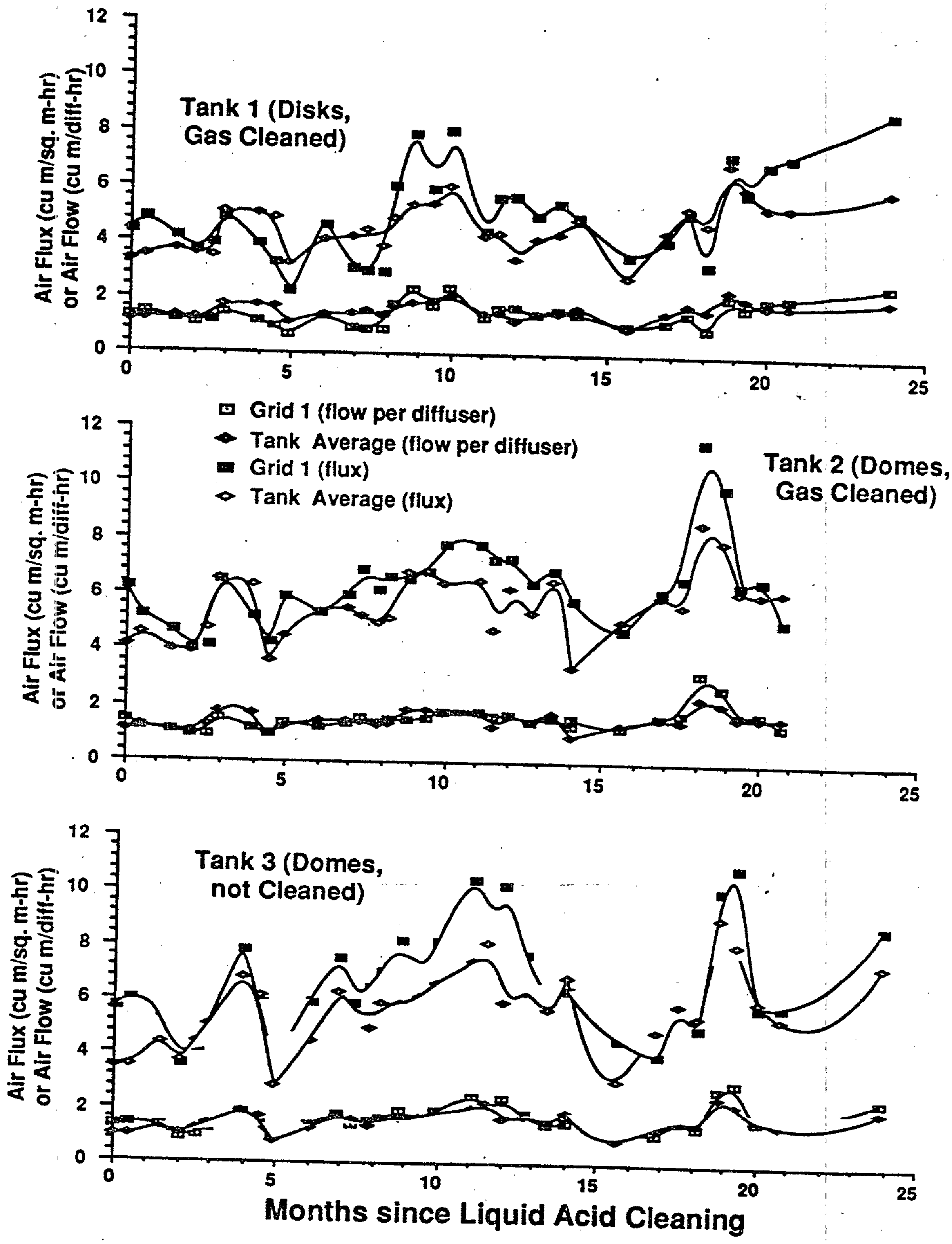

Figure 17 Air Flux versus Time at Whittier Narrows

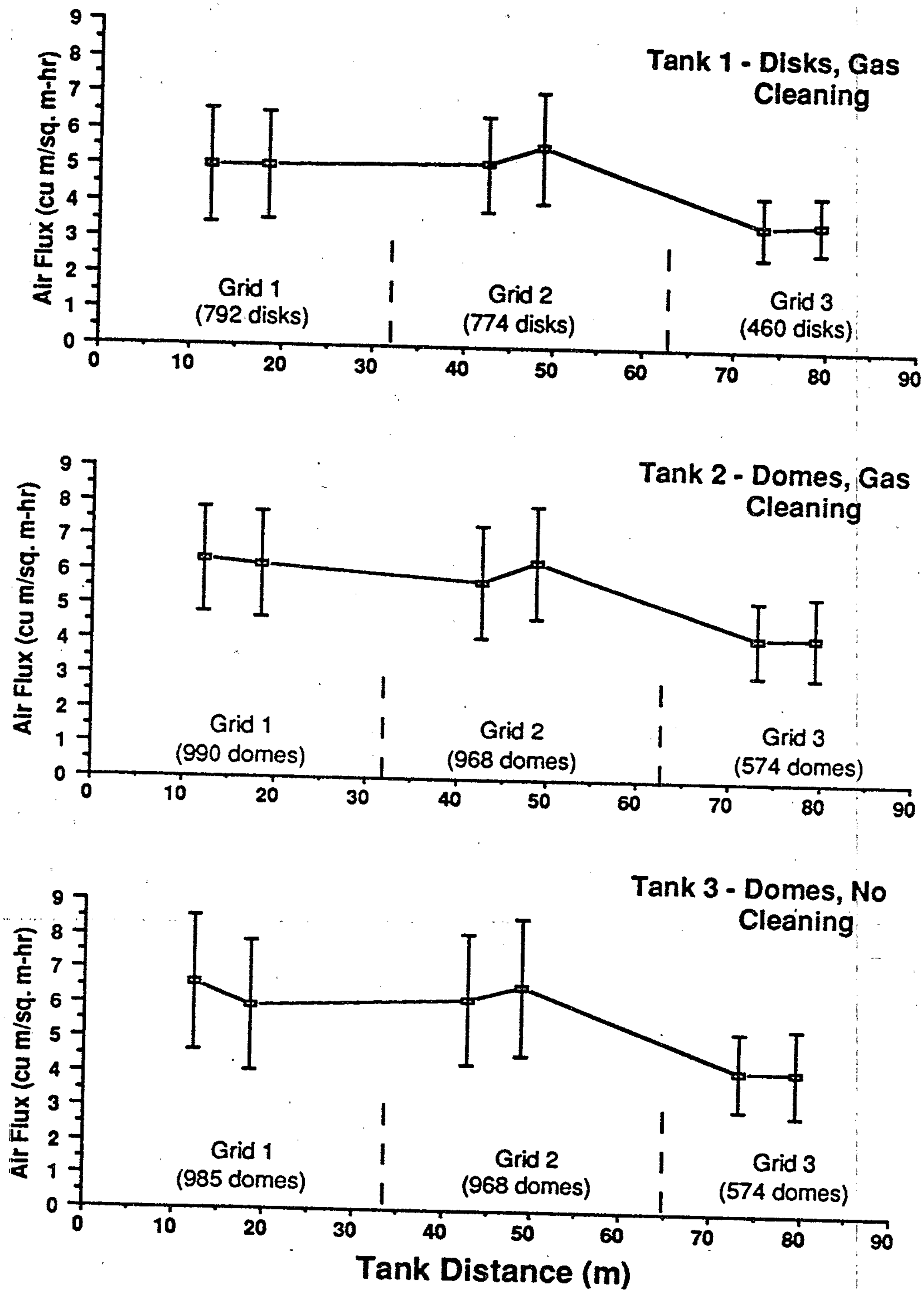

Figure 18 Air Flux versus Distance at Whittier Narrows

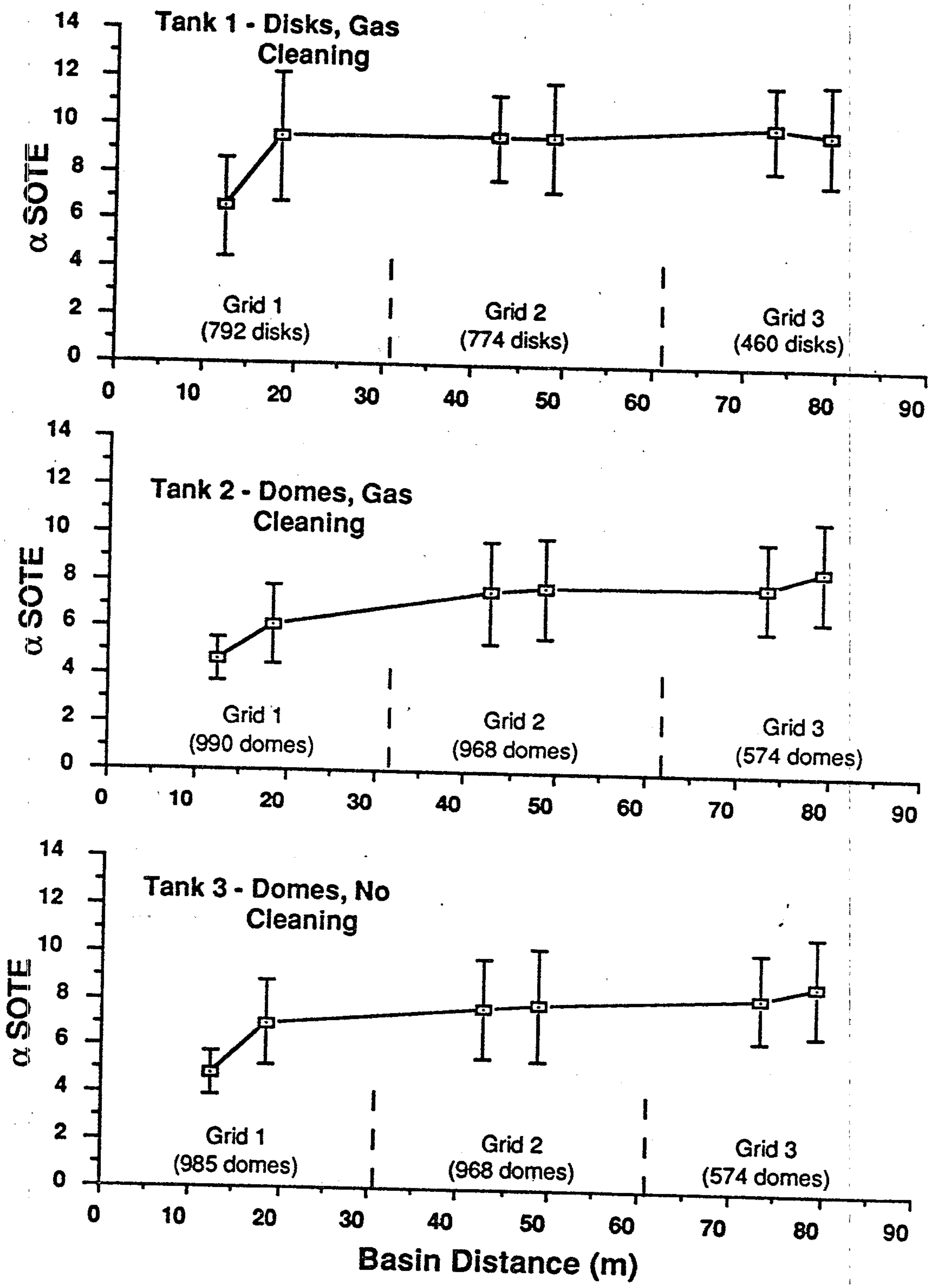

Figure 19 αSOTE versus Distance at Whittier Narrows

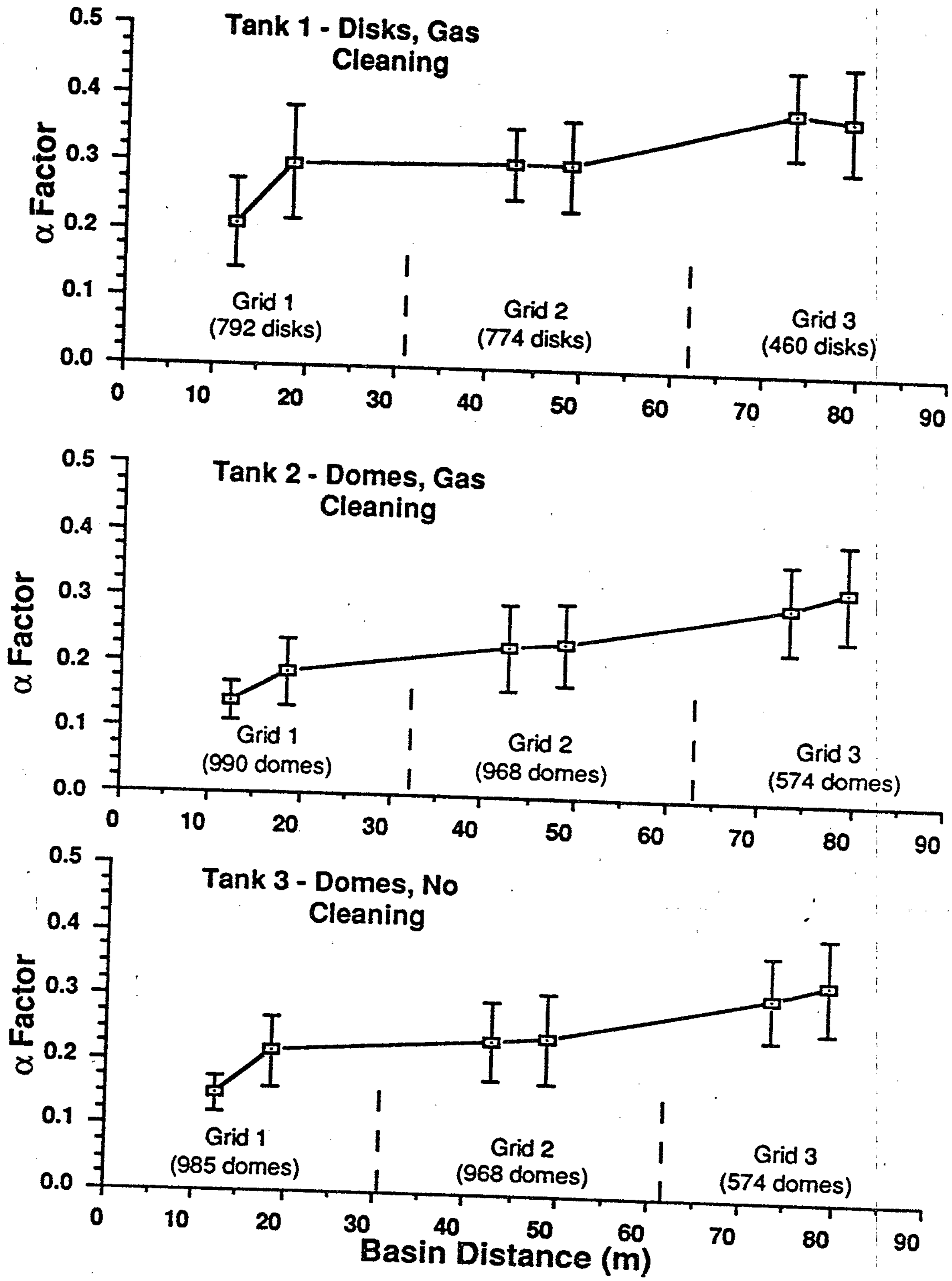

Figure 20 α Factor versus Distance at Whittier Narrows

In August 1986 plant operation was changed. The mixed liquor solids concentration and sludge retention time were reduced from the range of 820 to 1160 on the previous test dates to 700 mg/L on August 21. The F/M ratio, based upon primary effluent COD increased from approximately 1.4 to 2.1 day^{-1} on August 21. The SRT decreased from slightly greater than 2.0 days to 1.7 days. The lowest αSOTE occurred on October 17, 1986 when the MLVSS for all three tanks averaged 409 mg/L. The COD F/M was 2.2 day^{-1} and the SRT was 1.2 days. On October 31, 1986 the MLVSS was increased to 843 mg/L, with a corresponding COD F/M of 2.1 day^{-1}. The αSOTE for tank 1 increased from a low of 6.1 to 8.6% (tank 2 increased from 3.4 to 6.7%) from October 17 to October 31. On December 19, 1986 the MLVSS increased to 1080 mg/L with a corresponding COD F/M and SRT of 1.0 day^{-1} and 2.0 days, respectively. The αSOTE for tank 1 under these circumstances increased to 11.8%. During this period the plant routinely met its effluent permit.

It is unfortunate that changes in plant operation affected the study in this way, since the effects of diffuser fouling for the period of July to December 1986 are masked by the effects of changing plant operation; however, the impact of plant operation, particularly the parameters associated with high rate operation (e.g. high F/M, low SRT, low MLVSS or MLSS) were a particularly valuable finding. After October 1986, changes in plant operation were less dramatic and the data are less scattered.

The disk tank was essentially undisturbed until December 1987, when the plant was placed in step feed operation. The αSOTE and α factor seem to have declined because of the change to step feed.

In August 1988, the disk system was removed from service and manually cleaned using tank top hosing. This increased the αSOTE dramatically, from 5.9% measured on June 16 to 8.7% measured on August 12. Tank top hosing did not restore the disks to previous treatment efficiencies.

Stationary Testing

On July 22, 1986, a stationary test was performed to determine the change in α and αSOTE with the diurnal change in plant loading. The hoods were placed at tank lengths of 12, 73 and 43 meters in tanks 1, 2 and 3, respectively. This hood arrangement could be tested without moving the analyzer using existing hoses.

Figure 21 shows the results of the stationary testing. The transfer efficiencies were relatively constant from approximately 8 AM until slightly after 10 AM when they began to fall. Imposed on Figure 21 are the primary effluent COD's measured in a previous study. They show an increasing concentration up to about 2 PM (1400), which is typical of most domestic wastewaters. The highest plant loading corresponds with lowest alpha factors.

The experimental design for this study anticipated this changing plant load and its impact on aeration efficiency. As indicated previously the study goals were to evaluate HCl acid gas cleaning. Testing each position in the experimental tanks (1 and 2) within just a few minutes of the control tank (3) minimized time of day dependent variability in results. Also almost all tests were conducted on Fridays, which eliminated day-of-the-week variability which often occurs at domestic wastewater treatment plants.

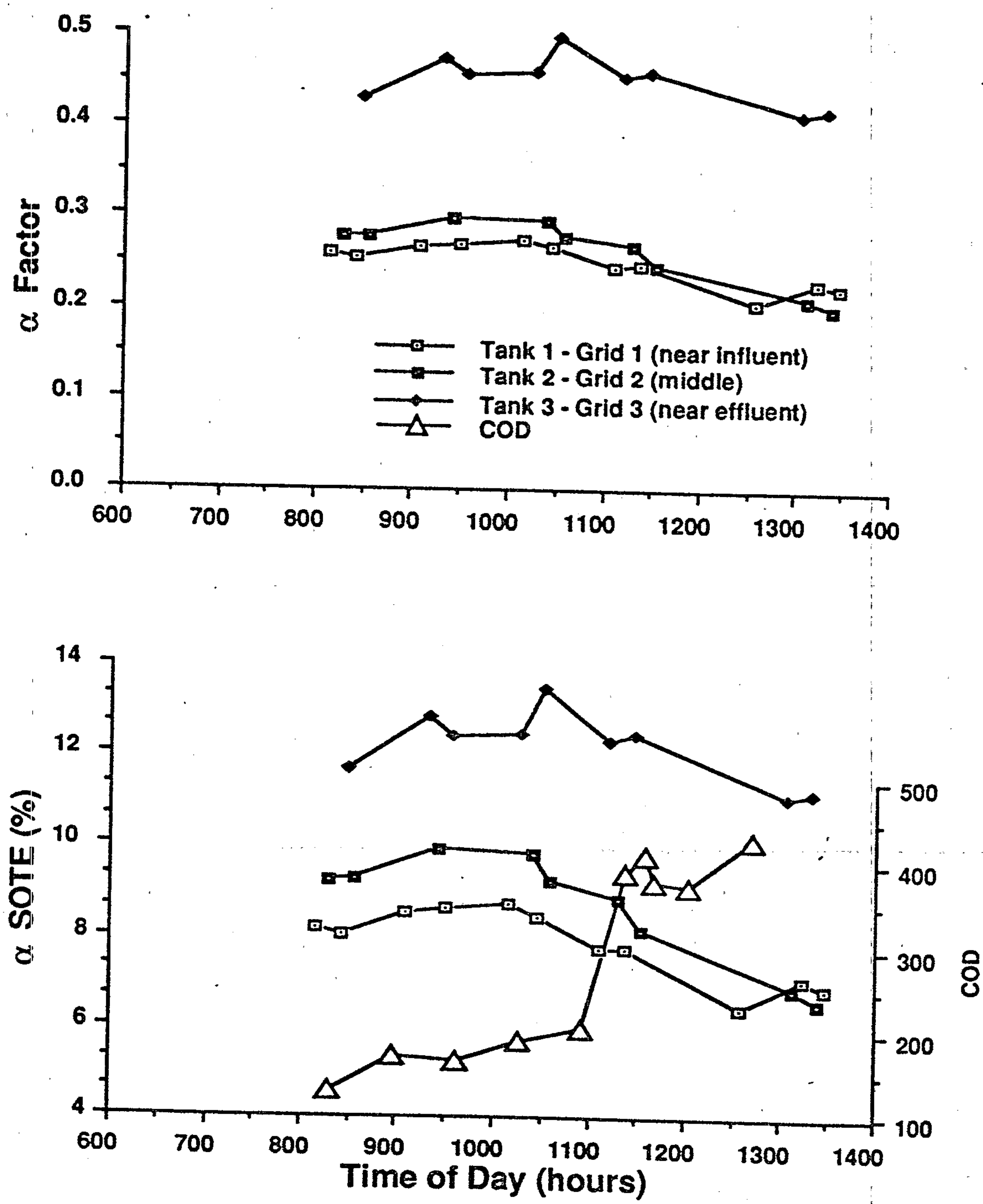

Figure 21 α Factor and αSOTE versus Time of Day

Off-Gas Testing During HCl Acid Gas Cleaning

There seems to be almost no effect of HCl acid gas cleaning in Figures 13-16. This is not surprising since the technique is designed to avoid diffuser fouling. To closely measure the effects of HCl acid gas cleaning, off-gas testing was performed simultaneously with cleaning on March 26 and 27, 1987.

The off-gas testing procedure was modified to monitor the effects of gas cleaning. On March 26 grids 1 of all three tanks were were tested in exactly the same fashion as a normal test. After finishing with grid 1, the hood in tank 1, which was being cleaned first, was left at the 18 meter position (position 2). Testing in tanks 2 and 3 was suspended. Off-gas testing continued in tank 1 at intervals during the cleaning. Hood flux was not balanced since flow weight averaging of these results was not applicable. Tests were conducted before, during and after cleaning. As cleaning proceeded to grids 2 and 3 of tank 1, the hoods were moved and testing was performed at the fourth and sixth hood positions. Grid 3 of tank 2 was also cleaned and tested on March 26.

On March 27 testing and cleaning resumed. At the beginning of the morning grids 1 of all three tanks were tested in the normal fashion. After completing testing of grid 1, testing in tanks 1 and 3 was suspended and testing of grids 1 and 2 in tank 2 was performed as it was being cleaned.

At the conclusion of these two days all three grids of tanks 1 and 2 had been HCl acid gas cleaned and tested. These test results include results before, during, and after HCl acid gas cleaning. Two sets of test data from grid 1 of tank 3 were collected which provided a control for tank 1, grid 1 before and after cleaning.

Figure 22 shows αSOTE for all six grids as a function of time. The graphs generally have a trend which shows high αSOTE near time zero, decreased αSOTE in the middle, and increased αSOTE at the conclusion of cleaning. This results because the air flow rate is increased from the nominal value of 5 m^3/hr/diff just after time zero to 15 to 20 m^3/hr-diffuser during cleaning and then back to the nominal value.

During this project there was some speculation that HCl acid gas cleaning temporarily lowered αSOTE immediately after cleaning. Figure 22 shows that this did not happen at Whittier Narrows. The grids in tank 1 all increased slightly in αSOTE at the end of cleaning, while the αSOTE in tank 2 remained almost the same after cleaning. The changes in efficiency show in Figure 22 from before to after testing should be viewed cautiously, since they are also a function of gas flow rate. Whittier Narrows WRP air flow rate controls are manually operated and it was not possible to exactly duplicate the gas flow rates before cleaning.

Figure 23 shows the αSOTE in grid 1 of tanks 1 to 3 on March 26 and 27. The αSOTE is plotted for hood positions 1 and 2, at 12.2 and 18.3 meters. The αSOTEs were generally lower on March 27 irrespective of cleaning. This result most probably occurs because the differences in day-to-day plant operation were greater than the immediate effects of HCl acid gas cleaning. Figure 24 shows the ratios of αSOTE at each station in tank 1 and 2 to the control tanks for the two days. This figure shows that the ratio of the HCl cleaned tank (tank 1) to the control tanks (tank 3) was slightly less after cleaning at hood position 1, and much greater at hood position 2.

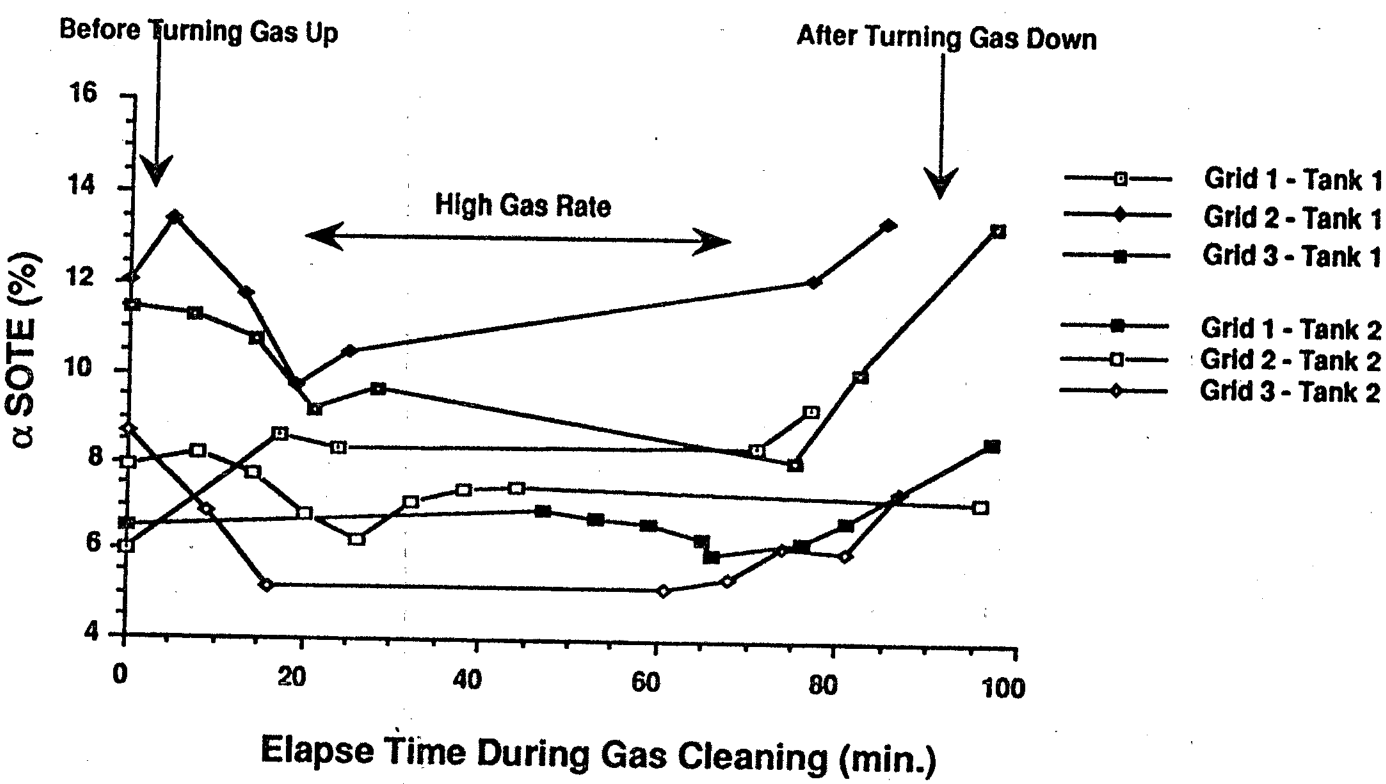

Figure 22 αSOTE during HCl Gas Cleaning

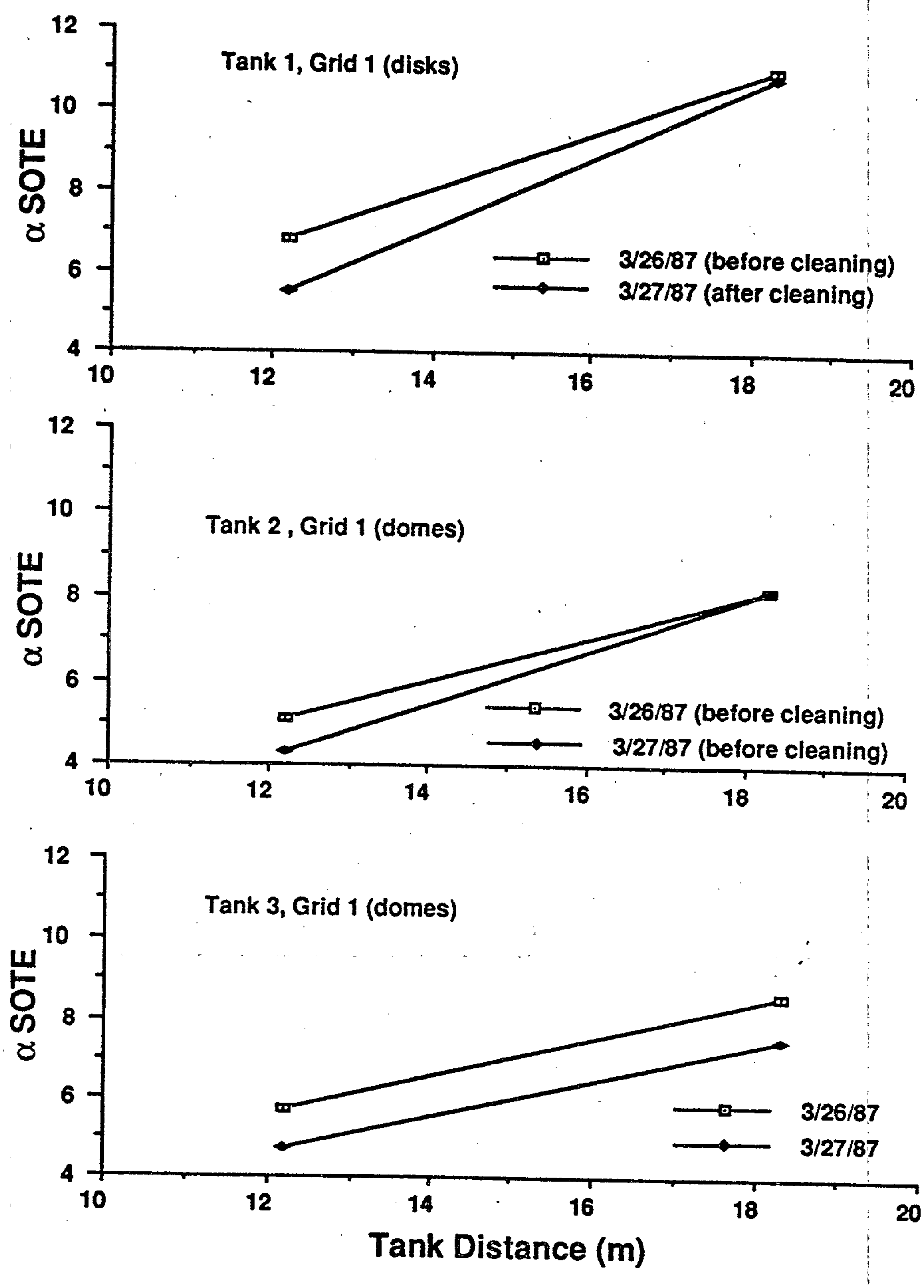

Figure 23 αSOTE for Grid 1 Before and After Cleaning

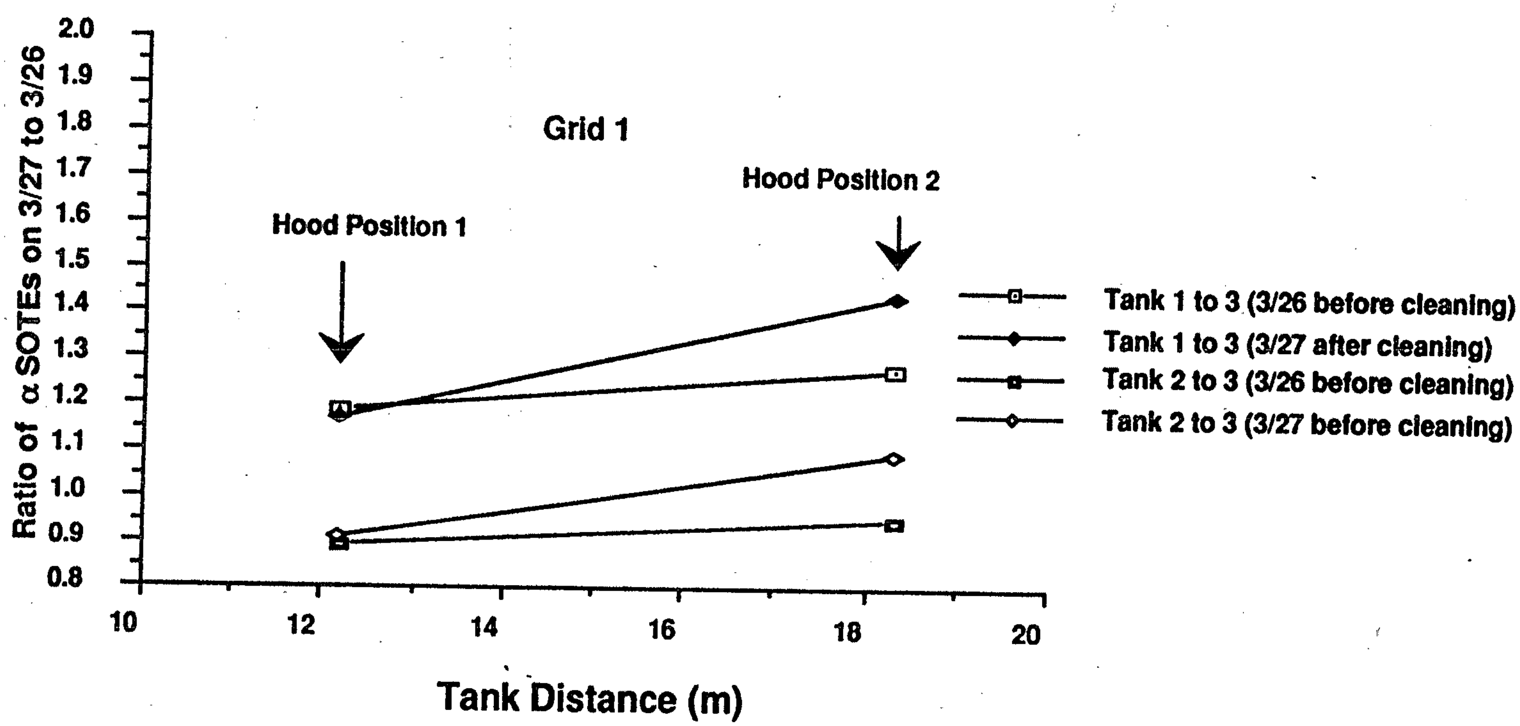

Figure 24 Ratio of αSOTE Before and After Cleaning

For tank 2 the ratio to the control is almost the same at position 1 and slightly greater at position 2. The net conclusion that can be made from this data is that before cleaning, tank 1 had 23.6% higher αSOTE than the control tank, while after cleaning it had 30.5% higher αSOTE than the control. Tank 2 which was not cleaned prior to off-gas testing, but was similarly better on March 27 than March 26 when compared to the control tank. On March 26 it was 7.6% lower in αSOTE than the control and on March 27 it was 0.5% higher than the control. Overall, on March 27 the αSOTE was lower for all three tanks than on March 26.

The effects of HCl acid gas cleaning on DWP have been discussed previously; however, it is interesting to note the changes in DWP during gas cleaning. The DWP is usually elevated before cleaning and usually decreases very shortly after the application of HCl gas. The decrease in DWP causes the air flow rate to increase.

Figure 25 shows the decrease in DWP after application of HCl gas during the March 26/27, 1987 cleaning. DWP data are shown for grids 2 and 3 of tank 1 and grids 1 and 3 of tank 2. DWP lines for the other grids were not functioning. Figure 26 shows the air flow rate to each grid during this same period. The increase in air flow rate is dramatic. For grid 2, tank 2 the flow rate increased from approximately 4,050 m^3/hr to almost 4,500 m^3/hr, or 10%. There is some speculation that this increase in flow rate is wholely or partially instrument error, since the flow measuring devices (venturi flow tubes in the case of Whittier Narrows) are calibrated for air and not the combination of air and HCl gas; however, this is not true because the HCl gas is introduced downstream of the flow measuring device. Also the flow rate remains elevated even after the HCl gas flow is terminated.

It is difficult to identify statistically significant conclusions from off-gas analysis during or immediately following HCl acid gas cleanings. This is not surprising in view of a cleaning philosophy of preventing fouling, as opposed to restoring a fouled tank. In a later section the fouling rates for all systems are regressed as a function of time, and the effects of HCl gas cleaning on maintaining high αSOTE and α factors are discussed.

Dome Replacement

Sixteen months after the initial liquid acid cleaning of all three tanks the performance of tanks 2 and 3 was so poor that Districts' personnel felt that they had to manually clean the domes in both tanks. During September and October 1987 tanks 2 and 3 were dewatered for cleaning. It is common practice during such cleanings to dewater the tanks to just a few centimeters above the diffusers so that the diffuser's air release pattern can be observed. In this way gasket leaks and uneven air distribution can be observed.

When tank 3 was dewatered the domes were observed and the number of malfunctioning domes were counted. The first half (toward influent side) of each grid were counted. Malfunctions were classified into plugged diffusers (no air flow, no gasket leakage), leakage around the dome bottom gasket, bolt breakages, and non-uniform air distribution ("hot spots").

Figure 27 shows the results of the survey. Normally functioning diffusers are indicated by an open circle; plugged diffusers are denoted by a closed circle. The stars indicated "hot spots" and the crosses indicate gasket leaks. The closed squares denote diffusers with both gasket leaks and hot spots. No bolt breakages were observed.

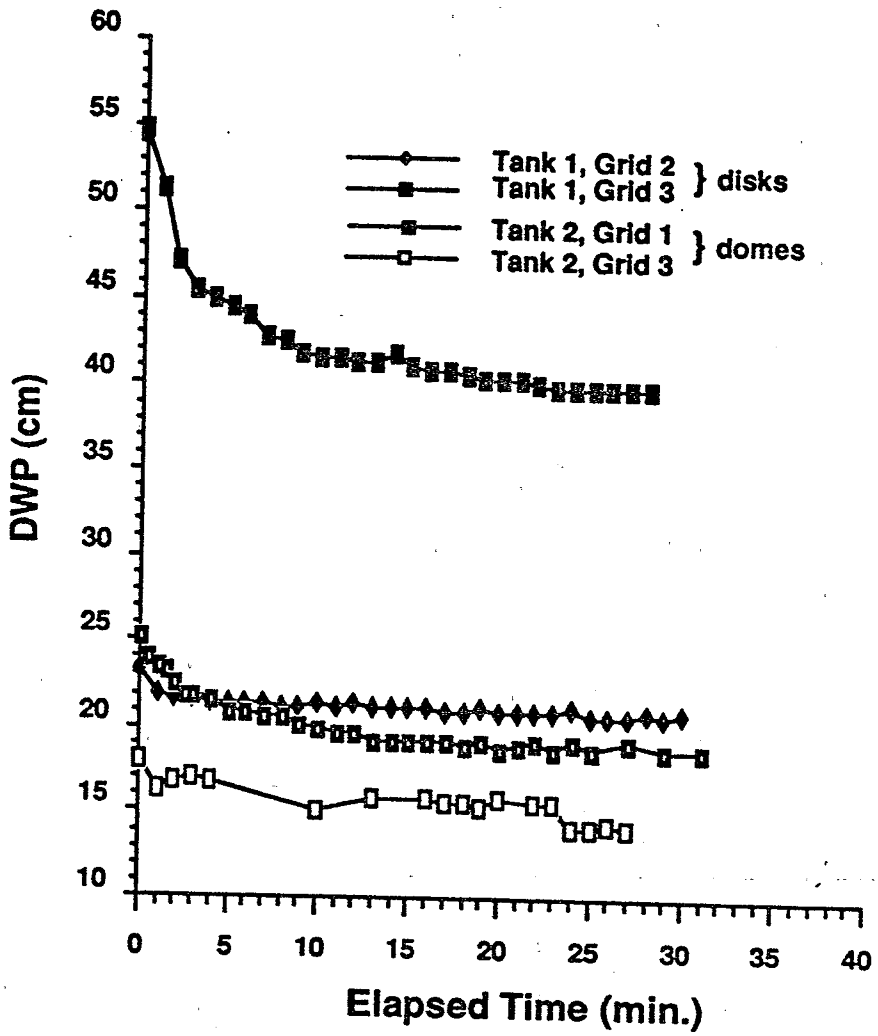

Figure 25 Decrease in DWP versus Time During HCl Acid Gas Cleaning

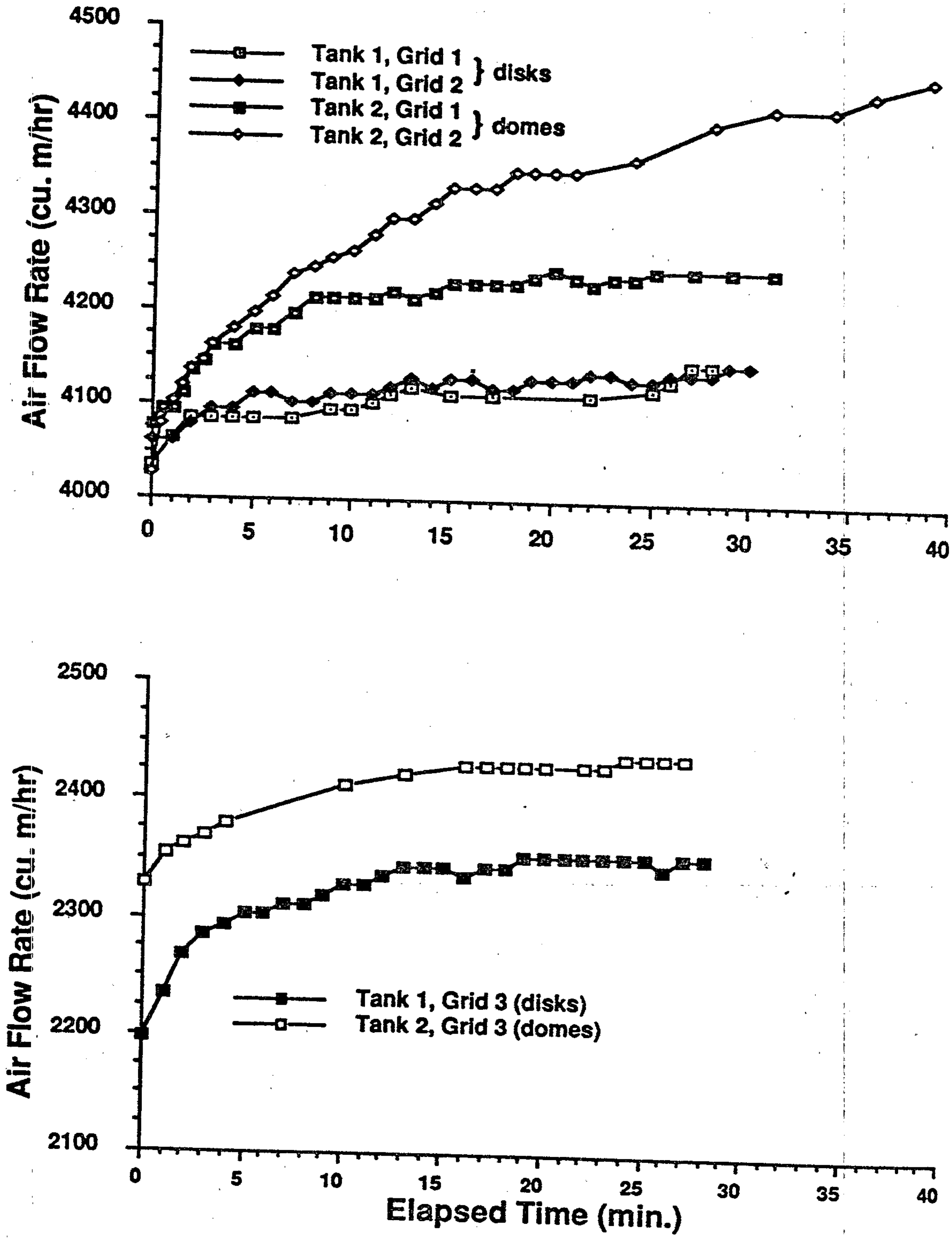

Figure 26 Air Flow Rate versus Time During HCl Acid Gas Cleaning

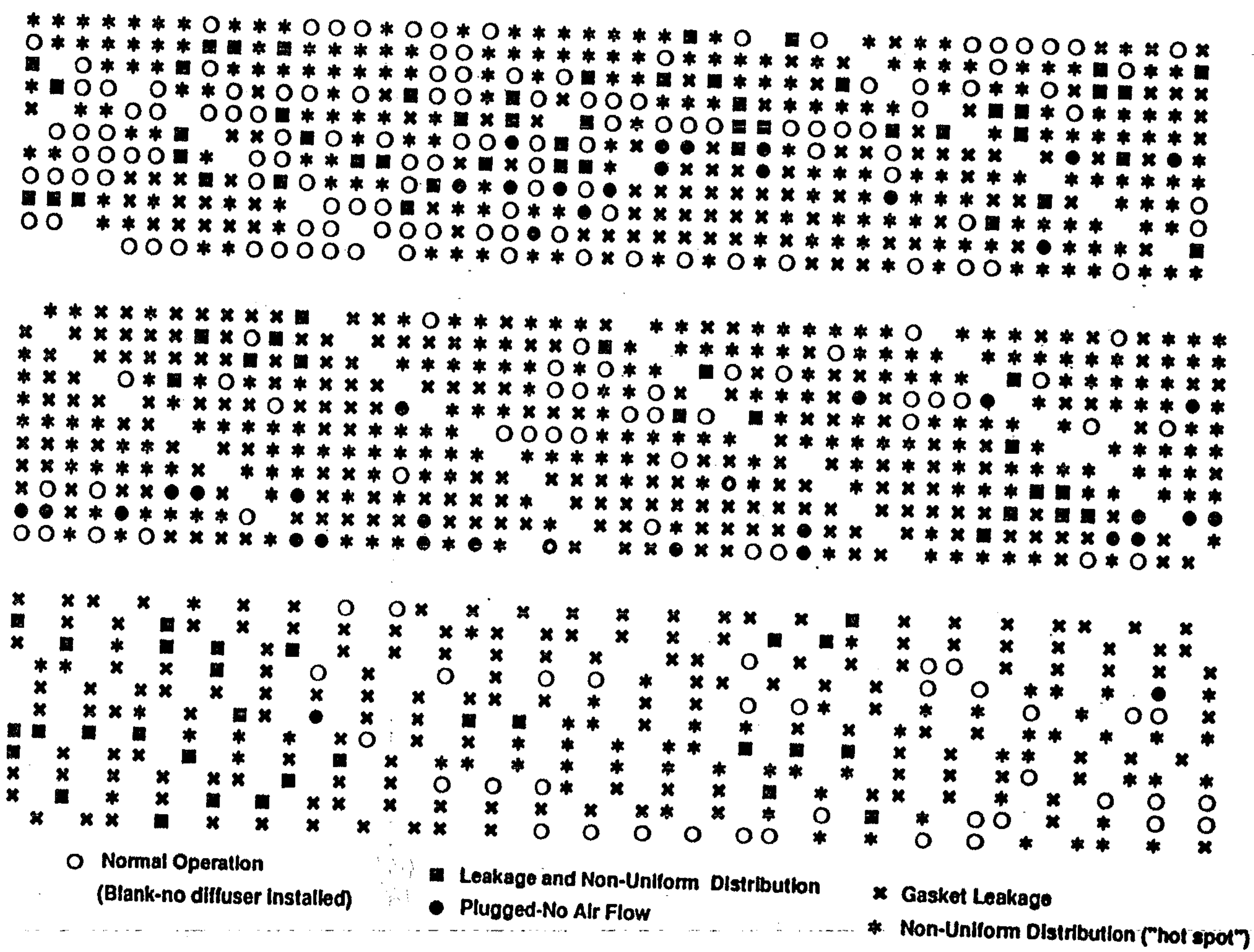

Figure 27 Dome Failures for Tank 3 at Whittier Narrows

Table 18. Diffuser Malfunctions for Tank 3 (Domes, uncleaned)

Grid %	Normal %	Clogged %	Gasket Leaks %	Non-Uniform Air Distribution %	Leaks & Non-Uniform Air Distribution %
1	26.1	3.3	41.0	19.2	10.4
2	9.2	4.8	42.9	39.4	3.8
3	12.8	0.7	22.6	53.5	10.4
Total*	16.6	3.3	37.5	34.7	7.9

* Columns must be weighted by the number of diffusers per grid to obtain the total

Table 18 summarizes the failure statistics. For grid 1 only 26% of the diffusers were performing properly. For grids 2 and 3 the number of properly functioning diffusers was only 9 and 13%, respectively. Grid 3 had the fewest clogged diffusers while having the most non-uniform air distributions. There appears to be few trends in the data shown in Table 18; however, the following speculation is offered, based upon the premise that the fouling rate of grids closest to the influent is greatest. The statistical analysis shown previously suggested that the early grids fouled more rapidly only on the basis of ratio of BRV to DWP.

> As the dome ages gas flow becomes uneven due to clogging at the dome surface. As a greater area of the dome surface is clogged the DWP increases. At some point during this period of increasing DWP, the gasket begins to leak, because of elevated pressure. The gasket leakage further reduces air flow rate through the dome causing even more non-uniform air distribution. Eventually no gas flow occurs through the dome and only gasket leakage occurs.

Tank 2 was similarly observed during dewatering, but detailed sampling was not performed; however, several small areas in each grid were counted, indicating that the gasket leakage rate was approximately the same as tank 3. It was also observed that the majority of the leaks were at the two edges of the dome furthest from the air manifold pipe. This supports the speculation that the PVC dome holders were warped and that this contributed to the leakage problem. The air flow rate to the tank was also increased and decreased while observing diffusers that were clogged, leaking or having non-uniform air distribution. The malfunctions did not change with changing air flow rate.

The domes were functioning so poorly that the Districts felt that they could not be cleaned in-situ. The domes were replaced with new domes that were purchased at the time of the original dome installation (1981/82) and kept in storage as spares for the San Jose Creek and Whittier Narrows WRP. Therefore, the domes tested and cleaned after October 1987 were new domes and gaskets manufactured at approximately the same time as the original domes, but there is no way of knowing if they were from the same batch as the original domes.

Gaskets and domes removed from tanks 2 and 3 were analyzed at this time. The underside of the domes appeared clean, except for a black stain that radiated outward from the middle of the dome. This stain was caused by the air striking the dome undersurface as it flowed in a narrow stream from the orifice hole in the dome mounting bolt. Almost all gaskets showed evidence of nonelastic deformation, which probably contributed to the leaks. Some gaskets appeared to have stretched under the air pressure and were no longer in contact with the entire lower side of the domes.

As indicated previously, the gaskets and bolts used at Whittier Narrows were different from the current Norton dome installation. The bolts were fiber-reinforced ABS and were purchased for future compatibility with the HCl gas cleaning process. The gaskets were a spongy material, as opposed to hard rubber and were standard issue at the time of purchase. When the domes were replaced in tank 2 several were replaced using hard rubber gaskets. In May 1988, tank 2 was again dewatered. All the fiber reinforced ABS bolts used with the hard rubber gaskets had failed.

In July 1988, tank 1 was dewatered for manual cleaning on inspection. There were five leaking "o-rings" in the entire tank. In some cases there was non-uniform air distribution, with the air exiting close to the disk periphery; however, this disappeared when the air flow rate was increased slightly.

Ratios of Transfer Rates

A final procedure was used to evaluate the improved transfer efficiencies that might be due to acid gas cleaning. The ratio of transfer efficiency just after cleaning to just before cleaning was calculated for each tank. Next, the ratio for each gas cleaned tank, (tanks 1 and 2) was divided by the same ratio for the uncleaned, control tank (tank 3). Equation 4 shows the overall ratio.

$$R_{i,j} = \frac{\alpha SOTE_{i,j} / \alpha SOTE_{i,j-1}}{\alpha SOTE_{3,j} / \alpha SOTE_{3,j-1}} \qquad (4)$$

where

i	=	tank number (1 or 2)
j	=	date of off-gas testing immediately following gas cleaning
j-1	=	date of off-gas testing immediately before gas cleaning

Generally the elapsed time between off-gas testing was 2 weeks. Table 12 shows the testing schedule.

Figure 28 shows the ratios. A value of 1 indicates that the test tank had the same αSOTE before and after the cleaning, relative to the control tank. It was necessary to normalize the transfer rates with respect to the control in order to remove the fluctuations in transfer rate due to influent changes and process operational changes. The mean value of the ratios for both tanks is approximately 1, and is also shown on Figure 28. This suggests that gas cleaning had no observable, immediate impact on αSOTE. The early part of the testing showed a ratio greater than 1.0 for Tank 1. The data at 15.6 months biases the average downward. If one excludes this data point the averages are greater than 1.0, but the 5% confidence intervals cross 1.0, suggesting that the data are not statistically significant.

VALENCIA

Off-gas testing was performed at Valencia on tank 4 beginning on May 27, 1987. Seven tests were performed with testing ending on June 14, 1988. For the first three tests air flow measurements were available. For the last four tests air flow measurements were unavailable, due to blockage in the manometer lines.

In order to estimate α factors for Valencia, it was necessary to use the hood gas flow rate to estimate the air flow rate per diffuser. At some plants this can be quite problematic because it is difficult to obtain a close balance between measured air flow rate and hood flow rate. At Whittier Narrows the air flow measurements were quite reliable and were used to calculate the air flow rate per diffuser in order to estimate SOTE and α factors.

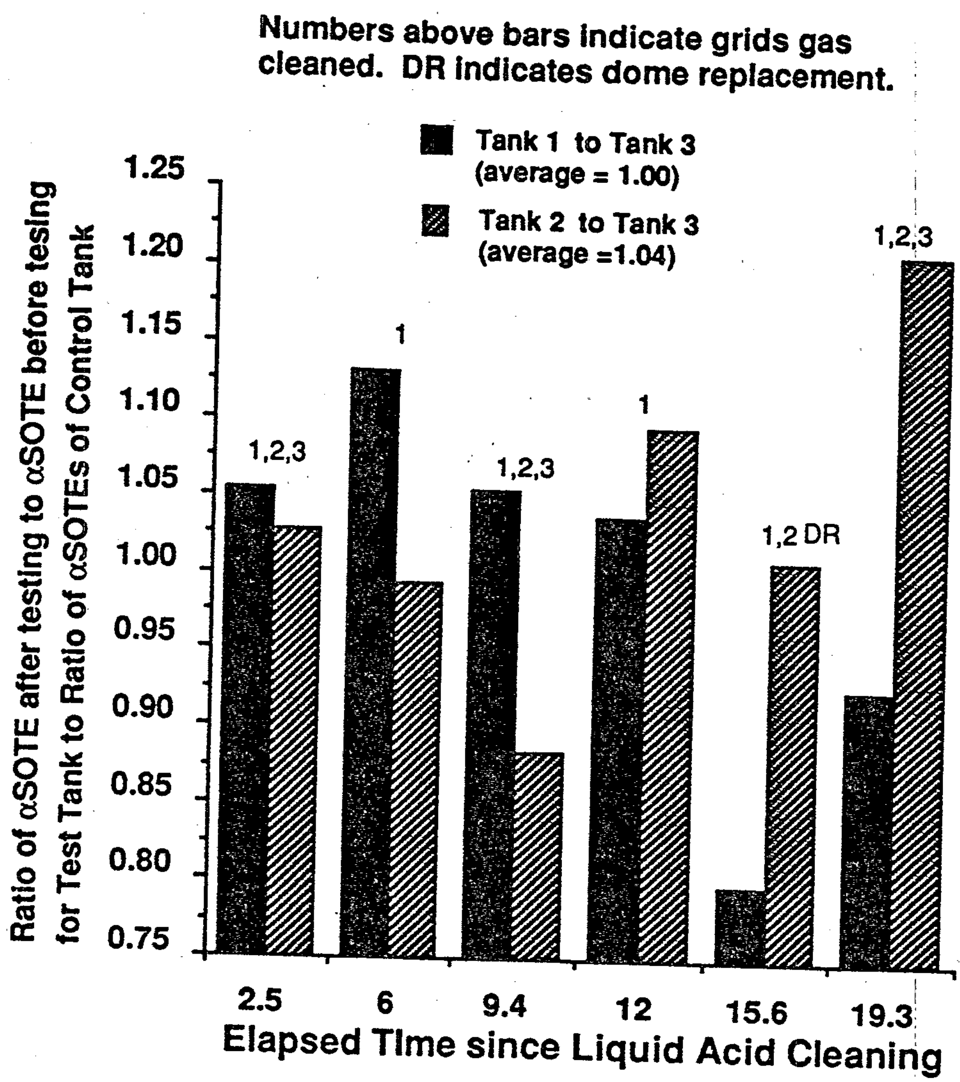

Figure 28 Normalized Ratio of αSOTEs Before and After Cleaning

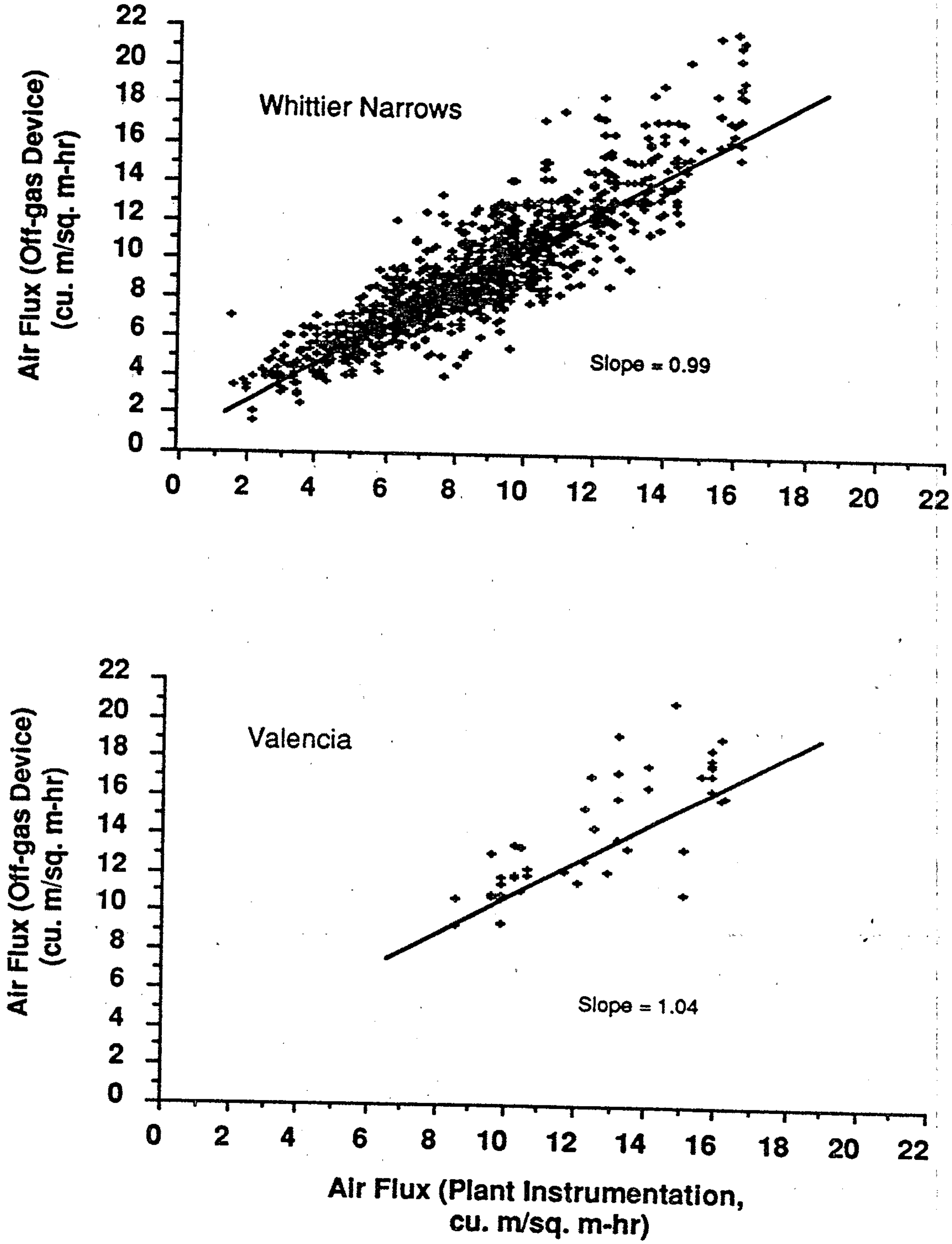

Figure 29 Hood Flux Versus Process Air Flux at Whittier Narrows and Valencia

Figure 29 shows the measured air fluxes using the air distribution system instrumentation and the air fluxes using the off-gas hood and analyzer rotameters. The top graph shows Whittier Narrows for all three tanks and all tests. The correlation between the two measured values is 0.993 (slope of the straight line) with an intercept of 0.0313 m^3/m^2-hr. The correlation coefficient (R^2) is 0.803. This is a good match between the process air flux and the hood fluxes. There is no bias in underestimating or overestimating the process air flow rate using hood flux. The scatter results from random error as well as maldistribution within the grid. Also at Whittier Narrows there was a small time difference between measuring hood flux and measuring plant air flow rate (± 5-10 minutes). The lower graph in Figure 29 shows the same data at Valencia for the first three tests. The fit is not as good ($R^2 = 0.6$) but the correlation is unbiased (slope = 1.04 with an intercept of 0.0642 m^3/m^2-hr).

This unbiased estimate of the process air flow rate from the hood air flux provides justification for using hood flux to estimate air flow rate per diffuser; therefore, the hood flux was used for tests 4 to 7 at Valencia. The hood fluxes were also used at Terminal Island to estimate air flow rate per diffuser for both the Parkson-Wyss and AERMAX tanks, since no plant instrumentation was available.

Figure 30 shows the αSOTE, α factor and air flux for Valencia for the 13 month period of observation. Figure 31 shows the αfactor and αSOTE versus tank distance. The error bars represent the standard deviation of the data. The trend of higher α factor in the stabilization zone to lower α factor in the contact zone and back to higher α factor in the effluent zone is consistent with expectations, and was also observed at the San Jose Creek WRP. α factors for endogenous activated sludge, as in the stabilization zone, are higher than α factors for non-endogenous activated sludge (Stenstrom and Gilbert, 1981).

Figure 32 shows the air flux versus tank distance. The air flux was not tapered so heavily as Whittier Narrows. The low flux at hood position 4 is possibly an artifact of the proximity of the hood locations to the baffle and the edge of grid 2A.

There is very little evidence for a declining oxygen transfer efficiency at Valencia. The drop in efficiency at months 7 and 9 are probably due to the increase in flux as opposed to other fouling phenomena.

TERMINAL ISLAND - PARKSON-WYSS

The upper half of Figure 33 shows the αSOTE and air flux of the Parkson-Wyss system as a function of time. The lower half of Figure 33 shows the αSOTE and air flux as a function of tank distance. Figure 34 shows the air flux, air flow per diffuser and DO concentration as a function of tank distance. The performance of the tank is highly variable and this can in part be attributed to changes in plant operation. The peak in air flux and the resulting decrease in αSOTE occurred because of tank overloading. No clean water data were available; therefore, no α factors were calculated.

After about four months of operation plant personnel decided to change the contacting pattern. Tank 5 (the spiral roll control tank) was removed and tank 2 was returned to service, allowing tanks 1, 2, and 3 to be operated in serpentine flow for step feed. Both tanks 4 and 6 would have been unaffected by this change, except that the sluice gates controlling the influent

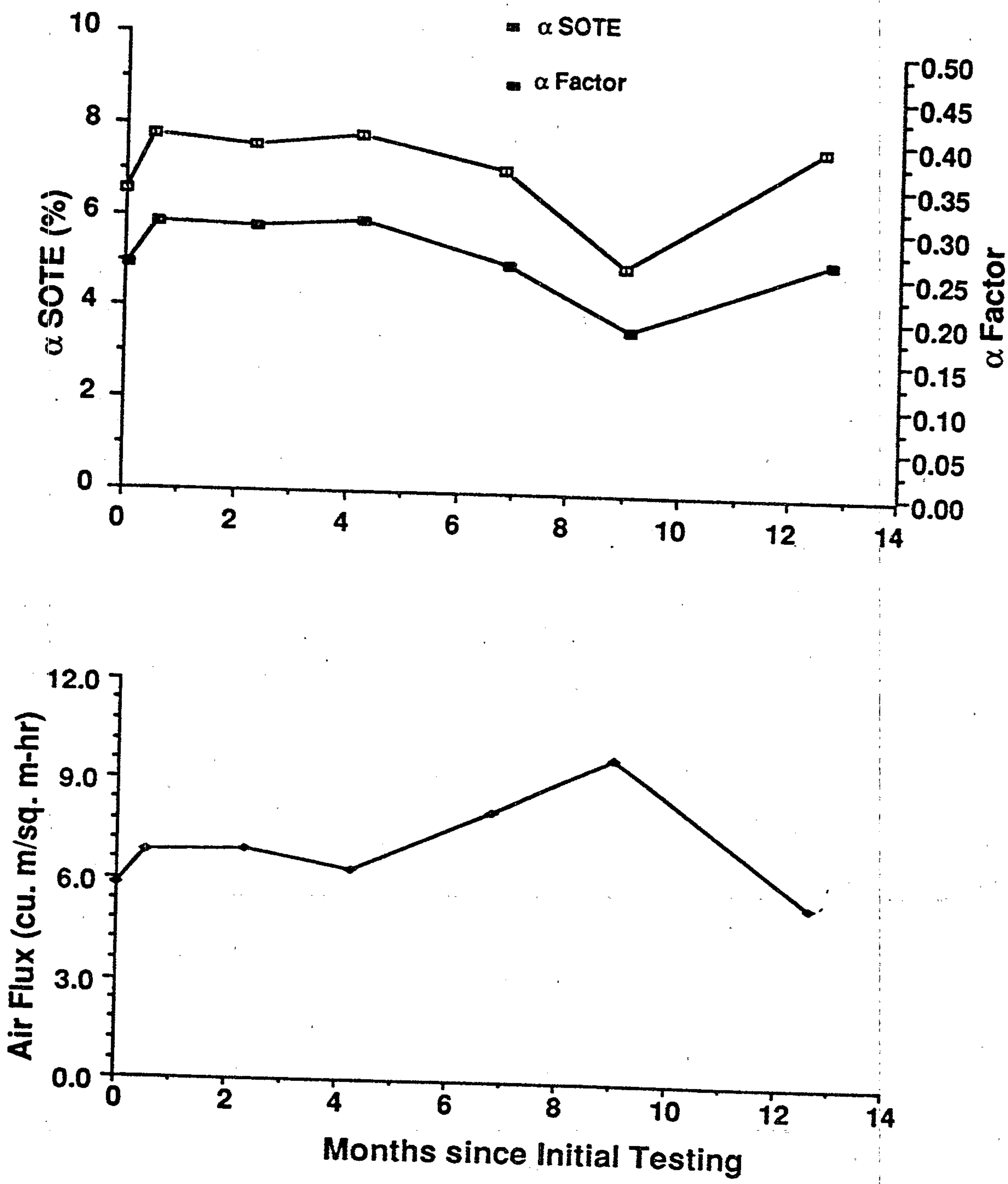

Figure 30 αSOTE, Air Flux and α Factor at Valencia

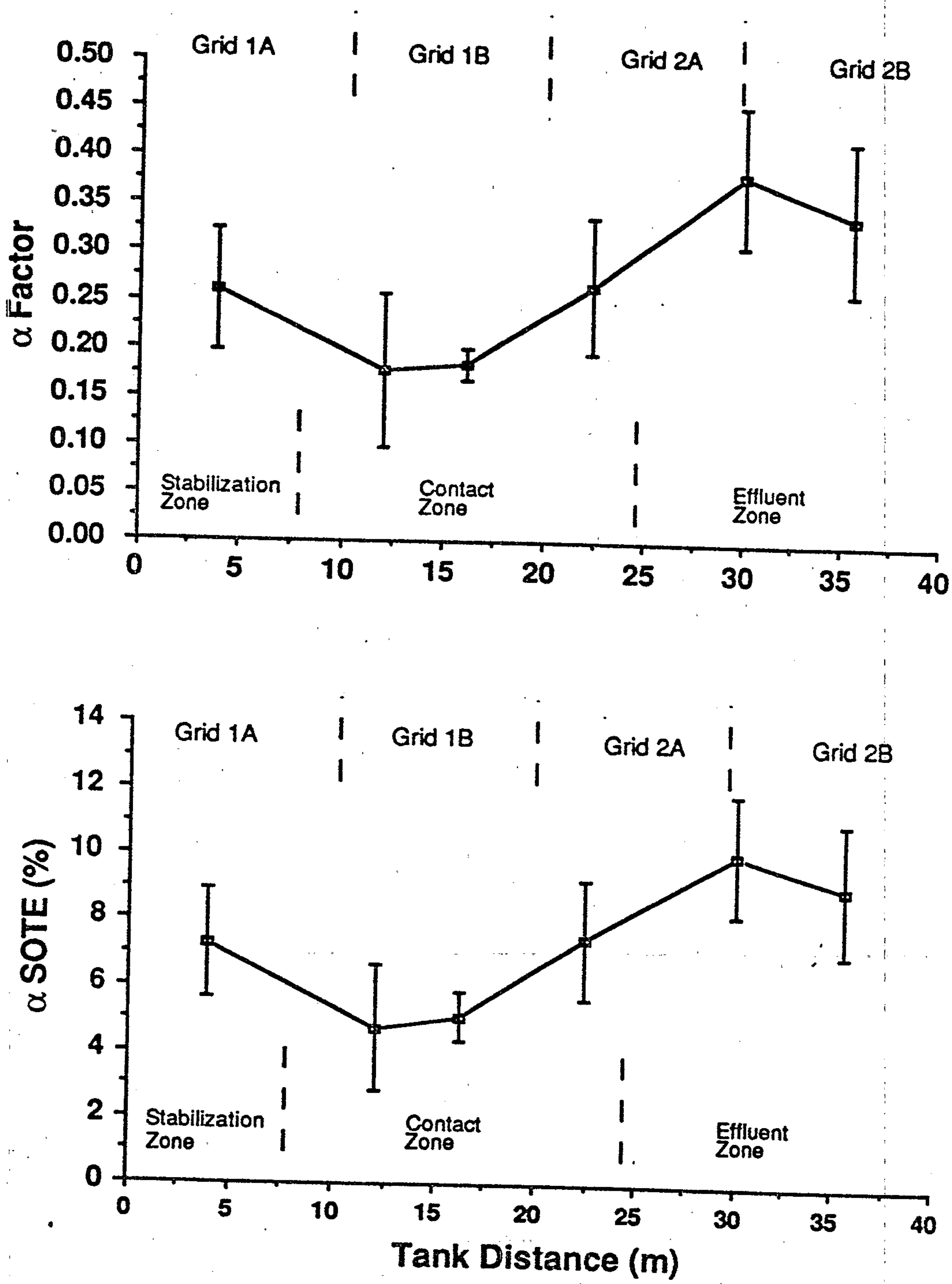

Figure 31 αSOTE and α Factor versus Distance at Valencia

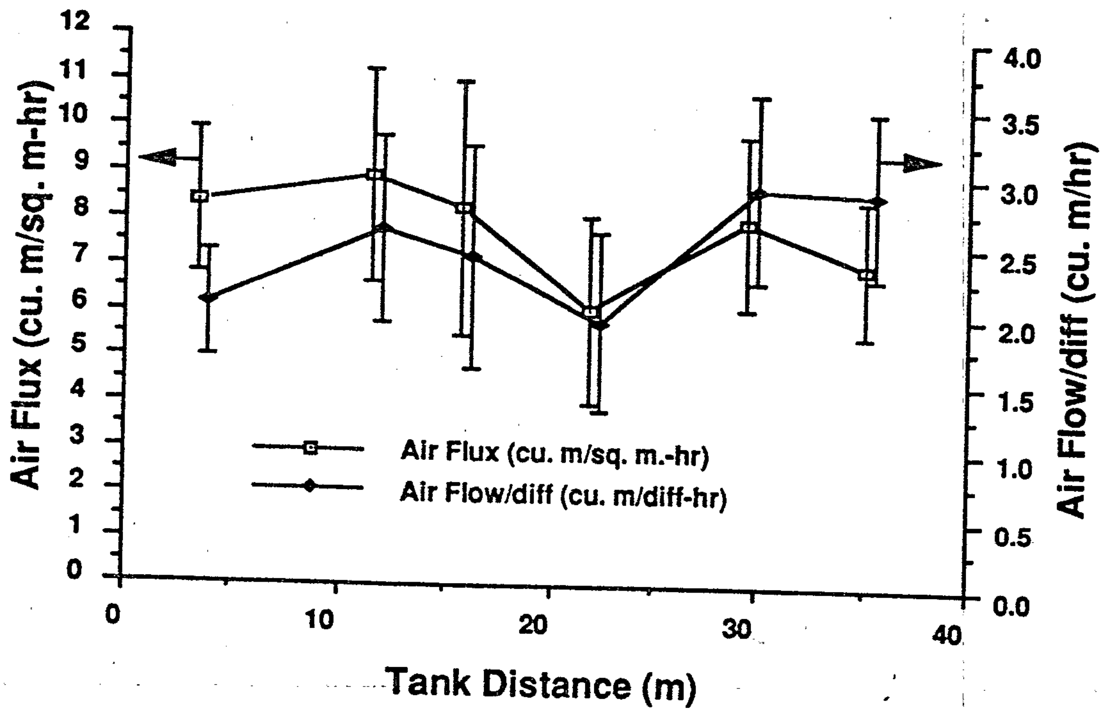

Figure 32 Air Flux versus Distance at Valencia

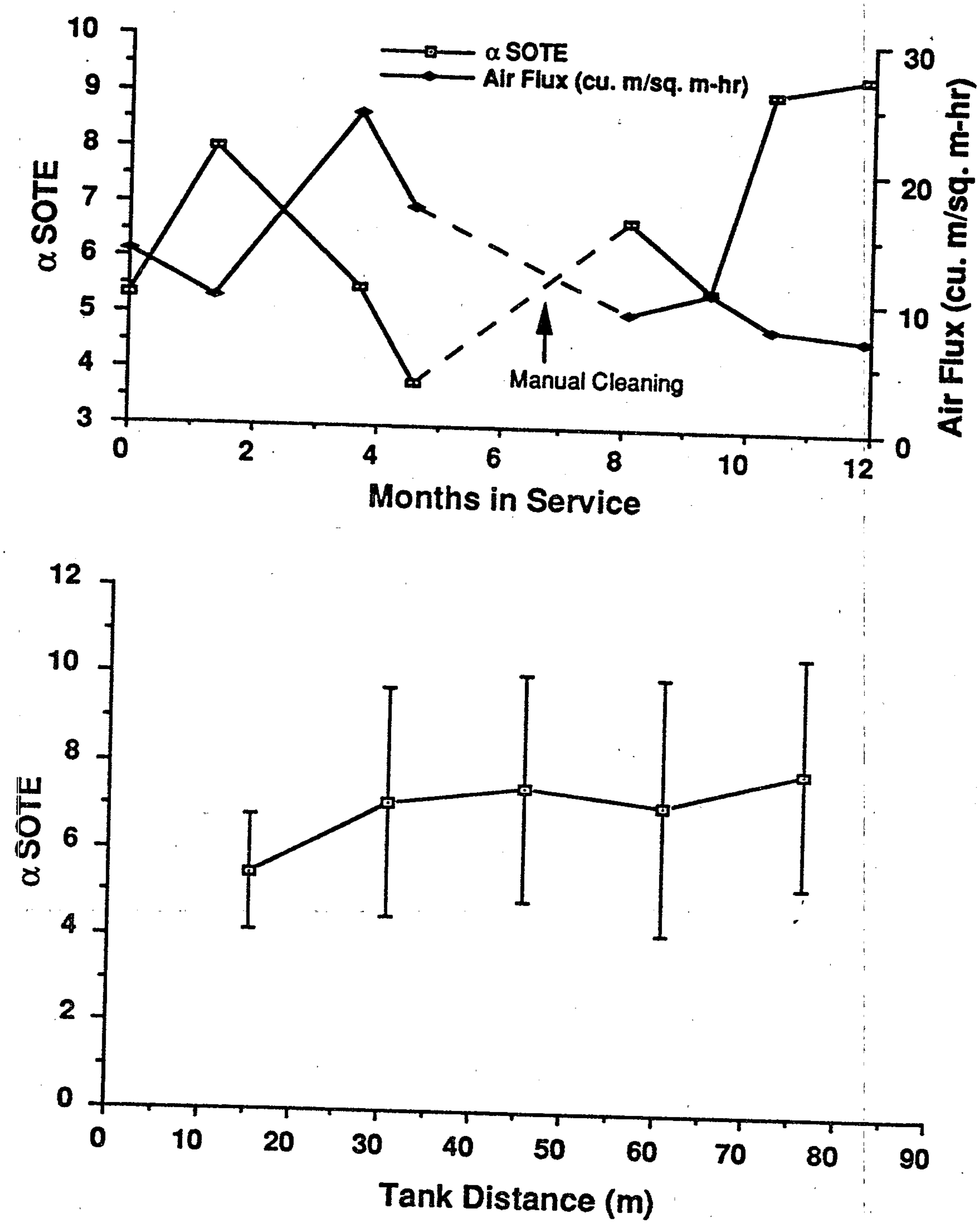

Figure 33 αSOTE, Air Flux and DO for Parkson-Wyss at Terminal Island

flow to each tank were not readjusted properly. There is no instrumentation to monitor flow rate to each tank. The loading on tanks 4 and 6 were greater than the overall plant coverage.

Between months 5 and 7 the Parkson-Wyss tank was dewatered for repair. The diffuser manifolds had failed in two places. The horizontal part of the first swing arm failed which effectively removed this arm from service. Also a hold down point on the eighth swing arm failed, allowing the manifold to rise slightly, increasing air flow rate. Fortunately both failures were far away from off-gas hood locations, and did not directly affect αSOTE measurements. These two malfunctions were repaired during dewatering. The diffusers were also cleaned by hosing from the tank top. The tank was out of service for approximately three weeks.

During dewatering diffuser characteristics were noted. The diffuser membranes were no longer as flexible or as loose as when they were new. The membranes had shrunk and were taut. Six diffusers showed excessive air flow which was later attributed to membrane ruptures. Several diffusers were sampled and most had sludge inside the membranes. The manufacturer, prior to operation of the tank, had indicated that minor differences in piping elevation might cause this problem.

Testing continued until month 12. The period from month 8 to month 12 is the most representative period of operation. The air flow per diffuser at this time was within the manufacturer's guidelines (3 m^3/hr or <5 SCFM/diffuser).

The Parkson-Wyss system was always able to provide sufficient DO concentration in tank 4. This resulted because the diffusers were elevated well above the floor during installation, providing sufficient pressure to allow as much as 20 m^3/diff-hr (12 SCFM/diffuser) gas flow rate. Tank 4 does not share its air header with other tanks, which allowed the air pressure to be increased.

The air flux, as shown in Figure 34 is tapered, showing a decline from 16 m^3/m^2-hr to 10 m^3/m^2-hr over the tank length. The αSOTE increases along tank length, which is mostly attributable to the decrease in air flow rate per diffuser.

The Parkson-Wyss system performed satisfactory throughout the study and there were no problems with its operation. It was decommissioned at the end of the study and the diffusers were salvaged. The Terminal Island treatment plant is being retrofitted with a full floor coverage ceramic dome system. This is not because of any lack of performance of the Parkson-Wyss system, but because of a preference for a ceramic grid system by City personnel. Also the City did not wish to reuse the swing arms, since they are old and prone to failure.

TERMINAL ISLAND - AERMAX

Figures 35 and 36 show the performance of the AERMAX system at Terminal Island. The first test showed an αSOTE of approximately 16%, which was the highest αSOTE measured anywhere in this study. The αSOTE declined in a nearly linear fashion to 8.5% after four months of operation.

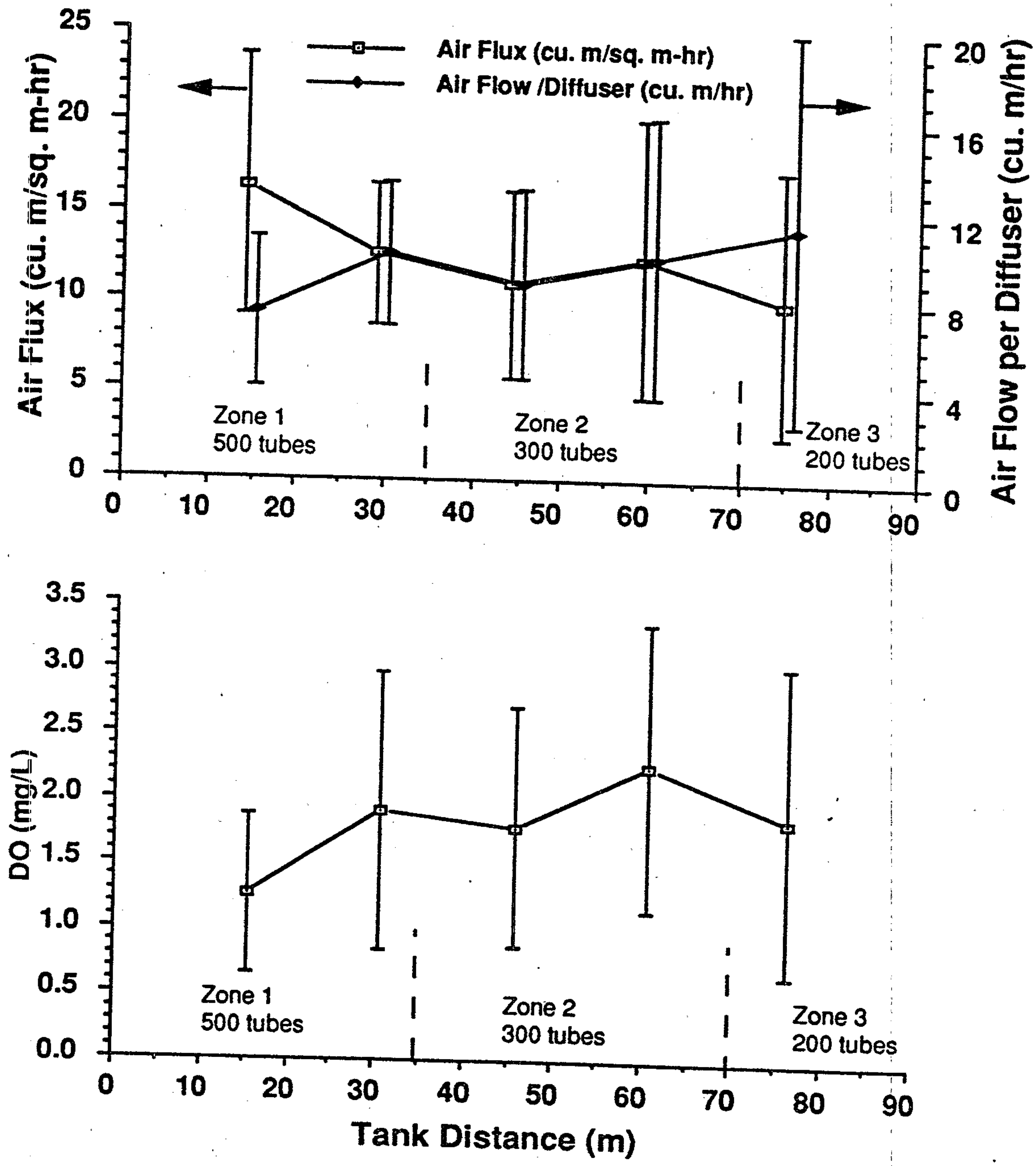

Figure 34 αSOTE and Air Flux versus Distance for Parkson-Wyss at Terminal Island

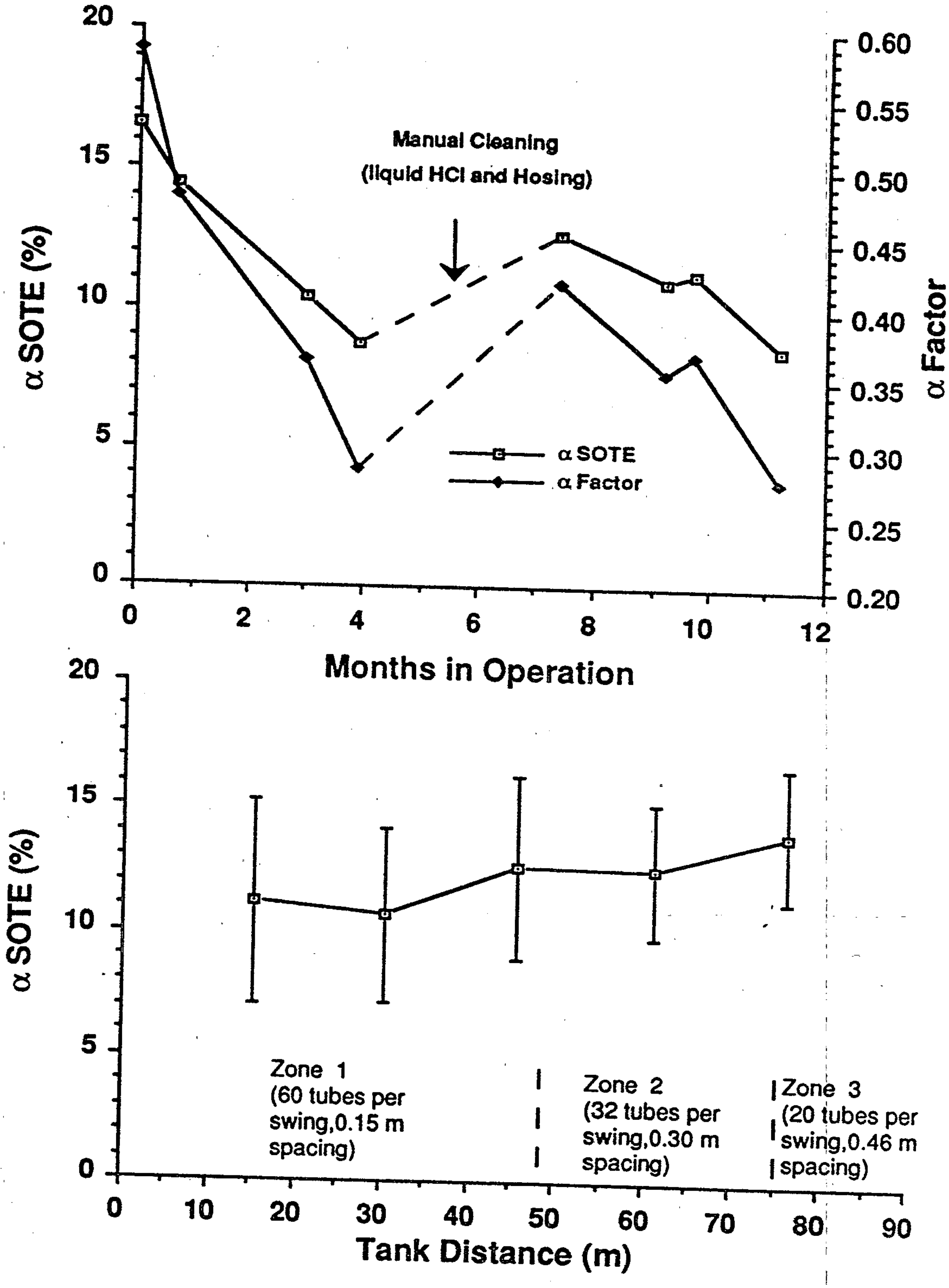

Figure 35 αSOTE, Air Flux and DO for AERMAX at Terminal Island

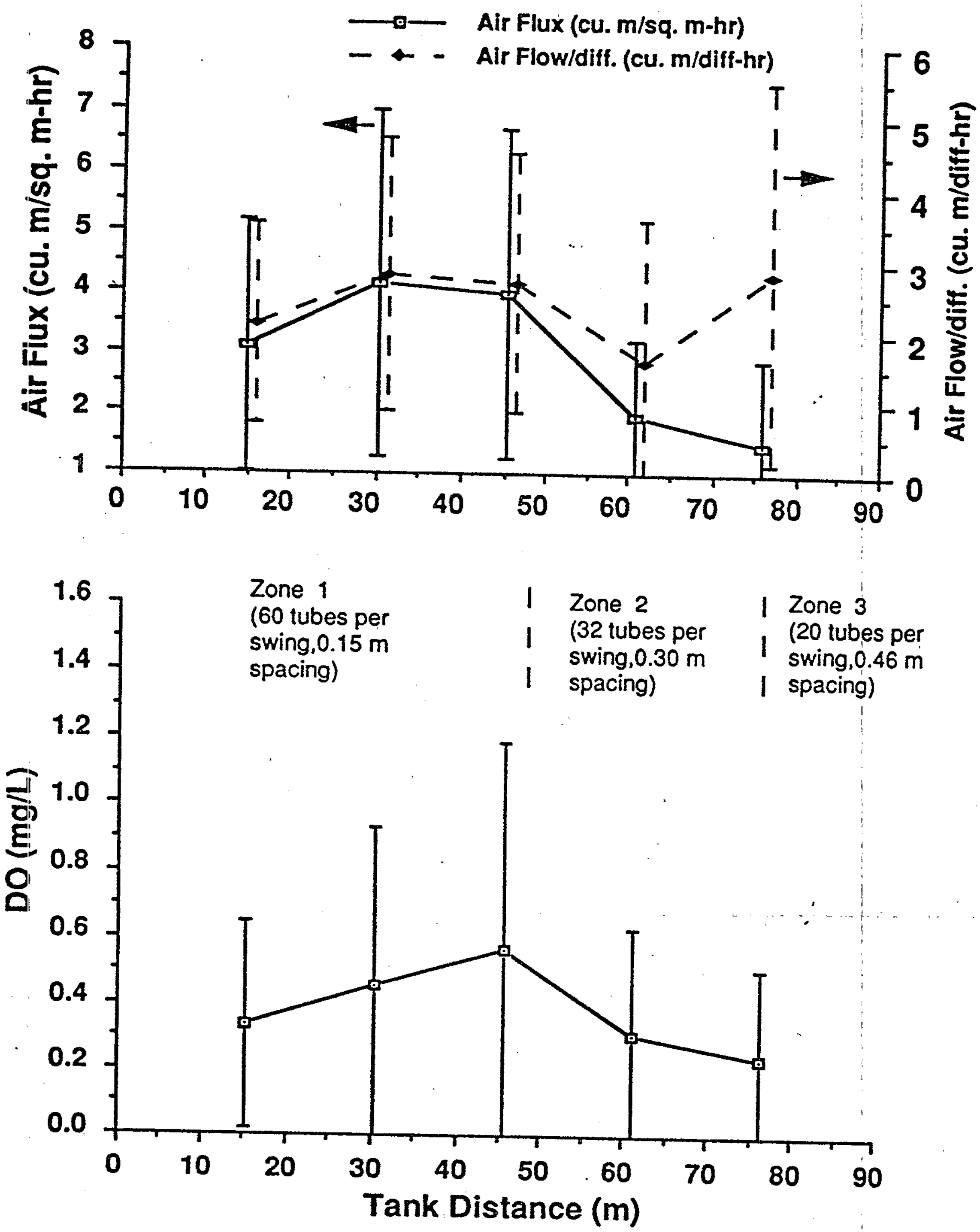

Figure 36 αSOTE and Air Flux versus Distance for AERMAX at Terminal Island

In December 1987 the second swing arm was lifted for inspection. When it was lifted two diffusers on swing arm 3 had moved and were overlapping the diffusers on swing arm 2. During lifting several diffusers were bent and one of the bosses on the swing arm failed. To repair this failure it was necessary to dewater the tank. The diffuser were hosed and liquid acid cleaned when the tank was dewatered.

The tank remained empty for 2.5 months and was exposed to sunlight during this period. The tank was placed back in service in month 7. αSOTE was 11.5% and gradually declined over the next four months. There seems to be no ill effects from the longer period of dewatering.

The air flux to tank 6 was always controlled by the pressure drop through the diffusers. This resulted because the diffusers were not mounted as high as necessary above the horizontal part of the swing arm. Several unsuccessful attempts were made to increase the air pressure and flow rate to the AERMAX system.

Unlike the Parkson-Wyss system, the AERMAX system shared an air header with tank 5 and the channel aeration system. The channel aeration system consumed too much air when the system pressure was increased. Therefore, it was not possible to increase system pressure. Fouling not only affected αSOTE but also reduced air flux, which probably accelerated the rate of fouling. Also the DO concentration was low which has been implicated in accelerated fouling rates (Rieth et al. 1988).

The AERMAX system, unlike the other systems described in this report, clearly shows fouling as a function of time. The results shown in Figure 35 are replotted in Figure 37 with time calculated as months in service since cleaning, or since the diffusers were new. The top of Figure 37 shows αSOTE versus time and the bottom shows α versus time. The straight lines are best fits, and the correlation coefficient (R^2) for all lines is greater than 0.9. The αSOTE decline is 1.9 percentage points per month for the first period and 1.0 percentage points per month for the second period. The second period is undoubtedly more typical of routine performance. The authors in previous studies have noted initial periods of excellent performance with new diffusers, which have never been achieved again in subsequent operation. The decline in α factor is similar. The decline in period 1 was 0.07 per month which decreased to 0.035 per month in period 2. The air flow rate per diffuser was changing because of increased pressure drop due to fouling and this decline has been included in the α calculations. Diffusers were collected at the end of the study and analyzed for DWP. Next, they were lab cleaned and reanalyzed. The DWP of four diffusers at 0.3 m^3/hr increased from 15.7 cm (6.2 in) new to 85 to 386 cm (average = 236 cm) over the period of the study. After nylon brushing while flushing from the inside with water, the DWP decreased to 34 cm. After high pressure hosing from the outside the DWP decreased to 20.3 cm.

The decline in air flow rate due to increased diffuser head loss limited the DO in the tank. Towards the end of the study influent flow had to be diverted to other tanks in order to achieve satisfactory DOs.

The AERMAX system was removed from service at the conclusion of testing for the same reasons that the Parkson-Wyss system was removed. The diffusers were salvaged for later reuse.

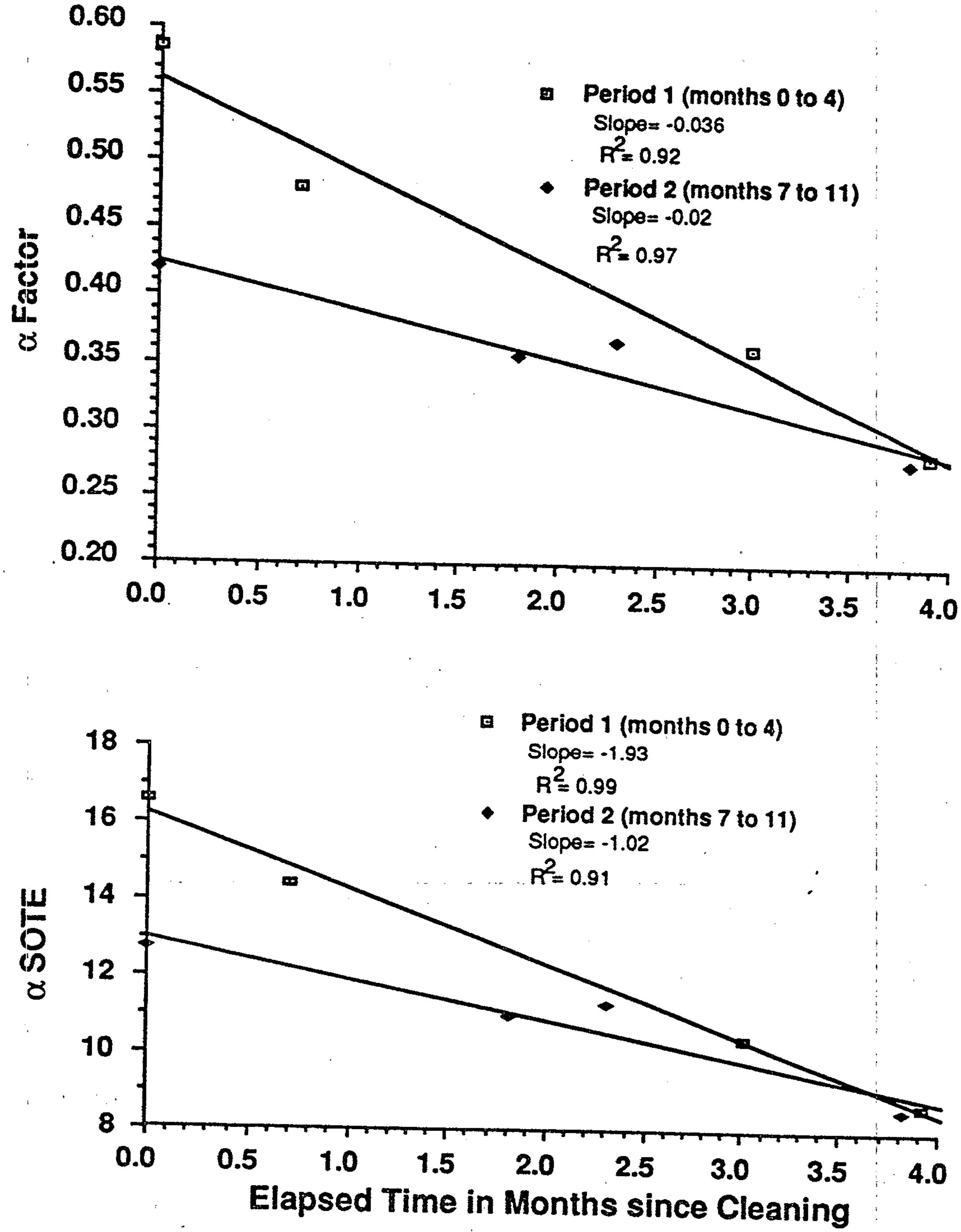

Figure 37 αSOTE and α Factor versus Months in Service for AERMAX - Terminal Island

TERMINAL ISLAND - SPIRAL ROLL

Tank 5 at Terminal Island was equipped with swing arms using FMC Chicago Pump "Discfusers." This tank served as a control for the first three months of the study. Off-gas testing was performed twice, but with limited success due to the high air fluxes. After equipping the off-gas instrument with a larger manometer and second vacuum cleaner it was not possible to capture 100% of the off-gas for all positions at all times. During periods of high flow rate it was not possible to perform a flow weighted average. Therefore, only limited data are available. The αSOTE for tank 5 ranged from 3.5 to 4.5%.

EFFECT OF PROCESS OPERATION ON AERATION EFFICIENCY

The proceeding sections have described the various observations of α factors and αSOTEs for the five different diffusers being evaluated. The discussions have been restricted to phenomena which are related to the diffuser characteristics or cleaning procedures. In this chapter aspects of process operation and their effects on α factors and αSOTE are discussed. Most of the discussion relates to Whittier Narrows, since the majority of data collection was there.

The period from August to October 1986 at Whittier Narrows shows dramatic changes in α factors, αSOTEs and process operation. From observing the data, especially from the point of view of operating the off-gas analyzer, one soon comes to believe that activated sludge process operating variables dramatically affect α and αSOTE. For example, after testing at Whittier Narrows on August 21, 1986 for only 30 minutes, the differences in αSOTE were readily apparent, as if one were testing a different plant or using a malfunctioning analyzer.

EFFECT OF SRT, F/M, MLVSS AND AIR FLUX

At first it was believed that a relationship between SRT and αSOTE or α could be easily obtained. Others have shown such a relationship for specific conditions (Brenner and Boyle, 1987). There are "outliers" which point to such a relationship. For example, the SRT at Whittier Narrows on the day of testing in month 4 (Figures 13-16) was 1.2 days, the lowest value in the entire study for any plant tested at any time. This day also corresponds to the lowest tank average α factor obtained anywhere, of 0.12. Some of the highest α factors were obtained at the highest SRT. The following discussion explores the reasons for a relationship between αSOTE, α and SRT. The reader is referred to the Process Data section where the calculation procedures for SR7, MCR, and MCRTA are discussed.

There are theoretical reasons why α should be a function of SRT. Current mathematical models of the activated sludge predict substrate concentration as a function of SRT. Since substrates are partially comprised of surfactants, lower substrate concentration, or higher SRT, implies lower surfactant concentration and higher α factors. Nevertheless, regressions of SRT, αSOTE and α factors have been disappointing, producing low R^2 and little statistical significance. Upon reflection there are reasons for the poor correlation which relate to the steady-state nature of SRT calculation. By definition the SRT can be related to the mean organism growth rate, as follows (Lawrence and McCarty, 1970):

$$\frac{1}{\theta_c} = \mu - K_D \qquad (5)$$

where

θ_c = SRT
μ = organism growth rate (T^{-1})
K_D = decay coefficient (T^{-1})

This relationship is only valid for steady-state conditions. When steady-state conditions exist the SRT can be equated to the wasting rate and mass of solids under aeration, as follows

$$\theta_c = \frac{XV}{Q_w X_w} \tag{6}$$

where

X	=	MLVSS concentration (mg/L)
V	=	aeration tank volume (l^3)
X_w	=	waste volatile solids concentration (mg/L)
Q_w	=	waste solids flow rate (l^3/T)

Equation 6 provides a "working definition" for SRT which is the foundation of its use throughout activated sludge plants in the United States; however, the success of SRT as a operational strategy exists because of its relationship to microbial growth rate, as shown in Equation 5. When steady-state conditions do not exist both Equations 5 and 6 are not valid, and Equation 7 is applicable as follows:

$$\frac{1}{\theta_c} = \mu - K_D - \frac{dX}{Xdt} \tag{7}$$

where

$$\frac{dx}{dt} = \text{time derivatives of X (mg/L-T)}$$

Although satisfactory effluent was produced throughout the study period, the SRT at Whittier Narrows ranged from 1.2 to over 4 days during the study and sometimes changed as much as 30 to 40% between the daily observations. Therefore, the SRT calculated by Equation 5 should be quite different than the true SRT (kinetically meaningful) calculated by Equation 7. For example, if the MLVSS concentration was to decrease from 1000 to 700 mg/L in one day, and if the SRT were 1.5 days before the change, the magnitude of the difference between Equations 5 and 7 would be 0.35 days^{-1}, a difference of 20% or more.

A further complication in successfully determining a relationship between SRT and α or αSOTE relates to sampling frequency. One must sample at twice the maximum frequency to estimate the parameter without aliasing. An SRT of 1.5 days implies a time constant of 0.66 days^{-1}, which means that SRT measurements would have to be made at a rate of 1.32 per day to correctly estimate SRT. Therefore, at SRT's less than 2 days, a daily measurement is too infrequent for proper estimation of SRT.

A final complication in measuring SRT is the accuracy of the parameters used to calculate it. There are three sources for experimental error: MLVSS measurement, waste sludge MLVSS measurement, and waste sludge flow rate. It is extremely difficult to accurately and precisely measure sludge flow rates and concentrations.

An alternate approach was taken to relate α and αSOTE to process operation and regressions of MLVSS and F/M (COD basis) were made. There are similar problems with measuring F/M as with SRT. The sampling frequency rate requirements are similar. F/M ratio is also valid only for steady state conditions; however, the magnitude of the time derivative is smaller than in the SRT equation. Equation 8 shows the same model arranged to calculate F/M.

$$\frac{Q(S_o-S)}{XV} = \frac{\mu}{Y} \tag{8}$$

where

S_o,S = influent and effluent substrate concentration (mg/L)
Y = biological yield (mass cells/mass substrate)

Since effluent substrate, S is usually small when compared to S_o, the left hand side of Equation 8 is nearly equal to the working definition of the F/M ratio, QS_o/XV. Equation 8 must also be rewritten for the nonsteady-state case, as follows:

$$\frac{Q(S_o-S)}{XV} = \frac{\mu}{Y} + \frac{dS}{Xdt} \tag{9}$$

The magnitude of the term $\frac{dS}{Xdt}$ is much smaller relative to the F/M ratio than the derivative term in the SRT equation, Equation 7. A change in the effluent substrate concentration for Whittier Narrows as a function of F/M is so small that it is hard to measure, but for the sake of example, suppose that the hypothetical change from 1000 mg/L MLVSS to 700 mg/L MLVSS mentioned previously produced a change of 10 mg/L in S. The difference in Equation 8 and 9 is only 0.012 mg S/mgX-day. If the F/M ratio for this case were 1.0 mgS/mgX-day, the difference would be approximately 1%; however, for Equation 7, the differences from the dynamic term could be more than 25%. Therefore, F/M ratio is a much better indicator of process conditions during nonsteady-state operation.

The experimental error in measuring F/M is less than in measuring SRT. It is easier to measure dilute liquid flow rates than sludge flow rates. Influent COD is probably more accurately and precisely measured than waste sludge MLVSS concentration.

It is important to note the sign of the error on SRT or F/M calculation. For both cases, the working definition of SRT and F/M, which includes the error, under estimates process loading. The SRT predicted by Equation 6 is always greater than the true SRT predicted by Equation 7, when the SRT is declining. Also, Equation 8 under estimates F/M when F/M is increasing.

Since F/M is also an indicator of growth rate and effluent substrate concentration, it should be related to αSOTE and α in the same way that SRT is related. MLVSS concentration should be correlated as well, since it is a component in the calculation of SRT and F/M ratio. Additionally, there is conflicting evidence (Stenstrom and Gilbert, 1981) implicating solids concentration affecting α factors.

The regressions on MLVSS and F/M were much more successful, and meaningful correlations were obtained. Figure 38 shows the average α factor for tanks 1 and 2 at Whittier Narrows as a function of F/M (COD basis) with best-fit regressions. The correlation coefficient (R^2) in both cases is less than 0.35. Tank 1 shows a more meaningful trend. The correlation in tank 2 is dominated by the two extreme points. For tank 1 the data from the period from just after liquid acid cleaning to the onset of step feed operation are plotted. For tank 2 the data from the period is from just after liquid acid cleaning to dome replacement are plotted.

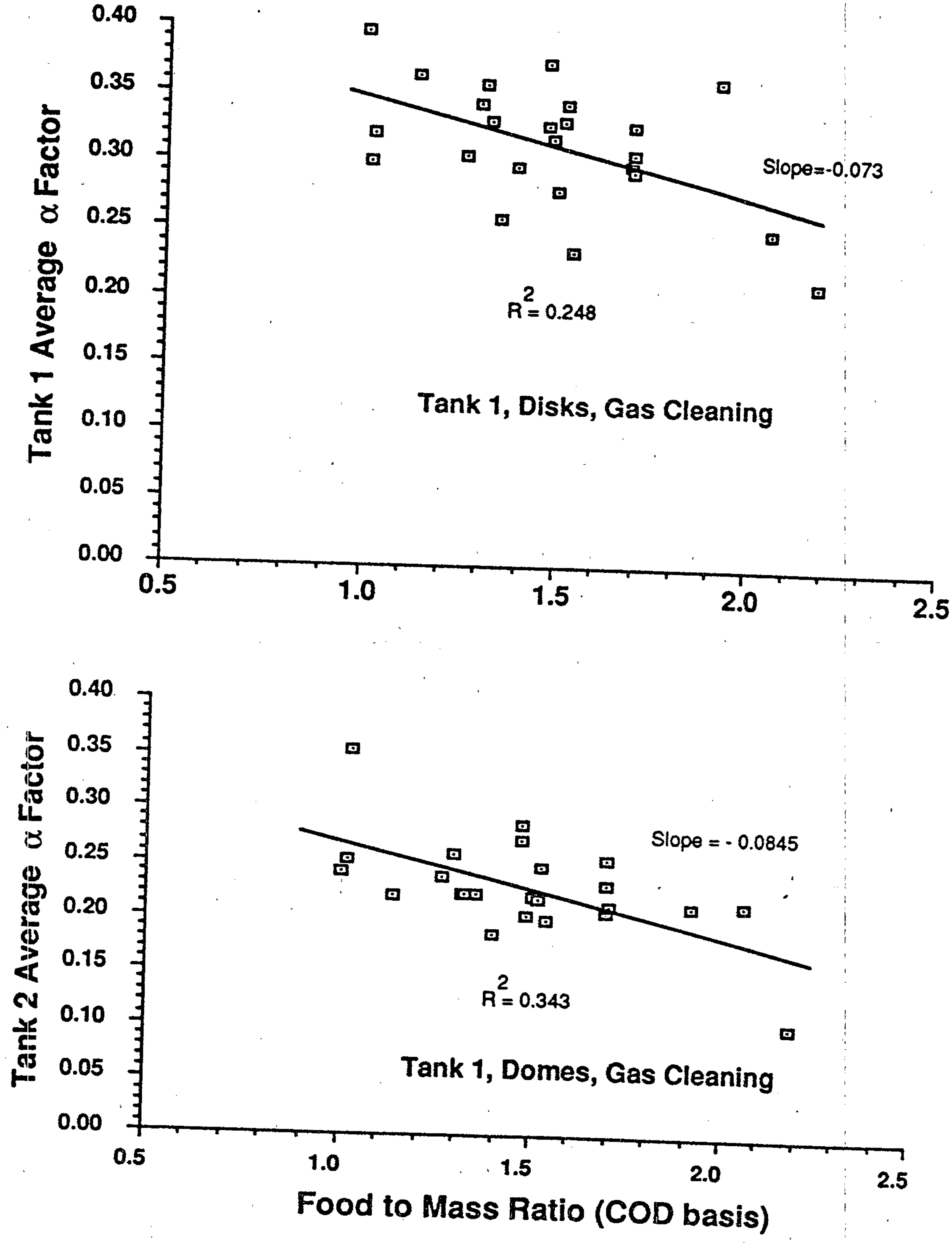

Figure 38 α Factor versus F/M for Tanks 1 and 2 at Whittier Narrows

Figure 39 shows the average α and αSOTE as a function of MLVSS concentration at hood position 1 for all three tanks at Whittier Narrows. The correlation (R^2) is approximately 0.5. The data for hood position 1 correlate much better than the tank average data. The αSOTE or α factor at position 1 may be more strongly influenced by MLVSS concentration due to rate of removal of soluble substrate, which according to the models described previously, should be linearly related to MLVSS concentration. The relationship shown in this figure is the most dramatic evidence for the low α factors observed in the August to October period of 1986. Figure 40 shows the tank average α factor for the plastic disks at Valencia. The trend is similar, but the absolute value of MLVSS concentration is quite different.

Figure 41 shows α factors as a function of air flux, and α decreases slightly with increasing air flux. A similar relationship was found by Hwang and Stenstrom (1983) for the column study at Whittier Narrows. One possible explanation for this phenomena is bubble collision. Bubbles coalesce in activated sludge mixed liquor; an increasing air flux will result in more bubble collisions in a fashion similar to increasing surface area or particle concentration for flocculation.

Figure 41 also shows the column results, which exhibit the same trend but with greater α factors. The α factors were greater because all experiments were conducted using a new diffuser. The air fluxes are much greater because the column was only 0.5 m in diameter. The air flow per diffuser spanned the range measured during this study, but the diffuser density was much greater.

It has been suggested that this relation between α and air flux is a function of plant load since increased plant load usually requires increased air flux. There is evidence to show that higher loading rates reduce α factors. There are two reasons why the relationship between α and air flux is plausible. A multiple linear regression of α factor with both air flux and load, as indicated by F/M (COD basis), was made and air flux was more significant than F/M ratio. The similar findings of Hwang (1983) were performed at constant load, and are therefore free of any spurious effects of plant load upon α.

TIME SERIES REGRESSIONS

The preceding part of this chapter discussed the effects of process variables on α and αSOTE. While this information is interesting and potentially more important than diffuser fouling, the goal of this research is to ascertain fouling rates over time in service. The only previous discussion of fouling over time was the result for the an AERMAX system at Terminal Island. This section describes fouling over time. This discussion primarily relates to Whittier Narrows.

To determine fouling over time the effects of F/M, air flux and time in service were investigated using multiple linear regression with SAS (1982). Models of the following form were used:

$$\alpha SOTE = a + b\, F/M + c\, AF + d\, TS \tag{10}$$

where

F/M	=	food-to-mass ratio, COD basis ($days^{-1}$)
AF	=	air flux (m^3/m^2-min)

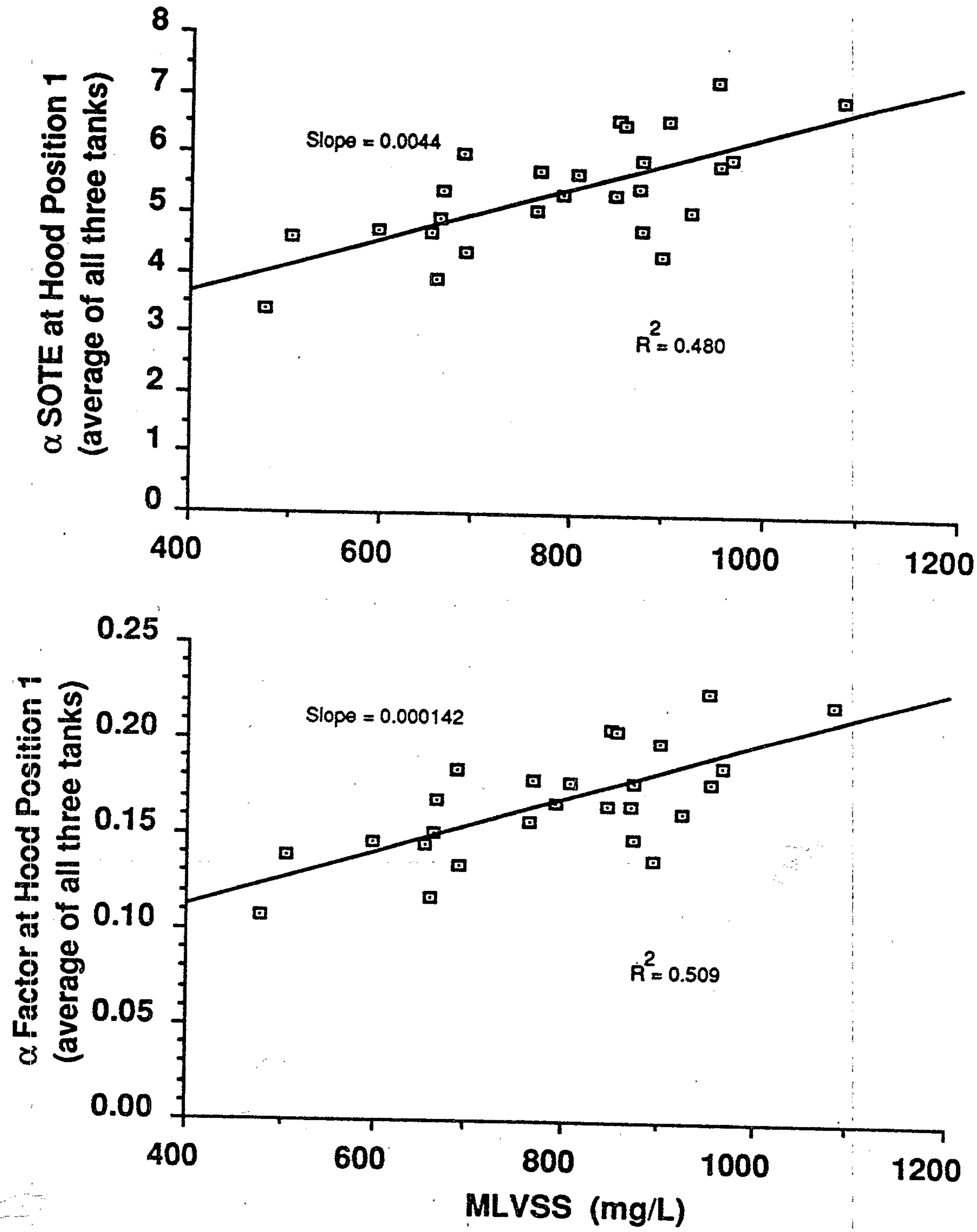

Figure 39 αSOTE and α Factor versus MLVSS Concentration for Hood Position 1, Tank 1 at Whittier Narrows

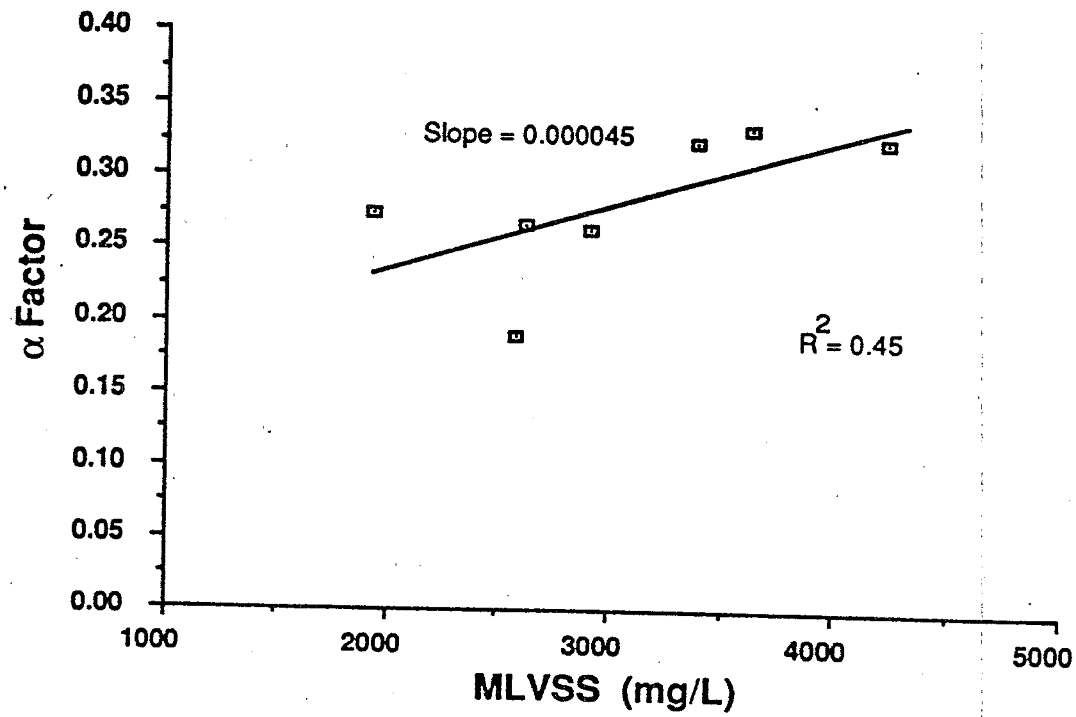

Figure 40 α Factor versus MLVSS Concentration at Valencia

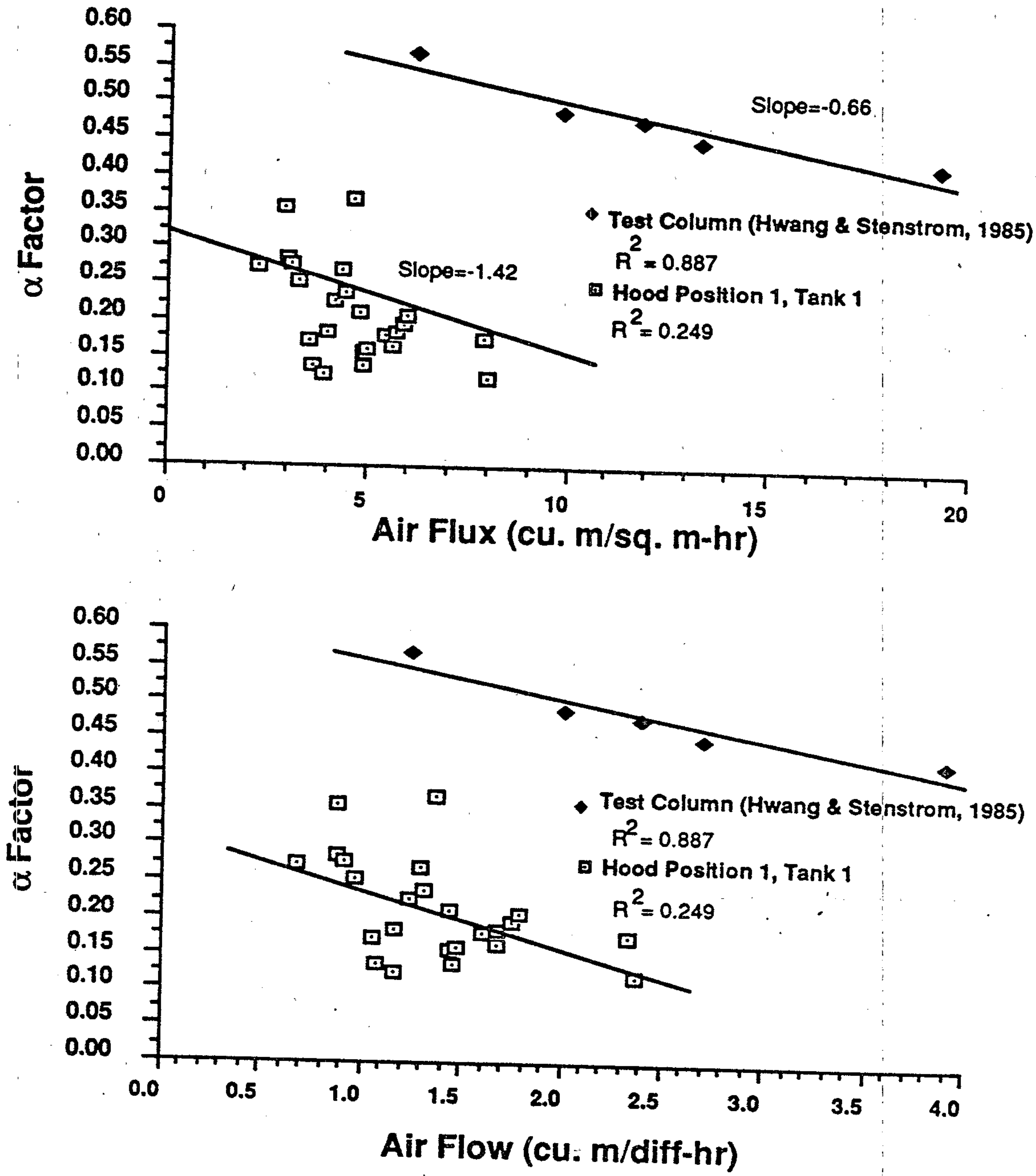

Figure 41 α Factor versus Air Flux at Whittier Narrows for Hood Position 1, Tank 1, and a Test Column

TS	=	time in service or since cleaning (months)
a,b,c,d	=	regression parameters

The same regressions were performed using α as the dependent variable, and MLVSS concentration was tested in place of F/M for certain regressions.

The period of regression was always a subset of the study period. The period prior to initial liquid acid cleaning was not used. Also the very first test after liquid cleaning was not used in all cases. For the dome system, the regressions covered the period up to dome replacement in September/October 1987. For the disk system, the period was longer, continuing until the onset of step feed operation, in December 1987.

Figure 42 shows the most successful time series regression for the disk system for αSOTE while Figure 43 shows similar regressions for α. The figures are plotted in the same way as Figures 13-16 for the sake of comparison.

The top of Figure 42 shows a regression for the period from liquid acid cleaning to the onset of step feed operation for tank 1 at Whittier Narrows. It includes the period of low SRT during months 1 to 4 in determining the parameters a through d. The predicted values show the same trend as the measured values, but miss the extremes. This regression accounted for only approximately 30% of the variability ($R^2 = 0.31$). The form of the regression is:

$$\alpha SOTE = 15.37 - 2.0375\ F/M - 38.977\ AF \tag{11}$$

F/M and AF flux are significant at 2.7% and 5.7%, respectively. Time in service is not significant, indicating that changes in process operation over-shadowed the effect of fouling.

The lower part of Figure 42 shows a similar regression, but using only the data points from month 6 to the onset of step feed operation. This period of operation is much more stable with respect to F/M and SRT. The regression accounted for 74% of the variability ($R^2 = 0.74$). The form of the regression is:

$$\alpha SOTE = 16.5 - 0.218\ TS - 58.4\ AF \tag{12}$$

In this case it appears that the effects of fouling can be separated from other aspects of process operation. F/M is not significant, which most probably results because it did not vary widely during this period. Both AF and TS were significant at the 1% level.

This result is similar in consequences to the AERMAX finding in that a statistically significant fouling effect was obtained. In the case of the AERMAX system for period 2, the decline was 1 percentage point of αSOTE per month, while in this case it is only 0.23 percentage point of αSOTE per month.

Figure 43 shows similar results for α. The regressions for the top and bottom of Figure 43 are

$$\alpha = 0.477 - 0.0673\ F/M - 0.814\ AF \tag{13}$$

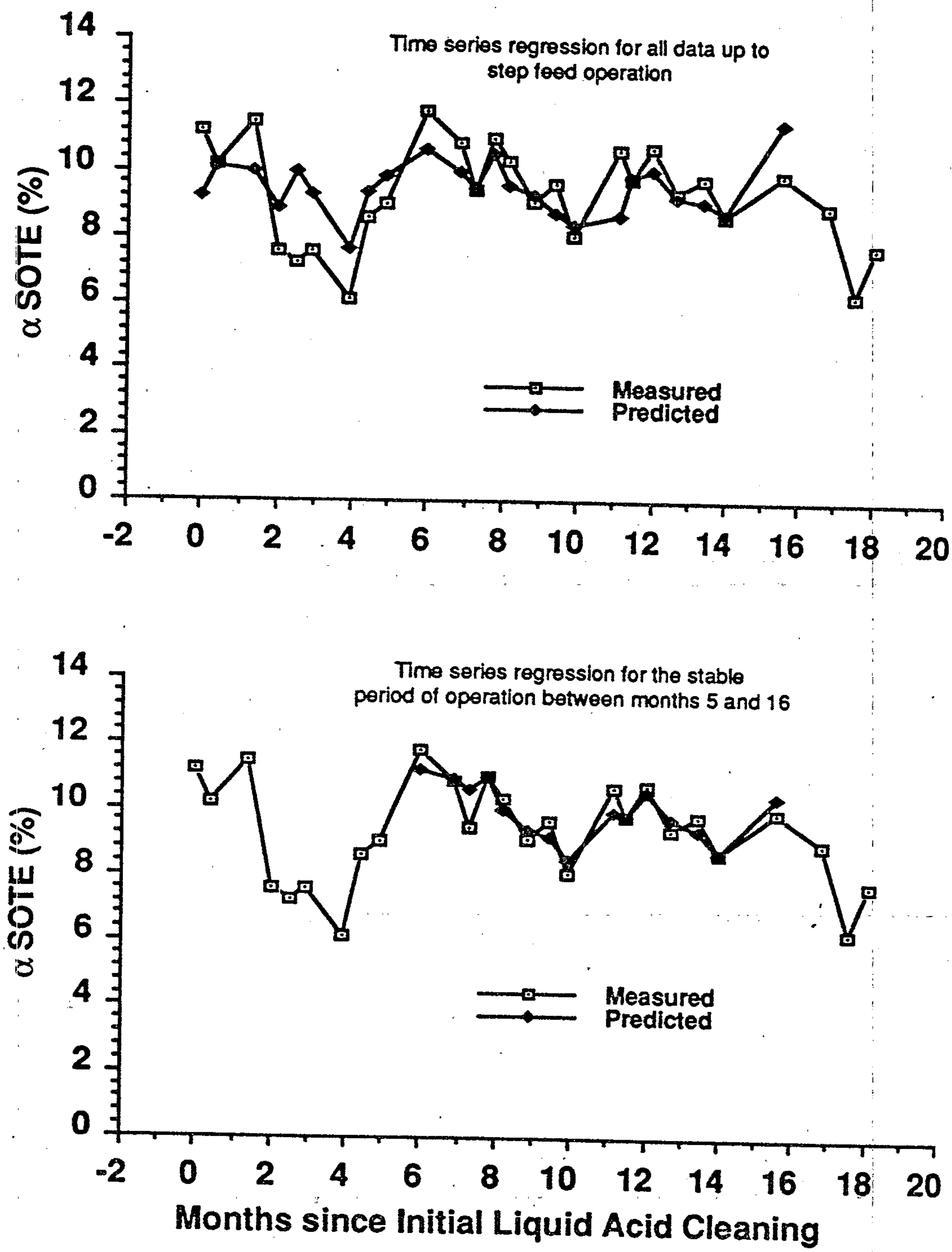

Figure 42 αSOTE versus Time for Tank 1 at Whittier Narrows

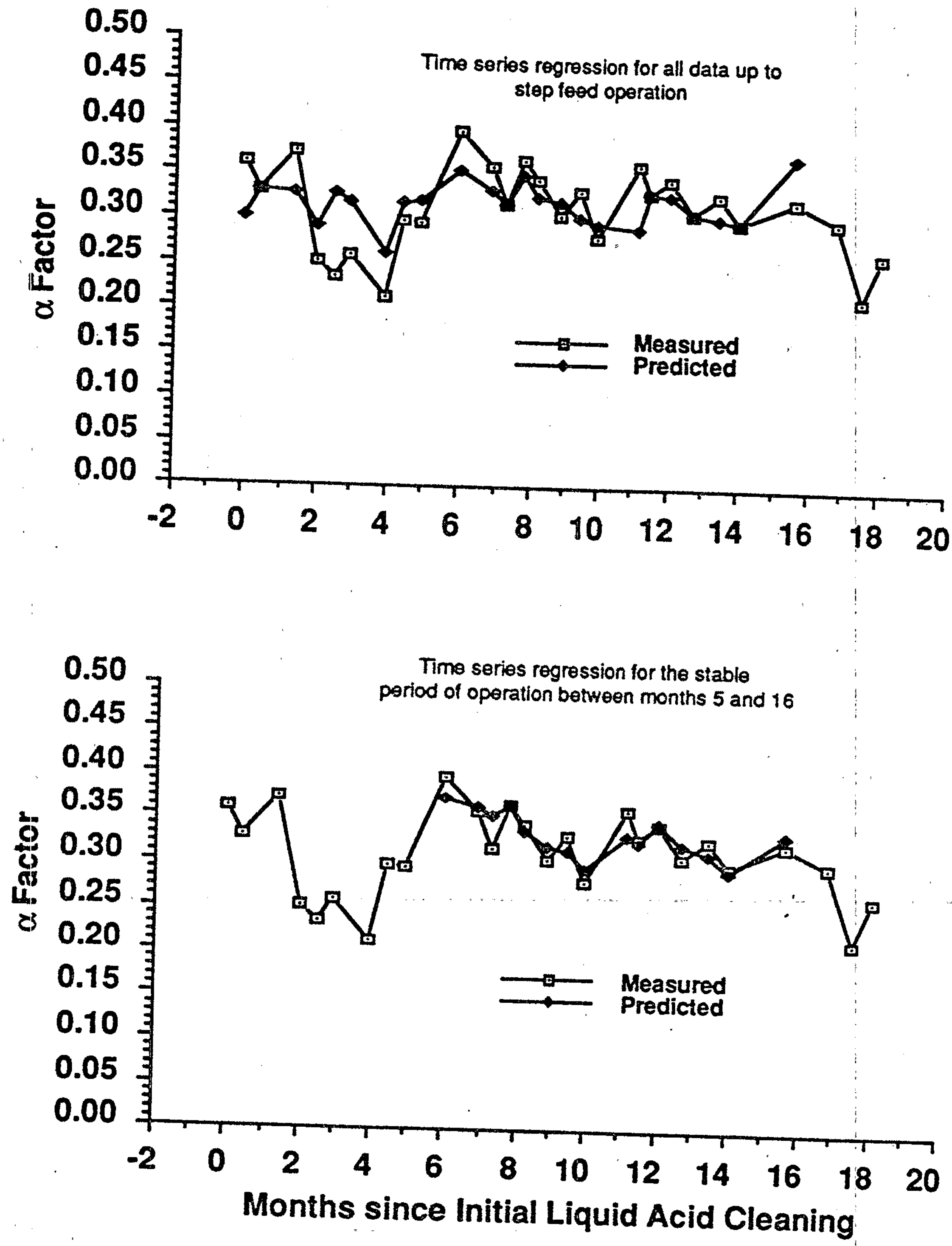

Figure 43 α Factor versus Time for Tank 1 at Whittier Narrows

$$\alpha = 0.520 - 0.00726\ TS - 0.524\ AF \qquad (14)$$

The significance levels and correlation coefficients are nearly identical to the regression for αSOTE.

Equations 11 through 14 have implications for future designers. They indicate that for F/M ratios of 1 to 1.5, and air fluxes of 0.1 m^3/m^2-min. or less, that the clean diffuser α and αSOTE are roughly 0.3 to 0.4, and 9 to 10%, respectively at the diffuser density and submergence used in this study.

CONCLUSIONS

This project has as it goals the investigation of fouling and diffuser cleaning techniques. The principal investigation was at the Whittier Narrows Water Reclamation Plant operated by the Los Angeles County Sanitation Districts. The Whittier Narrows project investigated the benefits of HCl acid gas cleaning on disk and dome ceramic diffusers. Shorter studies with reduced level of effort were conducted at the Valencia treatment plant, also operated by the Districts, and the Terminal Island Treatment plant, operated by the Bureau of Sanitation of the City of Los Angeles. The following conclusions are made.

1. The disk system at Whittier Narrows out performed the two dome systems for the duration of the study for almost all circumstances, with the one exception of one test conducted immediately after dome replacement. The magnitude of the difference in αSOTE was 2 percentage points (~ 9% αSOTE for disks versus 7% for domes). For the period of stable operation where nearly identical side-by-side test results were obtained, the difference was 2.8 percentage points (9.8 versus 7.0).

   The difference in performance of the two systems is probably not attributable to HCl acid gas cleaning, or at least not entirely attributable to cleaning, since the disk system was superior to the dome system prior to all cleaning and shortly after dome replacement as well. Dome gasket leakage was a major factor in the performance of the dome system and its overall impact on the conclusions of this study are unknown.

2. The domes at Whittier Narrows showed severe gasket leakage problems, both before and after acid gas cleaning. It is not clear what the cause of the leakage was, but the domes at Whittier Narrows used plastic bolts and spongy gaskets which may have contributed to the problem. Gaskets from sample diffusers showed non-elastic deformation which may have contributed to the problem. Plastic bolts with hard rubber gaskets failed.

3. The effects of HCl acid gas cleaning on the dome αSOTE were not discernible.

4. The effects of HCl acid gas cleaning was not detectable in the short term on the αSOTE of the disk system; however, two off-gas tests directly before and directly after acid gas cleaning provided partial evidence for improved αSOTE.

5. The HCl acid gas cleaning was effective in reducing diffuser DWP, BRV, and the quantity of fouling substances, for both dome and disk diffusers.

6. The plastic disks at the Valencia WRP showed αSOTEs approximately the same as the dome system at Whittier Narrows (7%). This fact might be construed to support the efficiency of acid gas cleaning because the disks at Whittier Narrows, which transferred 9.8% during the period of stable operations, have about the same clean water SOTE as the plastic disks. The Valencia WRP is operated at higher SRT and lower F/M which suggests that it should have had higher αSOTEs for the same conditions. No significant trend in transfer rates (e.g. decrease due to fouling) was observed.

7. During the period of stable operation the disks at Whittier Narrows, with HCl gas cleaning, decreased in αSOTE efficiency by 0.23 percentage points per month. The AERMAX system decreased by 1% per month at Terminal Island. These results are the most

significant findings with respect to fouling. The dome systems at Whittier Narrows decreased from an αSOTE of 10 to 12% when new, or just after liquid acid cleaning, to 7 to 8% within several weeks. The decline was too rapid to correlate to process operation or time in service, and may have been partially due to gasket leakage problems. The decreases were not necessarily linear, and one should not always expect a linear decrease in transfer efficiency.

8. It seems reasonable to use a tank average α factor of 0.25 for plants designed and operated in a fashion (low SRT) similar to the Whittier Narrows Water Reclamation Plant with similar aeration systems.

9. The effects of process operation, F/M, MLVSS and air flux, have a much more pronounced effect on αSOTE and α than fouling. Statistically significant relationships between α and αSOTE and F/M, MLVSS and air flux were obtained. α and αSOTE decrease with increasing F/M and air flux.

10. This evaluation of HCl gas cleaning efficiency probably did not best demonstrate the efficiency of the technique. The dome gasket leakage problem may have obscured results. Furthermore, a more frequent cleaning frequency may be beneficial.

REFERENCES

1. Anderson, A., Personal Communication, Gerlick-Mitchell Co., El Segundo, CA, July 30, 1987.

2. Barish, N., *Economic Analysis for Engineering and Managerial Decision Making*, McGraw Hill, New York, NY, pp. 685-700, 1962.

3. Boyle, W.C. and Redmon, D.T., "Biological Fouling of Fine Bubble Diffusers: State-of-the-Art," *ASCE Journal of Environmental Engineering Division*, **109**, 991, 1983.

4. Brenner, R.C. and Boule, W.C., "Status of Fine Pore Aeration in the United States," A manuscript presented at the 11th United States/Japan Conference on Sewage Treatment, Tokyo, Japan, October 12-14, 1987.

5. Downing, A.L., Bagley, R.W. and Boon, A.G., "The Performance of Mechanical Aerators," *J. Inst. of Sewage Purification*, 231, 1960.

6. Doyle, M.L. and Boyle, W.C., "Translation of Clean to Dirty Water Oxygen Transfer Rates," in *Aeration Systems: Design, Testing, Operation and Control*, W.C. Boyle, ed., Noyes Publications, Park Ridge, NJ, 1986.

7. Hwang, H.J. and Stenstrom, M.K., "Evaluation of Fine-Bubble Alpha Factors in Near Full-Scale Equipment," *JWPCF*, **57**, pp. 1142-1151, 1985.

8. Hwang, H.J., "Comprehensive Studies on Oxygen Transfer under Nonideal Conditions," Ph.D. Dissertation, Civil Engineering Dept., University of California, Los Angeles, CA, 1983.

9. Lawrence, A.W. and McCarty, P.L., "Unified Basis for Biological Treatment Design and Operation," *ASCE Journal of the Sanitary Engr. Division*, **96**, 757-778, 1970.

10. Mueller, J.A., "Comparison of Dual Nonsteady State and Steady State Testing of Fine Bubble Aerators at Whittier Narrows Plant, Los Angeles," a Report Submitted to the ASCE Committee on Oxygen Transfer Standards, Manhattan College, Bronx, NY, March 1982.

11. Redmon, D.T., Boyle, W.C. and Ewing, L., "Oxygen Transfer Efficiency Measurements in Mixed Liquor Using Off-Gas Techniques," *J. Water Pollution Control Fed.*, **55**, 1338 1983.

12. Rieth, M.G. et al., "Effects of Selected Design Parameters on the Fouling of Ceramic Diffusers," A manuscript presented at the 61st Annual Conference of the Water Pollution Control Federation, Dallas, TX, October 1988.

13. *SAS User's Guide*, SAS Institute, Inc., Cary, NC, 1982.

14. *Standard Methods for the Examination of Water and Wastewater*, 15th Edition, American Public Health Association, Washington, DC, 1980.

15. Schmit, F. et al., In Place Gas Cleaning of Diffusion Elements, U.S. Patent No. 4,382,867, May 10, 1983.

16. Stenstrom, M.K. and Gilbert, R.G., "Effects of Alpha, Beta and Theta Factor upon the Design, Specification and Operation of Aeration Systems," *Water Research*, **15**, pp. 643-654, 1981.

17. Yunt, F. and Hancuff, T.O., "Aeration Equipment Evaluation - Phase I. Clean Water Test Results," Los Angeles County Sanitation Districts, Los Angeles, CA.

18. Yunt, F. Personal Communication, November 8, 1982.

19. Yunt, F. and Hancuff, T., "Analysis of Shop Performance Tests of the Air Diffusion Equipment for the Valencia Water Reclamation Plant Stage Three," Los Angeles County Sanitation Districts, Whittier, CA, 1986.

20. Yunt, F. and Stenstrom, M.K., "Aeration Equipment Evaluation - Phase II. Process Water Test Results," Los Angeles County Sanitation Districts, Los Angeles, CA, 1990.

APPENDIX I SAMPLE DATA SHEET

Terminal Island

Tank No. _____ Location _______________ Date________

Time	Position	CO_2 Frac.	Sensor (Ref)	Sensor (Offgas)	MLSS Temp Temp (°C)	DO (mg/L)	Roto 0	Roto 1	Roto 2	Roto 3	Roto 4	Man 2 ("H_2O	Man 3 ("Hg)	Cell Temp (°F)	Offgas Temp (°F)

APPENDIX II WHITTIER NARROWS DIFFUSER DATA

KEY:

MO	=	month of year
DAY	=	day of month
YR	=	year (e.g. 86 = 1986)
SERVICE	=	months in service
CLEAN	=	N means no HCl gas cleaning, G means HCl gas cleaning
COND	=	condition of the diffuser during testing; dirty = as is, from tank; hose = after hosing in the laboratory; MM = liquid acid in the laboratory; in-situ = cleaned in tank
TANK	=	N3 means Norton domes, tank 3; N2 means Norton domes, tank 2; S means Sanitaire disks, tank 1
GRID	=	grid number
NO	=	sample number, 1 or 2
DWP5, DWP75 DWP10, DWP20	=	DWP in cm w.c. at 0.5, 0.75, 1.0, and 2.0 SCFM, respectively
DWPAVG	=	average of above
BRVAVG	=	BRV in cm w.c.
VFOUL	=	mg/cm^2 of volatile fouling material
NVFOUL	=	mg/cm^2 of nonvolatile fouling material
ACENTER, AMIDDLE AOUTER	=	air flux ($SCFM/ft^2$) in the center midway and outer parts of the diffuser, respectively
TFOUL	=	total fouling substances (mg/cm^2)
PVOLAT	=	fouling substance percent volatile
BRVDWP	=	ratio of BRV to DWP at 0.75 SCFM
DATE	=	date, years, months, days
.	=	missing data point (no data collected)

OBS	MO	DAY	YR	SERVICE	CLEAN	COND	TANK	GRID	NO	DWP5	DWP75	DWP10	DWP20	DWPAVG
1	6	5	86	18.0	N	DIRTY	S	1	1	44.450	67.818	.	325.628	.
2	6	5	86	18.0	N	DIRTY	S	1	2	23.368	25.654	.	41.148	.
3	6	5	86	18.0	N	DIRTY	S	2	1	25.146	27.686	.	44.704	.
4	6	5	86	18.0	N	DIRTY	S	2	2	22.352	24.892	.	40.132	.
5	6	5	86	18.0	N	DIRTY	S	3	1	22.098	24.638	.	40.894	.
6	6	5	86	18.0	N	AIR	S	3	1	22.098	24.638	.	40.894	.
7	6	5	86	18.0	N	DIRTY	S	3	2	18.288	19.558	.	28.448	.
8	5	30	86	18.0	N	DIRTY	S	1	1	21.082	24.638	44.704	48.768	34.798
9	5	30	86	18.0	N	DIRTY	N3	1	2	23.114	27.686	52.832	56.388	39.878
10	5	30	86	18.0	N	DIRTY	N3	2	1	26.416	31.750	62.484	67.310	46.990
11	5	30	86	18.0	N	DIRTY	N3	2	2	19.304	22.860	40.640	42.164	31.242
12	5	30	86	18.0	N	AIR	N3	2	2	19.304	22.860	40.640	42.164	31.242
13	5	30	86	18.0	N	DIRTY	N3	3	1	19.812	22.860	40.640	42.164	31.242
14	5	30	86	18.0	N	DIRTY	N3	3	2	18.796	22.352	42.164	45.212	32.004
15	7	8	86	18.0		HOSE	S	1	1	40.386	55.626	69.850	186.690	88.138
16	7	8	86	18.0		MM	S	1	1	22.606	24.130	25.146	30.988	25.654
17	7	8	86	18.0		HOSE	S	2	2	23.876	26.162	28.702	39.116	29.464
18	7	8	86	18.0		MM	S	2	2	21.590	23.368	24.638	32.258	25.400
19	7	8	86	18.0		HOSE	N3	1	2	24.130	27.432	30.734	48.768	32.766
20	7	8	86	18.0		MM	N3	1	2	21.082	23.622	25.908	40.640	27.940
21	7	8	86	18.0		HOSE	N3	3	1	22.352	24.892	27.432	34.798	27.432
22	7	8	86	18.0		MM	N3	3	1	19.304	21.082	22.606	29.718	23.114
23	7	8	86	18.0		INSITU	N3	1	2	.	11.684	.	.	.
24	7	8	86	18.0		INSITU	N3	3	1	.	15.748	.	.	.
25	9	10	87	15.5	N	DIRTY	N3	1	1	39.624	42.164	43.942	58.674	46.228
26	9	10	87	15.5	N	DIRTY	N3	1	2	23.114	25.146	255.778	44.704	87.122

OBS	BRVAVG	VFOUL	NVFOUL	ACENTER	AMIDDLE	AOUTER	TFOUL	PVOLAT	BRVDWP	DATE
1	131.826	2.1700	2.17000	3.90	1.9	1.3	4.3400	0.500000	0.51445	860605
2	92.202	9.1450	5.27001	3.00	2.2	1.4	14.4150	0.634409	0.27824	860605
3	92.456	2.1700	1.24000	2.00	2.3	1.5	3.4100	0.636364	0.29945	860605
4	154.940	2.4800	4.03001	4.50	2.9	0.7	6.5100	0.380952	0.16066	860605
5	91.694	0.7750	1.86000	2.40	2.0	1.5	2.6350	0.294118	0.26870	860605
6	44.450	0.7750	1.86000	2.40	2.0	1.5	2.6350	0.294118	0.55429	860605
7	63.246	0.7750	2.01500	3.10	2.4	1.4	2.7900	0.277778	0.30924	860605
8	98.806	4.4330	2.72801	5.40	2.6	2.0	7.1610	0.619048	0.24936	860530
9	175.006	7.0525	4.03001	1.60	2.3	4.1	11.0825	0.636364	0.15820	860530
10	64.008	2.2010	2.17000	5.80	2.1	2.5	4.3710	0.503546	0.49603	860530
11	104.140	2.0925	2.75901	7.40	2.2	1.5	4.8515	0.431310	0.21951	860530
12	30.988	2.0925	2.75901	7.40	2.2	1.5	4.8515	0.431310	0.73770	860530
13	387.858	2.4335	2.26300	0.40	0.8	6.0	4.6965	0.518152	0.05894	860530
14	248.666	2.2940	2.77451	4.10	2.2	3.1	5.0685	0.452599	0.08989	860530
15	93.980	.	.	5.40	2.4	1.0	.	.	0.59189	860708
16	31.496	.	.	4.50	2.8	0.9	.	.	0.76613	860708
17	35.306	.	.	5.90	2.1	0.9	.	.	0.74101	860708
18	24.892	.	.	3.80	1.8	1.5	.	.	0.93878	860708
19	49.276	.	.	3.00	0.9	5.1	.	.	0.55670	860708
20	35.052	.	.	2.70	0.7	5.3	.	.	0.67391	860708
21	83.312	.	.	1.20	1.1	5.5	.	.	0.29878	860708
22	36.068	.	.	3.60	2.1	3.3	.	.	0.58451	860708
23	17.018	.	.	.	.	.	.	.	0.68657	860708
24	22.606	.	.	.	.	.	.	.	0.69663	860708
25	84.328	2.0150	2.24750	5.50	3.0	1.7	4.2625	0.472727	0.50000	870910
26	38.862	7.2075	3.64251	4.60	2.3	2.8	10.8500	0.664286	0.64706	870910

OBS	MO	DAY	YR	SERVICE	CLEAN	COND	TANK	GRID	NO	DWP5	DWP75	DWP10	DWP20	DWPAVG
27	9	10	87	15.5	N	DIRTY	N3	2	1	41.402	55.118	64.516	77.216	59.690
28	9	10	87	15.5	N	DIRTY	N3	2	2	33.274	38.100	40.894	61.976	43.688
29	9	10	87	15.5	N	DIRTY	N3	3	1	46.482	49.530	51.816	81.280	57.404
30	9	10	87	15.5	N	DIRTY	N3	3	2	35.560	37.592	39.370	55.372	41.910
31	10	1	87	15.5	G	DIRTY	N2	1	1	25.908	28.956	30.480	38.354	30.988
32	10	1	87	15.5	G	DIRTY	N2	1	2	24.892	25.908	26.670	31.496	27.178
33	10	1	87	15.5	G	DIRTY	N2	2	1	24.892	25.908	26.416	32.004	27.432
34	10	1	87	15.5	G	DIRTY	N2	2	2	36.322	38.862	40.640	49.022	41.148
35	10	1	87	15.5	G	DIRTY	N2	3	1	32.258	33.782	35.052	42.164	35.814
36	10	1	87	15.5	G	DIRTY	N2	3	2	30.988	32.258	33.528	37.592	33.528
37	5	4	88	7.0	N	DIRTY	N3	1	1	20.574	22.098	23.114	30.480	24.130
38	5	4	88	7.0	N	DIRTY	N3	1	2	22.352	23.622	25.146	33.274	26.162
39	5	4	88	7.0	N	DIRTY	N3	2	1	18.034	19.558	20.320	26.670	21.082
40	5	4	88	7.0	N	DIRTY	N3	2	2	20.574	22.352	23.876	33.020	24.892
41	5	4	88	7.0	N	DIRTY	N3	3	1	25.654	26.924	27.432	29.464	27.432
42	5	4	88	7.0	N	DIRTY	N3	3	2	16.256	17.272	17.780	22.352	18.542
43	6	1	88	7.0	G	DIRTY	N2	1	1	16.510	18.034	19.304	25.908	20.066
44	6	1	88	7.0	G	DIRTY	N2	1	2	17.018	18.288	19.812	27.686	20.574
45	6	1	88	7.0	G	DIRTY	N2	2	1	18.034	20.574	23.114	37.592	24.892
46	6	1	88	7.0	G	DIRTY	N2	2	2	17.272	19.050	20.828	29.972	21.844
47	6	1	88	7.0	G	DIRTY	N2	3	1	16.764	18.034	19.304	26.416	20.066
48	6	1	88	7.0	G	DIRTY	N2	3	2	16.002	17.272	18.542	25.400	19.304
49	7	5	88	25.0	G	DIRTY	S	1	1	.	26.670	.	55.626	.
50	7	5	88	25.0	G	DIRTY	S	1	2	.	19.812	.	31.750	.
51	7	5	88	25.0	G	DIRTY	S	2	1	.	20.828	.	35.814	.
52	7	5	88	25.0	G	DIRTY	S	2	2	.	20.828	.	33.020	.

OBS	BRVAVG	VFOUL	NVFOUL	ACENTER	AMIDDLE	AOUTER	TFOUL	PVOLAT	BRVDWP	DATE
27	55.626	2.3250	1.31750	3.40	1.7	4.0	3.6425	0.638298	0.99087	870910
28	51.308	3.4100	2.01500	5.20	2.0	2.9	5.4250	0.628571	0.74257	870910
29	46.736	6.3550	2.55751	5.40	2.0	2.8	8.9125	0.713043	1.05978	870910
30	41.656	7.2075	2.55751	5.90	2.5	2.1	9.7650	0.738095	0.90244	870910
31	42.418	2.4800	3.02251	2.40	3.0	3.0	5.5025	0.450704	0.68263	871001
32	35.814	1.7825	2.55751	5.10	3.5	1.5	4.3400	0.410714	0.72340	871001
33	64.516	1.5500	0.93000	5.70	4.0	0.4	2.4800	0.625000	0.40157	871001
34	52.578	1.2400	0.93000	7.90	2.8	0.7	2.1700	0.571429	0.73913	871001
35	54.610	3.5650	1.62750	11.60	1.6	0.6	5.1925	0.686567	0.61860	871001
36	34.798	3.4100	1.24000	8.00	2.7	1.1	4.6500	0.733333	0.92701	871001
37	56.388	6.2000	4.03001	4.50	2.8	2.2	10.2300	0.606061	0.39189	880504
38	46.482	7.5950	4.80501	2.50	1.1	4.9	12.4000	0.612500	0.50820	880504
39	53.086	6.9750	4.80501	4.70	2.0	3.1	11.7800	0.592105	0.36842	880504
40	51.308	4.3400	2.63501	2.50	1.9	4.3	6.9750	0.622222	0.43564	880504
41	48.514	1.3950	0.46500	5.90	2.4	2.0	1.8600	0.750000	0.55497	880504
42	31.750	1.0850	0.31000	3.50	2.0	3.7	1.3950	0.777778	0.54400	880504
43	22.860	11.1755	6.72701	4.30	4.6	0.8	17.9025	0.624242	0.78889	880601
44	25.654	11.4390	6.46351	3.90	3.8	1.0	17.9025	0.638961	0.71287	880601
45	34.544	9.3310	5.06851	3.80	2.9	1.2	14.3995	0.648009	0.59559	880601
46	21.590	8.5095	5.89001	3.00	2.6	1.4	14.3995	0.590958	0.88235	880601
47	22.860	3.3790	1.13150	6.70	3.7	0.7	4.5105	0.749141	0.78889	880601
48	30.734	3.3170	1.17800	4.90	3.5	1.0	4.4950	0.737931	0.56198	880601
49	63.500	2.2010	0.93000	8.24	.	.	3.1310	0.702970	0.42000	880705
50	53.086	.	.	.	.	.	.	.	0.37321	880705
51	108.712	1.0897	0.69750	2.52	.	.	1.7872	0.609714	0.19159	880705
52	72.390	.	.	.	.	.	.	.	0.28772	880705

OBS	MO	DAY	YR	SERVICE	CLEAN	COND	TANK	GRID	NO	DWP5	DWP75	DWP10	DWP20	DWPAVG	BRVAVG	VFOUL	NVFOUL	ACENTER	AMIDDLE	AOUTER	TFOUL	PVOLAT	BRVDWP	DATE
53	7	5	88	25	G	DIRTY	S	3	1	.	21.844	.	40.640	.	54.102	1.11135	0.790502	2.6	.	.	1.90185	0.584352	0.40376	880705
54	7	5	88	25	G	DIRTY	S	3	2	.	25.908	.	48.006	.	38.862	.	.	.	.	.	.	.	0.66667	880705
55	7	5	88	25		HOSE	S	1	1	.	18.034	.	24.638	.	24.638	.	.	.	.	.	.	.	0.73196	880705
56	7	5	88	25		MM	S	1	1	.	17.526	.	23.114	.	18.288	.	.	.	.	.	.	.	0.95833	880705
57	7	5	88	25		HOSE	S	2	1	.	17.780	.	25.654	.	18.034	.	.	.	.	.	.	.	0.98592	880705
58	7	5	88	25		MM	S	2	1	.	17.018	.	24.892	.	15.494	.	.	.	.	.	.	.	1.09836	880705
59	7	5	88	25		HOSE	S	3	1	.	18.288	.	26.416	.	21.844	.	.	.	.	.	.	.	0.83721	880705
60	7	5	88	25		MM	S	3	1	.	17.526	.	24.384	.	18.034	.	.	.	.	.	.	.	0.97183	880705
61	7	5	88	0		NEW	S	4	.	.	11.811	.	14.605	.	12.446	.	.	.	.	.	.	.	0.94898	880705

APPENDIX III PLANT PROCESS DATA

This appendix contains a summary of the process data for Terminal Island, Valencia and Whittier Narrows for the period of testing and some period, up to one year, prior to testing. The average of all process data are presented, followed by monthly averages.

KEY:

QAVG	=	average influent flow rate (MGD)
QRAVG	=	average recycle flow rate (MGD)
QWAVG	=	average waste sludge flow rate (MGD)
QAIR	=	air flow rate (1000 sft^3/day)
PEFFSS	=	primary effluent TSS (mg/L)
SEFFSS	=	secondary effluent TSS (mg/L)
PECOD	=	primary effluent COD (mg/L)
SECOD	=	secondary effluent COD (mg/L)
PEBOD	=	primary effluent BOD_5 (mg/L)
FEBOD	=	secondary effluent BOD_5 (mg/L)
DO	=	aeration tank DO (mg/L) (Terminal Island only)
DOIMIN, DOIMAX	=	aeration tank maximum and minimum DO's (mg/L). Valencia and Whittier Narrows only
MCRT	=	mean cell retention time (days)
MCRTA	=	average mean cell retention time (days) (Valencia and Whittier Narrows only)
SRT	=	solids retention time (days) neglects secondary clarifier solids (Valencia and Whittier Narrows only)
MLSS	=	mixed liquor suspended solids (mg/L)
MLVSS	=	mixed liquor volatile suspended solids (mg/L)
XRAVG	=	recycle suspended solids (mg/L)
FM	=	food-to-mass ratio ($days^{-1}$) (COD and MLVSS tanks)
SVI or SVI1	=	sludge volume index (ml/G)
TEMP	=	mixed liquor temperature (°F)

Terminal Island

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
QAVG	489	20.58118609	2.05659022	14.5000000	28.2000000	0.09300222	10064.2000	4.22956	9.993
QRAVG	457	16.71006565	1.94378999	10.5000000	23.0000000	0.09092666	7636.5000	3.77832	11.632
QWAVG	457	0.34211160	0.10361310	0.0000000	0.9760000	0.00484682	156.3450	0.01074	30.286
QAIR	457	46.00464989	4.82418412	33.2000000	59.2000000	0.22566582	21024.1250	23.27275	10.486
PEFFSS	467	97.80299786	39.93744776	38.0000000	352.0000000	1.84808468	45674.0000	1594.99973	40.835
SEFFSS	489	13.08793456	6.27367954	4.0000000	62.0000000	0.28370560	6400.0000	39.35905	47.935
PECOD	487	391.66940452	102.67169474	204.0000000	1500.0000000	4.65249859	190743.0000	10541.47690	26.214
SECOD	489	81.46216769	23.30154915	36.0000000	214.0000000	1.05373248	39835.0000	542.96219	28.604
PEBOD	488	180.98565574	48.50607827	78.0000000	420.0000000	2.19576699	88321.0000	2352.83963	26.801
FEBOD	489	19.69325153	8.16830988	4.0000000	59.0000000	0.36938374	9630.0000	66.72129	41.478
DO	313	2.75814696	0.93016011	0.9000000	5.4000000	0.05257576	863.3000	0.86520	33.724
MCRT	447	16.19373602	6.88956488	3.7000000	85.0000000	0.32586524	7238.6000	47.46610	42.545
MLSS	456	2581.50877193	487.65699521	1550.0000000	4540.0000000	22.83663113	1177168.0000	237809.34498	18.890
MLVSS	456	2186.70228070	406.44069376	1333.0000000	3859.0000000	19.03332935	997136.2400	165194.03754	18.587
XRAVG	456	4894.44956140	886.73044685	2820.0000000	8080.0000000	41.52495776	2231869.0000	786290.88536	18.117
FM	457	0.23378556	0.07093287	0.0000000	0.5000000	0.00331810	106.8400	0.00503	30.341
FMCOD	456	0.50093533	0.14503794	0.0000000	1.6818182	0.00679202	228.4265	0.02104	28.953
SVI	456	110.31359649	31.72803924	45.0000000	223.0000000	1.48580157	50303.0000	1006.66847	28.762
TEMP	489	78.68507157	3.72835310	70.0000000	90.0000000	0.16860196	38477.0000	13.90062	4.738

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=3									
QAVG	31	21.05483871	1.27980173	18.7000000	25.6000000	0.22985918	652.700000	1.63789	6.078
QAIR	31	48.00000000	0.00000000	48.0000000	48.0000000	0.00000000	1488.000000	0.00000	0.000
PECOD	30	411.36666667	81.71332704	286.0000000	654.0000000	14.91874416	12341.000000	6677.06782	19.864
MLSS	31	3160.32258065	357.16461070	2425.0000000	3715.0000000	64.14865778	97970.000000	127566.55914	11.302
MLVSS	31	2600.44838710	302.13176057	2012.7500000	3083.4500000	54.26446611	80613.900000	91283.60075	11.618
MCRT	30	17.04333333	7.70757278	8.6000000	37.6000000	1.40720383	511.300000	59.40668	45.223
FM	31	0.19935484	0.05977377	0.1300000	0.3400000	0.01073569	6.180000	0.00357	29.984
FMCOD	30	0.45831186	0.12921518	0.3071667	0.7739474	0.02359136	13.749356	0.01670	28.194
SVI	31	93.09677419	18.62141212	58.0000000	148.0000000	3.34450435	2886.000000	346.75699	20.002
TEMP	31	73.93548387	2.75602956	70.0000000	79.0000000	0.49499752	2292.000000	7.59570	3.728
YEAR=87 MONTH=4									
QAVG	30	19.46666667	1.61252283	17.1000000	23.1000000	0.29440504	584.000000	2.60023	8.284
QAIR	30	50.00000000	0.00000000	50.0000000	50.0000000	0.00000000	1500.000000	0.00000	0.000
PECOD	30	434.00000000	107.17050546	286.0000000	750.0000000	19.56656778	13020.000000	11485.51724	24.694
MLSS	30	2818.03333333	602.91776092	2025.0000000	3945.0000000	110.07721933	84541.000000	363509.82644	21.395
MLVSS	30	2362.15300000	486.59473064	1713.6000000	3274.3500000	88.83963678	70864.590000	236774.43189	20.600
MCRT	29	16.92068966	14.46254718	8.7000000	85.0000000	2.68562759	490.700000	209.16527	85.473
FM	30	0.21933333	0.06927871	0.1200000	0.3500000	0.01264850	6.580000	0.00480	31.586
FMCOD	30	0.50576859	0.16115504	0.2422222	0.9722222	0.02942275	15.173058	0.02597	31.863
SVI	30	62.73333333	9.17618106	48.0000000	80.0000000	1.67533379	1882.000000	84.20230	14.627
TEMP	30	76.23333333	1.38173637	74.0000000	78.0000000	0.25226939	2287.000000	1.90920	1.813
YEAR=87 MONTH=5									
QAVG	31	17.51612903	1.18014032	14.5000000	20.3000000	0.21195946	543.000000	1.39273	6.737
QAIR	31	50.00000000	0.00000000	50.0000000	50.0000000	0.00000000	1550.000000	0.00000	0.000
PECOD	31	391.32258065	84.95464951	204.0000000	577.0000000	15.25830548	12131.000000	7217.29247	21.710
MLSS	30	2876.33333333	350.43060539	2210.0000000	3560.0000000	63.97958247	86290.000000	122801.60920	12.183
MLVSS	30	2454.14000000	306.15338206	1900.6000000	3097.2000000	55.89570447	73624.200000	93729.89334	12.475
MCRT	25	16.89200000	5.49719019	8.5000000	35.4000000	1.09943804	422.300000	30.21910	32.543
FM	31	0.15612903	0.04814405	0.0000000	0.2500000	0.00864693	4.840000	0.00232	30.836
FMCOD	31	0.37526952	0.11332118	0.0000000	0.5567544	0.02035308	11.633355	0.01284	30.197
SVI	30	99.43333333	18.34475089	60.0000000	140.0000000	3.34927796	2983.000000	336.52989	18.449
TEMP	31	79.90322581	1.95541707	75.0000000	86.0000000	0.35120327	2477.000000	3.82366	2.447
YEAR=87 MONTH=6									
QAVG	30	17.80333333	1.27805977	14.9000000	20.3000000	0.23334072	534.100000	1.633437	7.179
QAIR	30	50.00000000	0.00000000	50.0000000	50.0000000	0.00000000	1500.000000	0.000000	0.000
PECOD	30	361.60000000	62.57332251	240.0000000	510.0000000	11.42427341	10848.000000	3915.420690	17.305
MLSS	30	2588.00000000	305.40137524	1900.0000000	3190.0000000	55.75840744	77640.000000	93270.000000	11.801
MLVSS	30	2240.51666667	278.03487171	1634.0000000	2743.4000000	50.76199034	67215.500000	77303.389885	12.409
MCRT	28	23.13214286	15.29333076	12.6000000	84.6000000	2.89016785	647.700000	233.885966	66.113
FM	30	0.17933333	0.04517654	0.1000000	0.2700000	0.00824807	5.380000	0.002041	25.191
FMCOD	30	0.38646730	0.08107483	0.2525926	0.5125000	0.01480217	11.594019	0.006573	20.978
SVI	30	110.20000000	16.72165641	84.0000000	152.0000000	3.05294280	3306.000000	279.613793	15.174
TEMP	30	79.23333333	1.04000442	76.0000000	81.0000000	0.18987796	2377.000000	1.081609	1.313

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=7									
QAVG	31	19.53870968	0.92219933	17.40000000	21.50000000	0.16563189	605.700000	0.850452	4.720
QAIR	0	.	.	.	.	.	.	.	.
PECOD	31	411.03225806	103.27874382	271.00000000	786.00000000	18.54940998	12742.000000	10666.498925	25.127
MLSS	0	.	.	.	.	.	.	.	.
MLVSS	0	.	.	.	.	.	.	.	.
MCRT	0	.	.	.	.	.	.	.	.
FM	0	.	.	.	.	.	.	.	.
FMCOD	0	.	.	.	.	.	.	.	.
SVI	0	.	.	.	.	.	.	.	.
TEMP	31	79.29032258	2.00322321	75.00000000	83.00000000	0.35978951	2458.000000	4.012903	2.526
YEAR=87 MONTH=8									
QAVG	31	20.07741935	1.44053455	17.0000000	22.2000000	0.25872764	622.400000	2.07514	7.175
QAIR	31	45.76393548	2.24940223	39.1020000	49.8490000	0.40400457	1418.682000	5.05981	4.915
PECOD	31	359.87096774	85.76547166	255.0000000	604.0000000	15.40393344	11156.000000	7355.71613	23.832
MLSS	31	2760.00000000	355.04929235	2065.0000000	3420.0000000	63.76873539	85560.000000	126060.00000	12.864
MLVSS	31	2337.24354839	296.65811881	1775.9000000	2872.8000000	53.28137103	72454.550000	88006.03946	12.693
MCRT	31	17.23548387	4.93136549	10.6000000	30.6000000	0.88569939	534.300000	24.31837	28.612
FM	31	0.20032258	0.05828001	0.1100000	0.3300000	0.01046740	6.210000	0.00340	29.093
FMCOD	31	0.42231781	0.08772012	0.2868627	0.6388462	0.01575500	13.091852	0.00769	20.771
SVI	31	101.87096774	21.37247753	74.0000000	173.0000000	3.83861028	3158.000000	456.78280	20.980
TEMP	31	83.09677419	1.77679184	79.0000000	88.0000000	0.31912124	2576.000000	3.15699	2.138
YEAR=87 MONTH=9									
QAVG	30	21.59333333	1.41565955	18.7000000	25.4000000	0.25846289	647.800000	2.00409	6.556
QAIR	30	48.94333333	3.29698748	41.9000000	53.6000000	0.60194480	1468.300000	10.87013	6.736
PECOD	30	384.43333333	68.09966496	268.0000000	505.0000000	12.43324089	11533.000000	4637.56437	17.714
MLSS	30	2718.50000000	328.82012167	2105.0000000	3290.0000000	60.03406600	81555.000000	108122.67241	12.096
MLVSS	30	2322.39333333	303.28404455	1768.2000000	2862.3000000	55.37183751	69671.800000	91981.21168	13.059
MCRT	30	16.07333333	3.13401069	11.7000000	27.3000000	0.57218945	482.200000	9.82202	19.498
FM	30	0.25400000	0.05524865	0.1600000	0.3600000	0.01008698	7.620000	0.00305	21.751
FMCOD	30	0.48873315	0.08648818	0.3415385	0.6391905	0.01579051	14.661994	0.00748	17.696
SVI	30	104.13333333	16.07253673	75.0000000	151.0000000	2.93443031	3124.000000	258.32644	15.435
TEMP	30	85.76666667	2.54183389	82.0000000	90.0000000	0.46407325	2573.000000	6.46092	2.964
YEAR=87 MONTH=10									
QAVG	31	22.11935484	1.99422823	16.8000000	25.2000000	0.35817396	685.700000	3.97695	9.016
QAIR	31	50.55483871	5.57302065	39.9000000	59.2000000	1.00094406	1567.200000	31.05856	11.024
PECOD	31	429.41935484	112.83491605	254.0000000	811.0000000	20.26574918	13312.000000	12731.71828	26.276
MLSS	31	3146.77419355	528.77775481	2490.0000000	4540.0000000	94.97128836	97550.000000	279605.91398	16.804
MLVSS	31	2689.43709677	441.28502467	2141.4000000	3859.0000000	79.25713014	83372.550000	194732.47299	16.408
MCRT	31	15.19032258	3.09508803	7.1000000	22.7000000	0.55589422	470.900000	9.57957	20.375
FM	31	0.21129032	0.04022785	0.1300000	0.2900000	0.00722513	6.550000	0.00162	19.039
FMCOD	31	0.48387485	0.12802916	0.3057407	0.9438362	0.02299472	15.000120	0.01639	26.459
SVI	31	108.54838710	20.00139780	73.0000000	156.0000000	3.59235709	3365.000000	400.05591	18.426
TEMP	31	82.74193548	2.03253113	80.0000000	88.0000000	0.36505337	2565.000000	4.13118	2.456

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=11									
QAVG	30	20.79666667	1.42235437	18.6000000	23.6000000	0.25968519	623.900000	2.023092	6.839
QAIR	30	49.89666667	3.47031583	44.3000000	56.8000000	0.63359009	1496.900000	12.043092	6.955
PECOD	30	371.63333333	45.31155241	281.0000000	485.0000000	8.27271979	11149.000000	2053.136782	12.193
MLSS	30	2434.83333333	260.57126675	2040.0000000	3085.0000000	47.57358688	73045.000000	67897.385057	10.702
MLVSS	30	1971.86666667	237.46896869	1611.6000000	2591.4000000	43.35570362	59156.000000	56391.511092	12.043
MCRT	30	19.56000000	5.56804925	11.6000000	33.3000000	1.01658206	586.800000	31.003172	28.467
FM	30	0.22333333	0.04088110	0.1600000	0.3100000	0.00746383	6.700000	0.001671	18.305
FMCOD	30	0.47227598	0.07884016	0.3447222	0.6480603	0.01439418	14.168279	0.006216	16.694
SVI	30	66.96666667	16.85533443	45.0000000	105.0000000	3.07734896	2009.000000	284.102299	25.170
TEMP	30	80.53333333	0.93710241	79.0000000	83.0000000	0.17109071	2416.000000	0.878161	1.164
YEAR=87 MONTH=12									
QAVG	31	20.63870968	1.52919966	17.4000000	24.5000000	0.27465237	639.800000	2.338452	7.409
QAIR	31	42.56451613	3.43865753	36.1000000	48.2000000	0.61760112	1319.500000	11.824366	8.079
PECOD	31	335.93548387	44.95919297	234.0000000	442.0000000	8.07490943	10414.000000	2021.329032	13.383
MLSS	31	2378.38709677	270.86093325	1960.0000000	2915.0000000	48.64805972	73730.000000	73365.645161	11.388
MLVSS	31	1980.83064516	225.96725931	1646.4000000	2448.6000000	40.58491786	61405.750000	51061.202280	11.408
MCRT	31	15.47096774	3.05332535	10.7000000	23.8000000	0.54839342	479.600000	9.322796	19.736
FM	31	0.21129032	0.03422883	0.1300000	0.3100000	0.00614768	6.550000	0.001172	16.200
FMCOD	31	0.46853817	0.07835756	0.3380000	0.6668229	0.01407343	14.524683	0.006140	16.724
SVI	31	144.96774194	36.31297644	76.0000000	223.0000000	6.52200310	4494.000000	1318.632258	25.049
TEMP	31	75.96774194	1.99137927	71.0000000	80.0000000	0.35766228	2355.000000	3.965591	2.621
YEAR=88 MONTH=1									
QAVG	31	23.01935484	1.80100330	19.0000000	26.1000000	0.32346974	713.600000	3.24361	7.824
QAIR	31	45.39354839	2.70689681	40.6000000	51.2000000	0.48617302	1407.200000	7.32729	5.963
PECOD	31	372.00000000	66.33701832	227.0000000	532.0000000	11.91448021	11532.000000	4400.60000	17.833
MLSS	31	2674.35483871	326.82753336	2050.0000000	3525.0000000	58.69995784	82905.000000	106816.23656	12.221
MLVSS	31	2228.34838710	280.23445585	1681.0000000	2961.0000000	50.33159408	69078.800000	78531.35025	12.576
MCRT	31	15.38064516	2.40602291	11.3000000	20.1000000	0.43213447	476.800000	5.78895	15.643
FM	31	0.29290323	0.07142332	0.1700000	0.4600000	0.01282801	9.080000	0.00510	24.385
FMCOD	31	0.61666221	0.12289753	0.3584211	0.8624000	0.02207305	19.116529	0.01510	19.929
SVI	31	111.35483871	20.13545528	75.0000000	147.0000000	3.61643453	3452.000000	405.43656	18.082
TEMP	31	74.61290323	2.67927129	72.0000000	87.0000000	0.48121133	2313.000000	7.17849	3.591
YEAR=88 MONTH=2									
QAVG	29	22.03448276	2.02118704	20.3000000	28.2000000	0.37532501	639.000000	4.085197	9.173
QAIR	29	41.00689655	2.36823187	38.2000000	46.3000000	0.43976962	1189.200000	5.608522	5.775
PECOD	29	362.55172414	57.49322085	248.0000000	491.0000000	10.67622309	10514.000000	3305.470443	15.858
MLSS	29	2611.55172414	231.89862105	2255.0000000	3235.0000000	43.06249286	75735.000000	53776.970443	8.880
MLVSS	29	2236.21206897	202.00869397	1939.3000000	2782.1000000	37.51207274	64850.150000	40807.512438	9.034
MCRT	29	13.31724138	1.65617221	9.7000000	17.3000000	0.30754346	386.200000	2.742906	12.436
FM	29	0.27551724	0.06162016	0.1800000	0.4500000	0.01144258	7.990000	0.003797	22.365
FMCOD	29	0.56816970	0.10141737	0.3951923	0.7583333	0.01883273	16.476921	0.010285	17.850
SVI	29	146.79310345	16.64842187	112.0000000	190.0000000	3.09153433	4257.000000	277.169951	11.341
TEMP	29	74.89655172	1.89632780	71.0000000	78.0000000	0.35213923	2172.000000	3.596059	2.532

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=88 MONTH=3									
QAVG	31	21.82903226	1.45239883	18.9000000	26.5000000	0.26085853	676.700000	2.10946	6.654
QAIR	31	40.67419355	2.39331956	33.6000000	45.1000000	0.42985288	1260.900000	5.72798	5.884
PECOD	31	352.29032258	39.94929582	287.0000000	456.0000000	7.17510534	10921.000000	1595.94624	11.340
MLSS	31	2098.61290323	377.30047066	1550.0000000	3570.0000000	67.76516499	65057.000000	142355.64516	17.979
MLVSS	31	1802.15000000	319.30415072	1333.0000000	3034.5000000	57.34871843	55866.650000	101955.14067	17.718
MCRT	31	14.30967742	3.05737958	10.0000000	28.0000000	0.54912158	443.600000	9.34757	21.366
FM	31	0.25774194	0.05619666	0.1400000	0.4100000	0.01009322	7.990000	0.00316	21.803
FMCOD	31	0.53997118	0.08087733	0.2751724	0.7125000	0.01452600	16.739107	0.00654	14.978
SVI	31	118.54838710	20.66049162	60.0000000	149.0000000	3.71073384	3675.000000	426.85591	17.428
TEMP	31	76.25806452	2.03253113	73.0000000	83.0000000	0.36505337	2364.000000	4.13118	2.665
YEAR=88 MONTH=4									
QAVG	30	21.54666667	1.49360322	17.5000000	25.0000000	0.27269339	646.400000	2.230851	6.932
QAIR	30	42.15333333	3.34300436	35.3000000	48.3000000	0.61034630	1264.600000	11.175678	7.931
PECOD	30	387.86666667	72.23798472	264.0000000	573.0000000	13.18879125	11636.000000	5218.326437	18.624
MLSS	30	2187.16666667	252.81069425	1765.0000000	2945.0000000	46.15670667	65615.000000	63913.247126	11.559
MLVSS	30	1883.56500000	222.64938501	1517.9000000	2562.1500000	40.65003020	56506.950000	49572.748647	11.821
MCRT	30	14.24666667	2.04226604	8.6000000	18.5000000	0.37286506	427.400000	4.170851	14.335
FM	30	0.27933333	0.07524367	0.1700000	0.5000000	0.01373755	8.380000	0.005662	26.937
FMCOD	30	0.53291291	0.10165381	0.3600000	0.7142857	0.01855936	15.987387	0.010333	19.075
SVI	30	113.10000000	14.83321064	78.0000000	145.0000000	2.70816136	3393.000000	220.024138	13.115
TEMP	30	77.73333333	1.91064772	74.0000000	80.0000000	0.34883495	2332.000000	3.650575	2.458
YEAR=88 MONTH=5									
QAVG	31	20.15161290	1.07513440	17.1000000	22.2000000	0.19309984	624.700000	1.155914	5.335
QAIR	31	43.01935484	4.08512908	34.5000000	53.3000000	0.73371084	1333.600000	16.688280	9.496
PECOD	31	411.74193548	81.14553499	294.0000000	562.0000000	14.57416832	12764.000000	6584.597849	19.708
MLSS	31	2139.03225806	139.45381168	1920.0000000	2460.0000000	25.04664397	66310.000000	19447.365591	6.519
MLVSS	31	1847.78387097	120.42909421	1651.2000000	2115.6000000	21.62970384	57281.300000	14503.166731	6.517
MCRT	31	13.09354839	1.22798900	11.3000000	16.8000000	0.22055334	405.900000	1.507957	9.379
FM	31	0.26419355	0.06417550	0.1500000	0.4100000	0.01152626	8.190000	0.004118	24.291
FMCOD	31	0.55194243	0.12530492	0.3920000	0.8348551	0.02250543	17.110215	0.015701	22.703
SVI	31	153.41935484	20.87386595	112.0000000	210.0000000	3.74905700	4756.000000	435.718280	13.606
TEMP	31	79.35483871	1.11200681	76.0000000	81.0000000	0.19972232	2460.000000	1.236559	1.401
YEAR=88 MONTH=6									
QAVG	31	20.15161290	1.07513440	17.1000000	22.2000000	0.19309984	624.700000	1.15591	5.335
QAIR	30	42.00143333	5.92291606	33.2000000	56.1040000	1.08137158	1260.043000	35.08093	14.102
PECOD	30	491.00000000	248.06965095	276.0000000	1500.0000000	45.29111455	14730.000000	61538.55172	50.523
MLSS	30	2122.16666667	373.01586204	1605.0000000	2780.0000000	68.10306732	63665.000000	139140.83333	17.577
MLVSS	30	1839.11833333	318.89994552	1380.3000000	2418.6000000	58.22289792	55173.550000	101697.17526	17.340
MCRT	30	15.76333333	5.14060800	3.7000000	26.9000000	0.93854232	472.900000	26.42585	32.611
FM	30	0.28666667	0.08363852	0.1500000	0.4800000	0.01527023	8.600000	0.00700	29.176
FMCOD	30	0.64665449	0.27569115	0.3650000	1.6818182	0.05033409	19.399635	0.07601	42.633
SVI	30	118.76666667	23.29227093	76.0000000	166.0000000	4.25256740	3563.000000	542.52989	19.612
TEMP	31	79.35483871	1.11200681	76.0000000	81.0000000	0.19972232	2460.000000	1.23656	1.401

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Valencia

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VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
QAVG	547	6.42453382	0.92313584	4.0100000	9.2600000	0.03947044	3514.2200	0.8522	14.369
QRAVG	547	2.26552102	0.37610479	1.4800000	4.0500000	0.01608108	1239.2400	0.1415	16.601
QWAVG	547	0.13444223	0.03891171	0.0004000	0.2360000	0.00166374	73.5399	0.0015	28.943
QAIR	547	7.98098720	1.26496107	4.9000000	11.2200000	0.05408583	4365.6000	1.6001	15.850
PEFFSS	527	114.59962049	34.66582784	66.0000000	540.0000000	1.51006718	60394.0000	1201.7196	30.250
SEFFSS	538	8.04646840	6.28050667	1.0000000	52.0000000	0.27077187	4329.0000	39.4448	78.053
PECOD	528	330.29734848	42.42941043	209.0000000	529.0000000	1.84650308	174397.0000	1800.2549	12.846
SECOD	537	40.10242086	9.99004793	23.0000000	102.0000000	0.43110239	21535.0000	99.8011	24.911
PEBOD	78	176.32051282	37.67754286	97.0000000	337.0000000	4.26614165	13753.0000	1419.5972	21.369
FEBOD	78	8.21794872	5.23883460	1.0000000	28.0000000	0.59318121	641.0000	27.4454	63.749
DO1MAX	330	2.98151515	1.10972113	1.0000000	6.2000000	0.06108814	983.9000	1.2315	37.220
DO1MIN	328	0.52256098	0.24689539	0.1000000	2.9000000	0.01363252	171.4000	0.0610	47.247
MCRT	482	6.34292344	8.73730164	2.1718000	105.1338000	0.39797318	3057.2891	76.3404	137.749
MCRTA	547	5.33967002	1.59309817	2.3054000	11.4825000	0.06811596	2920.7995	2.5380	29.835
SRT	526	7.15543207	38.46950499	0.8920336	611.9738806	1.67735013	3763.7573	1479.9028	537.627
MLSS	547	3552.08043876	1204.56649024	1079.0000000	7132.0000000	51.50354400	1942988.0000	1450980.4294	33.912
MLVSS	546	2839.62910256	960.93822685	798.4600000	5919.5600000	41.12435968	1550437.4900	923402.2758	33.840
XRAVG	526	5649.64638783	1209.93140319	2086.0000000	9883.0000000	52.75551618	2971714.0000	1463934.0004	21.416
FM	78	0.56707197	0.30209893	0.1931652	1.8058051	0.03420597	44.2316	0.0913	53.273
FMCOD	527	1.05278120	0.43380594	0.3427604	3.3467347	0.01889688	554.8157	0.1882	41.206
SVI	547	209.71115174	82.71483696	93.0000000	741.0000000	3.53663104	114712.0000	6841.7443	39.442
TEMP	547	74.97623400	3.72956975	66.0000000	82.0000000	0.15946489	41012.0000	13.9097	4.974

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=1									
QAVG	31	4.78258065	0.32854191	4.0100000	5.6100000	0.05900787	148.260000	0.10794	6.870
QAIR	31	6.37741935	0.41610069	5.8000000	7.7000000	0.07473389	197.700000	0.17314	6.525
PECOD	27	336.11111111	30.70245960	295.0000000	416.0000000	5.90869111	9075.000000	942.64103	9.135
MLSS	31	2111.64516129	551.11066937	1458.0000000	3292.0000000	98.98239822	65461.000000	303722.96989	26.099
MLVSS	31	1778.32967742	479.96703565	1210.1400000	2831.1200000	86.20462440	55128.220000	230368.35531	26.990
MCRT	26	5.87655769	1.64436459	3.7098000	9.1925000	0.32248643	152.790500	2.70393	27.982
MCRTA	31	5.41130645	1.07894227	3.9409000	7.1665000	0.19378375	167.750500	1.16412	19.939
SRT	29	3.88756862	1.55550360	2.0542405	7.1162234	0.28884977	112.739490	2.41959	40.012
FM	4	0.53171753	0.14044365	0.3847845	0.7103587	0.07022182	2.126870	0.01972	26.413
FMCOD	27	1.18199631	0.30697656	0.6579483	1.7314968	0.05907767	31.913900	0.09423	25.971
SVI	31	171.51612903	54.35737973	93.0000000	350.0000000	9.76287360	5317.000000	2954.72473	31.692
TEMP	31	71.61290323	0.95489683	70.0000000	74.0000000	0.17150453	2220.000000	0.91183	1.333
YEAR=87 MONTH=2									
QAVG	28	4.83071429	0.23266457	4.3300000	5.2600000	0.04396947	135.260000	0.05413	4.816
QAIR	28	6.13214286	0.22452183	5.8000000	6.5000000	0.04243064	171.700000	0.05041	3.661
PECOD	27	347.66666667	31.58870295	306.0000000	428.0000000	6.07924872	9387.000000	997.84615	9.086
MLSS	28	1870.75000000	812.06684750	1293.0000000	4918.0000000	153.46620903	52381.000000	659452.56481	43.409
MLVSS	28	1570.07714286	666.15819851	1086.1200000	4032.7600000	125.89206622	43962.160000	443766.74544	42.428
MCRT	28	15.12206429	28.30739752	3.9837000	105.1338000	5.34959529	423.417800	801.30875	187.193
MCRTA	28	5.81172143	1.53197251	4.3874000	9.9916000	0.28951559	162.728200	2.34694	26.360
SRT	28	50.22154450	159.02438084	1.5840368	611.9738806	30.05278315	1406.203246	25288.75370	316.646
FM	4	0.77084819	0.09685810	0.6608871	0.8768416	0.04842905	3.083393	0.00938	12.565
FMCOD	27	1.47406322	0.26722623	0.5674226	1.9556677	0.05142771	39.799707	0.07141	18.129
SVI	28	191.64285714	23.05743920	152.0000000	265.0000000	4.35744643	5366.000000	531.64550	12.031
TEMP	28	71.85714286	1.14549959	69.0000000	74.0000000	0.21647907	2012.000000	1.31217	1.594
YEAR=87 MONTH=3									
QAVG	31	4.96580645	0.27483054	4.3500000	5.6900000	0.04936102	153.94000	0.0755	5.534
QAIR	31	6.12580645	0.29661169	5.6000000	6.5000000	0.05327303	189.90000	0.0880	4.842
PECOD	31	325.25806452	31.48435351	280.0000000	435.0000000	5.65475682	10083.00000	991.2645	9.680
MLSS	31	5011.87096774	1183.65103928	2853.0000000	7132.0000000	212.59000240	155368.00000	1401029.7828	23.617
MLVSS	31	4074.09322581	975.89725262	2282.4000000	5919.5600000	175.27632080	126296.89000	952375.4477	23.954
MCRT	30	8.26452000	1.95365623	4.5350000	11.3273000	0.35668720	247.93560	3.8168	23.639
MCRTA	31	8.73911613	1.59135813	6.3772000	11.4825000	0.28581636	270.91260	2.5324	18.210
SRT	30	7.31620125	2.37703625	3.4113391	11.0034635	0.43398546	219.48604	5.6503	32.490
FM	4	0.26539727	0.09953255	0.1931652	0.4126095	0.04976628	1.06159	0.0099	37.503
FMCOD	31	0.52965445	0.16799791	0.3427604	0.9226943	0.03017332	16.41929	0.0282	31.718
SVI	31	187.32258065	47.67975608	116.0000000	278.0000000	8.56353699	5807.00000	2273.3591	25.453
TEMP	31	71.87096774	0.95714630	70.0000000	74.0000000	0.17190855	2228.00000	0.9161	1.332

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=4									
QAVG	30	5.31266667	0.63830559	4.4900000	6.6100000	0.11653812	159.38000	0.4074	12.015
QAIR	30	6.08666667	0.58940843	4.9000000	7.5000000	0.10761076	182.60000	0.3474	9.684
PECOD	30	327.53333333	41.22916053	247.0000000	444.0000000	7.52738042	9826.00000	1699.8437	12.588
MLSS	30	4373.20000000	1044.45502701	2418.0000000	5895.0000000	190.69052620	131196.00000	1090886.3034	23.883
MLVSS	30	3445.34233333	776.97418207	1982.7600000	4564.5600000	141.85542871	103360.27000	603688.8796	22.551
MCRT	24	7.51565000	1.57204501	4.7336000	11.1731000	0.32089234	180.37560	2.4713	20.917
MCRTA	30	7.19407333	0.84058723	5.5765000	8.4903000	0.15346953	215.82220	0.7066	11.684
SRT	29	6.42402205	1.94037032	2.7978540	9.1714757	0.36031772	186.29664	3.7650	30.205
FM	5	0.38299509	0.08835493	0.2395894	0.4562434	0.03951353	1.91498	0.0078	23.069
FMCOD	30	0.67005580	0.21935987	0.3700090	1.2526935	0.04004945	20.10167	0.0481	32.738
SVI	30	214.23333333	33.75130479	148.0000000	288.0000000	6.16211699	6427.00000	1139.1506	15.754
TEMP	30	74.33333333	1.24105998	72.0000000	76.0000000	0.22658552	2230.00000	1.5402	1.670
YEAR=87 MONTH=5									
QAVG	31	5.77677419	0.46924327	4.9300000	6.7900000	0.08427858	179.080000	0.22019	8.123
QAIR	31	7.91290323	0.57604510	6.6000000	8.8000000	0.10346075	245.300000	0.33183	7.280
PECOD	29	343.31034483	50.35027553	286.0000000	509.0000000	9.34981144	9956.000000	2535.15025	14.666
MLSS	31	3137.58064516	941.04207395	1399.0000000	5163.0000000	169.01614591	97265.000000	885560.18495	29.993
MLVSS	31	2545.71806452	737.11184761	1147.1800000	4182.0300000	132.38919602	78917.260000	543333.87588	28.955
MCRT	23	5.64600000	4.03761820	2.9747000	23.2296000	0.84190159	129.858000	16.30236	71.513
MCRTA	31	4.95249355	1.24921016	3.8818000	8.0918000	0.22436477	153.527300	1.56053	25.224
SRT	27	4.33720923	2.94534675	1.5202751	17.1920326	0.56683225	117.104649	8.67507	67.909
FM	5	0.88902021	0.51894903	0.6037489	1.8058051	0.23208106	4.445101	0.26931	58.373
FMCOD	29	1.03773795	0.29308274	0.4631186	1.6986357	0.05442410	30.094401	0.08590	28.242
SVI	31	220.38709677	60.52474834	132.0000000	349.0000000	10.87056571	6832.000000	3663.24516	27.463
TEMP	31	77.29032258	1.10131886	75.0000000	80.0000000	0.19780271	2396.000000	1.21290	1.425
YEAR=87 MONTH=6									
QAVG	30	6.78333333	0.34150108	6.1000000	7.5000000	0.06234928	203.50000	0.1166	5.034
QAIR	30	7.94333333	0.77889547	6.3000000	10.2000000	0.14220621	238.30000	0.6067	9.806
PECOD	29	344.24137931	38.99144153	287.0000000	428.0000000	7.24052892	9983.00000	1520.3325	11.327
MLSS	30	3424.33333333	1028.07118811	1506.0000000	6454.0000000	187.69926015	102730.00000	1056930.3678	30.023
MLVSS	30	2784.05600000	852.93381130	1204.8000000	5292.2800000	155.72369617	83521.68000	727496.0865	30.636
MCRT	25	4.61356400	0.81028670	3.5918000	6.9671000	0.16205734	115.33910	0.6566	17.563
MCRTA	30	4.96110000	0.93282556	4.1577000	7.3378000	0.17030987	148.83300	0.8702	18.803
SRT	27	3.50263272	1.09910601	1.7087287	7.2607011	0.21152305	94.57108	1.2080	31.379
FM	5	0.53113586	0.21085836	0.2576331	0.7710279	0.09429873	2.65568	0.0445	39.700
FMCOD	29	1.13155947	0.35593665	0.5276355	2.2098638	0.06609578	32.81522	0.1267	31.455
SVI	30	208.20000000	29.63502122	160.0000000	299.0000000	5.41058987	6246.00000	878.2345	14.234
TEMP	30	79.13333333	0.68144539	78.0000000	80.0000000	0.12441434	2374.00000	0.4644	0.861

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=7									
QAVG	31	7.03612903	0.25964947	6.6300000	7.7300000	0.04663442	218.12000	0.06742	3.690
QAIR	31	8.14903226	0.53396851	7.2800000	8.9800000	0.09590357	252.62000	0.28512	6.553
PECOD	29	321.72413793	30.86016451	277.0000000	400.0000000	5.73058869	9330.00000	952.34975	9.592
MLSS	31	4033.64516129	957.02784872	2652.0000000	6700.0000000	171.88727582	125043.00000	915902.30323	23.726
MLVSS	31	3309.19870968	765.65412830	2174.6400000	5427.0000000	137.51554096	102585.16000	586226.24418	23.137
MCRT	26	6.28288462	2.86566358	3.3803000	16.1420000	0.56200287	163.35500	8.21203	45.611
MCRTA	31	5.54923871	1.38709658	3.6446000	8.1072000	0.24912990	172.02640	1.92404	24.996
SRT	28	5.19810606	2.59111448	2.4764135	11.8918977	0.48967461	145.54697	6.71387	49.847
FM	4	0.42322874	0.12837251	0.2501122	0.5519114	0.06418625	1.69291	0.01648	30.332
FMCOD	29	0.90410613	0.22898232	0.4658521	1.3884260	0.04252095	26.21908	0.05243	25.327
SVI	31	182.38709677	28.88907224	141.0000000	260.0000000	5.18863054	5654.00000	834.57849	15.839
TEMP	31	79.51612903	1.02862263	77.0000000	82.0000000	0.18474608	2465.00000	1.05806	1.294
YEAR=87 MONTH=8									
QAVG	31	7.11419355	0.42767413	6.1000000	8.1300000	0.07681254	220.54000	0.18291	6.012
QAIR	31	8.07419355	0.55073753	7.1000000	9.8000000	0.09891538	250.30000	0.30331	6.821
PECOD	31	352.93548387	35.10169558	289.0000000	435.0000000	6.30445064	10941.00000	1232.12903	9.946
MLSS	31	3918.93548387	900.13250637	2363.0000000	5857.0000000	161.66857067	121487.00000	810238.52903	22.969
MLVSS	31	3170.05967742	718.12307366	1961.2900000	4688.7600000	128.97871154	98271.85000	515700.74892	22.653
MCRT	30	5.73530667	4.58262120	2.7645000	28.6971000	0.83666833	172.05920	21.00042	79.902
MCRTA	31	5.27687097	1.23116915	3.8254000	8.1413000	0.22112451	163.58300	1.51578	23.331
SRT	31	4.67264893	4.67648920	2.4090651	28.6281608	0.83992225	144.85212	21.86955	100.082
FM	4	0.51817652	0.26668301	0.3422295	0.9144062	0.13334151	2.07271	0.07112	51.466
FMCOD	31	1.04497989	0.30384372	0.6296243	1.9800953	0.05457194	32.39438	0.09232	29.077
SVI	31	196.70967742	25.31954916	160.0000000	254.0000000	4.54752527	6098.00000	641.07957	12.872
TEMP	31	80.32258065	0.47519096	80.0000000	81.0000000	0.08534682	2490.00000	0.22581	0.592
YEAR=87 MONTH=9									
QAVG	30	6.87866667	0.38671680	6.3400000	7.6500000	0.07060451	206.36000	0.14955	5.622
QAIR	30	8.53633333	0.99904259	6.3700000	10.6400000	0.18239939	256.09000	0.99809	11.703
PECOD	29	332.96551724	30.75070587	282.0000000	411.0000000	5.71026273	9656.00000	945.60591	9.235
MLSS	30	3577.80000000	885.86623883	1170.0000000	6041.0000000	161.73630731	107334.00000	784758.99310	24.760
MLVSS	30	2837.84500000	670.56983009	936.0000000	4651.5700000	122.42874077	85135.35000	449663.89703	23.630
MCRT	29	6.99673448	4.34455564	3.7089000	26.0363000	0.80676373	202.90530	18.87516	62.094
MCRTA	30	5.89497333	1.02264779	4.4273000	8.1451000	0.18670909	176.84920	1.04581	17.348
SRT	29	5.47795089	3.54397109	2.7415930	21.1937919	0.65809891	158.86058	12.55973	64.695
FM	5	0.69522472	0.58888468	0.3156471	1.7366839	0.26335724	3.47612	0.34679	84.704
FMCOD	29	1.09993529	0.48876860	0.5966076	3.3467347	0.09076205	31.89812	0.23889	44.436
SVI	30	207.50000000	42.25517720	142.0000000	314.0000000	7.71470457	6225.00000	1785.50000	20.364
TEMP	30	79.86666667	0.77607915	78.0000000	81.0000000	0.14169202	2396.00000	0.60230	0.972

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=10									
QAVG	31	7.17483871	0.85059928	4.7900000	9.2600000	0.15277214	222.42000	0.72352	11.855
QAIR	31	8.80225806	0.95218594	6.7800000	10.4300000	0.17101764	272.87000	0.90666	10.818
PECOD	31	345.51612903	51.50525602	258.0000000	499.0000000	9.25061706	10711.00000	2652.79140	14.907
MLSS	31	3370.83870968	581.40617453	1943.0000000	4680.0000000	104.42363158	104496.00000	338033.13978	17.248
MLVSS	31	2647.64838710	472.94709378	1437.8200000	3650.4000000	84.94380562	82077.10000	223678.95351	17.863
MCRT	29	3.56732069	1.09844601	2.1875000	8.1283000	0.20397630	103.45230	1.20658	30.792
MCRTA	31	3.85462258	0.72056760	2.5818000	6.4166000	0.12941776	119.49330	0.51922	18.694
SRT	30	2.70019963	1.05076124	1.0848129	6.6679576	0.19184188	81.00599	1.10410	38.914
FM	4	0.57292993	0.22885801	0.3599885	0.8751820	0.11442900	2.29172	0.05238	39.945
FMCOD	31	1.22837083	0.44353980	0.5939704	2.6497879	0.07966210	38.07950	0.19673	36.108
SVI	31	183.03225806	35.24058633	110.0000000	258.0000000	6.32939615	5674.00000	1241.89892	19.254
TEMP	31	79.70967742	0.78288136	79.0000000	81.0000000	0.14060964	2471.00000	0.61290	0.982
YEAR=87 MONTH=11									
QAVG	30	6.99400000	0.44051381	6.3300000	7.8700000	0.08042645	209.820000	0.19405	6.298
QAIR	30	7.90133333	0.75908172	6.5700000	9.7000000	0.13858873	237.040000	0.57621	9.607
PECOD	30	319.40000000	48.07938837	247.0000000	416.0000000	8.77805519	9582.000000	2311.62759	15.053
MLSS	30	2293.93333333	536.84178195	1079.0000000	3437.0000000	98.01345126	68818.000000	288199.09885	23.403
MLVSS	30	1689.95900000	455.36530491	798.4600000	2680.8600000	83.13794980	50698.770000	207357.56092	26.945
MCRT	28	3.36254643	0.97263437	2.1718000	5.8436000	0.18381062	94.151300	0.94602	28.926
MCRTA	30	3.15282333	0.83387868	2.3054000	4.6871000	0.15224472	94.584700	0.69535	26.449
SRT	30	2.00402714	0.81039493	0.8920336	3.9344879	0.14795719	60.120814	0.65674	40.438
FM	4	0.86771794	0.20303435	0.6030443	1.0703471	0.10151717	3.470872	0.04122	23.399
FMCOD	30	1.75130151	0.48802740	1.0783851	3.0354069	0.08910120	52.539045	0.23817	27.867
SVI	30	151.70000000	32.07765362	94.0000000	203.0000000	5.85655149	4551.000000	1028.97586	21.145
TEMP	30	75.96666667	1.58621939	73.0000000	79.0000000	0.28960271	2279.000000	2.51609	2.088
YEAR=87 MONTH=12									
QAVG	31	6.96129032	0.43643054	6.2900000	7.8700000	0.07838524	215.80000	0.1905	6.269
QAIR	31	8.79838710	1.07067921	7.0500000	11.2200000	0.19229966	272.75000	1.1464	12.169
PECOD	31	326.25806452	43.13542067	223.0000000	407.0000000	7.74735026	10114.00000	1860.6645	13.221
MLSS	31	3382.38709677	1199.14079455	1484.0000000	5661.0000000	215.37204458	104854.00000	1437938.6452	35.453
MLVSS	31	2623.66290323	954.44499949	1157.5200000	4406.6200000	171.42338240	81333.55000	910965.2571	36.378
MCRT	25	5.05382800	3.57226432	2.4874000	21.1668000	0.71445286	126.34570	12.7611	70.684
MCRTA	31	4.18585161	0.74440432	3.3432000	5.7669000	0.13369896	129.76140	0.5541	17.784
SRT	30	3.57437256	2.67861295	1.7440373	16.5753667	0.48904558	107.23118	7.1750	74.939
FM	5	0.82707524	0.50343352	0.3328250	1.6556594	0.22514231	4.13538	0.2534	60.869
FMCOD	31	1.20433786	0.44297066	0.6110927	2.3848929	0.07955988	37.33447	0.1962	36.781
SVI	31	163.16129032	61.10269867	119.0000000	317.0000000	10.97436865	5058.00000	3733.5398	37.449
TEMP	31	71.06451613	2.78011371	66.0000000	76.0000000	0.49932316	2203.00000	7.7290	3.912

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=88 MONTH=1									
QAVG	31	6.84580645	0.42682373	6.0900000	8.0900000	0.07665980	212.22000	0.18218	6.235
QAIR	31	9.47161290	0.70136104	8.0800000	10.6600000	0.12596816	293.62000	0.49191	7.405
PECOD	31	318.32258065	44.64182426	239.0000000	439.0000000	8.01790833	9868.00000	1992.89247	14.024
MLSS	31	3702.74193548	866.42891487	1988.0000000	5780.0000000	155.61522694	114785.00000	750699.06452	23.400
MLVSS	31	2954.15516129	666.95358321	1590.4000000	4566.2000000	119.78839975	91578.81000	444827.08216	22.577
MCRT	29	4.90711034	1.27954966	3.0580000	8.9791000	0.23760641	142.30620	1.63725	26.075
MCRTA	31	4.80990000	0.60932778	3.8268000	6.1007000	0.10943850	149.10690	0.37128	12.668
SRT	31	3.59517823	1.36437791	1.7056966	6.5645283	0.24504951	111.45053	1.86153	37.950
FM	4	0.40406804	0.04737431	0.3372154	0.4489207	0.02368715	1.61627	0.00224	11.724
FMCOD	31	0.97862563	0.30981464	0.5386806	1.6332854	0.05564435	30.33739	0.09599	31.658
SVI	31	342.70967742	103.08805089	155.0000000	511.0000000	18.51516052	10624.00000	10627.14624	30.080
TEMP	31	69.45161290	0.99460913	67.0000000	71.0000000	0.17863707	2153.00000	0.98925	1.432
YEAR=88 MONTH=2									
QAVG	29	6.74827586	0.32036886	6.2400000	7.7400000	0.05949100	195.700000	0.1026	4.747
QAIR	29	8.94620690	0.90766739	6.9300000	10.2900000	0.16854960	259.440000	0.8239	10.146
PECOD	29	317.75862069	34.53947552	256.0000000	383.0000000	6.41381959	9215.000000	1192.9754	10.870
MLSS	29	3211.03448276	1058.28518580	1343.0000000	5695.0000000	196.51862546	93120.000000	1119967.5345	32.958
MLVSS	29	2646.11724138	866.09894506	1141.5500000	4442.1000000	160.83053650	76737.400000	750127.3826	32.731
MCRT	28	5.01770714	1.86453642	2.4836000	9.3349000	0.35236426	140.495800	3.4765	37.159
MCRTA	29	4.68811379	1.27887977	3.1361000	7.5146000	0.23748201	135.955300	1.6355	27.279
SRT	29	3.77916556	2.06527848	1.6793363	8.2321270	0.38351259	109.595801	4.2654	54.649
FM	4	0.52321079	0.17802996	0.2622924	0.6596628	0.08901498	2.092843	0.0317	34.026
FMCOD	29	1.14602337	0.48758418	0.5094436	2.4787627	0.09054211	33.234678	0.2377	42.546
SVI	29	334.06896552	198.82367117	100.0000000	741.0000000	36.92062886	9688.000000	39530.8522	59.516
TEMP	29	70.93103448	0.75266358	69.0000000	72.0000000	0.13976612	2057.000000	0.5665	1.061
YEAR=88 MONTH=3									
QAVG	31	6.71774194	0.29109803	6.3000000	7.3100000	0.05228275	208.25000	0.08474	4.333
QAIR	31	9.62516129	0.43209467	8.9000000	10.7600000	0.07760649	298.38000	0.18671	4.489
PECOD	30	348.10000000	57.59211512	282.0000000	529.0000000	10.51483353	10443.00000	3316.85172	16.545
MLSS	31	4111.51612903	934.92255904	1756.0000000	6452.0000000	167.91704859	127457.00000	874080.19140	22.739
MLVSS	30	3303.07833333	752.45567307	1387.2400000	5097.0800000	137.37898189	99092.35000	566189.53993	22.780
MCRT	25	9.14324000	19.40022348	3.0615000	102.1800000	3.88004470	228.58100	376.36867	212.181
MCRTA	31	5.62243548	0.86596611	4.3912000	7.0934000	0.15553211	174.29550	0.74990	15.402
SRT	29	10.56771459	35.32492757	1.8265239	194.1722684	6.55967437	306.46372	1247.85051	334.272
FM	4	0.45853733	0.21177281	0.3054792	0.7696259	0.10588641	1.83415	0.04485	46.184
FMCOD	29	0.94918214	0.35273504	0.4806918	1.8226179	0.06550125	27.52628	0.12442	37.162
SVI	31	248.45161290	60.34502946	145.0000000	341.0000000	10.83828724	7702.00000	3641.52258	24.288
TEMP	31	72.09677419	0.97825827	71.0000000	74.0000000	0.17570037	2235.00000	0.95699	1.357

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=88 MONTH=4									
QAVG	30	6.87933333	0.37477288	6.1100000	7.6600000	0.06842385	206.38000	0.14045	5.448
QAIR	30	8.38666667	0.63164445	7.2800000	9.7800000	0.11532197	251.60000	0.39897	7.532
PECOD	30	304.20000000	28.43431632	248.0000000	354.0000000	5.19137215	9126.00000	808.51034	9.347
MLSS	30	3636.40000000	566.63493082	3065.0000000	5444.0000000	103.45291116	109092.00000	321075.14483	15.582
MLVSS	30	2894.07166667	398.93931468	2473.6000000	4028.5600000	72.83602058	86822.15000	159152.57680	13.785
MCRT	26	5.43894615	2.90339907	2.5282000	18.6889000	0.56940341	141.41260	8.42973	53.382
MCRTA	30	4.89236667	0.50394480	3.9453000	5.6617000	0.09200731	146.77100	0.25396	10.301
SRT	29	3.79696047	1.90104457	1.8856594	12.4919706	0.35301511	110.11185	3.61397	50.068
FM	4	0.48142771	0.05690997	0.4090896	0.5467514	0.02845499	1.92571	0.00324	11.821
FMCOD	30	0.91848978	0.16465008	0.5961506	1.1989452	0.03006085	27.55469	0.02711	17.926
SVI	30	195.60000000	32.30949471	144.0000000	262.0000000	5.89887969	5868.00000	1043.90345	16.518
TEMP	30	74.06666667	1.25762045	71.0000000	76.0000000	0.22960903	2222.00000	1.58161	1.698
YEAR=88 MONTH=5									
QAVG	31	6.81419355	0.29606051	6.1600000	7.3000000	0.05317404	211.24000	0.08765	4.345
QAIR	31	8.27096774	0.43142674	7.3000000	9.0000000	0.07748653	256.40000	0.18613	5.216
PECOD	31	306.74193548	38.12170663	209.0000000	404.0000000	6.84686063	9509.00000	1453.26452	12.428
MLSS	31	4806.48387097	963.54452832	1878.0000000	6211.0000000	173.05770603	149001.00000	928418.05806	20.047
MLVSS	31	3827.78000000	784.34190803	1521.1800000	4968.8000000	140.87196528	118661.18000	615192.22869	20.491
MCRT	28	6.11440714	1.26988963	3.6172000	8.0245000	0.23998658	171.20340	1.61262	20.769
MCRTA	31	6.09591613	0.89605168	4.8809000	7.5838000	0.16093563	188.97340	0.80291	14.699
SRT	31	5.39078244	1.54819258	1.5336716	7.6658256	0.27806360	167.11426	2.39690	28.719
FM	4	0.42184076	0.08007370	0.3095206	0.4937775	0.04003685	1.68736	0.00641	18.982
FMCOD	31	0.72918175	0.26026994	0.3990307	1.5905424	0.04674586	22.60463	0.06774	35.693
SVI	31	178.48387097	31.09862909	143.0000000	273.0000000	5.58547867	5533.00000	967.12473	17.424
TEMP	31	74.09677419	0.59748577	73.0000000	75.0000000	0.10731161	2297.00000	0.35699	0.806
YEAR=88 MONTH=6									
QAVG	30	6.93166667	0.18055629	6.5400000	7.2800000	0.03296492	207.95000	0.03260	2.605
QAIR	30	7.96633333	0.64206823	7.1000000	9.5700000	0.11722508	238.99000	0.41225	8.060
PECOD	23	330.08695652	47.90133139	242.0000000	424.0000000	9.98811805	7592.00000	2294.53755	14.512
MLSS	30	3770.00000000	839.46444339	2915.0000000	5922.0000000	153.26453729	113100.00000	704700.55172	22.267
MLVSS	30	2875.24466667	558.25533502	2273.7000000	4323.0600000	101.92301328	86257.34000	311649.01908	19.416
MCRT	23	5.27411739	1.58079319	3.7069000	10.4981000	0.32961817	121.30470	2.49891	29.973
MCRTA	30	4.99418667	1.02982662	4.1035000	8.3893000	0.18801976	149.82560	1.06054	20.621
SRT	29	4.31042494	2.02188215	2.5669491	9.0954850	0.37545409	125.00232	4.08801	46.907
FM	5	0.52959108	0.08501597	0.3891247	0.6207603	0.03802030	2.64796	0.00723	16.053
FMCOD	23	1.04127058	0.23161197	0.5584186	1.5236713	0.04829443	23.94922	0.05364	22.243
SVI	30	201.40000000	72.43384616	145.0000000	373.0000000	13.22455049	6042.00000	5246.66207	35.965
TEMP	30	76.13333333	1.59164485	74.0000000	79.0000000	0.29059326	2284.00000	2.53333	2.091

Whittier Narrows

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
QAVG	1218	13.06271708	1.76789905	6.8900000	18.550000	0.05065634	15910.3894	3.1255	13.534
QRAVG	1218	3.30699507	0.69300437	1.8300000	5.590000	0.01985694	4027.9200	0.4803	20.956
QWAVG	1218	0.23642693	0.08505757	0.0200000	0.549000	0.00243719	287.9680	0.0072	35.976
QAIR	1218	11.97371617	2.05853447	7.0100000	18.420000	0.05898404	14583.9863	4.2376	17.192
PEFFSS	1206	91.27280265	18.22904636	36.0000000	181.000000	0.52491659	110075.0000	332.2981	19.972
SEFFSS	1214	9.42009885	3.45406192	2.0000000	34.000000	0.09913358	11436.0000	11.9305	36.667
PECOD	1210	230.99917355	22.51203151	143.0000000	326.000000	0.64717540	279509.0000	506.7916	9.746
SECOD	1213	38.72794724	5.80430466	22.0000000	70.000000	0.16665556	46977.0000	33.6900	14.987
PEBOD	190	102.46315789	20.40583511	40.0000000	176.000000	1.48039487	19468.0000	416.3981	19.915
FEBOD	190	5.17368421	1.76273660	1.0000000	9.000000	0.12788235	983.0000	3.1072	34.071
DO1MAX	1134	2.77680776	1.27550763	0.4000000	8.000000	0.03787708	3148.9000	1.6269	45.934
DO1MIN	1133	0.95066196	0.72956980	0.1000000	5.700000	0.02167464	1077.1000	0.5323	76.743
DO2MAX	1143	2.83788276	1.34415439	0.2000000	9.400000	0.03975814	3243.7000	1.8068	47.365
DO2MIN	1143	0.76386702	0.67439907	0.1000000	5.400000	0.01994775	873.1000	0.4548	88.287
DO3MAX	1128	3.35842199	1.34568883	0.8000000	8.500000	0.04006730	3788.3000	1.8109	40.069
DO3MIN	1127	0.87311446	0.80642148	0.1000000	5.500000	0.02402150	984.0000	0.6503	92.361
MCRT	1208	3.13326291	1.25232946	1.0283000	20.091400	0.03603173	3784.9816	1.5683	39.969
MCRTA	1218	3.01999089	0.80933191	1.7840000	8.338000	0.02319012	3678.3489	0.6550	26.799
SRT	1169	2.72058078	1.26333542	0.9936506	20.643600	0.03694974	3180.3589	1.5960	46.436
MLSS	1176	1047.00651927	190.51533598	555.3333333	1671.666667	5.55554002	1231279.6667	36296.0932	18.196
MLVSS	1169	770.82220654	146.02334066	409.0955556	1278.746667	4.27085694	901091.1594	21322.8160	18.944
XRAVG	1206	5807.36069652	1673.54954654	2122.0000000	12002.000000	48.19088706	7003677.0000	2800768.0847	28.818
FM	181	0.59345738	0.15647682	0.1877968	1.450409	0.01163083	107.4158	0.0245	26.367
FMCOD	1161	1.33867756	0.27953706	0.6125202	2.556257	0.00820396	1554.2046	0.0781	20.882
SVI1	1187	170.75484414	48.61196165	97.0000000	654.000000	1.41097002	202686.0000	2363.1228	28.469
TEMP	1215	76.43950617	3.69015160	66.0000000	83.000000	0.10586589	92874.0000	13.6172	4.828

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=85 MONTH=4									
QAVG	30	10.73966667	1.45843914	6.89000000	12.7100000	0.26627334	322.190000	2.127045	13.580
QAIR	30	9.50733333	1.56589059	7.27000000	11.6500000	0.28589120	285.220000	2.452013	16.470
PECOD	30	255.90000000	22.16917711	222.00000000	315.0000000	4.04751946	7677.000000	491.472414	8.663
MLSS	27	998.66666667	117.60069335	765.66666667	1261.3333333	22.63226399	26964.000000	13829.923077	11.776
MLVSS	27	707.36460905	88.44541817	564.04111111	882.9333333	17.02132866	19098.844444	7822.591995	12.504
MCRT	30	2.71334333	0.78034652	1.52510000	4.9418000	0.14247113	81.400300	0.608941	28.760
MCRTA	30	2.56023667	0.22627633	2.24730000	2.9165000	0.04131222	76.807100	0.051201	8.838
SRT	27	2.38241359	0.72160646	1.30609658	4.2840065	0.13887323	64.325167	0.520716	30.289
FM	4	0.49433236	0.10355553	0.42184385	0.6460798	0.05177777	1.977329	0.010724	20.949
FMCOD	27	1.31382759	0.29755346	0.73566773	1.9069501	0.05726419	35.473345	0.088538	22.648
SVI1	30	230.23333333	54.92859524	159.00000000	351.0000000	10.02854355	6907.000000	3017.150575	23.858
TEMP	30	74.53333333	0.81930725	73.00000000	76.0000000	0.14958435	2236.000000	0.671264	1.099
YEAR=85 MONTH=5									
QAVG	31	12.19870968	0.70306824	9.00000000	13.1100000	0.12627478	378.160000	0.4943049	5.763
QAIR	31	10.44580645	0.87667468	8.79000000	12.0000000	0.15745542	323.820000	0.7685585	8.393
PECOD	31	233.70967742	19.14539727	191.00000000	290.0000000	3.43861486	7245.000000	366.5462366	8.192
MLSS	30	1057.22222222	91.47837855	876.33333333	1242.3333333	16.70159049	31716.666667	8368.2937420	8.653
MLVSS	30	745.33740741	58.16150087	619.73333333	861.3511111	10.61878867	22360.122222	3382.7601836	7.803
MCRT	31	2.63500645	0.57933716	1.50740000	3.5857000	0.10405203	81.685200	0.3356315	21.986
MCRTA	31	2.50447742	0.32788028	2.09250000	3.3128000	0.05888904	77.638800	0.1075055	13.092
SRT	30	2.27137970	0.54555682	1.22486009	3.2111459	0.09960459	68.141391	0.2976322	24.019
FM	4	0.52061963	0.10766697	0.41813398	0.6690858	0.05383348	2.082479	0.0115922	20.681
FMCOD	30	1.27250410	0.12979579	0.92583000	1.5484122	0.02369736	38.175123	0.0168469	10.200
SVI1	31	160.48387097	24.82588833	118.00000000	204.0000000	4.45886117	4975.000000	616.3247312	15.469
TEMP	31	76.70967742	1.10131886	74.00000000	79.0000000	0.19780271	2378.000000	1.2129032	1.436
YEAR=85 MONTH=6									
QAVG	30	11.71500000	0.49666995	10.54000000	12.4600000	0.09067911	351.450000	0.246681	4.240
QAIR	30	10.79000000	0.47375972	10.02000000	11.9200000	0.08649630	323.700000	0.224448	4.391
PECOD	29	238.03448276	21.38838596	171.00000000	277.0000000	3.97172356	6903.000000	457.463054	8.985
MLSS	28	990.58333333	149.22691383	788.33333333	1318.6666667	28.20123592	27736.333333	22268.671811	15.065
MLVSS	28	708.64904762	106.49242838	559.71666667	939.8222222	20.12517729	19842.173333	11340.637303	15.028
MCRT	29	2.76545172	0.72162268	1.74210000	5.3096000	0.13400197	80.198100	0.520739	26.094
MCRTA	30	2.78816000	0.46133886	2.23090000	3.6835000	0.08422857	83.644800	0.212834	16.546
SRT	27	2.47770245	0.71832281	1.79378561	4.9104109	0.13824129	66.897966	0.515988	28.991
FM	3	0.60383858	0.03176767	0.56831205	0.6295129	0.01834107	1.811516	0.001009	5.261
FMCOD	27	1.33912907	0.23433927	0.83180836	1.7334854	0.04509861	36.156485	0.054915	17.499
SVI1	30	172.46666667	41.19234389	122.00000000	274.0000000	7.52065865	5174.000000	1696.809195	23.884
TEMP	30	79.20000000	1.09544512	76.00000000	80.0000000	0.20000000	2376.000000	1.200000	1.383

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=85 MONTH=7									
QAVG	31	11.90032258	0.58115680	10.06000000	12.8400000	0.10437884	368.910000	0.337743	4.884
QAIR	31	10.37451613	1.03926525	8.17000000	11.9000000	0.18665755	321.610000	1.080072	10.017
PECOD	31	217.48387097	15.34464286	197.00000000	270.0000000	2.75597922	6742.000000	235.458065	7.056
MLSS	29	866.39080460	118.99910194	579.00000000	1034.3333333	22.09757848	25125.333333	14160.786262	13.735
MLVSS	29	625.67938697	86.41128211	414.95000000	760.4855556	16.04617225	18144.702222	7466.909676	13.811
MCRT	30	2.65042333	0.74702214	1.39170000	4.2059000	0.13638696	79.512700	0.558042	28.185
MCRTA	31	2.51023226	0.47009407	1.78400000	3.3236000	0.08443139	77.817200	0.220988	18.727
SRT	29	2.31868817	0.69213351	1.14659237	3.7034318	0.12852597	67.241957	0.479049	29.850
FM	5	0.55013146	0.07019024	0.46948013	0.6580760	0.03139003	2.750657	0.004927	12.759
FMCOD	29	1.38242375	0.24379937	1.04074697	1.9243921	0.04527241	40.090289	0.059438	17.636
SVI1	31	212.83870968	38.33544641	137.00000000	318.0000000	6.88524943	6598.000000	1469.606452	18.012
TEMP	31	81.19354839	1.27591418	78.00000000	83.0000000	0.22916095	2517.000000	1.627957	1.571
YEAR=85 MONTH=8									
QAVG	31	11.98516129	0.80557586	9.28000000	13.1800000	0.14468570	371.540000	0.648952	6.721
QAIR	31	9.88516129	1.20773858	8.86000000	12.6300000	0.21691625	306.440000	1.458632	12.218
PECOD	31	219.83870968	21.15356042	197.00000000	289.0000000	3.79929161	6815.000000	447.473118	9.622
MLSS	31	903.50537634	132.00283024	646.66666667	1267.0000000	23.70840819	28008.666667	17424.747192	14.610
MLVSS	31	648.43086022	91.27347944	444.04444444	899.5700000	16.39320084	20101.356667	8330.848048	14.076
MCRT	31	2.91736774	0.74223872	1.80940000	5.0284000	0.13331001	90.438400	0.550918	25.442
MCRTA	31	2.86959677	0.52683580	2.27290000	3.9717000	0.09462250	88.957500	0.277556	18.359
SRT	31	2.45388519	0.69932171	1.48522819	4.6400123	0.12560189	76.070441	0.489051	28.499
FM	4	0.78088366	0.12602323	0.60778851	0.8982754	0.06301162	3.123535	0.015882	16.139
FMCOD	31	1.36989782	0.26703425	0.99201186	2.5279150	0.04796077	42.466833	0.071307	19.493
SVI1	31	167.22580645	32.22081075	106.00000000	259.0000000	5.78702845	5184.000000	1038.180645	19.268
TEMP	31	80.96774194	1.40199551	78.00000000	83.0000000	0.25180583	2510.000000	1.965591	1.732
YEAR=85 MONTH=9									
QAVG	30	11.46066667	0.75299372	9.83000000	12.5000000	0.13747722	343.820000	0.567000	6.570
QAIR	30	9.99033333	0.47480292	8.76000000	10.7600000	0.08668676	299.710000	0.225438	4.753
PECOD	30	223.70000000	21.46552971	193.00000000	278.0000000	3.91905161	6711.000000	460.768966	9.596
MLSS	28	839.59523810	145.14988300	565.00000000	1099.6666667	27.43074952	23508.666667	21068.488536	17.288
MLVSS	28	596.90138889	90.28150220	416.21666667	751.8700000	17.06160020	16713.238889	8150.749639	15.125
MCRT	29	3.06260690	1.06516073	1.91910000	5.9478000	0.19779538	88.815600	1.134567	34.780
MCRTA	30	2.80253667	0.51831177	2.25430000	4.0784000	0.09463035	84.076100	0.268647	18.494
SRT	28	2.73424352	1.11979707	1.71844335	6.1348315	0.21162176	76.558819	1.253945	40.955
FM	5	0.69368864	0.42605137	0.44107787	1.4504090	0.19053597	3.468443	0.181520	61.418
FMCOD	28	1.44818510	0.30525931	1.00010238	2.3603937	0.05768859	40.549183	0.093183	21.079
SVI1	30	196.70000000	32.70784995	134.00000000	259.0000000	5.97160907	5901.000000	1069.803448	16.628
TEMP	30	80.50000000	0.57235147	80.00000000	82.0000000	0.10449660	2415.000000	0.327586	0.711

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=85 MONTH=10									
QAVG	31	10.33064516	0.97667782	7.47000000	11.9800000	0.17541652	320.250000	0.953900	9.454
QAIR	31	9.45483871	0.60952917	7.95000000	10.5700000	0.10947467	293.100000	0.371526	6.447
PECOD	30	219.66666667	18.45279781	191.00000000	296.0000000	3.36900454	6590.000000	340.505747	8.400
MLSS	30	898.92222222	123.73311049	555.33333333	1113.3333333	22.59047191	26967.666667	15309.882631	13.765
MLVSS	30	659.54955556	97.45222329	409.09555556	841.7022222	17.79226032	19786.486667	9496.935824	14.776
MCRT	31	3.41289677	1.03426542	1.02830000	6.7078000	0.18575955	105.799800	1.069705	30.305
MCRTA	31	3.25411935	0.56741007	2.41380000	4.1278000	0.10190986	100.877700	0.321954	17.437
SRT	30	3.15840681	0.92853731	1.94729071	6.5907824	0.16952694	94.752204	0.862182	29.399
FM	4	0.50713229	0.18130387	0.26851226	0.6637839	0.09065193	2.028529	0.032871	35.751
FMCOD	29	1.15768666	0.24583273	0.73725849	1.7446469	0.04564999	33.572913	0.060434	21.235
SVI1	31	179.22580645	34.61089393	132.00000000	266.0000000	6.21630006	5556.000000	1197.913978	19.311
TEMP	31	79.22580645	0.99027530	77.00000000	81.0000000	0.17785869	2456.000000	0.980645	1.250
YEAR=85 MONTH=11									
QAVG	30	10.34766667	0.66072418	8.30000000	11.7500000	0.12063118	310.430000	0.436556	6.385
QAIR	30	9.44833333	0.64220033	7.71000000	10.4500000	0.11724920	283.450000	0.412421	6.797
PECOD	30	205.33333333	11.19523708	180.00000000	227.0000000	2.04396130	6160.000000	125.333333	5.452
MLSS	26	900.94871795	125.44731315	661.66666667	1154.6666667	24.60224222	23424.666667	15737.028376	13.924
MLVSS	26	645.94303419	94.19217922	460.96111111	846.7555556	18.47260615	16794.518889	8872.166626	14.582
MCRT	29	2.64364138	0.61604920	1.45860000	5.1931000	0.11439746	76.665600	0.379517	23.303
MCRTA	30	2.74101000	0.32571987	2.36590000	3.6287000	0.05946804	82.230300	0.106093	11.883
SRT	26	2.43872745	0.50232743	1.78121575	4.6136157	0.09851452	63.406914	0.252333	20.598
FM	3	0.47640210	0.05733875	0.41067084	0.5161440	0.03310454	1.429206	0.003288	12.036
FMCOD	26	1.10176334	0.17034093	0.76098805	1.4861892	0.03340661	28.645847	0.029016	15.461
SVI1	30	127.83333333	18.00399062	103.00000000	183.0000000	3.28706393	3835.000000	324.143678	14.084
TEMP	30	74.93333333	2.37709375	68.00000000	78.0000000	0.43399596	2248.000000	5.650575	3.172
YEAR=85 MONTH=12									
QAVG	31	10.18548387	0.67222436	8.90000000	11.6200000	0.12073506	315.750000	0.4518856	6.600
QAIR	31	8.92161290	0.82828778	7.01000000	10.9900000	0.14876488	276.570000	0.6860606	9.284
PECOD	30	208.53333333	23.74684492	172.00000000	272.0000000	4.33556088	6256.000000	563.9126437	11.388
MLSS	30	871.14444444	86.34940530	733.66666667	1045.0000000	15.76517237	26134.333333	7456.2197957	9.912
MLVSS	30	643.27944444	60.64226473	489.11111111	771.2000000	11.07171211	19298.383333	3677.4842714	9.427
MCRT	31	2.50832581	0.49712309	1.56950000	3.3285000	0.08928594	77.758100	0.2471314	19.819
MCRTA	31	2.48262258	0.22471176	2.05310000	2.8488000	0.04035942	76.961300	0.0504954	9.051
SRT	30	2.19255117	0.40843644	1.51745009	3.0833825	0.07456995	65.776535	0.1668203	18.628
FM	4	0.45484481	0.15980599	0.29849941	0.6614782	0.07990300	1.819379	0.0255380	35.134
FMCOD	29	1.10082086	0.20062459	0.86785632	1.5785630	0.03725505	31.923805	0.0402502	18.225
SVI1	31	184.09677419	38.73960492	138.00000000	274.0000000	6.95783844	5707.000000	1500.7569892	21.043
TEMP	31	73.12903226	0.95714630	70.00000000	74.0000000	0.17190855	2267.000000	0.9161290	1.309

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=86 MONTH=1									
QAVG	31	13.21096774	2.00830999	8.59000000	15.3800000	0.36070312	409.540000	4.033309	15.202
QAIR	31	12.91354839	2.05380062	8.88000000	14.6300000	0.36887348	400.320000	4.218097	15.904
PECOD	29	228.10344828	23.37481066	183.00000000	287.0000000	4.34059337	6615.000000	546.381773	10.247
MLSS	27	1022.93827160	124.63056645	767.66666667	1326.6666667	23.98516370	27619.333333	15532.778094	12.184
MLVSS	27	730.80213992	81.76644810	568.07333333	928.6666667	15.73596027	19731.657778	6685.752035	11.189
MCRT	29	2.88929310	1.77034993	1.37380000	10.9128000	0.32874573	83.789500	3.134139	61.273
MCRTA	31	2.61689677	0.53046949	2.09170000	3.9054000	0.09527513	81.123800	0.281398	20.271
SRT	26	2.12786693	0.60206284	1.57135513	4.6230102	0.11807424	55.324540	0.362480	28.294
FM	4	0.65570457	0.12677453	0.52467595	0.7850451	0.06338726	2.622818	0.016072	19.334
FMCOD	25	1.45466207	0.29277585	0.94008683	1.9579076	0.05855517	36.366552	0.085718	20.127
SVI1	31	186.58064516	56.33280524	127.00000000	407.0000000	10.11767050	5784.000000	3173.384946	30.192
TEMP	31	72.80645161	1.16674347	70.00000000	76.0000000	0.20955331	2257.000000	1.361290	1.603
YEAR=86 MONTH=2									
QAVG	28	14.77428571	0.96191718	12.02000000	16.5900000	0.18178526	413.680000	0.925285	6.511
QAIR	28	14.28678571	0.46957075	12.89000000	14.9400000	0.08874053	400.030000	0.220497	3.287
PECOD	26	219.61538462	22.18301499	176.00000000	262.0000000	4.35044716	5710.000000	492.086154	10.101
MLSS	27	1032.60493827	125.82741664	817.66666667	1301.3333333	24.21549762	27880.333333	15832.538778	12.185
MLVSS	27	764.12814815	84.46361283	625.14222222	970.8333333	16.25502987	20631.460000	7134.101892	11.054
MCRT	27	2.35511481	0.36143505	1.83730000	3.0443000	0.06955821	63.588100	0.130635	15.347
MCRTA	28	2.30785357	0.16282332	1.98820000	2.6069000	0.03077071	64.619900	0.026511	7.055
SRT	27	1.99479564	0.35371844	1.51757367	2.7912743	0.06807314	53.859482	0.125117	17.732
FM	4	0.72101419	0.20311797	0.51117915	0.9251901	0.10155898	2.884057	0.041257	28.171
FMCOD	25	1.42820622	0.19942786	1.10613649	1.7778751	0.03988557	35.705156	0.039771	13.964
SVI1	28	164.57142857	25.52620813	137.00000000	238.0000000	4.82399990	4608.000000	651.587302	15.511
TEMP	28	71.53571429	1.73166892	66.00000000	74.0000000	0.32725467	2003.000000	2.998677	2.421
YEAR=86 MONTH=3									
QAVG	31	14.01548387	0.94933604	12.01000000	16.0000000	0.17050579	434.480000	0.901239	6.773
QAIR	31	12.88870968	0.90679561	11.57000000	14.5500000	0.16286530	399.550000	0.822278	7.036
PECOD	30	219.50000000	20.11647121	183.00000000	262.0000000	3.67274835	6585.000000	404.672414	9.165
MLSS	30	1068.18888889	119.26806419	763.33333333	1271.3333333	21.77526972	32045.666667	14224.871137	11.165
MLVSS	30	797.59296296	90.30620782	556.16666667	966.2133333	16.48758237	23927.788889	8155.211171	11.322
MCRT	29	2.15368621	0.27775149	1.70430000	2.6715000	0.05157716	62.456900	0.077146	12.897
MCRTA	31	2.13806129	0.11675230	1.90340000	2.3212000	0.02096933	66.279900	0.013631	5.461
SRT	28	1.88017205	0.25995072	1.41444426	2.3343186	0.04912607	52.644817	0.067574	13.826
FM	4	0.54800996	0.16708941	0.37749825	0.7774021	0.08354471	2.192040	0.027919	30.490
FMCOD	29	1.28765574	0.19451874	0.90634305	1.8169788	0.03612122	37.342017	0.037838	15.106
SVI1	31	139.74193548	22.48550310	111.00000000	196.0000000	4.03851557	4332.000000	505.597849	16.091
TEMP	31	73.03225806	1.81629423	69.00000000	76.0000000	0.32621607	2264.000000	3.298925	2.487

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=86 MONTH=4									
QAVG	30	13.65966667	0.76407475	11.99000000	16.3000000	0.13950033	409.790000	0.5838102	5.594
QAIR	30	12.25100000	0.47405332	11.22000000	13.3100000	0.08654990	367.530000	0.2247266	3.870
PECOD	30	223.90000000	15.18699534	196.00000000	259.0000000	2.77275331	6717.000000	230.6448276	6.783
MLSS	28	1092.32142857	90.22338451	902.00000000	1307.6666667	17.05061699	30585.000000	8140.2591123	8.260
MLVSS	26	796.39769231	55.79898354	688.52666667	911.0077778	10.94308100	20706.340000	3113.5265635	7.006
MCRT	30	2.12388667	0.26378387	1.65440000	2.7322000	0.04816012	63.716600	0.0695819	12.420
MCRTA	30	2.12355667	0.13351070	1.84700000	2.3184000	0.02437561	63.706700	0.0178251	6.287
SRT	28	1.87107996	0.21253645	1.55402248	2.4409422	0.04016561	52.390239	0.0451717	11.359
FM	3	0.50813088	0.14682947	0.40453085	0.6761598	0.08477203	1.524393	0.0215589	28.896
FMCOD	26	1.26457748	0.12376413	1.09731875	1.6177479	0.02427214	32.879014	0.0153176	9.787
SVI1	30	161.13333333	26.93892624	120.00000000	239.0000000	4.91835253	4834.000000	725.7057471	16.718
TEMP	30	75.73333333	1.31131241	72.00000000	78.0000000	0.23941180	2272.000000	1.7195402	1.731
YEAR=86 MONTH=5									
QAVG	31	12.14032258	2.02476745	9.60000000	18.5500000	0.36365897	376.350000	4.099683	16.678
QAIR	31	10.35548387	1.30466557	8.74000000	16.1400000	0.23432485	321.020000	1.702152	12.599
PECOD	31	233.25806452	13.42129587	202.00000000	262.0000000	2.41053590	7231.000000	180.131183	5.754
MLSS	18	1053.62962963	121.08841306	770.66666667	1237.6666667	28.54081266	18965.333333	14662.403776	11.493
MLVSS	17	782.46712418	69.52828806	650.22888889	899.3711111	16.86308680	13301.941111	4834.182840	8.886
MCRT	31	2.72369355	0.69388987	1.60780000	4.5082000	0.12462630	84.434500	0.481483	25.476
MCRTA	31	2.71789355	0.37046545	2.21010000	3.4679000	0.06653756	84.254700	0.137245	13.631
SRT	18	2.68791320	0.73166449	1.82839351	4.5727084	0.17245497	48.382438	0.535333	27.221
FM	2	0.61491750	0.06643115	0.56794358	0.6618914	0.04697391	1.229835	0.004413	10.803
FMCOD	17	1.33823260	0.15119828	1.10232580	1.6095402	0.03667097	22.749954	0.022861	11.298
SVI1	31	176.48387097	22.78577183	139.00000000	229.0000000	4.09244543	5471.000000	519.191398	12.911
TEMP	31	77.51612903	1.06053344	76.00000000	80.0000000	0.19047743	2403.000000	1.124731	1.368
YEAR=86 MONTH=6									
QAVG	30	12.78966667	1.62351148	9.49000000	14.5500000	0.29641129	383.690000	2.635790	12.694
QAIR	30	10.45000000	1.47011142	7.57000000	12.8700000	0.26840440	313.500000	2.161228	14.068
PECOD	30	229.06666667	11.40155263	209.00000000	256.0000000	2.08162919	6872.000000	129.995402	4.977
MLSS	25	939.97333333	125.66614795	653.00000000	1116.3333333	25.13322959	23499.333333	15791.980741	13.369
MLVSS	22	683.89121212	67.97818340	545.11111111	791.3244444	14.49299740	15045.606667	4621.033418	9.940
MCRT	30	2.68678333	0.87197621	1.71770000	5.6989000	0.15920035	80.603500	0.760343	32.454
MCRTA	30	2.55696333	0.33757035	1.93990000	3.2642000	0.06163163	76.708900	0.113954	13.202
SRT	22	2.23714306	0.58032859	1.31379660	3.7667569	0.12372647	49.217147	0.336781	25.941
FM	2	0.70023389	0.18093065	0.57229660	0.8281712	0.12793729	1.400468	0.032736	25.839
FMCOD	22	1.54055992	0.19505335	1.18914399	1.9763636	0.04158551	33.892318	0.038046	12.661
SVI1	28	169.92857143	25.51532375	138.00000000	255.0000000	4.82194295	4758.000000	651.031746	15.015
TEMP	30	78.43333333	0.93526074	76.00000000	80.0000000	0.17075447	2353.000000	0.874713	1.192

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=86 MONTH=7									
QAVG	31	14.19290323	0.46222068	13.36000000	15.2200000	0.08301728	439.980000	0.213648	3.257
QAIR	31	11.84322581	0.79516618	10.40000000	13.6100000	0.14281606	367.140000	0.632289	6.714
PECOD	31	228.51612903	13.71585692	192.00000000	266.0000000	2.46344063	7084.000000	188.124731	6.002
MLSS	31	968.20430108	109.54747584	772.00000000	1209.0000000	19.67530748	30014.333333	12000.649462	11.315
MLVSS	31	696.14612903	86.11505854	530.10666667	842.2700000	15.46672110	21580.530000	7415.803307	12.370
MCRT	31	2.44014839	0.30338107	1.93160000	3.2041000	0.05448885	75.644600	0.092040	12.433
MCRTA	31	2.38230000	0.20791973	1.98810000	2.6533000	0.03734349	73.851300	0.043231	8.728
SRT	31	1.95403569	0.29075491	1.52187500	2.8308015	0.05222112	60.575106	0.084538	14.880
FM	5	0.60797154	0.10395604	0.46321758	0.7105770	0.04649056	3.039858	0.010807	17.099
FMCOD	31	1.56491715	0.21721110	1.25325599	2.0827500	0.03901227	48.512432	0.047181	13.880
SVI1	31	219.00000000	33.14513539	173.00000000	277.0000000	5.95304205	6789.000000	1098.600000	15.135
TEMP	31	79.41935484	0.56416272	78.00000000	80.0000000	0.10132661	2462.000000	0.318280	0.710
YEAR=86 MONTH=8									
QAVG	31	14.04064516	0.55514524	11.92000000	15.0600000	0.09970703	435.260000	0.3081862	3.954
QAIR	31	11.24741935	0.80781585	10.10000000	13.2200000	0.14508801	348.670000	0.6525665	7.182
PECOD	31	219.61290323	11.33924577	196.00000000	241.0000000	2.03658866	6808.000000	128.5784946	5.163
MLSS	31	817.47311828	92.54547528	675.00000000	1013.0000000	16.62165804	25341.666667	8564.6649940	11.321
MLVSS	31	590.23057348	66.71656242	484.77333333	739.4900000	11.98264834	18297.147778	4451.0997016	11.303
MCRT	31	2.16520968	0.19908764	1.86870000	2.5593000	0.03575720	67.121500	0.0396359	9.195
MCRTA	31	2.17074839	0.08345198	1.98880000	2.3349000	0.01498842	67.293200	0.0069642	3.844
SRT	31	1.73857148	0.16895857	1.45633228	2.1201158	0.03034585	53.895716	0.0285470	9.718
FM	4	0.71459385	0.11419619	0.55492319	0.8194618	0.05709809	2.858375	0.0130408	15.981
FMCOD	31	1.75218874	0.23255356	1.33791060	2.1447237	0.04176785	54.317851	0.0540812	13.272
SVI1	31	224.45161290	34.55414949	169.00000000	292.0000000	6.20610846	6958.000000	1193.9892473	15.395
TEMP	31	79.64516129	0.55065943	78.00000000	80.0000000	0.09890135	2469.000000	0.3032258	0.691
YEAR=86 MONTH=9									
QAVG	30	12.59433333	0.93837601	10.98000000	14.66000000	0.17132324	377.830000	0.880550	7.451
QAIR	30	10.87766667	1.24818401	8.36000000	13.61000000	0.22788618	326.330000	1.557963	11.475
PECOD	30	226.83333333	15.10214265	205.00000000	265.00000000	2.75726140	6805.000000	228.074713	6.658
MLSS	30	759.00000000	101.87032550	629.66666667	967.00000000	18.59889174	22770.000000	10377.563218	13.422
MLVSS	30	546.11311111	75.83190210	437.12666667	693.01666667	13.84494779	16383.393333	5750.477376	13.886
MCRT	30	2.21675333	0.40894569	1.65640000	3.25470000	0.07466293	66.502600	0.167237	18.448
MCRTA	30	2.13856667	0.12010611	1.91320000	2.40550000	0.02192828	64.157000	0.014425	5.616
SRT	30	1.91281407	0.42614888	1.38620793	3.08185166	0.07780379	57.384422	0.181603	22.279
FM	5	0.70456288	0.17106197	0.51530464	0.90247600	0.07650124	3.522814	0.029262	24.279
FMCOD	30	1.75323112	0.21676290	1.33574762	2.07426200	0.03957531	52.596934	0.046986	12.364
SVI1	30	212.50000000	40.51628025	137.00000000	307.00000000	7.39722688	6375.000000	1641.568966	19.066
TEMP	30	78.33333333	1.24105998	75.00000000	80.00000000	0.22658552	2350.000000	1.540230	1.584

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=86 MONTH=10									
QAVG	31	12.67419355	1.53012586	7.80000000	15.0000000	0.27481872	392.900000	2.341285	12.073
QAIR	31	13.23773871	2.38187378	8.63000000	18.4200000	0.42779716	410.369900	5.673323	17.993
PECOD	31	237.09677419	16.47898629	188.00000000	280.0000000	2.95971331	7350.000000	271.556989	6.950
MLSS	31	865.82795699	191.22793983	558.00000000	1182.3333333	34.34555189	26840.666667	36568.124970	22.086
MLVSS	31	624.40154122	137.64076191	412.92000000	882.8088889	24.72101061	19356.447778	18944.979339	22.044
MCRT	31	2.76743871	1.18457776	1.49290000	8.1860000	0.21275645	85.790600	1.403224	42.804
MCRTA	31	2.56841613	0.44052741	1.96010000	3.4130000	0.07912106	79.620900	0.194064	17.152
SRT	31	2.63802462	2.02231449	1.29743901	12.6475535	0.36321841	81.778763	4.089756	76.660
FM	5	0.68556019	0.12896091	0.51720240	0.8280574	0.05767307	3.427801	0.016631	18.811
FMCOD	31	1.64298496	0.32328069	1.17372318	2.5562574	0.05806293	50.932534	0.104510	19.676
SVI1	31	251.25806452	105.61880128	133.00000000	654.0000000	18.96969670	7789.000000	11155.331183	42.036
TEMP	31	76.29032258	0.52874369	75.00000000	77.0000000	0.09496517	2365.000000	0.279570	0.693
YEAR=86 MONTH=11									
QAVG	30	14.67098667	1.59727635	10.90000000	18.4300000	0.29162143	440.129600	2.5512918	10.887
QAIR	30	10.86833333	1.22668908	9.06000000	13.0700000	0.22396176	326.050000	1.5047661	11.287
PECOD	30	234.80000000	13.87232422	209.00000000	259.0000000	2.53272830	7044.000000	192.4413793	5.908
MLSS	30	1164.60000000	97.12414144	940.33333333	1342.3333333	17.73236105	34938.000000	9433.0988506	8.340
MLVSS	30	821.75066667	72.79043098	665.00000000	968.1777778	13.28965367	24652.520000	5298.4468419	8.858
MCRT	30	3.01992000	0.38996812	1.67880000	3.8047000	0.07119811	90.597600	0.1520751	12.913
MCRTA	30	2.95192333	0.20542994	2.60580000	3.2614000	0.03750620	88.557700	0.0422015	6.959
SRT	30	2.44577238	0.33304225	1.32038814	3.1257055	0.06080492	73.373171	0.1109171	13.617
FM	5	0.61049279	0.02909766	0.57036876	0.6382466	0.01301287	3.052464	0.0008467	4.766
FMCOD	30	1.39673322	0.19452570	0.94148143	1.8456630	0.03551537	41.901997	0.0378402	13.927
SVI1	30	155.60000000	29.65735357	105.00000000	221.0000000	5.41466718	4668.000000	879.5586207	19.060
TEMP	30	74.30000000	0.70221325	73.00000000	76.0000000	0.12820601	2229.000000	0.4931034	0.945
YEAR=86 MONTH=12									
QAVG	31	14.17645161	0.74762534	12.66000000	15.2500000	0.13427748	439.470000	0.558944	5.274
QAIR	31	11.48709677	1.25125322	9.13000000	15.7300000	0.22473171	356.100000	1.565635	10.893
PECOD	31	237.93548387	12.62520095	218.00000000	270.0000000	2.26755303	7376.000000	159.395699	5.306
MLSS	31	1129.25806452	141.06900622	855.00000000	1441.0000000	25.33674147	35007.000000	19900.464516	12.492
MLVSS	31	838.05025090	103.49261735	632.70000000	1080.7500000	18.58782280	25979.557778	10710.721847	12.349
MCRT	31	2.58848065	0.34167492	2.14820000	3.2091000	0.06136663	80.242900	0.116742	13.200
MCRTA	31	2.64202258	0.23590410	2.31520000	3.2087000	0.04236963	81.902700	0.055651	8.929
SRT	31	2.08589156	0.30828293	1.65035044	2.6925722	0.05536925	64.662638	0.095038	14.779
FM	5	0.64089305	0.13621334	0.49630275	0.7738629	0.06091646	3.204465	0.018554	21.254
FMCOD	31	1.35410785	0.21108640	1.00658575	2.0484322	0.03791224	41.977343	0.044557	15.589
SVI1	31	168.70967742	36.30903795	118.00000000	263.0000000	6.52129573	5230.000000	1318.346237	21.522
TEMP	31	71.19354839	0.98045414	70.00000000	73.0000000	0.17609476	2207.000000	0.961290	1.377

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=1									
QAVG	31	14.52387097	0.37158828	13.76000000	15.3800000	0.06673923	450.240000	0.1380778	2.558
QAIR	31	12.58935484	1.22740902	9.74000000	14.9600000	0.22044917	390.270000	1.5065329	9.750
PECOD	31	245.16129032	24.61584419	201.00000000	326.0000000	4.42113613	7600.000000	605.9397849	10.041
MLSS	31	1139.60215054	95.16953369	950.33333333	1351.0000000	17.09295284	35327.666667	9057.2401434	8.351
MLVSS	31	841.76007168	68.85874617	677.90444444	998.5000000	12.36739590	26094.562222	4741.5269244	8.180
MCRT	31	2.73880323	0.26920514	2.05760000	3.1774000	0.04835067	84.902900	0.0724714	9.829
MCRTA	31	2.73519677	0.14187530	2.47440000	3.0023000	0.02548156	84.791100	0.0201286	5.187
SRT	31	2.19545873	0.22127057	1.63544119	2.5503156	0.03974137	68.059221	0.0489607	10.079
FM	6	0.58770286	0.12461761	0.40531415	0.7423733	0.05087493	3.526217	0.0155295	21.204
FMCOD	31	1.40848154	0.17532949	1.13356309	1.9214870	0.03149011	43.662928	0.0307404	12.448
SVI1	31	140.77419355	19.79176542	104.00000000	171.0000000	3.55470601	4364.000000	391.7139785	14.059
TEMP	31	69.54838710	0.80988516	68.00000000	71.0000000	0.14545967	2156.000000	0.6559140	1.164
YEAR=87 MONTH=2									
QAVG	28	14.25428571	1.36692255	9.7300000	15.4900000	0.25832408	399.120000	1.868477	9.590
QAIR	28	13.57214286	1.21078596	11.6200000	15.9000000	0.22881704	380.020000	1.466003	8.921
PECOD	28	240.28571429	11.54654716	222.0000000	278.0000000	2.18209231	6728.000000	133.322751	4.805
MLSS	28	1305.98809524	143.01444522	1079.6666667	1671.6666667	27.02718971	36567.666667	20453.131540	10.951
MLVSS	28	952.59488095	88.44505503	781.6444444	1175.7388889	16.71454431	26672.656667	7822.527759	9.285
MCRT	28	3.29859286	0.43678872	2.5875000	4.1910000	0.08254531	92.360600	0.190784	13.242
MCRTA	28	3.25787500	0.28299306	2.7895000	3.7787000	0.05348066	91.220500	0.080085	8.686
SRT	28	2.63218654	0.34595068	2.0096080	3.3809842	0.06537853	73.701223	0.119682	13.143
FM	5	0.57234909	0.07155108	0.4792210	0.6460464	0.03199861	2.861745	0.005120	12.501
FMCOD	28	1.19678288	0.14102562	0.7714972	1.4365409	0.02665134	33.509921	0.019888	11.784
SVI1	28	125.89285714	11.61206042	105.0000000	146.0000000	2.19447315	3525.000000	134.839947	9.224
TEMP	28	70.57142857	0.63412649	70.0000000	72.0000000	0.11983864	1976.000000	0.402116	0.899
YEAR=87 MONTH=3									
QAVG	31	14.38000000	0.69356086	12.97000000	15.9300000	0.12456721	445.780000	0.481027	4.823
QAIR	31	14.59322581	0.85562214	12.80000000	15.9500000	0.15367427	452.390000	0.732089	5.863
PECOD	31	236.45161290	9.41218611	219.00000000	251.0000000	1.69047853	7330.000000	88.589247	3.981
MLSS	31	1315.53763441	136.87224856	989.00000000	1627.6666667	24.58298154	40781.666667	18734.012425	10.404
MLVSS	31	944.83673835	97.87351540	725.26666667	1182.7711111	17.57860229	29289.938889	9579.225017	10.359
MCRT	30	3.50537333	0.45113744	2.67630000	4.4492000	0.08236605	105.161200	0.203525	12.870
MCRTA	31	3.47273871	0.28728153	2.96540000	3.9066000	0.05159729	107.654900	0.082531	8.272
SRT	31	2.78560405	0.35952713	2.08429505	3.5493544	0.06457298	86.353725	0.129260	12.907
FM	5	0.53493797	0.11062696	0.37635930	0.6326942	0.04947388	2.674690	0.012238	20.680
FMCOD	31	1.20705216	0.17230117	0.84839768	1.7746019	0.03094620	37.418617	0.029688	14.275
SVI1	31	114.41935484	7.28822884	100.00000000	125.0000000	1.30900454	3547.000000	53.118280	6.370
TEMP	31	71.96774194	1.13970379	69.00000000	75.0000000	0.20469684	2231.000000	1.298925	1.584

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=4									
QAVG	30	14.17533333	1.43949880	10.2500000	15.4100000	0.26281532	425.260000	2.072157	10.155
QAIR	30	14.19733333	0.97140472	11.9700000	15.8500000	0.17735343	425.920000	0.943627	6.842
PECOD	30	243.90000000	9.14386925	228.0000000	269.0000000	1.66943448	7317.000000	83.610345	3.749
MLSS	30	1225.17777778	112.26892773	1060.0000000	1478.6666667	20.49740807	36755.333333	12604.312133	9.163
MLVSS	30	906.26522222	87.98669917	787.7333333	1069.5688889	16.06409996	27187.956667	7741.659230	9.709
MCRT	30	3.45452667	0.50783281	2.5816000	4.6722000	0.09271716	103.635800	0.257894	14.701
MCRTA	30	3.40610000	0.21870414	2.9474000	3.7346000	0.03992973	102.183000	0.047832	6.421
SRT	30	2.80228870	0.37585156	2.1148037	3.6821788	0.06862079	84.068661	0.141264	13.412
FM	5	0.58651774	0.11920927	0.4409368	0.7542933	0.05331201	2.932589	0.014211	20.325
FMCOD	30	1.27786547	0.19901691	0.7622582	1.5418621	0.03633535	38.335964	0.039608	15.574
SVI1	30	128.63333333	13.51495553	107.0000000	157.0000000	2.46748200	3859.000000	182.654023	10.507
TEMP	30	75.60000000	1.27576887	73.0000000	78.0000000	0.23292246	2268.000000	1.627586	1.688
YEAR=87 MONTH=5									
QAVG	31	14.76677419	0.81422924	10.63000000	15.2900000	0.14623989	457.770000	0.662969	5.514
QAIR	31	13.28193548	0.86747303	10.86000000	14.8200000	0.15580276	411.740000	0.752509	6.531
PECOD	31	231.87096774	11.78909648	209.00000000	257.0000000	2.11738423	7188.000000	138.982796	5.084
MLSS	31	1168.09677419	114.63469172	888.66666667	1390.6666667	20.58899843	36211.000000	13141.112545	9.814
MLVSS	31	852.21254480	84.85747368	666.50000000	1015.1866667	15.24085219	26418.588889	7200.790839	9.957
MCRT	31	3.28076129	1.02596872	1.97280000	6.7765000	0.18426942	101.703600	1.052612	31.272
MCRTA	31	3.02925484	0.43326175	2.46210000	4.3216000	0.07781611	93.906900	0.187716	14.303
SRT	31	2.64215641	0.86847697	1.58059817	5.6294021	0.15598307	81.906849	0.754252	32.870
FM	5	0.63332399	0.14157531	0.47922017	0.8659081	0.06331440	3.166620	0.020044	22.354
FMCOD	31	1.34449955	0.18540084	0.96848656	1.9241516	0.03329897	41.679486	0.034373	13.790
SVI1	31	154.61290323	22.41380143	124.00000000	241.0000000	4.02563758	4793.000000	502.378495	14.497
TEMP	31	77.35483871	0.79784656	76.00000000	79.0000000	0.14329747	2398.000000	0.636559	1.031
YEAR=87 MONTH=6									
QAVG	30	14.26066000	1.20742026	9.74000000	16.6098000	0.22044377	427.819800	1.457864	8.467
QAIR	30	12.76600000	1.98396086	10.28000000	15.8500000	0.36222004	382.980000	3.936101	15.541
PECOD	30	231.10000000	18.26500328	184.00000000	260.0000000	3.33471810	6933.000000	333.610345	7.904
MLSS	30	1135.67777778	166.18411715	754.33333333	1424.0000000	30.34092989	34070.333333	27617.160792	14.633
MLVSS	30	822.15411111	123.10333713	588.38000000	1036.7433333	22.47549155	24664.623333	15154.431614	14.973
MCRT	30	4.66690667	1.83385108	3.21130000	10.2089000	0.33481387	140.007200	3.363010	39.295
MCRTA	30	4.18103000	0.75406451	3.51150000	6.9123000	0.13767271	125.430900	0.568613	18.035
SRT	30	3.88440627	1.71228040	2.63490016	9.3963761	0.31261820	116.532188	2.931904	44.081
FM	7	0.57299140	0.11156231	0.45006929	0.7323352	0.04216659	4.010940	0.012446	19.470
FMCOD	30	1.36065752	0.28172389	0.83353961	2.0587452	0.05143551	40.819726	0.079368	20.705
SVI1	30	146.70000000	34.81096736	98.00000000	239.0000000	6.35558402	4401.000000	1211.803448	23.729
TEMP	29	78.96551724	0.77840306	78.00000000	80.0000000	0.14454582	2290.000000	0.605911	0.986

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=7									
QAVG	31	14.46903226	0.66054197	13.70000000	16.1600000	0.11863684	448.540000	0.436316	4.565
QAIR	31	12.78096774	1.26338000	10.02000000	14.5300000	0.22690975	396.210000	1.596129	9.885
PECOD	31	226.16129032	12.82730622	201.00000000	248.0000000	2.30385221	7011.000000	164.539785	5.672
MLSS	31	1059.24731183	140.28698014	845.66666667	1494.3333333	25.19628544	32836.666667	19680.436798	13.244
MLVSS	31	770.16075269	96.11281886	617.33666667	1075.9200000	17.26237186	23874.983333	9237.673949	12.480
MCRT	31	4.30006452	1.57067337	2.57500000	10.1059000	0.28210126	133.302000	2.467015	36.527
MCRTA	31	4.49260645	1.37819167	3.54060000	8.3380000	0.24753053	139.270800	1.899412	30.677
SRT	31	3.62681608	1.36787616	2.03829733	8.3712205	0.24567781	112.431299	1.871085	37.716
FM	5	0.57522196	0.09990486	0.43138590	0.6652100	0.04467881	2.876110	0.009981	17.368
FMCOD	31	1.42653525	0.19428218	1.00875013	1.8018574	0.03489411	44.222593	0.037746	13.619
SVI1	31	173.16129032	41.24810846	108.00000000	247.0000000	7.40837898	5368.000000	1701.406452	23.821
TEMP	31	79.87096774	0.67041954	78.00000000	81.0000000	0.12041090	2476.000000	0.449462	0.839
YEAR=87 MONTH=8									
QAVG	31	14.82129032	0.45494866	14.11000000	15.8000000	0.08171119	459.460000	0.206978	3.070
QAIR	31	12.77965806	1.89743659	10.26000000	16.4399000	0.34078967	396.169400	3.600266	14.847
PECOD	31	201.80645161	26.09012502	163.00000000	293.0000000	4.68592478	6256.000000	680.694624	12.928
MLSS	31	874.19354839	100.81132998	658.66666667	1021.3333333	18.10624937	27100.000000	10162.924253	11.532
MLVSS	31	637.23655914	74.32743025	475.76666667	755.2933333	13.34960056	19754.333333	5524.566887	11.664
MCRT	31	2.79784839	0.64134829	1.79340000	4.2357000	0.11518955	86.733300	0.411328	22.923
MCRTA	31	2.84821935	0.48554755	2.20540000	3.9030000	0.08720691	88.294800	0.235756	17.047
SRT	31	2.29024338	0.54295124	1.42017633	3.4272460	0.09751692	70.997545	0.294796	23.707
FM	5	0.75752365	0.15746571	0.58208710	0.9648898	0.07042081	3.787618	0.024795	20.787
FMCOD	31	1.57713826	0.29183400	1.17128301	2.4345341	0.05241493	48.891286	0.085167	18.504
SVI1	31	206.87096774	31.67200860	166.00000000	296.0000000	5.68846067	6413.000000	1003.116129	15.310
TEMP	31	80.67741935	0.74775650	80.00000000	82.0000000	0.13430103	2501.000000	0.559140	0.927
YEAR=87 MONTH=9									
QAVG	30	12.32666667	1.71815927	10.18000000	15.7200000	0.31369153	369.800000	2.952071	13.939
QAIR	30	13.75264000	1.91010443	10.47000000	16.1799000	0.34873576	412.579200	3.648499	13.889
PECOD	30	208.83333333	31.52129366	143.00000000	255.0000000	5.75497453	6265.000000	993.591954	15.094
MLSS	30	862.40555556	129.54124540	612.50000000	1156.0000000	23.65088741	25872.166667	16780.934259	15.021
MLVSS	29	653.72672414	102.75624418	441.00000000	878.5600000	19.08135551	18958.075000	10558.845719	15.719
MCRT	30	2.70531667	0.53688765	1.29630000	3.7071000	0.09802183	81.159500	0.288248	19.846
MCRTA	30	2.66702667	0.29331657	2.25340000	3.1318000	0.05355203	80.010800	0.086035	10.998
SRT	30	2.58175274	0.56087865	0.99365057	3.3353310	0.10240196	77.452582	0.314585	21.725
FM	5	0.56030896	0.14389825	0.34419200	0.7226051	0.06435325	2.801545	0.020707	25.682
FMCOD	29	1.32592662	0.34081658	0.70894154	2.0911113	0.06328805	38.451872	0.116156	25.704
SVI1	30	231.43333333	41.29346891	146.00000000	311.0000000	7.53912147	6943.000000	1705.150575	17.842
TEMP	30	81.30000000	0.65125873	80.00000000	83.0000000	0.11890303	2439.000000	0.424138	0.801

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=87 MONTH=10									
QAVG	31	14.37709677	0.96860103	10.10000000	15.7700000	0.17396588	445.690000	0.938188	6.737
QAIR	31	10.83870968	1.02841866	9.33000000	13.1000000	0.18470944	336.000000	1.057645	9.488
PECOD	31	222.00000000	23.84533497	147.00000000	280.0000000	4.28274859	6882.000000	568.600000	10.741
MLSS	31	1208.20430108	206.32846301	806.66666667	1581.6666667	37.05768592	37454.333333	42571.434648	17.077
MLVSS	31	879.87849462	157.95284515	548.98666667	1154.6666667	28.36916846	27276.233333	24949.101292	17.952
MCRT	31	4.40328065	1.76411550	2.81240000	10.1441000	0.31684450	136.501700	3.112104	40.064
MCRTA	31	3.95744839	0.81471319	2.56790000	5.1621000	0.14632681	122.680900	0.663758	20.587
SRT	31	3.80275286	1.77898024	2.21246641	10.0416945	0.31951428	117.885339	3.164771	46.781
FM	5	0.51778810	0.27757921	0.18779680	0.9488444	0.12413720	2.588940	0.077050	53.609
FMCOD	31	1.24608220	0.31588249	0.72012638	2.0771277	0.05673417	38.628548	0.099782	25.350
SVI1	31	148.80645161	36.54624409	100.00000000	249.0000000	6.56389921	4613.000000	1335.627957	24.560
TEMP	31	80.16129032	0.86010752	78.00000000	82.0000000	0.15447987	2485.000000	0.739785	1.073
YEAR=87 MONTH=11									
QAVG	30	14.36066667	0.90259753	10.26000000	15.6600000	0.16479101	430.820000	0.814682	6.285
QAIR	30	11.21900000	0.60211323	9.56000000	12.1400000	0.10993033	336.570000	0.362540	5.367
PECOD	30	237.43333333	17.35965067	196.00000000	286.0000000	3.16942409	7123.000000	301.357471	7.311
MLSS	30	1136.68888889	128.27454791	896.00000000	1358.6666667	23.41962115	34100.666667	16454.359642	11.285
MLVSS	30	817.55311111	93.61157056	647.96666667	1032.5866667	17.09105628	24526.593333	8763.126142	11.450
MCRT	30	3.44254000	0.95614452	1.78880000	6.2917000	0.17456731	103.276200	0.914212	27.774
MCRTA	30	3.30098667	0.44840858	2.72620000	4.3971000	0.08186783	99.029600	0.201070	13.584
SRT	30	2.87224655	0.96379517	1.44759674	6.2775353	0.17596412	86.167396	0.928901	33.555
FM	5	0.67481483	0.19210520	0.47099049	0.9851272	0.08591206	3.374074	0.036904	28.468
FMCOD	30	1.39673902	0.19939846	1.02076857	1.8886181	0.03640501	41.902171	0.039760	14.276
SVI1	30	159.63333333	29.14823391	118.00000000	242.0000000	5.32171508	4789.000000	849.619540	18.259
TEMP	30	77.26666667	1.63861450	74.00000000	79.0000000	0.29916871	2318.000000	2.685057	2.121
YEAR=87 MONTH=12									
QAVG	31	14.31645161	0.45987352	13.17000000	15.2400000	0.08259572	443.810000	0.211484	3.212
QAIR	31	13.79288710	1.75121158	10.90000000	17.1498000	0.31452688	427.579500	3.066742	12.696
PECOD	31	241.61290323	21.42222743	157.00000000	273.0000000	3.84754563	7490.000000	458.911828	8.866
MLSS	31	1076.02150538	135.42711407	838.33333333	1394.0000000	24.32342773	33356.666667	18340.503226	12.586
MLVSS	31	804.30161290	103.61057720	608.94333333	1017.6200000	18.60900901	24933.350000	10735.151707	12.882
MCRT	31	3.60547097	1.38510153	2.13200000	7.4810000	0.24877158	111.769600	1.918506	38.417
MCRTA	31	3.41440645	0.76245317	2.43140000	4.8020000	0.13694063	105.846600	0.581335	22.330
SRT	31	3.07030944	1.39408512	1.68505579	7.6986957	0.25038508	95.179593	1.943473	45.405
FM	5	0.59741472	0.14003765	0.42054486	0.7634797	0.06262674	2.987074	0.019611	23.441
FMCOD	31	1.44146203	0.19961956	1.13939408	1.9063182	0.03585273	44.685323	0.039848	13.848
SVI1	31	214.00000000	39.38443009	150.00000000	287.0000000	7.07365246	6634.000000	1551.133333	18.404
TEMP	31	72.12903226	1.56507583	70.00000000	74.0000000	0.28109592	2236.000000	2.449462	2.170

YEAR=88 MONTH=1

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
QAVG	31	12.54129032	1.86907774	8.45000000	14.7100000	0.33569627	388.780000	3.493452	14.903
QAIR	31	13.99933548	1.70537107	10.79000000	16.0999000	0.30629369	433.979400	2.908290	12.182
PECOD	31	239.09677419	27.79011196	168.00000000	296.0000000	4.99125145	7412.000000	772.290323	11.623
MLSS	31	1235.72043011	130.03281913	944.66666667	1555.6666667	23.35458375	38307.333333	16908.534050	10.523
MLVSS	31	939.70344086	91.22872180	726.80333333	1151.1933333	16.38516213	29130.806667	8322.679680	9.708
MCRT	31	4.02040000	1.36775435	2.31360000	8.3549000	0.24565593	124.632400	1.870752	34.020
MCRTA	31	3.80238065	0.81031388	2.61840000	5.0342000	0.14553667	117.873800	0.656609	21.311
SRT	31	3.25563109	1.17366415	1.80382058	6.5281740	0.21079630	100.924564	1.377488	36.050
FM	4	0.49788677	0.11464147	0.39462707	0.6472563	0.05732074	1.991547	0.013143	23.026
FMCOD	31	1.06087387	0.19522220	0.61252017	1.4374814	0.03506294	32.887090	0.038112	18.402
SVI1	31	158.29032258	24.35459375	106.00000000	208.0000000	4.37421417	4907.000000	593.146237	15.386
TEMP	29	70.34482759	1.00980416	67.00000000	72.0000000	0.18751592	2040.000000	1.019704	1.436

YEAR=88 MONTH=2

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
QAVG	29	12.47620690	1.36006936	9.3700000	14.1400000	0.25255854	361.810000	1.849789	10.901
QAIR	29	14.85515862	0.73308454	12.6300000	16.0697000	0.13613038	430.799600	0.537413	4.935
PECOD	29	255.68965517	19.40931928	221.0000000	314.0000000	3.60422011	7415.000000	376.721675	7.591
MLSS	29	1270.70114943	112.03862517	1049.6666667	1492.0000000	20.80505039	36850.333333	12552.653530	8.817
MLVSS	29	953.72114943	81.59177163	808.2433333	1096.4266667	15.15121163	27657.913333	6657.217198	8.555
MCRT	29	4.54785862	3.43800963	2.9129000	20.0914000	0.63842236	131.887900	11.819910	75.596
MCRTA	29	3.93696207	0.86496588	2.9987000	5.8214000	0.16062013	114.171900	0.748166	21.970
SRT	29	3.86216812	3.66872488	2.2587314	20.6436004	0.68126511	112.002875	13.459542	94.991
FM	5	0.51758164	0.11558015	0.3715173	0.6625497	0.05168901	2.587908	0.013359	22.331
FMCOD	29	1.11857596	0.19121945	0.6734882	1.4274888	0.03550856	32.438703	0.036565	17.095
SVI1	29	119.55172414	10.94984086	97.0000000	152.0000000	2.03333440	3467.000000	119.899015	9.159
TEMP	29	71.96551724	0.90564731	70.0000000	73.0000000	0.16817448	2087.000000	0.820197	1.258

YEAR=88 MONTH=3

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
QAVG	31	13.13096774	1.05340196	9.4800000	14.2900000	0.18919658	407.060000	1.109656	8.022
QAIR	31	13.63869677	1.05606287	12.1700000	16.3197000	0.18967449	422.799600	1.115269	7.743
PECOD	31	254.19354839	17.83520742	230.0000000	309.0000000	3.20329782	7880.000000	318.094624	7.016
MLSS	31	1253.92473118	118.96092448	1012.6666667	1618.6666667	21.36601277	38871.666667	14151.701553	9.487
MLVSS	31	974.38225806	91.92511723	820.2600000	1278.7466667	16.51023844	30205.850000	8450.227177	9.434
MCRT	31	3.26541290	0.87000735	2.4392000	7.2199000	0.15625793	101.227800	0.756913	26.643
MCRTA	31	3.16807419	0.29841565	2.8123000	3.7033000	0.05359703	98.210300	0.089052	9.419
SRT	31	2.63549483	0.85707664	1.9010149	6.7096483	0.15393551	81.700340	0.734580	32.521
FM	5	0.43582022	0.08325449	0.2930441	0.4931596	0.03723254	2.179101	0.006931	19.103
FMCOD	31	1.14149496	0.14794520	0.8610466	1.5745076	0.02657174	35.386344	0.021888	12.961
SVI1	31	133.12903226	12.31460362	115.0000000	164.0000000	2.21176810	4127.000000	151.649462	9.250
TEMP	31	73.64516129	1.56094815	72.0000000	76.0000000	0.28035456	2283.000000	2.436559	2.120

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
YEAR=88 MONTH=4									
QAVG	30	13.85700000	0.57858418	12.23000000	14.8400000	0.10563454	415.710000	0.3347597	4.175
QAIR	30	14.11765667	1.26653090	11.70000000	16.4399000	0.23123585	423.529700	1.6041005	8.971
PECOD	30	247.16666667	15.59417074	221.00000000	293.0000000	2.84709303	7415.000000	243.1781609	6.309
MLSS	30	1118.11111111	90.60208710	918.66666667	1272.0000000	16.54160229	33543.333333	8208.7381865	8.103
MLVSS	30	873.33722222	72.11180850	707.37333333	992.1600000	13.16575473	26200.116667	5200.1129250	8.257
MCRT	30	3.47770667	0.62090253	2.48660000	5.2458000	0.11336077	104.331200	0.3855200	17.854
MCRTA	30	3.49039333	0.25186680	2.99520000	4.0140000	0.04598438	104.711800	0.0634369	7.216
SRT	30	2.86541483	0.54338023	2.03604543	4.3165759	0.09920720	85.962445	0.2952621	18.963
FM	5	0.64911858	0.12135146	0.51200354	0.8331878	0.05427002	3.245593	0.0147262	18.695
FMCOD	30	1.30604671	0.13503773	1.05696811	1.6684912	0.02465440	39.181401	0.0182352	10.339
SVI1	30	145.36666667	12.78329549	125.00000000	179.0000000	2.33389977	4361.000000	163.4126437	8.794
TEMP	30	77.50000000	1.00858385	75.00000000	79.0000000	0.18414137	2325.000000	1.0172414	1.301
YEAR=88 MONTH=5									
QAVG	31	12.49612903	1.68629708	9.64000000	14.6900000	0.30286790	387.380000	2.843598	13.495
QAIR	31	11.77935484	1.49995541	8.70000000	14.4900000	0.26939994	365.160000	2.249866	12.734
PECOD	31	236.64516129	15.55752420	209.00000000	265.0000000	2.79421383	7336.000000	242.036559	6.574
MLSS	31	1089.70430108	127.00380360	877.66666667	1347.5000000	22.81055650	33780.833333	16129.966129	11.655
MLVSS	31	857.46392473	102.77302854	658.46000000	1037.5750000	18.45858083	26581.381667	10562.295395	11.986
MCRT	31	3.59628387	0.73056110	2.37980000	5.5820000	0.13121265	111.484800	0.533720	20.314
MCRTA	31	3.37394516	0.39831063	2.94280000	4.4364000	0.07153870	104.592300	0.158651	11.805
SRT	31	3.31537908	0.63769141	2.29199120	4.6006795	0.11453276	102.776752	0.406650	19.234
FM	5	0.59170865	0.13496186	0.39426620	0.7688743	0.06035678	2.958543	0.018215	22.809
FMCOD	31	1.17264316	0.29864588	0.69688403	1.8946275	0.05363838	36.351938	0.089189	25.468
SVI1	31	144.29032258	9.19852723	126.00000000	172.0000000	1.65210426	4473.000000	84.612903	6.375
TEMP	31	78.51612903	1.06053344	76.00000000	81.0000000	0.19047743	2434.000000	1.124731	1.351
YEAR=88 MONTH=6									
QAVG	30	12.23800000	1.39857169	10.63000000	14.5000000	0.25534309	367.140000	1.956003	11.428
QAIR	30	12.05433333	1.83905839	9.18000000	15.5000000	0.33576459	361.630000	3.382136	15.256
PECOD	30	241.60000000	24.91447440	188.00000000	289.0000000	4.54873988	7248.000000	620.731034	10.312
MLSS	30	1060.23333333	102.47919703	885.00000000	1264.0000000	18.71005596	31807.000000	10501.985824	9.666
MLVSS	30	822.76516667	81.40006766	672.60000000	1011.2000000	14.86155108	24682.955000	6625.971014	9.893
MCRT	30	4.73892333	1.09350081	2.85720000	7.2101000	0.19964502	142.167700	1.195744	23.075
MCRTA	30	4.66415333	0.61849239	3.78980000	6.1621000	0.11292074	139.924600	0.382533	13.261
SRT	30	5.00706826	1.43190341	2.50871244	8.8798193	0.26142860	150.212048	2.050347	28.598
FM	5	0.52275942	0.04524233	0.47602241	0.5935095	0.02023299	2.613797	0.002047	8.655
FMCOD	30	1.19531939	0.18440875	0.86336017	1.6917520	0.03366828	35.859582	0.034007	15.428
SVI1	27	140.62962963	21.70811289	108.00000000	184.0000000	4.17772827	3797.000000	471.242165	15.436
TEMP	30	79.33333333	0.80229556	78.00000000	80.0000000	0.14647846	2380.000000	0.643678	1.011

YEAR=88 MONTH=7

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
QAVG	31	11.05806452	1.04514567	9.69000000	13.7400000	0.18771370	342.800000	1.092329	9.451
QAIR	31	11.20741935	1.43820946	9.20000000	14.5600000	0.25831004	347.430000	2.068446	12.833
PECOD	31	238.19354839	18.16116618	199.00000000	274.0000000	3.26184174	7384.000000	329.827957	7.625
MLSS	31	1051.35483871	120.23401366	725.00000000	1254.3333333	21.59466634	32592.000000	14456.218041	11.436
MLVSS	31	814.38784946	101.57237931	514.75000000	953.2933333	18.24293786	25246.023333	10316.948238	12.472
MCRT	31	3.93462903	1.27590258	2.09130000	7.0176000	0.22915887	121.973500	1.627927	32.428
MCRTA	31	3.78890000	0.83138019	2.45140000	5.1202000	0.14932029	117.455900	0.691193	21.943
SRT	31	4.17369074	1.61475072	2.10867700	8.7321562	0.29001779	129.384413	2.607420	38.689
FM	5	0.56013462	0.17210459	0.40568505	0.8242525	0.07696751	2.800673	0.029620	30.726
FMCOD	31	1.08591084	0.18125965	0.80419689	1.5885231	0.03255519	33.663236	0.032855	16.692
SVI1	5	174.40000000	19.61631974	155.00000000	203.0000000	8.77268488	872.000000	384.800000	11.248
TEMP	31	81.09677419	0.87005129	80.00000000	82.0000000	0.15626582	2514.000000	0.756989	1.073

APPENDIX IV OFF-GAS DATA

This appendix contains a statistical summary for the off-gas data collected for Terminal Island, Valencia and Whittier Narrows for the entire period of testing. Note that averages in the text were calculated for selected periods of operation, and may not match the averages presented here.

Key

ASOTE1 - ASOTE6	=	αSOTE for hood locations 1 to 6
ASOTET	=	flow weighted average αSOTE for the entire basin
ALPHA1 - ALPHA6	=	α for hood locations 1 to 6
ALPHAT	=	flow weighted α for the entire basin
FLUM1 - FLUM6	=	hood flux (m^3/m^2-min) for hood positions 1 to 6
FLUMT	=	average hood flux for the entire basin
DO1 - DO6	=	DO (mg/L) at hood positions 1 to 6
DOT	=	average basin DO

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-----BASIN 1, WHITTIER-----

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
ASOTE1	35	6.57918279	2.02214952	3.50824073	11.43249516	0.34180565	230.27139776	4.08908867	30.736
ASOTE2	35	9.43882736	2.65548417	4.36932499	14.99287814	0.44885875	330.35895743	7.05159617	28.134
ASOTE3	35	9.53813865	1.78378615	6.34898457	12.82873371	0.30151489	333.83485284	3.18189302	18.702
ASOTE4	35	9.52677228	2.27792380	3.39660129	14.03466998	0.38503940	333.43702965	5.18893682	23.911
ASOTE5	35	10.09868778	1.79622037	5.36737328	13.98455062	0.30361666	353.45407231	3.22640762	17.787
ASOTE6	35	9.85715410	2.11670981	5.66521431	14.06566742	0.35778926	345.00039345	4.48046042	21.474
ASOTET	35	8.94717736	1.54768734	5.85570553	11.80321240	0.26160691	313.15120758	2.39533610	17.298
ALPHA1	35	0.20834406	0.06449000	0.11870880	0.36907770	0.01090080	7.29204211	0.00415896	30.954
ALPHA2	35	0.29727998	0.08128239	0.13598696	0.47311850	0.01373923	10.40479928	0.00660683	27.342
ALPHA3	35	0.30104521	0.05238025	0.20942241	0.39856087	0.00885388	10.53658245	0.00274369	17.399
ALPHA4	35	0.30081424	0.06754341	0.11202636	0.42557203	0.01141692	10.52849846	0.00456211	22.454
ALPHA5	35	0.38731313	0.06442366	0.20947269	0.50698647	0.01088959	13.55595947	0.00415041	16.633
ALPHA6	35	0.37954826	0.07758613	0.22581416	0.51233744	0.01311445	13.28418905	0.00601961	20.442
ALPHAT	35	0.30017537	0.04844134	0.19778511	0.39646833	0.00818808	10.50613796	0.00234656	16.138
FLUM1	35	0.08319474	0.02639613	0.03826104	0.14744625	0.00446176	2.91181581	0.00069676	31.728
FLUM2	35	0.08340025	0.02465903	0.04594462	0.14557827	0.00416814	2.91900892	0.00060807	29.567
FLUM3	35	0.08509377	0.02221973	0.04025598	0.14114726	0.00375582	2.97828194	0.00049372	26.112
FLUM4	35	0.09305978	0.02567449	0.04961009	0.15744021	0.00433978	3.25709227	0.00065918	27.589
FLUM5	35	0.05717092	0.01430952	0.03320937	0.08260955	0.00241875	2.00098205	0.00020476	25.029
FLUM6	35	0.05849458	0.01332763	0.03127193	0.08498089	0.00225278	2.04731043	0.00017763	22.784
FLUMT	35	0.07673567	0.01651026	0.04680917	0.11500882	0.00279074	2.68574857	0.00027259	21.516
DO1	35	0.36385714	0.57026837	0.01000000	3.20000000	0.09639295	12.73500000	0.32520601	156.729
DO2	35	0.84928571	0.76740792	0.05000000	3.35000000	0.12971561	29.72500000	0.58891492	90.359
DO3	35	1.45714286	1.09992599	0.10000000	4.95000000	0.18592143	51.00000000	1.20983718	75.485
DO4	35	2.81142857	1.15674720	0.45000000	5.30000000	0.19552596	98.40000000	1.33806408	41.144
DO5	35	2.32285714	1.10703584	0.27500000	4.90000000	0.18712321	81.30000000	1.22552836	47.658
DO6	35	2.05285714	1.02914820	0.27500000	4.55000000	0.17395780	71.85000000	1.05914601	50.132
DOT	35	1.64290476	0.78435343	0.24166667	3.94166667	0.13257993	57.50166667	0.61521031	47.742

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VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
BASIN 2, WHITTIER									
ASOTE1	34	4.65301059	0.94388194	2.48017292	7.05352099	0.16187442	158.20236016	0.89091311	20.285
ASOTE2	34	6.12861566	1.64866532	3.14307865	11.48837059	0.28274377	208.37293257	2.71809734	26.901
ASOTE3	34	7.55857069	2.18369554	3.01181907	15.14053558	0.37450070	256.99140343	4.76852621	28.890
ASOTE4	34	7.79652399	2.09255931	1.84019539	12.09394403	0.35887096	265.08181574	4.37880447	26.840
ASOTE5	34	7.91497713	1.89892167	4.57312398	12.94720482	0.32566238	269.10922225	3.60590350	23.991
ASOTE6	34	8.58216544	2.08396533	4.49884468	14.19851143	0.35739711	291.79362507	4.34291151	24.283
ASOTET	34	6.88929497	1.38993139	3.07378911	11.17990096	0.23837127	234.23602882	1.93190927	20.175
ALPHA1	34	0.14349510	0.02882749	0.07739326	0.21839662	0.00494387	4.87883327	0.00083102	20.090
ALPHA2	34	0.18819454	0.04904692	0.09819666	0.34608436	0.00841148	6.39861435	0.00240560	26.062
ALPHA3	34	0.23179392	0.06425945	0.09585268	0.45213825	0.01102040	7.88099336	0.00412928	27.723
ALPHA4	34	0.23942832	0.06172358	0.05856411	0.36311186	0.01058551	8.14056284	0.00380980	25.780
ALPHA5	34	0.29685948	0.06704159	0.17536340	0.46740509	0.01149754	10.09322248	0.00449458	22.584
ALPHA6	34	0.32278738	0.07398845	0.17246457	0.51184314	0.01268891	10.97477104	0.00547429	22.922
ALPHAT	34	0.22607448	0.04302483	0.10413790	0.35459809	0.00737870	7.68653240	0.00185114	19.031
FLUM1	34	0.10517571	0.02549263	0.06708381	0.19347816	0.00437195	3.57597403	0.00064987	24.238
FLUM2	34	0.10301441	0.02554353	0.05222896	0.16891360	0.00438068	3.50248984	0.00065247	24.796
FLUM3	34	0.09566422	0.02723142	0.04810761	0.16222120	0.00467015	3.25258362	0.00074155	28.466
FLUM4	34	0.10515172	0.02710784	0.06343989	0.18353880	0.00464896	3.57515848	0.00073483	25.780
FLUM5	34	0.06963597	0.01828099	0.03904809	0.11182426	0.00313516	2.36762307	0.00033419	26.252
FLUM6	34	0.07041444	0.01942725	0.03684372	0.11962914	0.00333175	2.39409090	0.00037742	27.590
FLUMT	34	0.09150941	0.02034691	0.05743616	0.14461082	0.00348947	3.11131999	0.00041400	22.235
DO1	34	0.31323529	0.56047988	0.05000000	3.30000000	0.09612151	10.65000000	0.31413770	178.933
DO2	34	0.68750000	0.85553567	0.05000000	3.70000000	0.14672316	23.37500000	0.73194129	124.442
DO3	34	1.27867647	1.33247793	0.10000000	5.35000000	0.22851808	43.47500000	1.77549744	104.208
DO4	34	2.15735294	1.29246841	0.40000000	4.95000000	0.22165650	73.35000000	1.67047460	59.910
DO5	34	1.88044118	1.32206185	0.28500000	4.70000000	0.22673174	63.93500000	1.74784753	70.306
DO6	34	1.95941176	1.21589396	0.22500000	4.90000000	0.20852409	66.62000000	1.47839813	62.054
DOT	34	1.37943627	0.96028678	0.40416667	4.25833333	0.16468782	46.90083333	0.92215070	69.614

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BASIN 3, WHITTIER

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
ASOTE1	34	4.83889650	0.93913220	1.91489689	6.12525315	0.16105984	164.52248090	0.88196928	19.408
ASOTE2	34	6.97122582	1.78199559	3.42911566	12.87866819	0.30560972	237.02167796	3.17550829	25.562
ASOTE3	34	7.69653968	2.07275094	3.70350801	13.44500680	0.35547385	261.68234899	4.29629647	26.931
ASOTE4	34	7.88076779	2.37144385	3.29337953	14.11073014	0.40669926	267.94610486	5.62374591	30.092
ASOTE5	34	8.26524546	1.87731031	5.07881879	13.35817808	0.32195606	281.01834551	3.52429399	22.713
ASOTE6	34	8.78364565	2.07380043	4.49928037	14.94042125	0.35565384	298.64395202	4.30064822	23.610
ASOTET	34	7.18004491	1.47883395	3.47832825	11.25467116	0.25361793	244.12152694	2.18694986	20.596
ALPHA1	34	0.14930371	0.02808062	0.05973268	0.18999944	0.00481579	5.07632629	0.00078852	18.808
ALPHA2	34	0.21440341	0.05303929	0.10696673	0.39252176	0.00909616	7.28971611	0.00281317	24.738
ALPHA3	34	0.23691001	0.06046369	0.11706232	0.39748041	0.01036944	8.05494032	0.00365586	25.522
ALPHA4	34	0.24269401	0.06844984	0.10419880	0.41937751	0.01173905	8.25159626	0.00468538	28.204
ALPHA5	34	0.31084143	0.06588390	0.19545181	0.48051355	0.01129900	10.56860848	0.00434069	21.195
ALPHA6	34	0.33171793	0.07272341	0.17309939	0.53514739	0.01247196	11.27840951	0.00528869	21.923
ALPHAT	34	0.23585650	0.04485806	0.11709132	0.35658675	0.00769309	8.01912098	0.00201225	19.019
FLUM1	34	0.11034193	0.03264550	0.06071331	0.18272800	0.00559866	3.75162571	0.00106573	29.586
FLUM2	34	0.09921061	0.03168800	0.04586258	0.18919676	0.00543445	3.37316082	0.00100413	31.940
FLUM3	34	0.10307112	0.03175825	0.05189990	0.19511446	0.00544650	3.50441801	0.00100859	30.812
FLUM4	34	0.10963626	0.03328312	0.04534934	0.18386239	0.00570801	3.72763280	0.00110777	30.358
FLUM5	34	0.06967404	0.01870386	0.03101057	0.09947636	0.00320769	2.36891748	0.00034983	26.845
FLUM6	34	0.06931146	0.02111082	0.01612537	0.12567050	0.00362048	2.35658965	0.00044567	30.458
FLUMT	34	0.09354090	0.02497870	0.04746480	0.15185130	0.00428381	3.18039074	0.00062394	26.704
DO1	34	0.28382353	0.46043796	0.02500000	2.60000000	0.07896446	9.65000000	0.21200312	162.227
DO2	34	0.64558824	0.74948140	0.05000000	3.70000000	0.12853500	21.95000000	0.56172237	116.093
DO3	34	1.17573529	1.11451316	0.10000000	4.85000000	0.19113743	39.97500000	1.24213959	94.793
DO4	34	2.12352941	1.30119323	0.30000000	5.30000000	0.22315280	72.20000000	1.69310383	61.275
DO5	34	1.87573529	1.33574808	0.17500000	4.65000000	0.22907891	63.77500000	1.78422293	71.212
DO6	34	1.91176471	1.26629134	0.15000000	5.10000000	0.21716717	65.00000000	1.60349376	66.237
DOT	34	1.33602941	0.88313313	0.25000000	4.10833333	0.15145608	45.42500000	0.77992412	66.101

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VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
VALENCIA									
ASOTE1	7	7.27765844	1.63932999	4.22975756	9.41314985	0.61960850	50.94360907	2.68740282	22.526
ASOTE2	7	4.71781018	1.92243602	2.79060074	7.49284788	0.72661252	33.02467126	3.69576024	40.748
ASOTE3	7	5.06941065	0.74885817	4.09766046	6.24348034	0.28304178	35.48587458	0.56078855	14.772
ASOTE4	7	7.43994336	1.81287836	4.90458950	9.87352272	0.68520361	52.07960350	3.28652793	24.367
ASOTE5	7	10.06560691	1.84065614	6.16892661	11.53506276	0.69570263	70.45924840	3.38801501	18.287
ASOTE6	7	9.05083043	1.98406871	5.07213471	10.86378745	0.74990748	63.35581299	3.93652863	21.921
ASOTET	7	7.04583846	1.01195896	4.98322130	7.80319801	0.38248453	49.32086923	1.02406093	14.363
ALPHA1	7	0.28396227	0.07416600	0.15729787	0.38508674	0.02803211	1.98773587	0.00550059	26.118
ALPHA2	7	0.20113374	0.09804954	0.11216626	0.32434551	0.03705924	1.40793620	0.00961371	48.748
ALPHA3	7	0.20453037	0.01737537	0.18183845	0.22473458	0.00656727	1.43171259	0.00030190	8.495
ALPHA4	7	0.28922094	0.08321999	0.20542248	0.40825822	0.03145420	2.02454660	0.00692557	28.774
ALPHA5	7	0.40401600	0.07994032	0.24829179	0.48534666	0.03021460	2.82811203	0.00639045	19.786
ALPHA6	7	0.35785219	0.08645521	0.19751520	0.45065950	0.03267700	2.50496536	0.00747450	24.159
ALPHAT	7	0.28258609	0.05135105	0.18878790	0.33385601	0.01940887	1.97810262	0.00263693	18.172
FLUM1	7	0.14015411	0.02594950	0.10325791	0.16998626	0.00980799	0.98107878	0.00067338	18.515
FLUM2	7	0.14929993	0.03858711	0.08797182	0.21421330	0.01458456	1.04509952	0.00148897	25.845
FLUM3	7	0.13787150	0.04638143	0.06821922	0.18364274	0.01753053	0.96510052	0.00215124	33.641
FLUM4	7	0.10099657	0.03399689	0.04524204	0.15365805	0.01284962	0.70697599	0.00115579	33.661
FLUM5	7	0.13339907	0.03105553	0.09957645	0.18583665	0.01173789	0.93379347	0.00096445	23.280
FLUM6	7	0.11703291	0.02468361	0.09021046	0.16243175	0.00932953	0.81923037	0.00060928	21.091
FLUMT	7	0.12979235	0.02138298	0.08241298	0.14214376	0.00808201	0.90854644	0.00045723	16.475
DO1	7	0.98571429	0.75039672	0.25000000	2.15000000	0.28362330	6.90000000	0.56309524	76.127
DO2	7	0.57142857	0.63891649	0.10000000	1.90000000	0.24148774	4.00000000	0.40821429	111.810
DO3	7	0.36785714	0.36420984	0.10000000	1.15000000	0.13765838	2.57500000	0.13264881	99.009
DO4	7	0.30000000	0.21794495	0.10000000	0.75000000	0.08237545	2.10000000	0.04750000	72.648
DO5	7	2.38571429	0.99025009	0.70000000	3.75000000	0.37427935	16.70000000	0.98059524	41.507
DO6	7	2.45714286	1.03860025	0.70000000	3.90000000	0.39255400	17.20000000	1.07869048	42.269
DOT	7	1.17797619	0.47994933	0.40000000	1.92500000	0.18140379	8.24583333	0.23035136	40.744

SAS

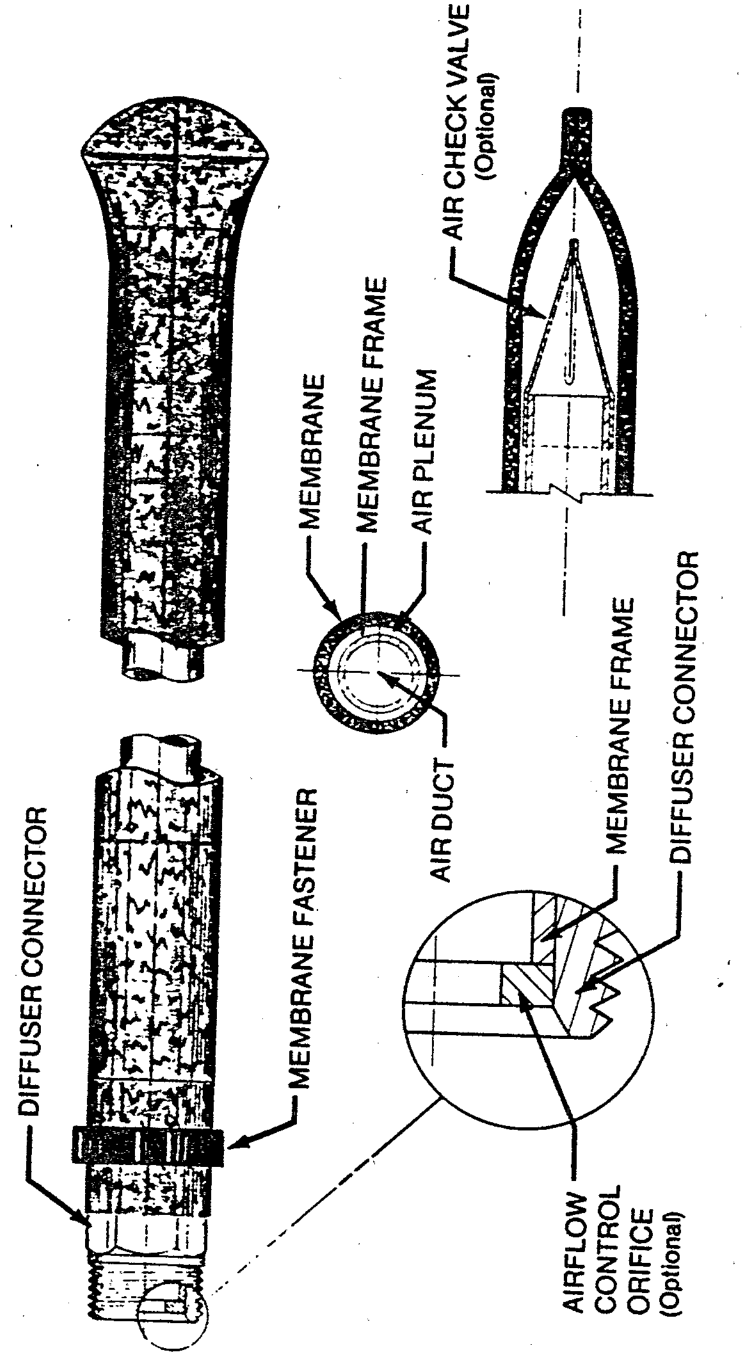
VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
TERMINAL ISLAND, PARKSON-WYSS									
ASOTE1	8	5.46753785	1.34109321	3.63561957	7.52688430	0.47414805	43.74030282	1.79853100	24.528
ASOTE2	8	7.10450182	2.62573575	3.96733729	10.01259005	0.92833778	56.83601455	6.89448821	36.959
ASOTE3	8	7.47183846	2.62074508	3.62240449	11.08078007	0.92657331	59.77470765	6.86830476	35.075
ASOTE4	8	7.10243674	2.93779741	2.82850556	11.21408484	1.03866824	56.81949389	8.63065365	41.363
ASOTE5	8	7.91200856	2.64750705	3.97354297	12.64330959	0.93603509	63.29606848	7.00929357	33.462
ASOTET	8	6.66830556	1.99013564	3.77851716	9.37002114	0.70361920	53.34644449	3.96063986	29.845
FLUM1	8	0.27163346	0.12186042	0.17360219	0.54499376	0.04308416	2.17306766	0.01484996	44.862
FLUM2	8	0.20849715	0.06648909	0.14086483	0.31729890	0.02350744	1.66797719	0.00442080	31.890
FLUM3	8	0.18028840	0.08799787	0.09669722	0.37099093	0.03111194	1.44230718	0.00774362	48.809
FLUM4	8	0.20476276	0.12915196	0.09385011	0.41322704	0.04566211	1.63810210	0.01668023	63.074
FLUM5	8	0.16426730	0.12337346	0.06185511	0.40410035	0.04361910	1.31413843	0.01522101	75.105
FLUMT	8	0.20588981	0.09625872	0.11792066	0.40396963	0.03403260	1.64711851	0.00926574	46.753
DO1	8	1.27083333	0.61060405	0.60000000	2.26666667	0.21588113	10.16666667	0.37283730	48.048
DO2	8	1.91041667	1.07315502	0.45000000	3.80000000	0.37941760	15.28333333	1.15166171	56.174
DO3	8	1.78541667	0.92089663	0.95000000	3.46666667	0.32558612	14.28333333	0.84805060	51.579
DO4	8	2.25625000	1.10722510	0.90000000	4.06666667	0.39146319	18.05000000	1.22594742	49.074
DO5	8	1.85833333	1.17726479	0.46666667	4.16666667	0.41622596	14.86666667	1.38595238	63.351
DOT	8	1.81625000	0.84381492	0.96000000	3.18000000	0.29833362	14.53000000	0.71202361	46.459

SAS

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
TERMINAL ISLAND AERMAX									
ASOTE1	8	11.13360831	4.09986737	7.25251336	18.81633643	1.44952201	89.06886647	16.80891249	36.824
ASOTE2	8	10.65606259	3.49391870	5.24300729	15.80361571	1.23528680	85.24850069	12.20746792	32.788
ASOTE3	8	12.63463199	3.68343384	5.59361097	16.97413728	1.30229052	101.07705592	13.56768486	29.153
ASOTE4	8	12.48996812	2.71141242	8.50230566	16.71090430	0.95862905	99.91974495	7.35175729	21.709
ASOTE5	8	13.99368678	2.70633539	9.82120316	17.72273732	0.95683405	111.94949424	7.32425126	19.340
ASOTET	8	11.73673886	2.74895007	8.61141449	16.59664259	0.97190062	93.89391085	7.55672648	23.422
ALPHA1	8	0.36438115	0.13414131	0.23688441	0.61243416	0.04742611	2.91504920	0.01799389	36.813
ALPHA2	8	0.35604296	0.12475313	0.16831076	0.54616402	0.04410689	2.84834367	0.01556334	35.039
ALPHA3	8	0.41910999	0.12522305	0.18354878	0.55995984	0.04427303	3.35287990	0.01568081	29.878
ALPHA4	8	0.41510372	0.10130546	0.27530305	0.59334140	0.03581689	3.32082976	0.01026280	24.405
ALPHA5	8	0.46932878	0.11010860	0.31933816	0.66986431	0.03892927	3.75463028	0.01212390	23.461
ALPHAT	8	0.39163903	0.10243943	0.27799746	0.58531776	0.03621781	3.13311224	0.01049384	26.157
FLUM1	8	0.05191096	0.03475274	0.02512635	0.12643329	0.01228695	0.41528765	0.00120775	66.947
FLUM2	8	0.06898563	0.04749811	0.02545638	0.15704407	0.01679312	0.55188505	0.00225607	68.852
FLUM3	8	0.06610230	0.04537393	0.02107750	0.14700837	0.01604211	0.52881842	0.00205879	68.642
FLUM4	8	0.03270906	0.02110743	0.01612353	0.08022666	0.00746260	0.26167245	0.00044552	64.531
FLUM5	8	0.02454523	0.02329371	0.00909832	0.07989347	0.00823557	0.19636180	0.00054260	94.901
FLUMT	8	0.04885063	0.02881080	0.02373830	0.09503439	0.01018616	0.39080508	0.00083006	58.977
DO1	8	0.33333333	0.31282126	0.05000000	0.83333333	0.11059902	2.66666667	0.09785714	93.846
DO2	8	0.45416667	0.47748930	0.05000000	1.23333333	0.16881796	3.63333333	0.22799603	105.135
DO3	8	0.56250000	0.62581693	0.05000000	1.76666667	0.22125970	4.50000000	0.39164683	111.256
DO4	8	0.30625000	0.32280240	0.05000000	0.90000000	0.11412788	2.45000000	0.10420139	105.405
DO5	8	0.23958333	0.26561362	0.05000000	0.83333333	0.09390860	1.91666667	0.07055060	110.865
DOT	8	0.37916667	0.33781158	0.07000000	0.92666667	0.11943443	3.03333333	0.11411667	89.093

APPENDIX V SELECTED DIFFUSER DRAWINGS

AERMAX TPD DIFFUSER — S and P SERIES



MODEL NO.	NOM. LGTH.	NOM. DIA.	WT.	QTY.
-124	27 In.	1.25 In.	1.50 lbs.	
-130	33 In.	1.25 In.	1.75 lbs.	
-136	39 In.	1.25 In.	2.00 lbs.	
-	In.	1.25 In.	lbs.	

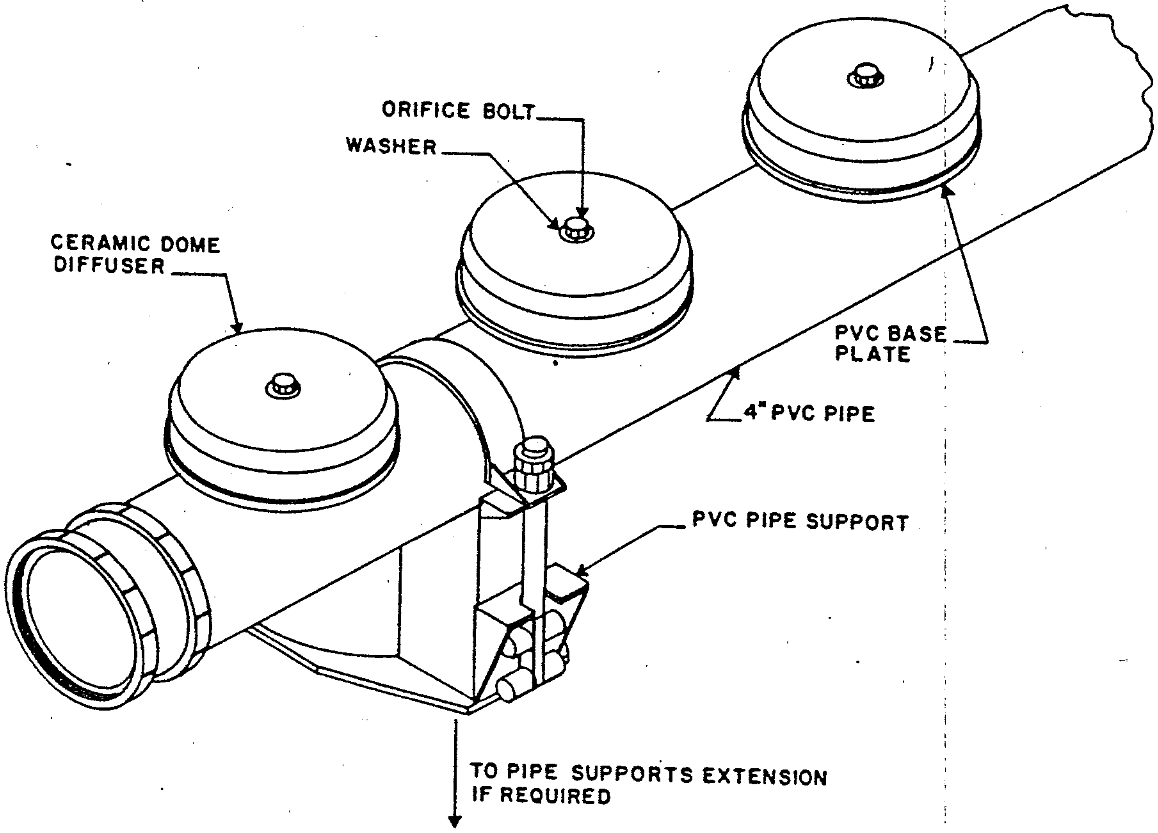
	STANDARD	OPTIONS
DIFFUSER CONNECTOR	☐ 304SS	☐ PVC
MEMBRANE FASTENER	☐ ACETAL	☐ OTHER*
MEMBRANE FRAME	☐ 304SS	☐ OTHER*
MEMBRANE	☐ HE	☐ UHE
CONTROL ORIFICE	☐ NO	☐ YES
CHECK VALVE	☐ NO	☐ YES

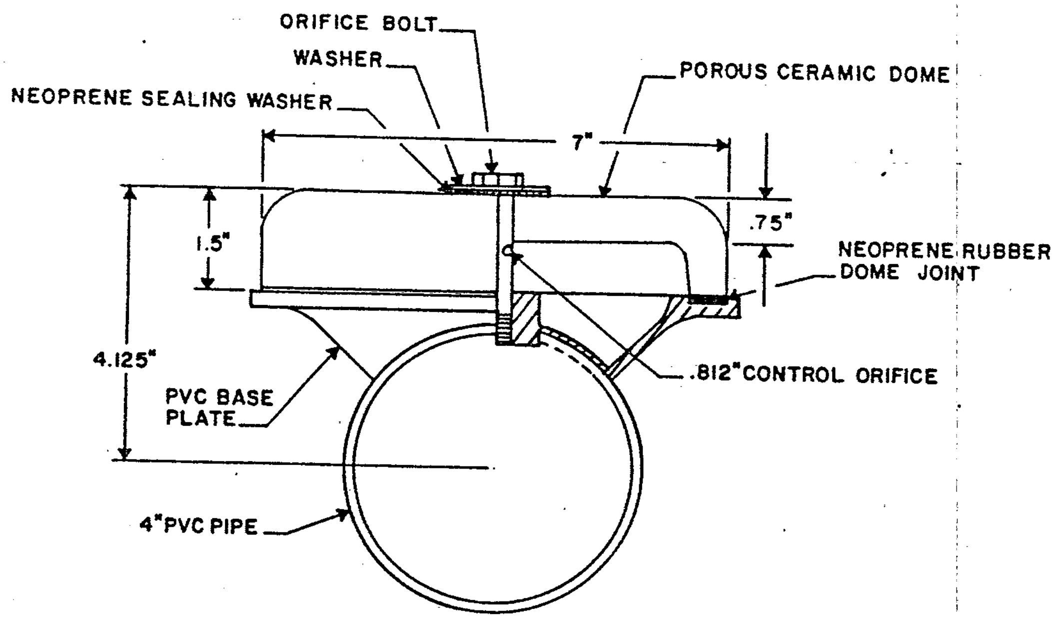
* material to be specified

AERSYSTEMS
ENGINEERED PRODUCTS BY
AERATION TECHNOLOGIES, INC.

AERMAX Diffuser (Drawing courtesy of AERTEC)

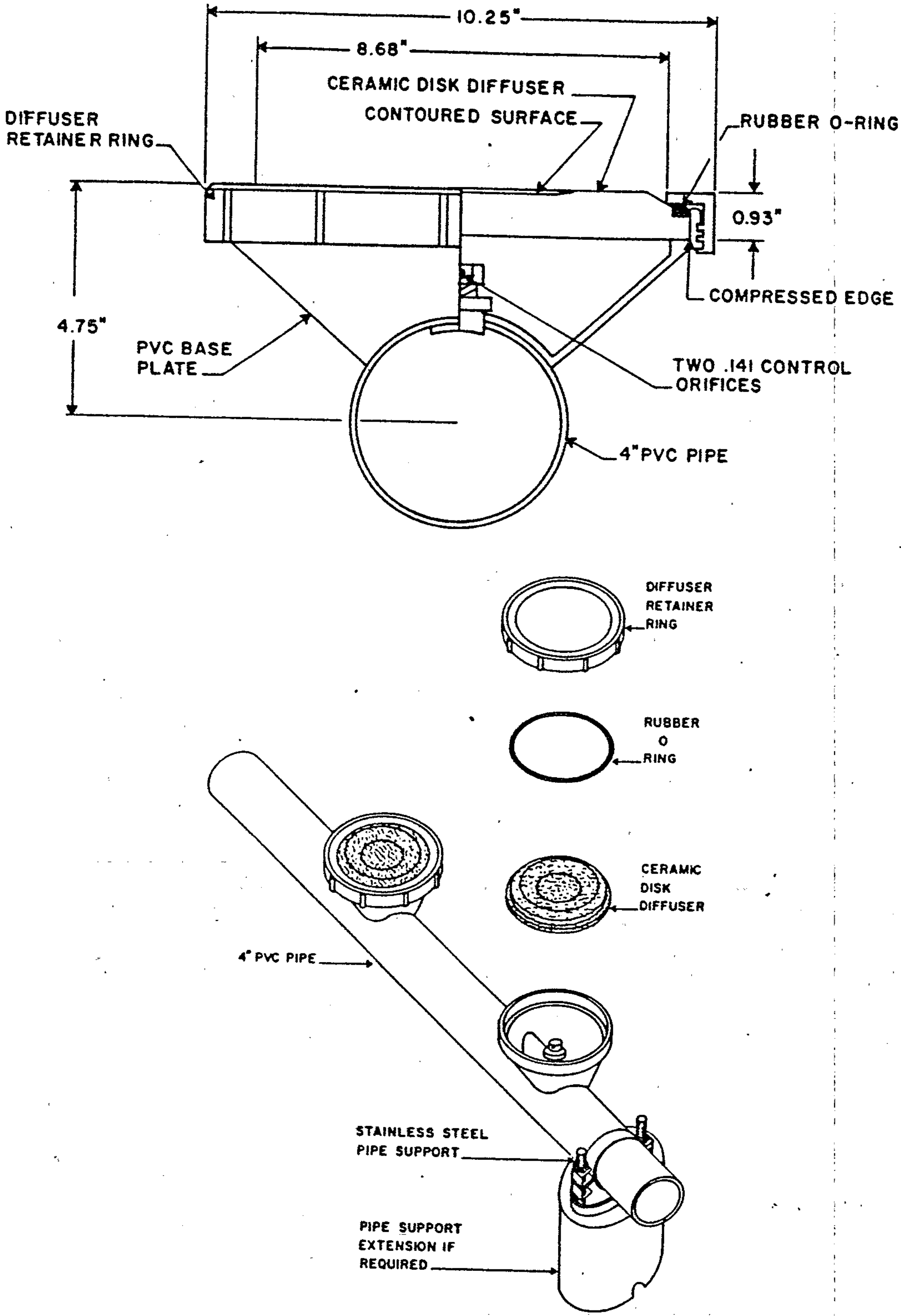
FG. 200.10.87





COURTESY OF NORTON COMPANY

Norton Dome Diffuser (Drawing courtesy of LACSD)



Sanitaire Disk Diffuser (Drawing courtesy of LACSD)