EXHIBIT 4 TO PRE-FILED TESTIMONY IN SUPPORT OF
CITGO'S PETITION FOR AN ADJUSTED STANDARD (AS 2008-008)

JAMES E. HUFF, P.E.
Vice President

Expertise: Wastewater Treatment Planning and Design
Stream Surveys/Antidegradation Analysis

Experience:

Since 1980, Mr. Huff has been vice president of Huff & Huff, Inc. responsible for projects pertaining to wastewater treatment, design and operation, water quality studies, hazardous waste management, groundwater and soil remediation, and compliance assessments.

Mr. Huff has directed 15 municipal wastewater treatment design projects. Examples of municipal design projects are listed below:

- Belt filter press system for aerobic digested sludge, with sludge mixer and control system.
- Sludge storage pad with enclosure
- Bar screen
- Grit, washer replacement
- Tertiary filter rehabilitation
- Secondary/Tertiary high flow bypass with chlorine contact tank and flow measurement and blending
- Anaerobic digester supernatant treatment for ammonia removal using SBRs (1999 ACEC-IL Engineering Excellence Merit Award project.)
- Conversion from chlorine to sodium hypochlorite disinfection
- Conversion of wet weather storage facilities to store-treat basins, with effluent disinfection
- In-stream high purity oxygen injection into effluent and receiving stream for increasing stream D.O
- 1 million gallon excess flow storage/treatment concrete tank for new CSO with disinfection

Mr. Huff is currently the Project Manager for preparation of a Facilities Plan for the Village of New Lenox and in 2007 completed for the Village of Barrington a Facilities Plan that evaluated the treatment options for future nutrient removal and the need to upgrade to Class A sludge. Mr. Huff has also conducted several CSO studies including Long-term Control Plans, Nine Minimum Controls, O&M Plans, and Water Quality Impact Studies. He is currently working on CMOM evaluations for three communities. Two novel in-stream aeration systems, using high-purity oxygen on a shallow Illinois stream, were designed by the firm, and have operated successfully for over twenty years. In stream aeration feasibility is currently being investigated on Salt Creek under a contract with the DuPage River/Salt Creek Work Group. Mr. Huff has also completed two value engineering projects, one on an expanded wastewater treatment plant and the other for an excess flow holding tank to offload the sewer system. The Galesburg Sanitary District pretreatment ordinance and revisions have been prepared under Mr. Huff's direction.

Mr. Huff has designed industrial wastewater treatment plants ranging in size from less than one thousand gallons per day to eight million gallons per day. He has assisted two petroleum refineries with biological nitrification issues and evaluated the impact an industrial user's sodium sulfate discharge would have on the POTW, including the anaerobic sludge process. Mr. Huff directed the treatablility studies for breakpoint chlorination for ammonia discharge in an inorganic wastewater stream from a petroleum refinery and assisted in the full-scale start up, and directed a treatablility study evaluating another industrial discharger's proposed sodium sulfate discharge will have on an Indiana POTW. Mr. Huff has worked in a variety of industries on wastewater projects, including: petroleum refineries, cosmetics, foundries, plating, printed circuit boards, inorganic and organic chemical plants, pharmaceutical manufacturers, and meat packing. Examples of industrial wastewater designs are listed below:

- Sequential batch reactors (SBRs) for BOD_5/COD reduction at pharmaceutical plant, pretreatment system subject to the Pharmaceutical Categorical Pretreatment Standards
- Replacement of a rotary drum pre-coat filter with a belt filter press for cosmetic wastewater stream, with polymer addition
- Side stream SBR for nitrification on meat packing three-stage lagoon
- Breakpoint chlorination for ammonia removal at chemical plant, petroleum refinery and also a meat packer
- Land application, with winter lagoon at chemical plant
- Copper removal from printed circuit board facility using sodium borohydride
- Integrated settling basin/ sludge drying beds at foundry
- Completed a preliminary engineering evaluation for a chemical plant for upgrading its overloaded wastewater land application system, which included conversion of the winter storage lagoon to an aerated lagoon with an anaerobic first stage lagoon

He has also designed cluster wastewater treatment systems with subsurface discharge for seven residential developers/country clubs, an outdoor event facility, and a temple. These systems are typically 10,000 to 20,000 gpd, utilizing two SBRs, computer controlled, followed by a large leach field. These unique systems are permitted under the IDPH under a unique experimental use permit provision.

On the Fox River, Mr. Huff was project manager for a group of municipal dischargers on a project to collect and analyze weekly water quality samples along the river, its tributaries, and outfalls at over 30 locations to establish a better database on un-ionized ammonia levels. Mr. Huff has directed fish, mussel, benthic, and water quality surveys for municipal, storm water, and industrial discharges located on the following waterways: Beaver Creek, Cedar Creek, Deep Run, Flint Creek, Mississippi River, Thorn Creek, North Kent Creek, Tyler Creek, Kiswaukee River, Chicago Sanitary & Ship Canal, and Casey Fork Creek, and has completed antidegradation studies as part of many of these studies. Thermal studies, mixing zone studies, and multi-part diffuser designs have been completed for a variety of clients. A thermal study on the Illinois River is on-going. Sediment sampling, Sediment Oxygen Demand, and habitat evaluations have been completed on Salt Creek and the DuPage Rivers.

From 2004 to 2007, Mr. Huff was the lead consultant for NIPC (now CMAP) to review FPA requests for consistency with the Commission's Water Quality Management Plan. Mr. Huff has completed over 150 FPA requests, including the Facilities Plan associated with these. Antidegradation and nutrients have been two major issues on many of these applications. Mr. Huff serves on the Illinois Nutrient Technical Advisory Committee, representing the American Council of Engineering Companies – Illinois (ACEC-IL). Mr. Huff has been involved in eleven site specific rule changes and adjusted standards in Illinois. These studies have included ammonia, D.O., BOD_5, TSS, TDS, and sulfates.

From 1987 through 1990, Mr. Huff was a part-time faculty member, teaching the senior level environmental courses in the Civil Engineering Department at IIT-West in Wheaton, Illinois.

From 1976 to 1980, Mr. Huff was Manager of Environmental Affairs for Akzo Nobel Chemicals, a diversified industrial chemical manufacturer. At Akzo, Mr. Huff was responsible for all environmental activities at eight plants located throughout the United States and Canada. Technical work included extensive biological and chemical treatability studies as well as designing new facilities, including two wastewater pretreatment facilities, a land application system, and an incinerator system.

Previously, Mr. Huff was an Associate Environmental Engineer in the Chemical Engineering Section at IIT Research Institute (IITRI). Much of this work involved advanced wastewater treatment development, including applying a combination of ozone/UV treatment of cyanide, PCB's, RDX, HMX, and TNT and the use of catalytic oxidation of cyanide using powdered activated (carbon impregnated with copper in refinery activated sludge units. At Mobil Oil's Joliet Refinery Mr. Huff was employed as an Advanced Environmental Engineer during the construction and start-up of the largest grassroots refinery ever constructed. Mr. Huff was responsible for wastewater training, permitting start-up, and technical support as well as for water supply, solid waste, and noise abatement issues at the refinery from 1971 to 1973.

Membership

Illinois Association of Wastewater Agencies
American Council of Engineering Companies - IL
    Environmental Committee 1999 – 2005
        Chairman-June 2000-2004
    Board of Directors – 2005-2009
    Vice President-2007-2009
Water Environment Federation Member
Illinois Water Environment Federation
National Water Well Association

Licenses: Registered Professional Engineer- Illinois
Class 2 Wastewater Operator-Illinois
Class K Industrial Wastewater Operator-Illinois

Education:

1966-1970	Purdue University, West Lafayette, Indiana B.S. in Chemical Engineering
1970-1971	Purdue University, West Lafayette, Indiana M.S.E. in Environmental Engineering
1974-1976	University of Chicago Graduate School of Business. Part time
Honors:	Omega Chi Epsilon (Chem. Engr. Honorary) President's Academic Award Graduated with Distinction Fellowship from the Federal Water Quality Admin.
Thesis:	"Destabilizing Soluble Oil Emulsions Using Polymers with Activated Carbon," Major Professor, Dr. James E. Etzel

Selected Papers:

"Ozone-U.V. Treatment of TNT Wastewater," E.G. Fochtman and J.E. Huff, International Ozone Institute Conference, Montreal, May 1975.

"Characterization of Sensory Properties: Qualitative, Threshold, and Supra-Threshold," J.E. Huff and A. Dravnieks, American Water Works Assoc. Seminar, Minneapolis, MN, June 1975.

"Control of Rendering Plant Odors by Wet Scrubbers: Results of Plant Tests," R.H. Snow, J.E. Huff, and W. Boehme, APCA Conference Boston, MA, June 1975.

"Alternative Cyanide Standards in Illinois, a Cost-Benefit Analysis," L.L. Huff and J.E. Huff, 31st Annual Purdue Industrial Waste Conference, Lafayette, IN, May 1976.

"Cyanide Removal from Refinery Wastewaters Using Powdered Activated Carbon," J.E. Huff, J.M. Bigger, and E.G. Fochtman, American Chemical Society Annual Conference, New Orleans, LA, March 1977. Published in Carbon Adsorption Handbook, P.N. Cheremisinoff and F. Ellerbusch, Eds., Ann Arbor Science Publishers, Inc., 1978.

"Industrial Discharge and/or Pretreatment of Fats, Oils and Grease," J.E. Huff and E.F. Harp, Eighth Engineering Foundation Conference on Environmental Engineering, Pacific Grove, CA, February 1978.

"A Review of Cyanide of Refinery Wastewaters," R.G. Kunz, J.E. Huff, and J.P. Casey, Third Annual Conference of Treatment and Disposal of Industrial Wastewater and Residues, Houston, TX, April 1978. Published as: "Refinery Cyanides: A Regulatory Dilemma," Hydrocarbon Processing, pp 98-102, January 1978.

"Treatment of High Strength Fatty Amines Wastewater - A Case History," J.E. Huff and C.M. Muchmore, 52nd Conference - Water Pollution Control Federation, Houston, TX, October 1979. Published JWPCF, Vol. 54, No. 1, pp 94-102, January 1982.

"A Proposal to Repeal the Illinois Pollution Control Board's Construction Permit Water Regulations," J.H. Russell and J.E. Huff, Chicago Bar Record, Vol. 62, No. 3, pp 122-136, Nov.-Dec., 1980.

"Measurement of Water Pollution Benefits - Do We Have the Option?" L.L. Huff, J.E. Huff, and N.B. Herlevson, IL Water Pollution Control Assn 3rd Annual Conference, Naperville, IL, May 1983.

"Evaluation of Alternative Methods of Supplementing Oxygen in a Shallow Illinois Stream," J.E. Huff and J.P. Browning, IL Water Pollution Control Assn 6th Annual Meeting, Naperville, IL, May 7, 1985.

"Technical and Economic Feasibility of a Central Recovery Facility for Electroplating Wastes in Cook County, IL," J.E. Huff and L.L. Huff, 1986 Governor's Conference on Science and Technology in Illinois, Rosemont, IL, Sept. 3, 1986.

"Biomonitoring/Bioassay," J.E. Huff, Federation of Environmental Technologists Seminar, Harvey, IL, December 11, 1989.

"Storm Water Discharges," J.E. Huff, Federation of Environmental Technologists Environment '90 Seminar, Milwaukee, WI, March 7, 1990.

"Engineering Aspects of Individual Wastewater System Design," J.E. Huff, 22nd Annual Northern Illinois Onsite Wastewater Contractors Workshop, St. Charles, IL, February 27, 1995.

"Total Maximum Daily Loadings (TMDL) and Ammonia Conditions in the Fox River Waterway," J. E. Huff and S. D. LaDieu, Illinois Water '98 Conference, Urbana, IL, Nov. 16, 1998.

"The Illinois Ammonia Water Quality Standards: Effluent Implications & Strategies for Compliance," L.R. Cunningham & J. E. Huff, Illinois Water '98 Conference, Urbana, IL, Nov. 16, 1998.

"Impact of a High Sulfate and TDS Industrial Discharge on Municipal Wastewater Treatment," J.L. Daugherty, J.E. Huff, S.D. LaDieu, and D. March, WEFTEC 2000, Anaheim, CA, October 17, 2000.

"Phase II Storm Water Regulations – Compliance Strategies For The Gas Transmission/Distribution Industry," J.E. Huff, American Gas Association 2003 Operations Conference, Orlando, Florida, April 28, 2003.

"Endocrine Disruptors or Better Living Through Chemistry" Illinois Association of Wastewater Agencies Fall Meeting, Bloomington, IL, November 14, 2003.

"Permitting Wastewater Treatment Plant Expansions in Northeast Illinois in the 21st Century", J.E. Huff , 28th Annual Illinois Water Environment Association Conference, Bloomington, IL, March 6, 2007.

Figure 1
ANNUAL AVERAGE INFLUENT AMMONIA CONCENTRATION
Sanitary & Ship Canal

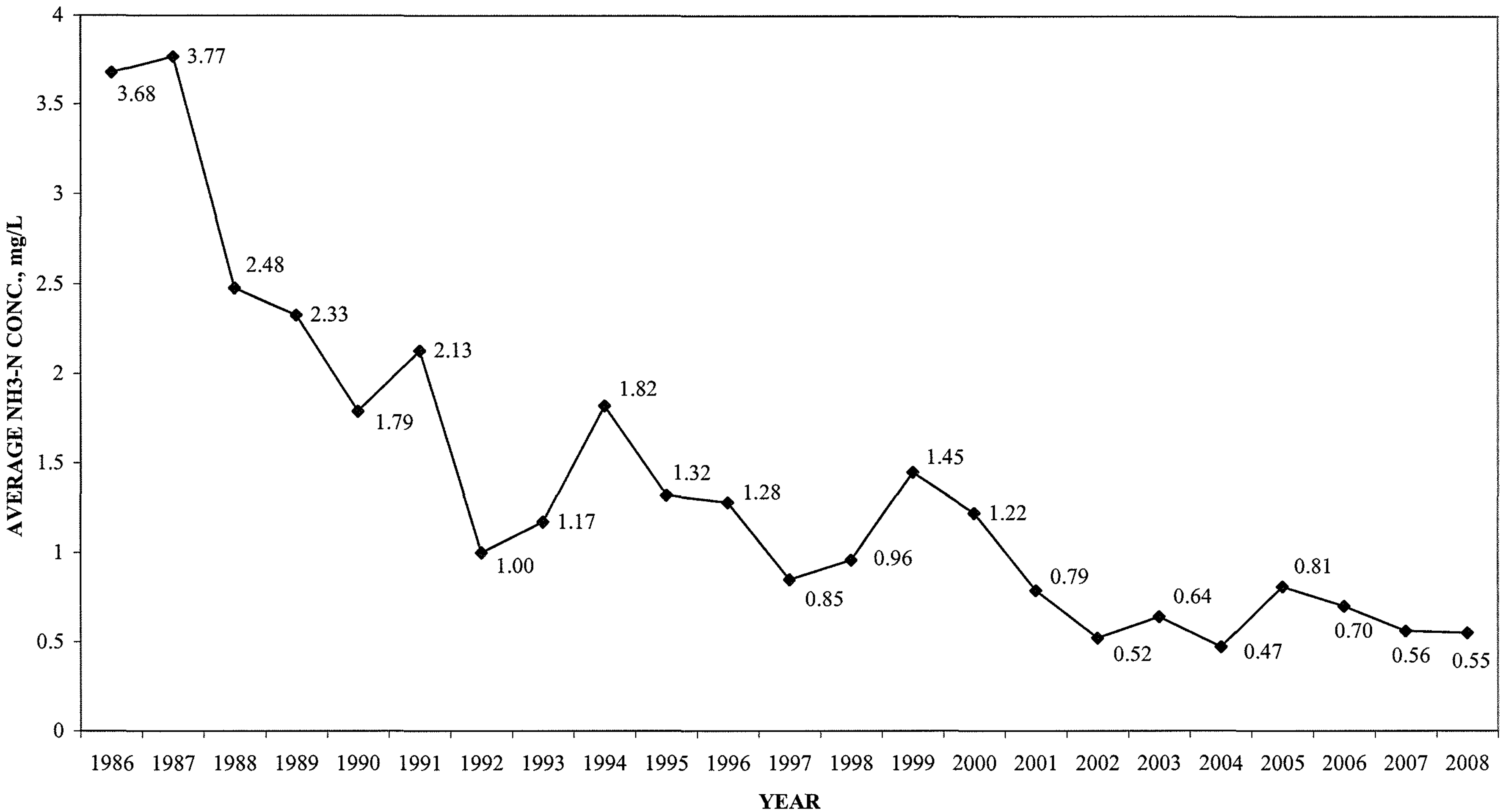
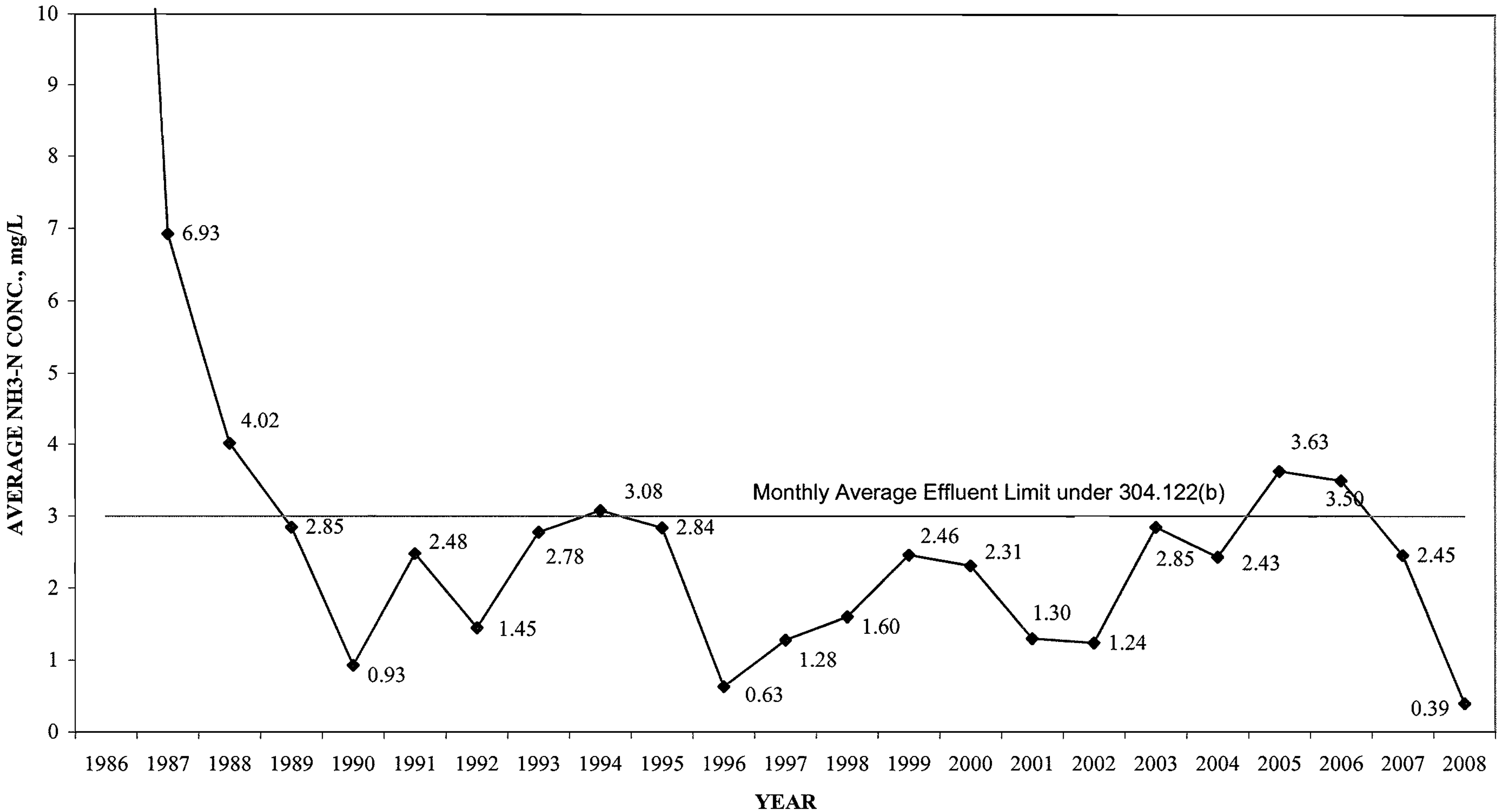


Figure2
ANNUAL AVERAGE EFFLUENT AMMONIA CONCENTRATION
Lemont Refinery



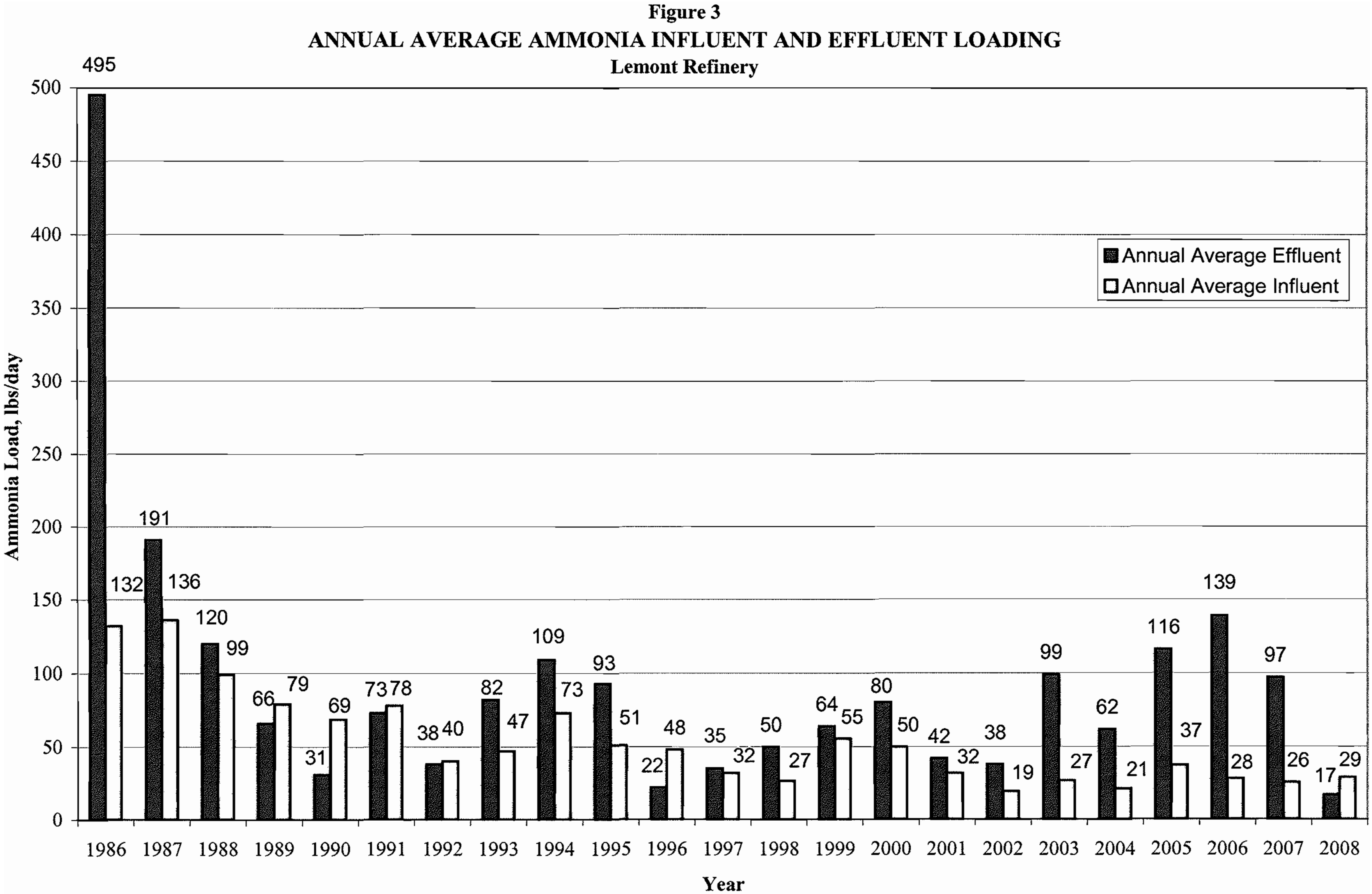


Figure 3
ANNUAL AVERAGE AMMONIA INFLUENT AND EFFLUENT LOADING
Lemont Refinery
Annual Average Effluent
Annual Average Influent
Ammonia Load, lbs/day
Year
0
50
100
150
200
250
300
350
400
450
500
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
495
132
191
136
120
99
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82
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109
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93
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99
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116
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EXHIBIT 6 TO PRE-FILED TESTIMONY IN SUPPORT OF
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DESCRIPTION OF AWARE ENVIRONMENTAL INC.

AWARE Environmental® (AEI) is a multi-disciplined environmental consulting firm with its office located in Charlotte, North Carolina. AEI personnel are internationally recognized authorities in the environmental field and provide services to clients worldwide.

The services provided by AEI include professional services ranging from site assessment and remediation activities to planning, conceptual design and construction management, with comprehensive services in the following major areas:

- Air Pollution
- Civil and Environmental Engineering
- Disposal Facilities
- Economic Evaluations
- Environmental Audits
- Environmental Site Assessments
- Hazardous and Solid Waste Management
- Incineration
- Land Use Planning
- Operational Services
- Permitting and Licensing
- SARA Reporting
- SPCC, Spill Control Plans and Storm Water Management
- Utilities
- Waste Site Remediation
- Wastewater Management
- Water Resources Development
- Water and Wastewater Treatment

Specific services provided by AEI include preliminary studies and evaluations, conceptual design and budget estimates, detailed design and contract negotiations, project management, procurement of major equipment, management of bidding procedures, contract award assistance, project cost accounting and control, construction contract preparation and management, preparation of operating procedures and manuals, and training of operating and maintenance personnel.

AEI has experience serving municipalities and industrial clients with services including site investigation and remediation services, wastewater treatability studies, wastewater treatment plant designs and upgrades, landfills, air pollution abatement systems, storm water management, and interfacing with the regulatory agencies.

AEI is an acknowledged international authority in the designing and implementing wastewater management technology. Projects ranging from management of cold weather extremes in Saskatchewan to treatment of complex petro-chemical wastes in Texas, development of new, innovative technology to create designs that maximize reliable performance and cost-effectiveness. Our personnel have extensive experience in process and engineering design of water and wastewater treatment, sludge handling systems, plant utility systems and support facilities. We are skilled in developing projects from initial planning phases, conducting pilot treatability investigations as required, facilitating process or preliminary design, and evaluating all economic considerations.

AEI's operational services troubleshooting team develops strategies to optimize plant operations for clients. These include: preparation of operating manuals, training of plant operators, plant start-up services, and temporary management of plant operations. AEI consultation usually results in improved facility performance while reducing energy consumption and staffing requirements.

AEI personnel have instituted a series of technical courses and publications for consulting, industrial and governmental engineers. Important current topics and technical concepts in waste monitoring and treatment practices are incorporated with examples of practical application.

Received, Clerk's Office **August 1, 2008**

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Related Client Listing

Petroleum and Refining

- C&T Refining, Charlotte, North Carolina
- Clark Oil, Blue Island, IL
- Clark Oil, Hartford, IL
- Ethyl Corporation, Orangeburg, South Carolina
- Hess Oil Virgin Islands Corp., St. Croix, USVI
- Kerr-McGee, Oklahoma City, Oklahoma
- Statis Terminals, Brownsville, Texas
- Statis Terminals, Halifax, Novia Scotia, Canada
- Unocal Corporation, Los Angeles, California

Nitrification and Ammonia Removal

- Bear Island Paper Co., Ashland, VA
- Buckeye Technologies, Perry, FL
- Carolina Turkeys, Mt. Olive, NC
- City of Gastonia, NC
- City of Greenville, NC
- City of Lexington, North Carolina
- City of Robertsdale, Alabama
- City of Winston-Salem, North Carolina
- Continental Pharma - Landen, Belgium
- Clariant Corporation, Mt. Holly, NC
- Cuddy Foods, Marshville, NC
- Degussa Chemical Corporation, Mobile, Alabama
- East Port Charlotte Wastewater Treatment Plant, Port Charlotte, Florida
- Ethyl Corporation, Orangeburg, South Carolina
- Fleischmann's Yeast, Gastonia, NC
- G.E. Plastics, Ottawa, Illinois
- Hunley Creek WWTP, Monroe, NC

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McNeil Specialty, MacIntosh, AL

Sandoz Chemicals, Mt. Holly, NC

Rauch Industries, Gastonia, NC

UNO-VEN Refinery, Lemont, Illinois

Yorkshire America, Lowell, NC

EXHIBIT 7 TO PRE-FILED TESTIMONY IN SUPPORT OF
CITGO'S PETITION FOR AN ADJUSTED STANDARD (AS 2008-008)

ROBERT M. STEIN, P.E.

EDUCATION:

M.S., Environmental Engineering, Vanderbilt University, 1971

B.E., Civil Engineering, Memphis State University, 1969

B.A., Applied Sciences, Memphis State University, 1968

REGISTRATION:

Professional Engineer, 1975

Wastewater Treatment Plant Operator Grade IV

EXPERIENCE:

Mr. Stein has considerable experience in all phases of industrial environmental control, including environmental audits, in-plant controls, design of grass roots facilities, troubleshooting and upgrading existing treatment facilities, nitrification biomonitoring and toxicity reduction, development of BAT programs, operational assistance, water quality analysis, and permitting and negotiations with regulatory authorities. Industrial experience includes chemicals, food processing, iron and steel, metal finishing, petroleum refining, pulp and paper, printing and textiles. Mr. Stein was appointed by the North Carolina Department of Environmental Management to serve as a member of the Champion Variance Committee (1995-1996). Mr. Stein has authored over 50 publications in the environmental field.

REPRESENTATIVE PROJECTS:

BAT study on effluent nutrient compliance for dye manufacturer, Yorkshire Americas (formerly Crompton & Knowles), Lowell. NC.

BAT study on effluent nutrient compliance for organic chemical and textile dye manufacturer, Clariant Corporation, Mt. Holly, NC.

Assistance in optimizing operations to achieve compliance with effluent total nitrogen and total phosphorus limits, Greenville Utilities Commission, Greenville, North Carolina.

Development of process design to upgrade pulp and paper wastewater treatment system to comply with total nitrogen criteria, Buckeye Florida LP, Perry, FL.

Ammonia removal treatment efficiency evaluation, GE Chemicals, Ottawa, IL.

Evaluation of upgrade alternatives for a refinery wastewater treatment plant, Hess ST. Croix, ST. Croix, VI.

Upgrade of chemical plant wastewater treatment plant, Degussa Corporation, Mobile, AL.

Industrial wastewater pretreatment system optimization and conceptual design for textile manufacturer, UFI Microfibres, Inc., Jasper, GA.
Treatability study to evaluate impact of increased chromium discharge from textile manufacturer on municipal WWTP, UFI Microfibres, Winston-Salem, NC.

Analysis of alternatives for reduction of a color discharge from a textile dye operations to a municipal plant, UFI Microfibres, Providence, RI.

Water Quality Analysis, High Rock Lake, prepared for Davidson County and the City of Lexington.

Beneficial Reuse of Vegetable Refinery Residuals, C and T Refinery, Charlotte, NC.

Development of a Toxicity Reduction Program, Alcoa Corporation, Badin, NC.

Development of a wastewater management program for a new automobile manufacturing facility, Nissan Motors, Smyrna, Tennessee.

Operational assistance and evaluation of ammonia removal alternatives, Union Oil Corporation, Lemont, Illinois.

Treatment of ABS wastewater, Borg-Warner Corporation, Washington, West Virginia.

Development of a toxicity reduction program, organic chemical plant, northeastern United States.

Development of a wastewater management program for a new alkylamines manufacturing facility, Air Products and Chemicals, St. Gabriel, Louisiana.

Development of a toxicity reduction program and system optimization, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Analysis of water corrosion, Yadkin County Schools, Yadkinville, North Carolina.

Development of a water effect ratio for a pulp and paper wastewater, Stone Container Corporation, Hodge, Louisiana

Operational assistance and development of a sludge management program, Ethyl Corporation, Orangeburg, South Carolina.
Development and implementation of a municipal toxicity reduction program, City of Gastonia, North Carolina.

Upgrading of pulp and paper aerated stabilization basin, Mead Corporation, Kingsport, Tennessee.

Analysis of color removal alternatives for a pulp and paper wastewater, Westvaco Corporation, Covington, Virginia.

Dewatering and disposal of an electronics manufacturing sludge, United Chem-Con, Williamston, South Carolina.

Evaluation and upgrade of a treatment system for a naval air rework facility, U.S. Naval Air Station, Norfolk, Virginia.

Waste identification and design of wastewater treatment facilities for a naval ordnance station, Louisville, Kentucky.

Optimization of treatment system performance, Vasarette Corporation, Hamilton, Alabama.

Toxicity reduction analysis for a pulp and paper mill wastewater, Mead Corporation, South Lee, Massachusetts.

Development of alternatives for compliance with EPA cluster rules, Mead Corporation, Stevenson, Alabama.

Development of plant management programs, maintenance programs, industrial waste surveys, cost evaluations, user charge systems, and sewer use ordinance, Winston-Salem, North Carolina.

Contract management and facility optimization, Hopewell, Virginia.

Assessment of operability of a 110 mgd treatment plant, U.S. EPA Region IV, Atlanta, Georgia.

Determination of design and operations deficiencies, Middlesboro, Kentucky.

Analysis of alternatives to reduce wasteloads for a secondary fibers/deinking mill, Westvaco Corporation, Tyrone, Pennsylvania.

Design and Operation of a Regional Industrial WWTP, LNVA, Beaumont, TX.

Design of Water Treatment System, E.I. DuPont, Old Hickory, Tennessee.

Analysis and Optimization of a Municipal Water Treatment System, City of Southern Pines, North Carolina.

Mill water balance and analysis of water quality requirements, James River Corporation, Parchment, Michigan.

Review of water and wastewater treatment plants, design of treatment plant upgrade to handle a deinking wastewater, Bear Island Paper Company, Ashland, Virginia.

Design of deinking wastewater treatment system, City of West Sacramento, California.

Evaluation of a sulfite mill wastewater treatment facility, Flambeau Paper Corporation, Park Falls, Wisconsin.

Development of wastewater treatment modifications for a mill expansion, Westvaco Corporation, Covington, Virginia.

Aeration analysis and treatment plant optimization, Boise Cascade, Rumford, Maine.

BAT investigations for a 2,400-TPD linerboard mill, Great Southern Paper Company, Cedar Springs, Georgia.

BAT evaluations for upgrading the wastewater management system, Gilman Paper Company, St. Mary's, Georgia.

Process and operational assessment at a joint municipal/industrial wastewater treatment plant, Erie, Pennsylvania.

Process and operational evaluation at a combined industrial/municipal treatment plant, Hopewell, Virginia.

Wastewater treatability investigations and process design, Westvaco Corporation, Charleston, South Carolina.

Aerated lagoon treatment of cold climate pulp and paper mill wastewater, Parsons and Whittemore, Prince Albert, Saskatchewan.

Wastewater characterization, process design and start-up assistance, James River Corporation, Kalamazoo, Michigan.

Service with expert testimony:

- City of Muscatine – Muscatine, Iowa
- Waldorf Paper Company – Minneapolis, Minnesota
- Hampton Roads Sanitation District – Norfolk, Virginia
- City of Reidsville – Reidsville, North Carolina
- Cuddy Farms – Monroe, North Carolina
- Lathrop and Gage – Kansas City, KS

PROFESSIONAL ENDEAVORS:

AWARE Environmental Inc.
Senior Consultant
2005 – Present

AWARE Environmental Inc.®
Sr. Vice-President
1999 - 2005

AWARE Environmental Inc.®
President
1988 - 1999

HDR Environmental Technologies, Inc.
An HDR Infrastructure Company
Director of Process Engineering
1984 - 1988

AWARE, Inc.
Vice President in Charge of Process and
Operational Services Division
1970 - 1984

PROFESSIONAL ACTIVITIES:

Technical Association of the Pulp and Paper Industry (TAPPI)

Water Environment Federation

American Water Works Association

International Association on Water Pollution Research

HONORS AND AWARDS:

F.W. Kellogg Award, Memphis State University

Environmental Leadership Award, 1995, TAPPI

PUBLICATIONS:

"Control of Sludge Bulking at a Sulfite Based Pulp and Paper Mill," *Proceedings of the 1985 TAPPI Environmental Conference*, April 1985.

"An Innovative Approach to Aeration System Modeling," *Proceedings of the 1983 Triangle Environment Conference,* March 1983.

"Analysis of a Submerged Aeration Facility," *Proceedings of the 1983 TAPPI Environmental Conference,* April 1982.

"Solving Winter Operation Problems at Biological Wastewater Treatment Plants," *Proceedings of the 1995 NC WEF Conference,* November 1995.

"Development of a Scheduled Maintenance System for a Wastewater Treatment Facility: A Case Study," Presented at the 1982 Kentucky-Tennessee WPCF Conference.

"High Temperature Effects of the Activated Sludge Process Treating Industrial Wastewater," *Proceeding of the 1981 TAPPI Environmental Conference,* April 1981.

"Troubleshooting and Upgrading of the Winston-Salem Anaerobic Digester-Power Generation Operations," Presented at the 53rd Annual WPCF Conference, 1980.

"Startup Considerations for Industrial Waste Treatment Facilities," Presented at the WWEMA Conference, June 1979.

"Tests Show Submerged Static Aerators Offer Advantages," *Water & Sewage Works*, September 1978.
"Operational Optimization of a 36 mgd Activated Sludge Facility at Winston-Salem, North Carolina," Presented at the 50th Annual WPCF Conference, October 1977.

"Upgrading and Optimizing an Activated Sludge System by Operations Techniques," Presented at the 1977 Mid-Atlantic Industrial Waste Conference, June 1977.

"Equalization of Time Variable Waste Loads," *Journal of the Environmental Engineering Division--ASCE*, June 1976.

"Testing and Application of Static Aerators," Presented at the 1976 TAPPI Environmental Conference, April 1976.

"Sludge Handling Methodology for Refinery Sludges," Presented at the University of Tulsa Conference on Management of Petroleum Refinery Wastewaters, January 1976.

"Analysis of Alternatives for Removal of Suspended Solids in Pulp and Paper MillEffluents," *Journal of the Technical Association of Pulp and Paper Association*, October 1975.

"Ozonation of Organic Chemicals Wastewater," Presented at the Second International Symposium of Ozone Technology, May 1975.

Stein, R.M.; Adams, Carl E., Jr.; Eckenfelder, W. Wesley. *Process Design Techniques for Industrial Waste Treatment*, 1974.

A Study of Aerobic Sludge Digestion Comparing Pure Oxygen and Air," *Proceedings of the 27th Purdue Industrial Waste Conference*, May 1972.

"Evaluation of Bench Scale, Pilot Scale and
Full Scale Operating Data," TAPPI Committee Report.

"Comparison of Pilot and Full-Scale Performance Data for a Combined Pulp and Paper Mill and Industrial Wastewater at Elevated Temperatures," Presented at the 1981 TAPPI Environmental Conference, April 1981.

"Evaluation of Problems in Operation of the High Temperature Pure Oxygen Activated Sludge Process," Presented at the 53rd WPCF Conference, October 1980.

"Treatment of a Wheat Processing Plant Wastewater," *Proceedings of the Georgia Tech Food Processing Waste Conference*, Atlanta, Georgia 1987.

"Optimization of Wastewater Treatment Plants," Presented at the 1986 NC WPCF Conference, November 1986

"Perils in Closing a Drum Storage Facility," *North Carolina Professional Engineering Magazine,* September-October 1985.
"Anaerobic Treatment Options," Presented at the 1985 Nebraska WPCF Conference, November 1985.

"Upgrading of a Secondary Fibers Wastewater Pretreatment System," *Proceedings of the 1986 TAPPI Environmental Conference,* April 1986.

"Analysis of Alternatives to Optimize Plant Operations," Presented at the 1986 Triangle Environmental Conference, April 1986.
"Underground Storage Tanks Design and Containment," Presented at the 1988 GAA Environmental Conference, September 1988.

"The Future of Solid Waste Disposal in the Pulp and Paper Industry," *Pulp and Paper,* September 1988.

"Utilization of Computer Modeling for Development of an Effluent Diffuser Design," *Proceedings of the 1992 TAPPI Environmental Conference*, April 1992.

"Experience with WTP System Performance Upgrade and Enhancement," Presented at the 1993 NCASI Southern Regional Meeting, June 1993.

"Approaches for Water Conservation and Waste Reduction in the Food Industry," *Proceedings of the 1994 AWWA Conference*, May 1994.

"Deinking Sludge Management," Presented at the 1994 TAPPI/ACTP New Trends in Papermaking Symposium, August 1994.

"Energy Efficient Aeration Approaches," Presented at the 1994 TAPPI/ACTP New Trends in Papermaking Symposium, August 1994.

"Performance of Municipal Biological Nutrient Removal Systems Under Winter and Storm Flow Conditions," *Proceedings of the 1994 WEF Conference*, October 1994.

"Effluent Toxicity Reduction at a Municipal Wastewater Treatment Plant with Significant Industrial Contribution". Presented at the 4th EPA National Wastewater Treatment Technology Transfer Workshop, Kansas City, Missouri, May 1995.

"Use of Clean Sampling Protocol for Monitoring Pulp and Paper Wastewaters". *Proceedings of the 1996 TAPPI Environmental Conference,* May 1996.

Disinfection Interference in a Nitrified Wastewater Treatment Plant Effluent, North Carolina WEF Advanced Topics in Wastewater Treatment, September 1996.

"Operational Optimization of an Enhanced Biological Nutrient Removal System", Proceedings of the 1997 N.C. WEF Conference, November 1997.

A Success Story on Reduction of Effluent Toxicity at an Industrial WWTP", Proceedings of the 1997 N.C. WEF Conference, November 1997.

"Upgrade of Specialty Paper Manufacturing Wastewater Treatment Facility", Proceedings of the 1998 TAPPI Environmental Conference, April 1998.

"Optimization of a Recycle Linerboard Mill WWTP", Proceedings of the 2000 TAPPI Environmental Conference, May 2000.

Đuke Power State Park – Lake Restoration and Watershed Management", Proceedings of the 2001 WEFTEC Conference, October 2001.

"Effluent Toxicity Reduction at a 9 MGD Municipal Treatment Plant", Proceedings of the 1994 WEF Environmental Conference.

"Physical-Chemical Treatment of Industrial Wastewater", N.C. WEF/AWWA Conference – Inside the Fence: Understanding Industrial Pretreatment, June 2001.
"North Carolina Lake Restoration Project Examines Land Use and Non Point Sources" WEF Watershed and Wet Weather Bulletin, April 2002

"Microbiological Growth in Pulp and Paper Wastewaters" Tappi International Environmental Conference, May 2003

"Industrial Nutrient Removal Case Histories" NC AWWA/WEF Conference, November 2003

"Approaches to Comply with Total Nitrogen BAT Criteria" Proceedings of the Vanderbilt University Conference on Industrial

Wastewater and Best Available Treatment Technologies, February 2003

"Approaches to Evaluate Toxicity and Inhibition of Specific Chemical Discharges" Proceedings of the NC AWWA/WEF Conference, November 2001

"Upgrading of a Treatment Plant at a Specialty Paper Mill" Presented at NCASI Central State Regional Meeting, May 1999

"Approaches to Reduce Nutrient Discharges" Proceedings of the 2001 NC AWWA/WEF Conference, November 2002

"Full Scale Water Reclamation/Reuse Experience at an Industrial Plant", Proceedings of the 2004 NC AWWA/WEF Conference, November 2004

"Concepts to Improve Settling, Effluent Quality and Sludge Management", Proceedings of the 2004 NC AWWA/WEF Conference, November 2004

SHORT COURSE PRESENTATIONS:

Introduction to Environmental Control in the Pulp and Paper Industry - Case Histories of End of Pipe and In-Mill Treatment Technologies, TAPPI.

Activated Sludge Plant Operations Short Course - Nutrients and Nitrification/Denitrification, TAPPI.

Advanced Wastewater Treatment - Upgrading of Biological Wastewater Treatment Plants, TAPPI.

Biological Waste Water Treatment, Auburn University.

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EXHIBIT 8 TO PRE-FILED TESTIMONY IN SUPPORT OF
CITGO'S PETITION FOR AN ADJUSTED STANDARD (AS 2008-008)

GEORGE P. TYRIAN, P.E.

EDUCATION: B.S., Chemical Engineering, University of Rochester, Rochester, NY, 1981

REGISTRATION: Professional Engineer, 1990

EXPERIENCE: Mr. Tyrian is specialized in industrial wastewater and hazardous waste management, with over seventeen years experience. Industrial experience includes food processing, organic chemicals, petroleum refining, pulp and paper, metal finishing, pharmaceutical, and waste management. His experience includes environmental audits, stormwater permitting, treatability studies, preliminary and detailed design, toxicity reduction, and permitting and construction management of wastewater facilities, chemical feed systems, and fueling systems. Hazardous waste management experience includes site assessment and remediation, as well as permitting and design of underground storage tank systems. All training and medical monitoring in compliance with OSHA (1910.120) is kept current.

REPRESENTATIVE PROJECTS:

Conducted two sludge depth studies in 1995 and 1997 as part of an aerated stabilization basin evaluation. Project also included sediment sampling, water quality evaluation and tracer studies using lithium chloride. Recommended mixer specifications and placement to improve basin performance in lieu of dredging was also presented, Willamette, Kingsport, TN.

Overall compliance review, including Tier II, Form R reporting, Process Safety Management, Risk Management Plans, SPCC Plans and Stormwater Pollution Prevention Plans for twelve (12) dairy and ice-cream facilities throughout Southeast. Confidential Client, North Carolina.

Preliminary and final design of sulfur dioxide effluent dechlorination system. Lancaster, SC

Preliminary and final design of chlorination system modifications to allow breakpoint chlorination. Confidential Client, Florida

Preliminary and final design of biological treatment modifications for upgrade and expansion of biological wastewater treatment facilities treating pulp and paper wastewater, Bear Island Paper Company, Ashland, Virginia.

Preliminary detailed design and construction assistance for biological treatment modifications to meet pretreatment limits for secondary fiber pulp and paper wastewater, Keyes Fiber Company, Albertville, Alabama.

Analysis of in-plant controls for pretreatment of a plating wastewater. Developed mass balance, evaluated chemical usage and recovery alternatives - National Textile Engravers, Charlotte, North Carolina.

Provide detailed review of state-of-the-art treatment technologies for secondary fiber pulp and paper wastewater, including ultra filtration, RO, SBR, anaerobic treatment, activated sludge treatment and sludge handling methods, Keyes Fiber Company, Albertville, Alabama.

Preliminary and detailed design of a sewer system and pump station to handle from 1-7 MGD of raw secondary fiber effluent. James River Company, Kalamazoo, Michigan.

Preliminary design of biological treatment alternatives for a pulp and paper mill, including existing system upgrade, conversion to activated sludge system, wastestream supplemental oxygenation and discharge relocation, Gilman Paper Company, St. Mary's, Georgia.

Analysis of wasteloads and pretreatment of a vitamin E manufacturer, Phoenix Laboratories, Hicksville, New York.

Evaluation of waste sources and control alternative for a potato chip facility. Evaluated starch recovery and sale, Mitchum, Inc. Charlotte, North Carolina.

Evaluation of alternatives for monitoring clarifier sludge blankets, effluent solids and sludge consistence at a biological wastewater treatment facility treating pulp and paper wastewater, Southeast Paper Manufacturing Company, Dublin, Georgia.

Performed sampling and mass balance calculations to determine wastewater treatment plant loading due to reboiler condensate, Bear Island Paper Company, Ashland, Virginia.

Preliminary design of denitrifying oxidation ditch alternatives to increase ditch aeration for municipality. Alternatives considered included mechanical aeration, rotor aeration and diffused aeration, then completed final design, construction observation, operator training and O&M manual for mechanical aeration alternative, Confidential Client, Florida.

Preliminary and final design of a landfill leachate treatment system. System included pH adjustment, ammonia stripping, neutralization, aerated lagoon biological treatment, and chlorination. Treated effluent will be discharged into POTW, Toytown Landfill, Florida.

Project Manager providing detailed design and construction observation of 10,000 gal outdoor storage and feed facility for 50% sodium hydroxide for municipal WWTP, Lower Muddy Creek, Winston-Salem, North Carolina.

Construction engineer for modification, start-up and operation of groundwater treatment system designed to utilize air stripping technology to remove 1,1,1-trichloroethane and trichloroethylene. Design modifications performed to date include automating the treatment system, the addition of a second groundwater pumping well and the installation of double-walled containment piping. Confidential Client, Charlotte, North Carolina.

Construction engineer for installation, start-up and operation of a vacuum extraction system for remediating 1,1,1-trichloroethane and trichloroethylene contaminated soils underneath an industrial building. As part of the project, an existing vapor degreaser was closed under RCRA post-closure permit application and the area remediated in accordance with an approved Closure Plan. The system has been in operation since January 1991. Confidential Client, Charlotte, North Carolina.

Construction engineer for the installation of an outdoor vacuum extraction system for remediation of 1,1,1-trichloroethane and trichloroethylene from the soil above the water table on site. This system included a catalytic oxidation unit for destruction of organic vapors removed from soil and groundwater by the remediation systems. Confidential Client, Charlotte, North Carolina.

Project Manager for preparation of specifications for the removal of 17 underground storage tanks containing gasoline, Jet-A, and diesel fuel. This project also entailed the design of 12 replacement underground tanks and fueling systems for an aviation facility, the production of a bid package and the initial construction engineering services. South Carolina Aeronautics Commission, Columbia, South Carolina.

Developed a Site Assessment program, and initiated the site investigation, which included preliminary sampling, and cleanup of the soil, and assessment of potential groundwater contamination for tetrachloroethylene distributor. This report included site survey, area impact, possible impact on area wells, monitoring well design and location, and sampling procedure. Confidential Client, Long Island, New York.

Prepared draft report on proposed groundwater contamination investigation, site survey, area impact, possible impact on area wells, monitoring well design and location, and sampling procedure. Hilord Chemical, Hauppauge, New York.

Reviewed operations at a batch chemical pharmaceutical plant to identify and quantify emissions. These emission estimates were then modeled to identify and prioritize sources of off-site odors generated from the facility. Confidential Client, Belgium.

Reviewed both process and waste handling operations at a batch chemical pharmaceutical facility to characterize waste water discharges and streams currently being incinerated on-site to allow advance scheduling of waste management operations and waste minimization alternatives. Confidential Client, Augusta, Georgia.

Prepared Draft Environmental Impact Statement for an alternate fuel blending facility (final hazardous waste disposal facility). DEIS submitted, state comments never answered. Site later became Shore Realty Superfund site.

Preliminary design of a toluene and methylene chloride stripper for a membrane manufacturer as part of bid package for wastewater treatment plant. Confidential Client, Hauppauge, New York.

Assisted in preparation of Remedial Action Plan for groundwater contamination site. Responsibilities included determination of treatability of respective contaminants. Confidential Client, Florida.

Completed design modeling of existing venturi-cyclone scrubber system on incinerator to improve system performance and meet air emission limitations. Royal Metals, Stamford, Connecticut.

Design and construction of vacuum system for gold recovery operations for a precious metals recovery plant. Confidential Client, Westbury, New York.

Prepared group stormwater permit for six steel fabrication facilities. Chicago Bridge and Iron, Oak Brook, Illinois.

Prepared general permit, sampling plan and Stormwater Pollution Prevention Plan for a steel fabrication facility, CBI-NaCon, Fontana, California

Reviewed facility operations to determine stormwater permit options for five specialty gas blending facilities, then drafted Stormwater Pollution Prevention Plan for three facilities. Liquid Carbonic, Oak Brook, Illinois.

Preliminary and final design and permit submittal of an effluent diffuser for an industrial WWTP, Reeves Brothers, Spartanburg, South Carolina.

Preliminary and final design of an industrial WWTP, Reeves Brothers, Spartanburg, SC.

Preliminary, final design, construction review, startup and operator training of an acid and caustic pH neutralization system for an industrial WWTP, Reeves Brothers, Spartanburg, SC.

Preparation of a BMP Plan and update of SPCC plan for TMP and Bleach Kraft coated paper/newsprint mill, Bowater, Catawba, South Carolina.

Construction, observation, and pilot assessment of VES and air sparge system for petroleum and DCE remediation of soil and groundwater. Project included design and installation of a horizontal VES well and interim assessment to determine location of additional wells, Confidential Client, Charlotte, North Carolina.

Construction and observation of VES and air sparge system for acetone and styrene remediation of soil and groundwater for fiberglass fabricator, Confidential Client, Wilson, North Carolina.

Preparation of Stormwater Pollution Prevention Plan and permit application for recycle mill manufacturing median grade paper, Jackson Paper, Sylva, North Carolina.

Toxicity reduction evaluation for textile treating facility, Confidential Client, North Carolina.

Conducted Phase I environmental audits and environmental compliance audits for over 25 facilities, including steel fabricators, non-destructive testing facilities, heat treating facilities, foundries, plastic piping manufacturers, natural gas separators, compressor gas manufacturers, and dairy industries.

Involved in preparation and implementation of Stormwater Pollution Prevention Plans for various industries, including pulp and paper, steel fabrication, textiles, compressed gas manufacturing, and carbon dioxide production facilities. States involved include California, Virginia, North Carolina, South Carolina, Louisiana, Texas, and Georgia.

Completed site remediation of Bunker C/Diesel spill for PRP as part of EPA Superfund Emergency Removal Remediation project, also included evaluation of mobile thermal remediation and field screening analyses, and extensive soil/water characterization and disposal options, Confidential Client, Cincinnati, Ohio.

Development of toxicity reduction program and preliminary design through construction of treatment plant modifications to reduce toxicity, University of North Carolina at Chapel Hill, Chapel Hill, NC.

Completed remediation and closure of hazardous waste storage area, Confidential Client, Illinois.

Conducted toxicity reduction evaluation on treatment of permethrin-containing wastewaters for discharge to POTW and on receiving stream, Confidential Client, North Carolina.

Conducted temperature modeling of wastewater treatment systems for various industries to determine winter operating problems and modifications. Industries modeled included pulp and paper and grain processing industries.
Prepared and updated Stormwater Pollution Prevention Plan, SPCC Plan, and Oil Spill Contingency Plan for TMP mill, Bear Island Paper Company, Ashland, Virginia.

Updated SPCC plans for several industries, including TMP, Kraft, and Recycle pulp and paper industries and textile industries.

Responsible for operator training and O&M manual preparation for varied projects including operation of soil and groundwater remediation systems, pH neutralization systems, wastewater treatment plants, and stormwater inspection and sampling.

Conducted toxicity reduction evaluation on treatment of electrostatic – precipitation wastewaters for discharge to POTW Firestone, NC.

Budgetary cost estimate of treatment plant upgrades for vegetable oil refinery. Upgrades included pH control system, API separator, DAF modifications, temperature control system, tank and aeration basin upgrades, Loders, IL.

Preliminary and final design and construction assistance of pretreatment system for margarine and mayonnaise production plant. System included API separator DAF unit and chemical addition, Dean Foods, KS.

Preliminary detailed design, shop drawing review and construction assistance for treatment system for high TDS and low TDS wastewaters for chemical manufacturer, Degussa, AL.

Preliminary detailed design of biological treatment modifications for upgrade and expansion of biological wastewater treatment plant for pulp and paper mill, including converting existing clarifiers to aeration n basin, addition of new secondary clarifiers, tertiary clarifier, and final filter, Abitibi Consolidated, TX.

Preliminary design through startup of pH control systems and system expansions for sports drink manufacturer at four production facilities, Quaker Oats, IL.

Detailed design of furfural neutralization system, Quaker Oats, IA.

PROFESSIONAL ENDEAVORS:

AWARE Environmental® Inc.
August 1990 - present

HDR Engineering, Inc.
1985-1990

Donnelly Engineering/Wastemizer Corp.
1981-1985

PROFESSIONAL ACTIVITIES: American Institute of Chemical Engineers

PUBLICATIONS:

Stein, R.M., Fiss, E.C. and Tyrian, G.P. TAPPI: Atlanta Press. 1989. "Water Supply and Treatment", Second Edition, Chapter 7, Pumping Systems.

Harrington, B.T., Tyrian, G.P. "Performance of a Temperature Model in Predicting Aerator Lagoon Effluent Temperatures," Proceedings TAPPI Conference, 1989.

Fiss, E.C., Stein, R.M., and Tyrian G.P. "Investigation of Oxidation Ditch Performance in Treatment of Domestic Wastewater."

Stein, R.M. and Tyrian, G.P. "Approaches for a Paper Mill Wasteload Reduction."

Tyrian, G.P., Wagoner, D.L., Fiss, E.C., and Stein, R.M. "Approaches for Water Conservation and Water Reduction in the Food Industry." Proceedings AWWA Conference, 1994.
Tyrian, G.P. and Stein, R.M. "Pretreatment of Potato Chip Wastewater Using Hydrocyclones." Proceedings, 1993 Food Industry Environmental Conference.

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TECHNICAL REVIEW OF AMMONIA TREATMENT AT THE WASTEWATER TREATMENT PLANT – CITGO PETROLEUM CORPORATION, LEMONT REFINERY

Prepared for:

CITGO Petroleum Corporation
Lemont Refinery
Lemont, Illinois

Prepared by:

AWARE Environmental Inc.
9305-J Monroe Road
Charlotte, NC 28270-1490

AEI Job No. N356-06
AEI Document No. 35606r004

February 2008

EXECUTIVE SUMMARY

CITGO Petroleum Corporation operates a petroleum refinery (Lemont Refinery) in Lemont, Illinois. The process wastewater and stormwater from the refinery are treated in the refinery's wastewater treatment facility and are discharged into the Chicago Sanitary and Ship Canal under a National Pollutant Discharge Elimination System (NPDES) permit issued by the State of Illinois. The wastewater treatment facility utilized by Lemont Refinery surpasses the criteria for Best Available Technology Economically Achievable (BAT) for treatment of refinery wastewaters as define by the U.S. EPA. Specifically, the refinery treatment system includes sour water strippers which provide greater than 95 percent ammonia removal, oil and solids removal, flow equalization, clarification, single-stage activated sludge treatment and final polishing.

The U.S. EPA effluent limitations guidelines provide mass based limits for ammonia nitrogen (and other parameters) based on refinery production, with the use of BAT treatment technology. The Illinois regulations contain ammonia discharge standards which are much more stringent than the U.S. EPA limitations. The Illinois standards would require Lemont Refinery to meet a 3.0 mg/l ammonia nitrogen discharge standard. Lemont Refinery has been unable to consistently comply with the 3.0 mg/l limit. The Illinois Pollution Control Board granted the refinery a site specific rule change effective through December 31, 2008. The refinery has consistently achieved compliance with these regulations and typically provides an effluent quality significantly better than the regulatory criteria.

Lemont Refinery is in the process of preparing a request for an adjusted standard for its discharge of ammonia. AWARE Environmental Inc. (AEI) was retained to conduct a technical review of the ammonia removal capacities of the wastewater treatment system. The primary objectives of this review are to:

1. Determine if the present wastewater treatment system is consistent with the U.S. EPA BAT criteria;

2. Determine if the wastewater treatment system operating conditions are conducive to biological nitrification; and

3. Evaluate alternative ammonia removal technologies and the cost of those technologies to determine if changes in the present wastewater treatment system are warranted as part of a program to achieve compliance with the 3 mg/l ammonia nitrogen criteria.

The results of this evaluation indicate that Lemont Refinery has a wastewater treatment system which exceeds BAT criteria and which allows the facility to comply with U.S. EPA refinery discharge regulations. The long term performance data has demonstrated that the refinery wastewater treatment facility has achieved compliance with the current mass based limitations for ammonia nitrogen contained in the NPDES permit, but that the refinery has not been able to consistently meet a 3.0 mg/l ammonia nitrogen limit as per the Illinois regulations.

A review of the wastewater treatment technologies employed at the other Illinois Refineries was conducted. These refineries were Conoco-Phillips, Roxana, IL; Exxon-Mobil, Joliet, IL; and Marathon, Robinson, IL. The wastewater treatment processes employed by these Refineries are very similar to those utilized at the Lemont Refinery.

A review of the activated sludge treatment plant was performed with regard to factors which control the ability of a biological treatment facility to achieve nitrification. These factors include food to microorganism ratio (F/M), sludge age, dissolved oxygen concentration, temperature, pH, and alkalinity. The review indicates that these parameters have been maintained in the ranges favorable to nitrification. However, in spite of this, the refinery treatment facility has been unable to meet the 3.0 mg/l ammonia nitrogen standard on a consistent basis.

Lemont Refinery has maintained an ongoing optimization program which has resulted in improved ammonia nitrogen removal. The program has been expanded to address changes in the petroleum refinery industry. The refinery has spent over $45,000,000 over the last ten years on capital projects related to ammonia control and reduction.

As a result of changes in crude quality, Lemont refinery has experienced a five-fold increase in wastewater treatment chemical addition costs over the last 4 years. Lemont refinery has and is continuing to conduct research which addresses the environmental impacts caused by crude quality fluctuations. Crude quality fluctuations confirm AEI's previous analysis which indicated that the capability of the wastewater treatment system is limited, in large part, due to the inherent variability of refinery wastewater.

Potential alternative technologies were evaluated for upgrading the wastewater treatment facility with additional nitrogen removal technologies which would increase the likelihood of consistently meeting the 3.0 mg/l ammonia nitrogen standard. Several alternatives were screened and preliminary process designs and budget cost estimates were developed for the four most viable alternatives. These four alternatives include powdered activated carbon addition (PACT), fixed media biological treatment, membrane bioreactors, and breakpoint chlorination. Addition of a fixed media biological reactor would be the most cost-effective alternative. The fixed media system would utilize a rotating biological contractor (RBC) and would have an estimated capital cost of $13,500,000 and an estimated annual operating cost of $1,220,000. The estimated total annualized cost for the addition of the fixed media reactor system over a ten (10) year period at 8 percent interest is $3,220,000/year.

Even with the ammonia removal upgrades, the ability of the treatment system to consistently meet the 3.0 mg/l ammonia nitrogen standard is uncertain. Based on the significant cost of upgrading the system, and the uncertainty that the upgraded system would achieve consistent compliance with the 3.0 mg/l ammonia nitrogen standard, upgrading the treatment system with additional treatment technologies for ammonia removal is not justified.

We recommend that Lemont Refinery continue its ongoing research studies and projects designed to optimize the existing wastewater treatment system. These efforts should be directed toward obtaining the maximum possible ammonia removal on a consistent basis. Continued development of operational data under the varying conditions inherent with refinery wastes will help to improve the performance of the system, and will allow the maximum ammonia removal capability of the system to be achieved.

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SECTION 1.0
INTRODUCTION

CITGO Petroleum Corporation (CITGO) operates a petroleum refinery (Lemont Refinery) in Lemont, Illinois. The refinery produces gasoline, a variety of other fuels, coke, and solvents from crude oil. Lemont Refinery was formerly owned and operated by the UNO-VEN Company, and had previously been operated as the Union Oil Refinery. On May 1, 1997 PDV Midwest Refining, L.L.C. purchased the Lemont Refinery and contracted with CITGO to operate the refinery.

The process wastewater generated by the refinery and the contaminated stormwater runoff from the facility are treated in a single stage activated sludge wastewater treatment plant. The treated wastewater is discharged to the Chicago Sanitary and Ship Canal under a National Pollutant Discharge Elimination System (NPDES) permit. The current permit (No. IL0001589) was issued by the Illinois Environmental Protection Agency (IEPA) on July 28, 2006, became effective August 1, 2006 and was modified on June 22, 2007. The permit expires on July 31, 2011.

The State of Illinois has ammonia nitrogen discharge standards for sources which discharge greater than 100 lb/day of ammonia nitrogen, such as the Lemont Refinery. These criteria are contained in the State of Illinois Rules and Regulations under Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter I: Pollution Control Board. Section 304.122 (b) of this regulation sets monthly average discharge standards at 3.0 mg/l of ammonia nitrogen.

Lemont Refinery has been unable to consistently meet the 3.0 mg/l ammonia concentration standard. As a result, the Illinois Pollution Control Board (IPCB) granted the refinery a site specific rule change for ammonia under Section 304.213 of the Illinois regulations. The current site specific rule was adopted in 1998, as an extension of a previous rule change, and is effective through December 31, 2008. This site specific rule change exempts the facility from the ammonia limits under Section 304.122(b) of the Illinois regulations and requires that the facility meet the U.S. EPA Best Available Technology Economically Achievable (BAT) limitations for ammonia pursuant to 40 CFR 419.23 (1992). Under the site specific rule, the facility is required to meet a monthly average ammonia limit of 9.4 mg/l, a daily maximum ammonia limit of 26.0 mg/l, to continue its efforts to reduce ammonia discharges and to monitor and report nitrogen concentrations of its oil feedstocks.

Lemont Refinery has retained AWARE Environmental Inc. (AEI) of Charlotte, North Carolina to evaluate current conditions, to evaluate potential alternatives for upgrading the treatment system to meet a 3.0 mg/l limit, and to evaluate the need to re-apply for a site specific rule change. AEI conducted a conceptual evaluation of Lemont Refinery wastewater treatment system, and the available alternatives to achieve ammonia removal from a refinery wastewater. The primary objectives of this program were to:

1. Determine if the present wastewater treatment system is consistent with the U.S. EPA BAT criteria;
2. Determine if the wastewater treatment system operating conditions are conducive to biological nitrification; and
3. Evaluate alternative ammonia removal technologies, and the cost of those technologies to determine if changes in the present wastewater treatment system are warranted as part of a program to achieve compliance with the 3.0 mg/l ammonia nitrogen criteria.

This report presents the AEI findings.

SECTION 2.0
REGULATORY REVIEW

There are a wide range of regulations which control the wastewater discharges from petroleum refineries. The primary regulatory drivers for determining the ammonia discharge limitations from Lemont Refinery are the U.S. EPA effluent limitations guidelines and the State of Illinois water pollution regulations. As a part of the development of this report, current regulations and potential pending changes in regulations which may impact Lemont Refinery wastewater treatment operations and/or ammonia discharge were reviewed.

2.1 U.S. EPA EFFLUENT LIMITATIONS GUIDELINES

The U.S. EPA has developed effluent limitations guidelines for the petroleum refining industry which are included in 40 CFR 419. The basis for these guidelines are included in the 1982 *Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Petroleum Refining Industry* (EPA 440/1-82/014). These guidelines provide effluent load-based limitations for conventional pollutants based on the Best Practicable Control Technology Currently Available (BPT) (40 CFR 419.22) and for non-conventional pollutants based on Best Available Technology Economically Achievable (BAT) (40 CFR 419.23). Conventional pollutants include BOD_5, TSS, oil and grease, and pH. Non-conventional pollutants include COD, ammonia nitrogen, sulfide, phenolic compounds, total chromium, and hexavalent chromium. The effluent limitations guidelines are based on actual effluent flows and pollutant concentrations obtained by refineries employing BAT and BPT treatment technologies.

EPA guidelines define five (5) general subcategories of refineries based on the production processes employed. These categories are summarized in Table 2-1. Lemont Refinery is classified as Subcategory B – Cracking Refinery. Under the guidelines, effluent limitations are calculated for each individual facility based on the refining subcategory, the maximum feedstock processing rate and the process configuration.

TABLE 2-1

U.S. EPA REFINERY SUBCATEGORIES

Subcategory	Basic Refinery Operations Included
A - Topping	Topping and catalytic reforming whether or not the facility includes any other process in addition to topping and catalytic reforming. This subcategory is not applicable to facilities which include thermal processes (coking, visbreaking, etc.) or catalytic cracking.
B – Cracking	Topping and cracking, whether or not the facility includes any processes in addition to topping and cracking, unless specified in one of the subcategories listed below.
C – Petrochemical	Topping, cracking and petrochemical operations whether or not the facility includes any process in addition to topping, cracking and petrochemical operations', except lube oil manufacturing operations.
D – Lube	Topping, cracking and lube oil manufacturing processes, whether or not the facility include any process in addition to topping, cracking and lube oil manufacturing processes, except petrochemical operations'.
E – Integrated	Topping, cracking, lube oil manufacturing processes and petrochemical operations, whether or not the facility includes any processes in addition to topping, cracking and lube oil manufacturing processes and petrochemical operations'.

The term "petrochemical operations" shall mean the production of second generation petrochemicals (i.e. alcohols, ketones, cumene, styrene, etc.) or first generation petrochemicals and isomerization products (i.e. BTX, olefins, cyclohexane, etc.) when 15% or more of the refinery production is as first generation petrochemicals and isomerization products.

Source: Development Document for Effluent Limitations Guidelines and Standards for the Petroleum Refining Point Source Category, EPA 440/1-82-014, October 1982, 64-65.

The U.S. EPA BAT guidelines are based on the implementation of in-plant water reuse/conservation measures to minimize the volume of wastewater discharge, and the use of sour water strippers to reduce ammonia and sulfide loads in the process wastewater. These in-refinery controls should be followed by end-of-pipe treatment technologies. The U.S. EPA BAT model, as found in the 1982 “Development Document”, is based on a wastewater treatment plant (WWTP) that includes the following treatment processes:

1. Flow equalization;
2. Initial oil and solids removal (API separator or baffle plate separator);
3. Additional oil/solids removal (clarifiers or dissolved air flotation);
4. Biological treatment; and
5. Filtration or other final polishing steps.

As a part of this report preparation, contacts were made with the U.S. EPA personnel responsible for developing guidelines for the Petroleum Refinery subcategory to determine if modifications to the effluent guidelines for petroleum refinery are anticipated. According to U.S. EPA personnel, U.S. EPA has no immediate plans to revise the effluent guidelines. The 304 (m) process involves substantial public input and generally, leads to lengthy studies before any type of rule making is identified. Presently, petroleum refineries are not being considered for updated guidelines.

2.2 ILLINOIS WATER POLLUTION REGULATIONS

Under the current Illinois water pollution regulations, as amended through November 21, 2005, the State of Illinois has established ammonia nitrogen limitations for discharges into the Illinois River system. Under Section 304.122 (b) of the regulations, ammonia nitrogen discharges of greater than 100 lb/day are required to meet a 3.0 mg/l monthly average effluent ammonia nitrogen limit. This limitation is significantly more stringent than the ammonia nitrogen standards in the U.S. EPA effluent limitations guidelines.

Lemont Refinery discharges treated wastewater into the Chicago Sanitary and Ship Canal, a secondary contact waterway, and periodically discharges more than 100 lb/day of ammonia nitrogen. Therefore, Lemont Refinery discharge is regulated by the 3.0 mg/l ammonia nitrogen discharge rule.

The refinery has not been able to consistently meet the 3.0 mg/l ammonia limit under the Illinois regulations. Based on the results of previous evaluations performed in conjunction with the petitions for the site specific rule changes, no economically feasible treatment methods were identified which could ensure consistent compliance with a 3.0 mg/l ammonia nitrogen limit. As discussed above, site specific rule changes were granted by the IPCB to the refinery under Section 304.213 of the Illinois water pollution regulations. The site specific rule change exempts the refinery from the ammonia limits under Section 304.122 of the Illinois regulations and requires the refinery to meet the U.S. EPA BAT limitations for ammonia nitrogen pursuant to 40 CFR 419.23 (1992). The facility is also required to comply with a monthly average ammonia nitrogen limit of 9.4 mg/l and a daily maximum ammonia nitrogen limit of 26.0 mg/l. In addition, as part of the site specific rule change, the refinery is required to continue its efforts to reduce ammonia discharge and to monitor and report nitrogen concentrations of its oil feedstocks.

SECTION 3.0
ANALYSIS OF EXISTING FACILITY
WITH RESPECT TO BAT AND NITRIFICATION

A detailed analysis of the wastewater treatment program was conducted in order to determine if the refinery continues to be a BAT facility. Included in this analysis were evaluations of the refinery wasteloads and the current wastewater treatment program. These were conducted with regard to the ability of the system to provide consistent biological nitrification. The objects of this analysis were to:

1. Determine if the waste loadings, and the hydraulic and ammonia loads in particular, are consistent with BAT criteria;
2. Determine if the BAT effluent limitations guidelines and discharge permit criteria are being met;
3. Determine if the physical facility is consistent with the EPA BAT technology model; and
4. Evaluate the present treatment program to determine if it is consistent with the refinery's objective of improving ammonia removal, and if additional changes in the program are warranted.

The results of this analysis are presented in this section.

Currently, the refinery does not have long term crude supply agreements or super tanker unloading facilities which could provide a fairly consistent grade of crude to the refinery. Therefore, crude quality will vary significantly. In addition, the refinery is processing heavier crudes. These factors affect the feed stock. There are frequent feed stock fluctuations which result in chemical and operating changes throughout the day. These fluctuations affect the water quality discharged to the wastewater treatment plant.

The maximum monthly production rate for Lemont refinery observed during the period of 1997 to present was 170,341 barrels per day which occurred in September 2005. The maximum production of each individual process is presented in Table 3-1. The United States Environmental Protection Agency uses these process capacities as the basis for defining effluent

TABLE 3-1

OBSERVED MAXIMUM MONTHLY PRODUCTION RATES[1]

Process	Max Production Rate (bbl/day)
Crude Processes	
Desalting	168,626
Atmospheric Distillation	168,626
Vacuum Distillation	82,807
Cracking Processes	
Fluid Catalytic Cracking	69,098
Delay Coking	40,326
Needle Coking	6,413
Asphalt Production	
Asphalt Production	4,329
Asphalt Oxidation	10,935

(1) This is based on the monthly average production rates for the period used to develop the current NPDES permit. Note that the maximum monthly production rate reached 170,341 in September 2005. (This was after the time period utilized for NPDES development).

criteria. The specific calculations to define the present design criteria are presented in Appendix A.

The waste load to the refinery treatment system has become more variable. Several of the factors which affect the waste loads are:

1. Operate consistently at design thru put rates;
2. Changes in the quality of crude; and
3. Feedstocks with a higher percentage of heavy crude.

Specifically, these problems are as follows:

1. Because of increased gasoline demand, refineries are operating at design capacities and there is very little production variability on a month to month basis. This provides less time for turnarounds and the potentials for malfunctions or upsets to occur is increased at higher production levels.
2. Crude oil is delivered by pipelines and the nature of the pipeline sources means that there can be significant variability on a batch to batch basis. Lemont has to continually review the quality of the crude and make adjustments in chemicals and processing factors especially in the crude desalting units. This variability can result in increased wasteloads to the wastewater treatment plant.
3. Heavy crude is of a poorer quality than sweet crude. Heavy crude is most readily available in the Midwest US because it is directly piped to this area. Heavy crude results in more solid materials and asphaltenes. Therefore, the wasteloads in terms of COD, oil and grease and TSS are greater than with other types of crude processed at the refinery. This places a much greater emphasis on the wastewater treatment program to maintain compliance with effluent criteria.

3.1 ANALYSIS OF REFINERY WASTELOADS

The U.S. EPA effluent guidelines for the petroleum refinery category are based on the use of sour water strippers. Sour water generally results from water brought into direct contact with a hydrocarbon stream, such as when steam is used for stripping or mixing, or when water is used as a washing medium, as in desalting. The U.S. EPA development document reported maximum sour water stripper ammonia removal efficiencies of 95 percent or greater. In an analysis of Lemont Refinery which was conducted in conjunction with the 1992 site specific rule change, the combined average ammonia removal observed in the sour water strippers was 95 percent.

Lemont Refinery has maintained an ongoing program to optimize the performance of the sour water strippers. This can be seen based on the data from the last fifteen years. During this time period, the sour water stripper operation has been very effective. The data presented in the 1997 rule change request showed that ammonia removal efficiencies averaged in excess of 96.4 percent, and monthly average efficiencies have been observed in excess of 99 percent. The data for the past ten years is presented in Table 3-2 and shows an average removal of 96.8 percent with a number of monthly average removal efficiencies exceeding 99 percent. This type of performance is indicative of the facility’s diligent program of improving performance. This represents performance well exceeding the U.S. EPA model refinery objective and continues to show improved removals since our analysis of the data as part of previous site specific rule change applications.

A review of the characteristics of the primary effluent was performed in order to evaluate the influent conditions to the activated sludge system. Design parameters were also evaluated for potential additional treatment technologies to improve ammonia removal. The monthly average secondary influent characteristics for the period August 1997 to March 2007 are presented in Table 3-3.

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Sour Water Stripper - Ammonia Removal

	non-CN service			CN service		
Date	Inf.-mg/l	Eff.-mg/l	% Removal	Inf.-mg/l	Eff.-mg/l	% Removal
Jan '97	3369	12	99.6	4517	64	98.6
Feb '97	4043	7	99.8	4141	42	99.0
March '97	1909	4	99.8	2783	65	97.7
Apr '97	944	4	99.6	4037	50	98.8
May '97	992	4	99.6	3900	43	98.9
June '97	1013	5	99.5	3840	2	99.9
July '97	596	32	94.6	2732	42	98.5
Aug '97	1204	4	99.7	3816	61	98.4
Sept '97	1118	9	99.2	3949	74	98.1
Oct '97	1520	3	99.8	4120	64	98.4
Nov '97	1799	7	99.6	3317	79	97.6
Dec '97	1399	5	99.6	4134	131	96.8
Average	1659	8	99.5	3774	60	98.4
Jan '98	1594	7	99.6	3686	105	97.2
Feb '98	1086	8	99.3	3383	86	97.5
Mar '98	1128	42	96.3	3204	69	97.8
Apr '98	986	14	98.6	2705	50	98.2
May '98	963	24	97.5	1564	13	99.2
June '98	1288	303	76.5	2569	77	97.0
July '98	1216	16	98.7	2944	123	95.8
Aug '98	1434	34	97.6	2867	80	97.2
Sept '98	1401	27	98.1	2956	132	95.5
Oct '98	1095	22	98.0	2871	85	97.0
Nov '98	887	17	98.1	3097	79	97.4
Dec '98	877	16	98.2	2964	94	96.8
Average	1163	44	96.2	2901	83	97.1
Jan '99	1162	9	99.2	2896	48	98.3
Feb '99	1132	46	95.9	3360	100	97.0
Mar '99	610	11	98.2	2397	76	96.8
Apr '99	1134	27	97.6	2877	120	95.8
May '99	3974	38	99.0	3163	77	97.6
June '99	4332	15	99.7	3579	74	97.9
July '99	5153	19	99.6	3575	84	97.7
Aug '99	2550	18	99.3	3016	77	97.4
Sept '99	1495	13	99.1	2641	122	95.4
Oct '99	870	13	98.5	2724	89	96.7
Nov '99	851	14	98.4	2807	94	96.7
Dec '99	800	8	99.0	2676	72	97.3
Average	2005	19	99.0	2976	86	97.1
Jan '00	1099	17	98.5	3080	90	97.1
Feb '00	1184	6	99.5	3157	99	96.9
Mar '00	1058	6	99.4	3039	143	95.3
Apr '00	1437	14	99.0	2739	110	96.0
May '00	1342	10	99.3	3040	101	96.7
June '00	1198	19	98.4	2912	122	95.8
July '00	1296	18	98.6	3017	118	96.1
Aug '00	1206	10	99.2	2813	103	96.3

Stripper-NH3N

Sept ' 00	627	7	98.9	2708	156	94.2
Oct ' 00	924	20	97.8	3028	123	95.9
Nov ' 00	1967	20	99.0	3056	107	96.5
Dec ' 00	1489	28	98.1	4055	126	96.9
	1236	15	98.8	3054	117	96.2
Jan ' 01	1269	32	97.5	2999	166	94.5
Feb ' 01	726	16	97.8	3130	109	96.5
Mar ' 01	886	27	97.0	2669	130	95.1
Apr ' 01	1506	3	99.8	3250	72	97.8
May ' 01	1988	3	99.8	3486	102	97.1
June ' 01	2056	4	99.8	3499	111	96.8
July ' 01	1246	9	99.3	3111	106	96.6
Aug ' 01	933	7	99.2	2854	66	97.7
Sept ' 01	7060	294	95.8	10178	411	96.0
Oct ' 01	2505	145	94.2	3602	180	95.0
Nov ' 01	1361	26	98.1	1562	142	90.9
Dec ' 01	1217	27	97.8	1567	121	92.3
	1896	49	98.0	3492	143	95.5
Jan ' 02	1665	17	99.0	1755	97	94.5
Feb ' 02	1880	13	99.3	1902	97	94.9
Mar ' 02	1147	14	98.8	1763	79	95.5
Apr ' 02	769	39	94.9	1920	116	94.0
May ' 02	477	21	95.6	1724	18	99.0
June ' 02	737	13	98.2	2877	79	97.3
July ' 02	654	14	97.9	3020	80	97.4
Aug ' 02	961	9	99.1	3937	173	95.6
Sept ' 02	989	7.0	99.3	3621	117	96.8
Oct ' 02	1632	39	97.6	1769	63	96.4
Nov ' 02						
Dec ' 02	1259	123	90.2	1630	292	82.1
	1106	28	97.3	2356	110	94.8
Jan-03	590	29	95.1	2824	29	99.0
Feb-03	760	54	92.9	3141	42	98.7
Mar-03	739	23	96.9	2263	69	97.0
Apr-03	922	84	90.9	2755	148	94.6
May-03	993	62	93.8	2667	170	93.6
Jun-03	789	2	99.7	2286	106	95.4
Jul-03	1362	8	99.4	2585	94	96.4
Aug-03	1341	15	98.9	2253	86	96.2
Sep-03	1256	12.0	99.0	2024	66	96.7
Oct-03	1109	51	95.4	2149	62	97.1
Nov-03	834	65	92.2	2384	112	95.3
Dec-03	1062	104	90.2	2537	71	97.2
	980	42	95	2489	88	96.4
Jan-04	838	11	98.7	2741	109	96.0
Feb-04	689	13	98	2938	80	97.3
Mar-04	558	7	99	2065	42	98.0
Apr-04	738	4	99	2460	35	98.6
May-04	832	3	100	2725	24	99.1
Jun-04	922	20	98	2802	99	96.5
Jul-04	805	26	97	1833	51	97.2
Aug-04	980	17	98.3	3208	73	97.7

Stripper-NH3N

Sep-04	628	16	97.5	2405	58	97.6
Oct-04	531	5	99.1	2005	97	95.2
Nov-04	662	5	99.2	2333	61	97.4
Dec-05	698	46	93.4	2338	64	97.3
	740	14	98	2488	66	97
Jan-05	716	8	99.0	1844	42	97.7
Feb-05	876	12	98.7	2762	64	97.7
Mar-05	554	11	98.0	1800	54	97.0
Apr-05	1080	7	99.3	2310	54	97.7
May-05	1223	40	96.7	2242	61	97.3
Jun-05	989	19	98.0	2563	63	97.5
Jul-05	894	20	97.7	2853	82	97.1
Aug-05	1218.00	42.10	96.54	2880.00	125.00	95.66
Sep-05	1460.00	17.00	98.84	3218.00	77.00	97.61
Oct-05	1174.00	10.00	99.15	2705.00	57.00	97.89
Nov-05	962.00	6.00	99.38	2025.00	55.00	97.28
Dec-05	967.00	6.00	99.38	1586.00	71.00	95.52
	1009.42	16.51	98.40	2399.00	67.02	97.17
Jan-06	1150.00	5.40	99.53	2620.00	159.00	93.93
Feb-06	1305.00	5.00	99.62	2443.00	184.00	92.47
Mar-06	1035.00	25.00	97.58	2763.00	96.00	96.53
Apr-06	1111.00	14.00	98.74	2355.00	121.00	94.86
May-06	856.00	30.00	96.50	2219.00	68.00	96.94
Jun-06	869.00	10.00	98.85	21730.00	123.00	99.43
Jul-0-6	762.00	7.00	99.08	2453.00	102.00	95.84
Aug-06	872.00	6.60	99.24	14962.00	107.00	99.28
Sep-06	756.00	13.00	98.28	2362.00	94.00	96.02
Oct-06	337.00	16.00	95.25	1063.00	64.00	93.98
Nov-06	557.00	17.00	96.95	946.00	66.00	93.02
Dec-06	858.00	81.00	90.56	1665.00	92.00	94.47
	872.33	19.17	97.52	4798.42	106.33	95.57
Jan-07	1185.00	113.00	90.46	3095.00	213.00	93.12
Feb-07	2072.00	57.00	97.25	8033.00	89.00	98.89
Mar-07	858.00	48.00	94.41	2443.00	109.00	95.54
AVG.						
OVER	1284.46	25.32	97.88	3152.29	90.61	96.76
PERIOD						

g:nh398-Stripper Data

Table 3-3
Secondary System
Influent Waste Loads

Date	AI Flow (MGD)	AI pH (SU)	AI Alk (mg/l)	AI TSS (mg/l)	AI TSS (lb/day)	AI COD (mg/l)	AI COD (lb/day)	AI BOD (mg/l)	AI BOD (lb/day)	AI Tot. Cr (mg/l)	AI Tot. Cr (lb/day)	AI O&G (mg/l)	AI O&G (lb/day)	AI NH_3-N (mg/l)	AI NH_3-N (lb/day)	AI Fluor. (mg/l)	AI Fluor (lb/day)	AI Phenol (mg/l)	AI Phenol (lb/day)	AI Sulfide (mg/l)	AI Sulfide (lb/day)	AI CN (mg/l)	AI CN (lb/day)
Aug-97	3.86	8.3	220	75	2414	495	15935	183	5891	0.020	0.6	32.8	1056	16.9	544	1.59	51	12.8	412	0.6	19	0.081	2.61
Sep-97	3.59	8.1	277	161	4820	881	26378	239	7156	0.020	0.6	43.6	1305	19.6	587	2.51	75	16.3	488	0.8	24	0.099	2.96
Oct-97	3.42	8.3	244	105	2995	1027	29293	266	7587	0.040	1.1	147.9	4219	18.5	528	2.43	69	12.7	362	0.1	3	0.100	2.85
Nov-97	3.30	8.8	272	357	9825	858	23614	213	5862	0.070	1.9	63.0	1734	21.2	583	2.21	61	11.7	322	1.9	52	0.080	2.20
Dec-97	3.78	8.9	247	118	3720	718	22635	200	6305	0.070	2.2	65.2	2055	17.4	549	2.01	63	14.2	448	0.8	25	0.093	2.93
Average	3.59	8.5	252	163	4755	796	23571	220	6560	0.04	1.3	70.50	2074	18.7	558	2.2	64	13.5	406	0.8	25	0.091	2.71
Minimum	3.30	8.1	220	75	2414	495	15935	183	5862	0.02	0.6	32.80	1056	16.9	528	1.6	51	11.7	322	0.1	3	0.080	2.20
Maximum	3.86	8.9	277	357	9825	1027	29293	266	7587	0.07	2.2	147.90	4219	21.2	587	2.5	75	16.3	488	1.9	52	0.100	2.96
Jan-98	5.18	8.4	212	67	2894	435	18793	139	6005	0.04	1.7	29.6	1279	17.0	734	1.5	66	9.0	389	0.1	4	0.054	2.33
Feb-98	4.45	8.6	243	62	2301	744	27612	205	7608	0.04	1.5	62.8	2331	14.9	553	1.8	67	9.4	350	0.2	7	0.056	2.08
Mar-98	5.35	8.3	224	93	4150	695	31010	194	8656	0.07	3.1	37.8	1687	12.5	558	2.9	130	10.1	451	0.1	4	0.042	1.87
Apr-98	4.50	8.2	226	61	2289	984	36930	182	6830	0.03	1.1	23.7	889	9.6	360	2.3	85	12.8	480	0.1	4	0.033	1.24
May-98	4.98	9.4	311	51	2118	533	22137	245	10176	0.02	0.8	29.3	1217	19.0	789	12.6	523	9.5	393	4.2	174	0.017	0.71
Jun-98	4.65	9.8	415	191	7407	664	25751	336	13030	0.03	1.2	34.1	1322	39.8	1543	10.1	392	12.2	473	30.0	1163	0.067	2.60
Jul-98	5.20	8.9	238	69	2992	438	18995	193	8370	0.03	1.3	22.2	963	17.8	772	3.0	130	16.1	698	0.1	4	0.057	2.47
Aug-98	4.31	8.7	321	64	2301	610	21927	245	8807	0.03	1.1	29.9	1075	24.0	863	4.5	160	26.1	938	1.1	40	0.055	1.98
Sep-98	4.50	8.6	215	64	2402	431	16175	136	5104	0.05	1.9	31.2	1171	16.8	631	2.8	107	12.9	484	0.4	15	0.065	2.44
Oct-98	4.50	8.6	230	44	1651	470	17639	169	6343	0.06	2.3	27.9	1047	16.7	627	2.7	101	14.0	525	0.8	30	0.065	2.44
Nov-98	4.24	8.5	282	38	1344	544	19237	199	7037	0.04	1.4	27.8	983	21.7	767	2.9	102	16.6	587	8.5	301	0.058	2.05
Dec-98	3.59	8.3	292	38	1138	814	24372	213	6377	0.04	1.2	42.3	1266	26.8	802	2.4	73	18.2	545	7.1	213	0.146	4.37
Average	4.62	8.7	267	70	2749	614	23381	205	7862	0.04	1.5	33.2	1269	19.7	750	4.1	161	13.9	526	4.4	163	0.060	2.2
Minimum	3.59	8.2	212	38	1138	431	16175	136	5104	0.02	0.8	22.2	889	9.6	360	1.5	66	9.0	350	0.1	4	0.017	0.7
Maximum	5.35	9.8	415	191	7407	984	36930	336	13030	0.07	3.1	62.8	2331	39.8	1543	12.6	523	26.1	938	30.0	1163	0.146	4.4
Jan-99	4.78	9.1	381	43	1714	833	33208	296	11800	0.04	1.6	49.2	1961	34.8	1387	1.92	77	8.0	318	17.8	710	0.051	2.03
Feb-99	4.96	8.8	348	26	1076	534	22090	223	9225	0.05	2.1	12.5	517	28.8	1191	4.38	181	11.7	484	7.5	310	0.049	2.03
Mar-99	4.58	9.4	351	87	3323	561	21429	262	10008	0.04	1.5	17.7	676	39.2	1497	3.61	138	17.0	649	9.1	348	0.082	3.13
Apr-99	4.23	9.2	313	23	811	405	14288	186	6562	0.04	1.4	7.9	279	22.3	787	3.75	132	10.6	374	5.1	180	0.055	1.94
May-99	5.72	10	414	63	3005	449	21419	212	10113	0.05	2.4	8.5	405	16.9	806	3.98	190	9.0	429	6.0	286	0.043	2.05
Jun-99	5.04	8.9	245	29	1219	311	13072	123	5170	0.04	1.7	8.1	340	12.6	530	4.06	171	7.1	300	1.2	50	0.052	2.19
Jul-99	4.27	9.4	293	29	1033	364	12963	161	5733	0.04	1.4	9.5	338	17.2	613	3.65	130	14.8	527	4.2	150	0.059	2.10
Aug-99	3.89	9.5	338	42	1363	486	15767	242	7851	0.03	1.0	30.4	986	24.6	798	2.68	87	18.7	607	3.8	123	0.055	1.78
Sep-99	3.56	9.2	315	24	713	516	15320	220	6532	0.05	1.5	18.1	537	23.4	695	4.77	142	16.1	478	8.1	240	0.33	9.80
Oct-99	4.25	9.5	346	58	2056	624	22118	201	7124	0.05	1.8	74.8	2651	14.6	517	3.85	136	16.0	567	1.9	67	0.142	5.03
Nov-99	3.93	8.7	290	65	2130	761	24943	219	7178	0.05	1.6	105.2	3448	14.0	459	7.10	233	12.5	410	0.1	3	0.078	2.56
Dec-99	4.19	8.8	279	81	2831	758	26488	196	6849	0.09	3.1	80.9	2827	19.8	692	2.70	94	12.2	426	1.7	59	0.111	3.88
Average	4.45	9.21	326	48	1773	550	20259	212	7845	0.05	1.8	35.2	1247	22.4	831	3.87	143	12.8	464	5.5	211	0.09	3.2
Minimum	3.56	8.70	245	23	713	311	12963	123	5170	0.03	1.0	7.9	279	12.6	459	1.92	77	7.1	300	0.1	3	0.04	1.8
Maximum	5.72	10.00	414	87	3323	833	33208	296	11800	0.09	3.1	105.2	3448	39.2	1497	7.10	233	18.7	649	17.8	710	0.33	9.8
Jan-00	4.35	8.8	290	48	1741	478	17341	150	5442	0.10	3.6	43.4	1575	27.6	1001	2.98	108	16.8	609	0.1	4	0.071	2.58
Feb-00	4.54	8.7	256	40	1515	425	16092	155	5869	0.09	3.4	58.2	2204	15.9	602	3.33	126	12.4	470	0.1	4	0.056	2.12
Mar-00	4.26	8.7	358	109	3873	536	19043	265	9415	0.07	2.5	63.3	2249	30.8	1094	4.22	150	6.9	246	2.2	78	0.134	4.76
Apr-00	5.14	8.5	254	94	4030	529	22677	262	11231	0.08	3.4	50.8	2178	13.1	562	3.14	135	8.6	369	0.1	4	0.063	2.70
May-00	5.64	8.5	240	41	1929	222	10442	82	3857	0.07	3.3	11.6	546	11.8	555	3.38	159	7.9	373	0.1	5	0.047	2.21
Jun-00	6.56	9	254	86	4705	254	13896	127	6948	0.06	3.3	19.2	1050	13.4	733	4.55	249	6.5	357	0.1	5	0.091	4.98
Jul-00	4.98	8.8	258	131	5441	350	14537	179	7434	0.09	3.7	36.7	1524	16.8	698	6.39	265	13.0	540	0.1	4	0.05	2.08
Aug-00	4.46	9.2	322	110	4092	577	21462	201	7476	0.12	4.5	28.4	1056	25.0	930	4.64	173	17.0	632	0.3	11	0.087	3.24
Sep-00	4.65	9.2	334	71	2753	433	16792	166	6438	0.07	2.7	38.0	1474	16.5	640	4.51	175	8.8	343	0.15	6	0.055	2.13
Oct-00	3.58	9.5	413	71	2120	559	16690	141	4210	0.07	2.1	40.0	1194	23.6	705	4.91	147	14.6	436	1.0	30	0.074	2.21
Nov-00	4.05	9.1	300	69	2331	496	16753	153	5168	0.06	2.0	45.6	1540	16.9	571	3.46	117	10.8	365	0.9	30	0.057	1.93
Dec-00	4.04	9.6	467	50	1685	532	17925	242	8154	0.07	2.4	8.6	290	23.0	775	5.81	196	12.2	411	5.5	185	0.055	1.85
Average	4.69	8.97	312	77	3018	449	16971	177	6804	0.08	3.1	37.0	1407	19.5	739	4.3	167	11.3	429	0.9	31	0.07	2.7
Minimum	3.58	8.50	240	40	1515	222	10442	82	3857	0.06	2.0	8.6	290	11.8	555	3.0	108	6.5	246	0.1	4	0.05	1.9

Received, Clerk's Office August 1, 2008

Table 3-3
Secondary System
Influent Waste Loads

Date	AI Flow (MGD)	AI pH (SU)	AI Alk (mg/l)	AI TSS (mg/l)	AI TSS (lb/day)	AI COD (mg/l)	AI COD (lb/day)	AI BOD (mg/l)	AI BOD (lb/day)	AI Tot Cr (mg/l)	AI Tot. Cr (lb/day)	AI O&G (mg/l)	AI O&G (lb/day)	AI NH_3-N (mg/l)	AI NH_3-N (lb/day)	AI Fluor. (mg/l)	AI Fluor. (lb/day)	AI Phenol (mg/l)	AI Phenol (lb/day)	AI Sulfide (mg/l)	AI Sulfide (lb/day)	AI CN (mg/l)	AI CN (lb/day)
Maximum	6.56	9.60	467	131	5441	577	22677	265	11231	0.12	4.5	63.3	2249	30.8	1094	6.4	265	17.0	632	5.5	185	0.13	5.0
Jan-01	6.04	9.75	367	81	4080	462	23273	180	9067	0.06	3.0	30.2	1521	19.7	992	5.10	257	10.35	521	0.5	25	0.054	2.72
Feb-01	6.19	9.4	316	60	3097	441	22766	192	9912	0.05	2.6	30.9	1595	16.5	852	1.74	90	7.78	402	0.9	46	0.103	5.32
Mar-01	5.33	9.6	351	112	4979	609	27071	255	11335	0.05	2.2	57.4	2552	18.1	805	2.86	127	6.62	294	0.3	13	0.059	2.62
Apr-01	5.32	9.4	397	92	4082	446	19788	175	7765	0.05	2.2	21.8	967	11.1	492	2.69	119	10.6	470	0.8	35	0.202	8.96
May-01	4.30	8.8	270	56	2008	580	20800	173	6204	0.05	1.8	33.1	1187	15.9	570	4.93	177	11.3	405	0.6	22	0.204	7.32
Jun-01	5.11	9.1	277	72	3068	467	19902	201	8566	0.03	1.3	23.7	1010	17.7	754	4.04	172	13.0	554	2.2	94	0.331	14.11
Jul-01	4.01	8.6	250	64	2140	540	18059	212	7090	0.04	1.3	39.8	1331	22.0	736	3.00	100	13.8	462	1.5	50	0.093	3.11
Aug-01	5.07	8.9	233	31	1311	311	13150	120	5074	0.04	1.7	15.9	672	9.67	409	2.08	88	5.36	227	0.5	21	0.039	1.65
Sep-01	3.73	9.0	255	39	1213	322	10017	104	3235	0.06	1.9	13.1	408	8.37	260	2.51	78	9.39	292	0.6	19	0.046	1.43
Oct-01	4.67	9.2	208	34	1324	258	10049	152	5920	0.03	1.2	14.7	573	12.9	502	1.11	43	17.6	685	0.1	4	0.063	2.45
Nov-01	3.32	9.15	234	71	1966	382	10577	205	5676	0.01	0.3	37.7	1044	20.6	570	1.77	49	12.0	332	0.1	3	0.062	1.72
Dec-01	3.54	8.7	256	77	2273	444	13108	144	4263	0.01	0.3	57.9	1709	15.1	446	3.23	95	17.3	511	0.1	3	0.063	1.86
Average	4.72	9.13	285	66	2629	439	17380	176	7009	0.04	1.6	31.4	1214	15.6	616	3	116	11.3	430	0.7	28	0.11	4.4
Minimum	3.32	8.60	208	31	1213	258	10017	104	3235	0.01	0.3	13.1	408	8.4	260	1	43	5.4	227	0.1	3	0.04	1.4
Maximum	6.19	9.75	397	112	4979	609	27071	255	11335	0.06	3.0	57.9	2552	22.0	992	5	257	17.6	685	2.2	94	0.33	14.1
Jan-02	3.44	9.45	278	43	1234	292	8377	138	3959	0.01	0.3	22.3	640	12.2	350	2.50	72	11.4	327	0.1	3	0.047	1.35
Feb-02	4.34	9.3	297	38	1375	461	16686	153	5538	0.01	0.4	26.7	966	16.5	597	1.65	60	7.6	275	2.1	76	0.071	2.57
Mar-02	5.01	8.6	283	29	1212	380	15878	183	7646	0.01	0.4	11.6	485	14.5	606	1.55	65	7.13	298	0.1	4	0.075	3.13
Apr-02	5.29	8.9	216	43	1897	392	17294	180	7941	0.01	0.4	14.2	626	9.2	406	2.25	99	4.67	206	0.1	4	0.030	1.32
May-02	4.96	8.7	292	236	9762	493	20394	128	5295	0.01	0.4	19.6	811	7.61	315	2.57	106	12.3	509	0.1	4	0.039	1.61
Jun-02	4.60	8.9	298	124	4757	770	29540	194	7443	0.02	0.8	77.1	2958	10.9	418	2.70	104	12.3	472	0.13	5	0.063	2.42
Jul-02	4.80	8.4	262	91	3643	631	25260	179	7166	0.03	1.2	68.3	2734	10.3	412	2.50	100	12.1	484	0.1	4	0.056	2.24
Aug-02	4.72	8.8	278	64	2519	394	15510	119	4684	0.01	0.4	35.3	1390	10.8	425	3.38	133	13.4	527	0.1	4	0.13	5.12
Sep-02	4.16	8.4	334	422	14641	954	33098	213	7390	0.01	0.3	54.1	1877	14.4	500	2.77	96	15.0	520	0.1	3	0.182	6.31
Oct-02	3.92	8.7	402	86	2812	858	28050	246	8042	0.03	1.0	81.4	2661	11.7	383	9.94	325	16.1	526	0.26	9	0.172	5.62
Nov-02	3.17	8.5	408	133	3516	834	22049	173	4574	0.13	3.4	76.5	2022	16.2	428	13.70	362	2.72	72	0.5	13	0.065	1.72
Dec-02	3.68	9.4	660	76	2333	719	22067	273	8379	0.02	0.6	51.0	1565	25.1	770	6.22	191	8.78	269	16.7	513	0.634	19.46
Average	4.34	8.8	334	115	4142	598	21184	182	6505	0.03	0.8	44.8	1561	13	468	4.31	143	10.3	374	1.7	54	0.130	4
Minimum	3.17	8.4	216	29	1212	292	8377	119	3959	0.01	0.3	11.6	485	8	315	1.55	60	2.7	72	0.1	3	0.030	1
Maximum	5.29	9.5	660	422	14641	954	33098	273	8379	0.13	3.4	81.4	2958	25	770	13.70	362	16.1	527	16.7	513	0.634	19
Jan-03	4.51	9.1	483	535	20123	2069	77822	229	8613	0.11	4.1	86.1	3239	24.4	918	5.53	208	10.8	406	3.0	113	0.243	9.14
Feb-03	4.40	9.3	339	194	7119	1144	41980	237	8697	0.02	0.7	121.8	4470	16.8	616	4.72	173	12.7	466	3.9	143	0.443	16.26
Mar-03	5.03	8.8	345	93	3901	722	30288	145	6083	0.02	0.8	53.9	2261	11.7	491	2.53	106	7.63	320	4.0	168	0.605	25.38
Apr-03	4.95	9.2	259	526	21715	556	22953	166	6853	0.01	0.4	44.4	1833	16.5	681	1.82	75	7.93	327	3.1	128	0.371	15.32
May-03	5.79	8.9	260	285	13762	819	39548	172	8306	0.03	1.4	54.4	2627	14.4	695	1.80	87	8.07	390	1.1	53	0.242	11.69
Jun-03	4.62	9.0	237	52	2004	462	17801	186	7167	0.01	0.4	24.7	952	16.0	616	2.18	84	8.46	326	2.3	89	0.551	21.23
Jul-03	5.64	9.4	253	90	4233	282	13265	103	4845	0.01	0.5	6.1	287	10.1	475	2.88	135	6.59	310	2.1	99	0.440	20.70
Aug-03	5.61	9.7	351	142	6644	378	17686	158	7392	0.01	0.5	20.3	950	10.5	491	1.57	73	7.95	372	0.7	33	0.220	10.29
Sep-03	4.16	9.29	304	200	6939	605	20990	180	6245	0.01	0.3	49.7	1724	8.55	297	1.25	43	9.1	315	1.6	56	0.492	17.07
Oct-03	4.18	9.26	297	200	6972	606	21126	183	6380	0.01	0.3	52.3	1823	8.36	291	1.25	44	9.37	327	1.71	60	0.538	18.76
Nov-03	4.19	9.66	315	163.4	5710	457.9	16001	229.6	8023	0.011	0.4	42.6	1489	15.3	535	2.72	95	8.95	313	1.65	58	0.324	11.32
Dec-03	4.79	8.4	310	908	36273	1067	42625	238.8	9540	0.02	0.8	137.3	5485	20.73	828	4.02	161	9.8	391	1.47	59	0.357	14.26
Average	4.82	9.2	313	282	11283	764	30174	186	7345	0.02	0.9	57.8	2262	14	578	2.69	107	8.9	355	2.2	88	0.402	16
Minimum	4.16	8.4	237	52	2004	282	13265	103	4845	0.01	0.3	6.1	287	8	291	1.25	43	6.6	310	0.7	33	0.220	9
Maximum	5.79	9.7	483	908	36273	2069	77822	239	9540	0.11	4.1	137.3	5485	24	918	5.53	208	12.7	466	4.0	168	0.605	25
Jan-04	4.51	8.8	265	47.7	1794	363	13639	154	5792.464	0.01	0.4	13.3	500	14.4	542	3.7	139	8.03	302	1.18	44	0.286	10.8
Feb-04	5.86	9.5	269	46.3	2263	414	20233	155	7575.222	0.01	0.5	34.9	1706	12.04	588	2.2	108	8.5	415	3.3	161	0.319	15.6
Mar-04	5.72	9	218	53	2528	354	16887	138	6583.262	0.02	1.0	8.42	402	10.5	501	1.6	76	8.1	386	1.07	51	0.245	11.7
Apr-04	5.69	9.6	304	65.7	3118	441	20927	215	10202.74	0.012	0.6	13.6	645	8.8	418	2.4	114	8.4	399	6.2	294	0.476	22.6
May-04	5.42	9	277	30.9	1396.8	393	17765	168	7594.07	0.014	0.6	6.61	299	5.98	270	2.4	108	7.87	356	8.7	393	0.622	28.1
Jun-04	5.99	9.1	208	111	5545.2	291	14537	127.9	6389.449	0.01	0.5	20.1	1004	13.3	664	1.24	62	5.4	270	1.01	50	0.331	16.5
Jul-04	5.18	8.9	196	87	3758.5	285	12312	132	5702.558	0.019	0.8	11	475	8.24	356	1.33	57	6.83	295	0.1	4	0.062	2.7

Received, Clerk's Office August 1, 2008

Table 3-3
Secondary System
Influent Waste Loads

Date	AI Flow (MGD)	AI pH (SU)	AI Alk (mg/l)	AI TSS (mg/l)	AI TSS (lb/day)	AI COD (mg/l)	AI COD (lb/day)	AI BOD (mg/l)	AI BOD (lb/day)	AI Tot Cr (mg/l)	AI Tot Cr (lb/day)	AI O&G (mg/l)	AI O&G (lb/day)	AI NH_3-N (mg/l)	AI NH_3-N (lb/day)	AI Fluor (mg/l)	AI Fluor. (lb/day)	AI Phenol (mg/l)	AI Phenol (lb/day)	AI Sulfide (mg/l)	AI Sulfide (lb/day)	AI CN (mg/l)	AI CN (lb/day)
Aug-04	4.56	8.5	248	30	1140.9	261	9925.9	101	3841.07	0.014	0.5	6.8	259	8.9	338	1.57	60	10.8	411	0.12	5	0.072	2.7
Sep-04	4.09	8.8	202	40	1364.4	347	11836	144	4911.926	0.01	0.3	12.1	413	14.2	484	5.29	180	8.4	287	0.32	11	0.177	6.0
Oct-04	3.95	8.4	209	95	3129.6	724	23851	164	5402.652	0.03	1.0	52	1713	11.7	385	5.09	168	7.07	233	0.1	3	0.093	3.1
Nov-04	4.44	8.6	221	174	6443.2	491	18182	184	6813.446	0.016	0.6	60.2	2229	19.3	715	2.01	74	8.3	307	2.6	96	0.488	18.1
Dec-04	5.98	8.5	183	65	3241.8	410	20448	143	7131.868	0.021	1.0	62	3092	19.8	987	1.77	88	8.53	425	0.45	22	0.53	26.4
Average	5.1	8.892	233.3	70.467	2976.9	397.8	16712	152	6495	0.0155	0.7	25	1061	12	521	3	103	8	340	2	95	0.308	14
Minimum	3.95	8.4	183	30	1140.9	261	9925.9	101	3841	0.01	0.3	7	259	6	270	1	57	5	233	0	3	0.062	3
Maximum	5.99	9.6	304	174	6443.2	724	23851	215	10203	0.03	1.0	62	3092	20	987	5	180	11	425	9	393	0.622	28
Jan-05	6.4	8.8	248	38.4	2049.6	350	18682	152	8113.152	0.019	1.0	12.2	651	7.96	425	1.05	56	8.6	459	0.22	12	0.303	16.2
Feb-05	5.83	9.4	260	61.2	2975.7	422	20519	188	9140.974	0.02	1.0	10.9	530	9.68	471	1.91	93	8.4	408	1.30	63	0.2	9.7
Mar-05	5.47	9	245	70	3193.4	388	17700	171	7800.986	0.03	1.4	16.2	739	12.18	556	1.76	80	7.8	356	0.42	19	0.223	10.2
Apr-05	6.31	9.3	224	87	4578.4	479	25208	148	7788.559	0.026	1.4	42.9	2258	7.64	402	2.08	109	8.6	453	0.20	11	0.217	11.4
May-05	4.26	9.8	219	127	4512.1	445	15810	199	7070.152	0.019	0.68	19.6	696	14.3	508	1.78	63	13.2	469	0.80	28	0.329	11.7
Jun-05	4.90	9.5	229	64	2615.4	508	20760	182	7437.612	0.014	0.6	37	1512	12.87	526	2.09	85	8.8	360	0.63	26	0.399	16.3
Jul-05	5.50	9.00	225	357	16376	812	37246	185	8485.95	0.015	0.7	48	2201.8	13	596	1.64	75	9.12	418	0.097	4	0.14	6.4
Aug-05	4.67	8.5	208	498	19396	1032	40194	187	7283.239	0.014	0.5	57.4	2235.6	12.15	473	1.6	62	9.48	369	0.1	4	0.185	7.2
Sep-05	4.15	9	210	393	13602	984	34057	188	6506.868	0.02	0.7	76.7	2654.7	15.04	521	1.96	68	11.02	381	0.1	3	0.13	4.5
Oct-05	4.01	9.1	192	201	6722.1	793	26521	154	5150.284	0.022	0.7	65.1	2177.2	13.01	435	1.7	57	10.2	341	0.195	7	0.18	6.0
Nov-05	2.67	8.7	184	98	2182.2	460	10243	164	3651.919	0.013	0.3	20	445.36	13.91	310	1.49	33	12.22	272	0.111	2	0.207	4.6
Dec-05	5.24	8.4	197	148	6467.8	850	37146	173	7560.377	0.014	0.6	53.2	2324.9	12.84	561	1.52	66	11.05	483	0.204	9	0.242	10.6
Average	4.95	9	220	179	7056	627	25341	174	7166	0.019	1	38	1535	12.05	482	2	71	9.87	397	0	16	0.230	10
Minimum	2.67	8	184	38	2050	350	10243	148	3652	0.013	0	11	445	7.64	310	1	33	7.80	272	0	2	0.130	4
Maximum	6.40	10	260	498	19396	1032	40194	199	9141	0.030	1	77	2655	15.04	596	2	109	13.20	483	1	63	0.399	16
Jan-06	5.67	9.4	263	86	4066.8	535	25299	179	8464.5	0.011	0.5	38.5	1820.6	16.2	766.1	1.3	61	9.8	463.4	0.181	8.6	0.216	10.2
Feb-06	5.45	9.5	229	141	6408.9	804	36544	169	7681.6	0.02	0.9	75	3409	12.7	577.3	1.31	60	10.6	481.8	0.37	16.8	0.277	12.6
Mar-06	5.68	8.6	195	71	3363.4	979	46376	121	5731.9	0.012	0.6	38	1800.1	16	757.9	1.87	89	7.4	350.5	0.1	4.7	0.145	6.9
Apr-06	5.63	8.3	204	105	4930.2	708	33244	126	5916.2	0.022	1.0	40	1878.2	15.15	711.4	3.1	146	7.43	348.9	0.149	7.0	0.311	14.6
May-06	4.94	9.1	301	129	5314.7	698	28757	212	8734.3	0.015	0.6	135	5561.9	24.4	1005.3	4.3	177	7.81	321.8	0.877	36.1	0.34	14.01
Jun-06	4.91	8.9	396	484	19820	1344	55036	173	7084.2	0.02	0.8	103	4217.8	14.64	599.5	2.58	106	9.19	376.3	0.13	5.3	0.27	11.1
Jul-06	4.73	9	281	352	13886	1096	43235	188	7416.3	0.02	0.8	135	5325.5	17.4	686.4	3.24	128	8.09	319.1	0.15	5.9	0.3	11.8
Aug-06	5.38	8.2	226	305	13685	734	32934	151	6775.2	0.013	0.6	103	4621.5	19.86	891.1	2.13	96	8.74	392.2	0.111	5.0	0.272	12.2
Sep-06	6.11	8.6	208	108	5503.4	644	32817	166	8458.9	0.011	0.6	77	3923.7	17.29	881.1	2.47	126	9.28	472.9	0.464	23.6	0.225	11.5
Oct-06	5.22	8.3	184	56	2437.9	455	19808	136	5920.7	0.019	0.8	17	740.09	12.2	531.1	4.52	197	2.77	120.6	0.1	4.4	0.119	5.2
Nov-06	4.48	9.5	272	690	25781	795	29704	232	8668.262	0.01125	0.42	56	2092.3	11.91	445.0	5.28	197	2.944	110.0	0.1	3.7	0.093	3.5
Dec-06	6.7	9.25	285	84.5	4721.7	532	29727	182	10169.8	0.015	0.84	45	2514.5	22.14	1237.14	1.69	94.4338	9.17	512.4	0.99	55.31922	0.273	15.255
Average	5.41	9	254	218	9160	777	34457	170	7585	0.016	0.71	72	3159	16.7	757	3	123	8	356	0	15	0.237	11
Minimum	4.48	8	184	56	2438	455	19808	121	5732	0.011	0.42	17	740	11.9	445	1	60	3	110	0	4	0.093	3
Maximum	6.7	10	396	690	25781	1344	55036	232	10170	0.022	1.03	135	5562	24.4	1237	5	197	11	512	1	55	0.34	15
Jan-07	5.7	9.3	329	129	6132.4	656	31185	256	12169.7	0.01	0.475	54	2567.1	36.3	1725.63	1.98	94	9.8	465.9	4.57	217.2	0.527	25.053
Feb-07	5.1	9.2	297	46.5	1977.8	931	39599	186	7911.3	0.011	0.468	30.9	1314.3	40.12	1706.46	1.86	79	10.3	438.1	5.48	233.1	0.367	15.61
Mar-07	6.52	9.2	243	138	7504	783	42577	82	4458.898	0.016	0.870029	124	6742.7	23	1250.67	1.25	67.971	7.93	431.208	2.75	149.5362	0.242	13.159
							0		0		0		0		0		0		0		0		0
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This data was analyzed statistically to determine the occurrence probability for flow and pollutants based on the crude production rate of the refinery. The statistical analysis utilized the data from August 1997 to March 2007. However, the data for the period August 2001 through December 2002 were not included in this analysis because the crude unit was out of service. Therefore, the waste loads were not typical during this period.

The statistically determined 90 percentile occurrences were utilized to estimate average monthly conditions, and the 95 percentile occurrences were utilized to develop maximum daily conditions. The production based flow values (in gal/bbl) and pollutant loads (in lb/1000 bbl) were multiplied by 170,341 bbl/day, the maximum monthly crude charge observed during this period, to determine design conditions for the refinery WWTP. The statistical analysis of this data is included in Appendix B. A summary of the data is presented in Table 3-4.

Based on our analyses of the production based flow data, the refinery had reduced water usage and even with the changes in production and crude quality, the refinery has maintained the reduced water usage.

These data show that TSS, oil and grease and COD wasteloads have increased by greater than 60% as compared to historical data. These results are consistent with the increased usage of heavy crudes. The increased COD and TSS loads place an increased stress on the wastewater treatment plant and require more extensive operation in order to maintain effluent quality and comply with the effluent regulations. The BOD is lower; however, the higher COD is expected to result in a much slower to degrade organic component and requirements for tighter wastewater treatment plant operation in order to achieve effluent quality criteria is needed.

TABLE 3-4

SUMMARY OF DESIGN WASTEWATER LOADINGS

	Design Monthly Average Loading		Design Monthly Average Loading	
Parameter	**lb/1,000 bbl[1]**	**lb/day**	**lb/1,000 bbl[2]**	**lb/day**
Flow	39[3]	6.64[4]	42[3]	7.15[4]
BOD_5	59	10,050	63	10,731
TSS	41	6,984	46	7,835
O&G	19	3,236	22	3,748
COD	232	39,519	255	43,437
NH_3	6.25	1,065	7	1,192
Phenol	3.45	588	3.7	630
Sulfide	0.6	102	0.71	121
Fluoride	1.2	204	1.34	228

NOTE: Crude Charge = 170,341 bbl/day

(1) 90 percentile occurrence

(2) 95 percentile occurrence

(3) gal/bbl

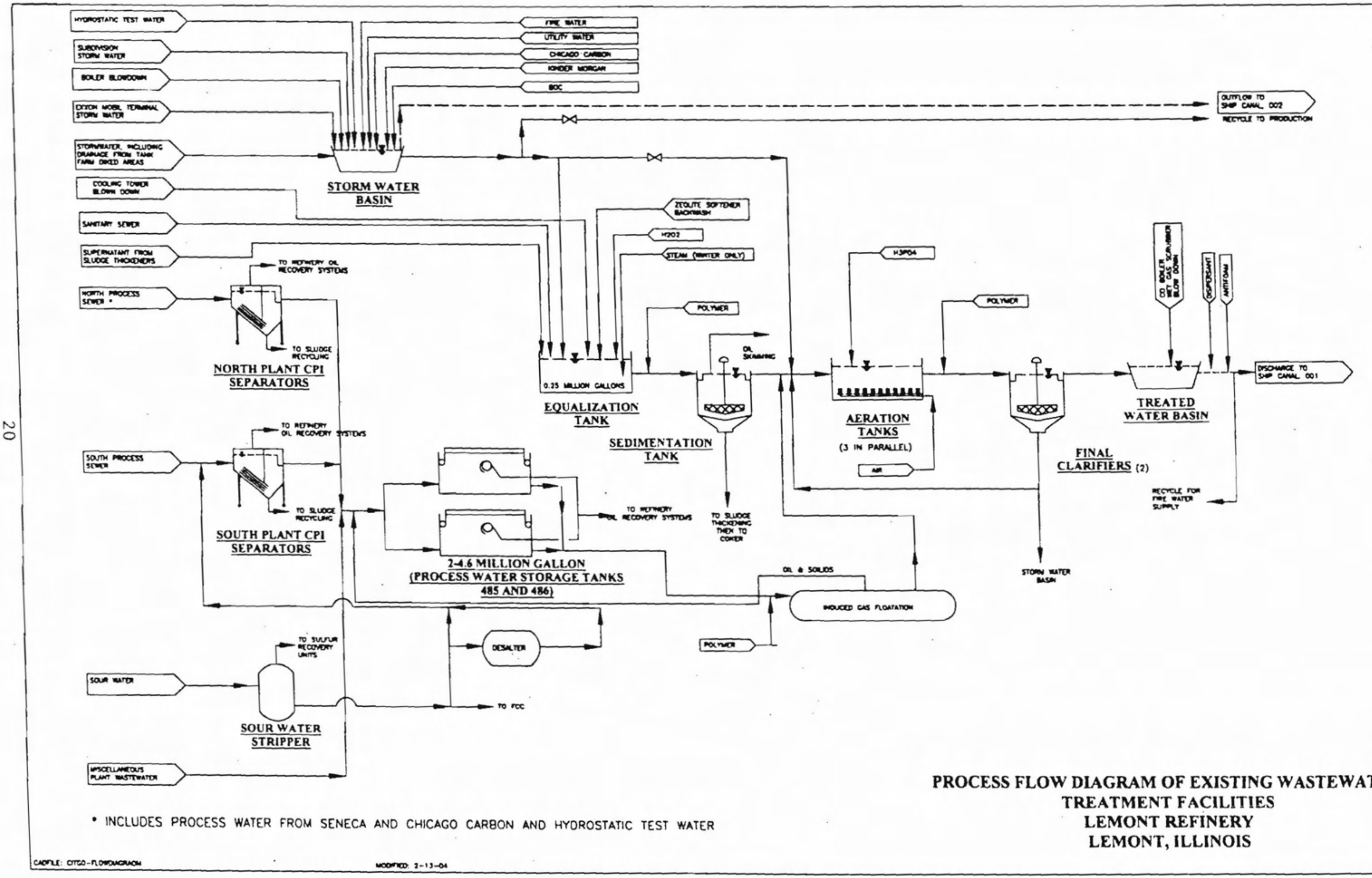
(4) MGD

3.2 CURRENT WASTEWATER COLLECTION AND TREATMENT SYSTEM

The refinery has an extensive wastewater collection and treatment system. This system has continued to be upgraded and improved. Figure 3-1 shows the Process Flow Diagram for Lemont Refinery wastewater treatment system. A process design summary of the system is presented in Table 3-5. This section presents a review of the specific components of the facility.

Separate collection systems for the process and non-process wastewaters have been developed. The process wastewaters from the north plant and south plant areas of the refinery are collected separately and can be pretreated in separate corrugated plate interceptors (CPI) for removal of free oils and settleable solids. Cyanide and non-cyanide sour waters are stripped separately and then combined with the south plant area process wastewaters upstream of the south plant CPI separators. Stormwater and non-process wastewater from the refinery are collected and directed into a 52 million gallon (MG) stormwater basin. This stormwater basin provides in excess of 14 days equalization capacity.

The discharge from the north plant and the south plant areas is pumped to two (2) 4.6 MG process wastewater storage tanks (TK485 and TK486). These tanks, which replaced a single 2 MG tank (Tank 114), were put in service in early 1993. These tanks provide approximately five (5) days of equalization capacity. The tanks are equipped with floating roofs with oil skimmers and provide removal of free oils and settleable solids. The tanks are operated in parallel and provide adequate capacity to allow shutdown and servicing of either of the tanks without disruption of the treatment process. In 2000, the refinery installed an induced gas floatation (IGF) system to treat the discharge from tanks 485 and 486. The induced gas floatation system induces gas bubbles into the chemically treated process stream. This allows floatation and skimming of the oil and suspended solids. The objective of the IGF is to remove insoluble oil/organics and suspended solids. This allows this stream to go directly to the activated sludge system.



PROCESS FLOW DIAGRAM OF EXISTING WASTEWAT[ER]
TREATMENT FACILITIES
LEMONT REFINERY
LEMONT, ILLINOIS

Figure 3-1

TABLE 3-5

PROCESS DESIGN SUMMARY EXISTING WASTEWATER TREATMENT PLANT

Unit	Plant Configuration
Stormwater Basin	
Capacity, MG	52.0
Process Wastewater Storage Tank (TK485 & TK486)	
No. Units	2
Capacity (each), MG	4.6
Total Detention Time, days	4.2
Induced Gas Flotation	
Vessels	1
Outside Diameter (ft)	10
Length (ft)	30
Operating Pressure (psig)	12
Temperature (°F)	85-130
Equalization Tank	
Capacity, gal	250,000
Depth, ft	16
Detention Time, @ 6.0 MGD, hrs	1.0
Sedimentation Tank	
Diameters, ft	100
Side Water Depth, ft	16
Surface Area, sq ft	7,850
Overflow Rate, @ 6.0 MGD, gpd/sq ft	764
Aeration Tanks	
No. of Tanks	3
Total Volume, MG	1.92
Depth, ft	12
Detention Time, @ 6.0 MGD, hrs	7.7
Aeration	
Number of Blowers (2 on-line, 1 spare)	3
Horsepower, each	300
Total Horsepower Applied	600
Air Flow Rate, each, scfm	5,500
Discharge Pressure, psig	7.0
Total Operating Capacity, scfm	10,000
Final Clarifier(s)	
Total Number	2
Diameter, ft	100
Side Water Depth, ft	14
Surface Area, sq ft (each unit)	7,854
Overflow Rate, @ 6.0 MGD, gpd/sq ft	382
Treated Water Basin	
Capacity, MG	16

This modification has reduced the wasteload to the equalization basin and the sedimentation tank. The 0.25 MG equalization tank still receives the cooling tower blow down, sanitary sewer discharge, supernatant from sludge thickeners and the Zeolite softener backwash.

Stormwater is pumped from the stormwater basin into the equalization tank where it is mixed with these streams, or it can be by-passed around the equalization tank and added directly to the aeration basins. The combined equalization provided by the 9.2 MG in process wastewater storage tanks, the 52 MG stormwater basin and the 0.25 MG equalization tank allows the process wastewater and stormwater additions to the treatment plant to be controlled and regulated to obtain the best performance through the WWTP.

To provide optimum conditions for ammonia nitrogen removal in the winter, stream is injected into the equalization tank. The stream addition is provided to maintain aeration basin operating temperatures of greater than 70°F. Since 1997, the minimum monthly average aeration basin temperature has been over 73°F.

The combined wastewaters flow to a single stage activated sludge treatment system which includes three (3) aeration basins operated in parallel with a total aeration basin volume of 1.92 MG. Aeration is provided by a fine-bubble diffused aeration system. Phosphorus is added to the aeration basins as a nutrient for the biological organisms. The activated sludge is settled in one of the two 100 ft diameter secondary clarifiers.

Because of air pollution regulations, the refinery has installed a scrubber on the carbon monoxide boiler associated with the Fluid Catalytic Cracker (FCC) unit. This unit began operation in October 2007. The purge stream from this unit is treated in a new physical-chemical treatment system as shown in Figure 3-2. This purge treatment unit (PTU) is designed to handle 300 gpm and this stream can contain an elevated ammonia nitrogen discharge. Therefore, a breakpoint chlorination-dechlorination system has been

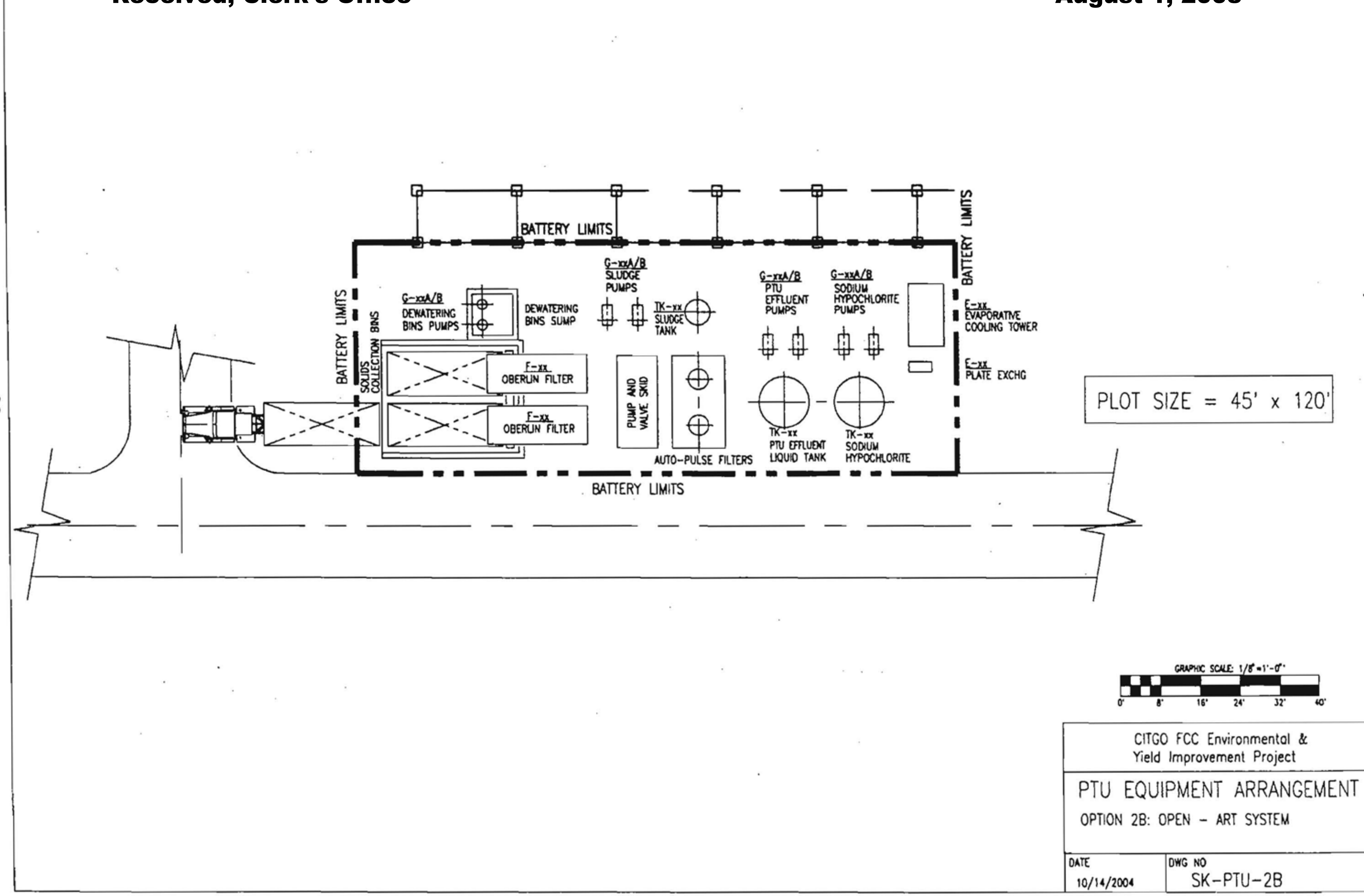


Figure 3-2
PTU Treatment System

installed to treat the ammonia nitrogen in this discharge. As shown in Figure 3-1, this stream discharges to the treated water basin where it is combined with the discharge from the activated sludge system. The purge stream is inorganic and high in total dissolved solids and is not compatible with a biological treatment system.

The tertiary treatment system consists of a 16 million gallon polishing lagoon known as the Treated Water Basin (TWB). The purpose of the TWB is to provide additional settling of any carryover solids from the secondary clarifier and provide further BOD_5 reduction. The TWB serves as a holding/polishing pond. This water can be recycled to the refinery for fire protection. The treated effluent from the TWB is discharged to the Chicago Sanitary and Ship Canal.

Our analysis of Lemont Refinery's wastewater treatment system indicates that it exceeds the BAT technology for wastewater treatment as presented in the 1982 U.S. EPA "Development Document". The BAT criteria used as the basis for the U.S. EPA effluent limitations guidelines are compared with the refinery wastewater treatment system in Table 3-6. As shown in Table 3-6 the refinery treatment system contains all of the BAT components outlined by U.S. EPA. In addition to complying with the U.S. EPA model technology, the facility has continually made improvements and upgrades to its wastewater management program to reduce effluent ammonia and improve the overall performance of the treatment system. A summary of the improvements and upgrades from 1997 to present is presented in Table 3-7. This program represents a total expenditure in excess of $45,000,000. Based on the continued compliance with the effluent criteria and improvements in effluent quality, it appears that these improvements and upgrades have been successful.

3.3 COMPARISON OF LEMONT REFINERY'S WASTEWATER TREATMENT PERFORMANCE WITH BAT

To determine if the performance of the treatment system is consistent with BAT, an analysis of the treatment plant data was conducted. A detailed review of the WWTP performance data for the period August 1997 to March 2007 was conducted. The secondary system operations data and final effluent data are presented in Table 3-8.

TABLE 3-6

COMPARISON OF BAT GUIDELINES WITH LEMONT REFINERY'S WASTEWATER TREATMENT SYSTEM

BAT Guidelines	Lemont Refinery System
• Sour water strippers	• Sour water strippers provide in excess 96.5% average ammonia removal efficiency
• Flow equalization	• Two (2) 4.6 MG process wastewater storage tanks providing approximately 4.2 day equalization capacity in addition to a 52 MG stormwater capacity which provide 14 days equalization and a 0.25 MG equalization tank
• Initial oil and solids removal	• CPI separators • Additional oil and solids removal in the two 4.6 MG process wastewater storage tanks
• Additional oil and solids removal	• 100 ft diameter primary clarifier with polymer addition • Induced gas flotation
• Biological treatment	• Single-stage activated sludge system
• Filtration or other final polishing	• 16 MG final polishing pond

TABLE 3-7

SUMMARY OF WASTE TREATMENT MODIFICATIONS/UPGRADES

1997-2007(1)

Year	Project
2000	Installed induced gas flotation system with polymer addition to remove insoluble oil/organics and suspended solids from the process water storage tank discharge.
2003	Added additional strippers in the sour water system for ammonia removal.
2003	Upgrade of Sanitare diffused aerators to improve oxygen transfer – Cell B.
2006	Upgrade phosphoric acid feed system to optimize the performance of nitrifying organisms.
2006	Upgrade of Sanitare diffused aerators to improve oxygen transfer – Cell A.
2007	Installing purge treatment unit (PTU) to treat the discharge from the FCC wet gas scrubber air pollution control project. The treatment unit includes wastewater filtration, solids dewatering, breakpoint chlorination/dechlorination, heat exchanger, and evaporative cooling tower.
2007	Upgrade of Sanitare diffused aerators to improve oxygen transfer – Cell C.

Table 3-8
Secondary System
Operating History

Date	Al Flow (MGD)	Aer Basin TSS mg/l	Aeration Volatile Fraction	Aer Tk Temp °F	R Sludge TSS mg/l	Ave Sludge Wasted MGD	Sludge Wasted gpm	Ave Sludge Wasted lb/day	Basin DO (AE)	Detention Time days	Aer Inf BOD	F/M 1 day	Sludge Age Days	Clar pH (SU)	Clar Alk mg/l	Clar TSS mg/l	Clar TSS #/day	Clar COD mg/l	Clar COD #/day	Clar BOD mg/l	Clar BOD #/day	Clar NH_3-N mg/l	Clar NH_3-N #/day	Clar Tot CN mg/l	Clar Tot CN #/day	Clar Phenol mg/l	Clar Phenol #/day	Final BOD #/day	Final TSS #/day
Aug-97	3.86	5958	0.73	91	15213	4.41E-02	30.6	5591	4.0	0.50	183	0.06	14	7.4	105	34	1095	85	2736	6.7	216	0.50	16.1	0.020	0.6	0.03	1.0	186	371
Sep-97	3.59	6803	0.77	85	16612	4.59E-03	3.19	636	3.7	0.53	239	0.07	75	7.4	132	27	808.4	76	2275	8.5	254	5.01	150.0	0.021	0.6	0.035	1.0	215	343
Oct-97	3.42	8560	0.80	85	25756	5.04E-03	3.50	1083	2.7	0.56	266	0.06	51	7.4	128	56	1597	108	3080	7.2	205	5.00	142.6	0.028	0.8	0.078	2.2	186	336
Nov-97	3.30	7942	0.79	87	21962	8.21E-04	0.57	150	3.0	0.58	213	0.05	162	7.5	109	23	633	103	2835	13.3	366	0.52	14.3	0.027	0.7	0.076	2.1	174	349
Dec-97	3.78	8165	0.79	86	21076	1.15E-04	0.08	20	3.6	0.51	200	0.05	222	7.4	149	18	567.5	78	2459	6.0	189	0.48	15.1	0.025	0.8	0.05	1.6	125	377
Average	3.59	7486	0.78	87	20124	1.09E-02	7.59	1496	3	0.54	220	0.06	84	7.42	125	32	940	90	2677	8	246	2.3	67.6	0.024	0.7	0.054	1.6	177	355
Minimum	3.30	5958	0.73	85	15213	1.15E-04	0.08	20	3	0.50	183	0.05	14	7.40	105	18	567	76	2275	6	189	0.5	14.3	0.020	0.6	0.030	1.0	125	336
Maximum	3.86	8560	0.80	91	25756	4.41E-02	30.6	5591	4	0.58182	266	0.066	222	7.5	149	56	1597	108	3080	13	366	5.0	150.0	0.028	0.8	0.078	2.2	215	377
Jan-98	5.18	7883	0.78	85	28677	1.32E-03	0.92	317	3.7	0.37	139	0.05	107	7.3	122	20	864	82	3542	4.8	207	0.39	16.8	0.019	0.8	0.083	3.6	180	294
Feb-98	4.45	10244	0.78	82	28704	1.41E-03	0.98	338	3.9	0.43	205	0.05	116	7.4	153	29	1076	89	3303	7.4	275	0.68	25.2	0.018	0.7	0.057	2.1	168	439
Mar-98	5.35	10060	0.77	83	24161	7.20E-05	0.05	15	3.6	0.36	194	0.05	132	7.3	147	27	1205	81	3614	12.7	567	0.3	13.4	0.011	0.5	0.053	2.4	245	231
Apr-98	4.50	10782	0.77	84	33338	8.06E-05	0.056	22	2.6	0.43	182	0.04	113	7.4	139	40	1501	140	5254	12.2	458	1.09	40.9	0.023	0.9	0.112	4.2	443	653
May-98	4.98	8706	0.77	85	21455	3.30E-03	2.29	590	2.8	0.39	245	0.07	71	7.5	114	33	1371	119	4942	10.7	444	3.94	163.6	0.013	0.5	0.067	2.8	326	696
Jun-98	4.65	7974	0.8	89	22549	4.55E-03	3.16	856	2.1	0.41	336	0.10	47	7.5	111	48	1861	107	4150	21.4	830	2.47	95.8	0.019	0.7	0.061	2.4	522	485
Jul-98	5.20	8836	0.78	95	27605	1.09E-04	0.076	25	3.9	0.37	193	0.06	107	7.6	115	30	1301	88	3816	8.1	351	0.24	10.4	0.012	0.5	0.071	3.1	322	629
Aug-98	4.31	7994	0.79	95	21044	1.02E-04	0.071	18	2.6	0.45	245	0.07	95	7.5	119	37	1330	120	4313	7.8	280	0.67	24.1	0.011	0.4	0.057	2.0	185	527
Sep-98	4.50	8842	0.78	91	20766	1.21E-04	0.084	21	3.9	0.43	136	0.04	148	7.4	103	25	938.3	101	3791	6.9	259	0.63	23.6	0.009	0.3	0.04	1.5	139	410
Oct-98	4.50	7411	0.78	84	20416	1.28E-04	0.089	22	4.0	0.43	169	0.05	161	7.4	109	19	713.1	81	3040	3.0	113	0.38	14.3	0.011	0.4	0.045	1.7	107	382
Nov-98	4.24	7122	0.8	76	19118	9.79E-05	0.068	16	3.1	0.45	199	0.06	96	7.2	107	33	1167	103	3642	11.0	389	1.11	39.3	0.016	0.6	0.062	2.2	243	418
Dec-98	3.59	10325	0.82	77	23113	8.52E-04	0.592	164	2.8	0.53	213	0.04	133	7.1	97	36	1078	105	3144	9.1	272	0.62	18.6	0.039	1.2	0.049	1.5	204	287
Average	4.62	8848	0.79	86	24246	1.01E-03	0.70	200	3.3	0.42	205	0.06	111	7.38	120	31	1200	101	3879	9.59	370	1.0	40.5	0.017	0.6	0.063	2.4	257	454
Minimum	3.59	7122	0.77	76	19118	7.20E-05	0.05	15	2.1	0.36	136	0.04	47	7.10	97	19	713	81	3040	3.00	113	0.2	10.4	0.009	0.3	0.040	1.5	107	231
Maximum	5.35	10782	0.82	95	33338	4.55E-03	3.16	856	4.0	0.53	336	0.10	161	7.6	153	48	1861	140	5254	21.4	830	3.9	163.6	0.039	1.2	0.112	4.2	522	696
Jan-99	4.78	8586	0.85	76	23693	5.77E-03	4.01	1141	2.1	0.40	296	0.09	44	7.3	142	50	1993	176	7016	38.2	1523	26.8	1068	0.056	2.2	0.182	7.3	230	282
Feb-99	4.96	5786	0.85	81	16227	9.07E-05	0.06	12	6.1	0.39	223	0.10	48	7.2	100	46	1903	136	5626	16.8	695	3.52	145.6	0.017	0.7	0.063	2.6	271	529
Mar-99	4.58	4702	0.88	84	13396	4.81E-03	3.34	537	5.4	0.42	262	0.13	21	7.2	116	79	3018	113	4316	14.8	565	0.88	33.6	0.022	0.8	0.024	0.9	299	438
Apr-99	4.23	4146	0.84	85	11296	1.96E-03	1.36	184	7.6	0.45	186	0.10	34	7.2	104	50	1764	154	5433	10.7	377	0.64	22.6	0.017	0.6	0.016	0.6	349	321
May-99	5.72	4900	0.84	88	12848	7.92E-05	0.06	8	6.3	0.34	212	0.13	125	7.5	118	13	620	66	3149	6.5	310	0.76	36.3	0.012	0.6	0.023	1.1	409	461
Jun-99	5.04	5099	0.79	91	13757	9.99E-04	0.69	115	6.3	0.38	123	0.06	76	7.4	133	23	967	61	2564	6.4	269	0.76	31.9	0.009	0.4	0.015	0.6	333	442
Jul-99	4.27	5315	0.78	98	15292	1.08E-04	0.08	14	5.3	0.45	161	0.07	130	7.5	121	18	641	77	2742	5.9	210	0.85	30.3	0.011	0.4	0.021	0.7	243	511
Aug-99	3.89	5279	0.79	97	13970	8.58E-04	0.60	100	5.4	0.49	242	0.09	104	7.7	122	22	714	64	2076	12.5	406	0.87	28.2	0.012	0.4	0.027	0.9	305	431
Sep-99	3.56	5698	0.82	93	15092	1.05E-03	0.73	132	4.3	0.54	220	0.07	176	7.6	110	13	386	62	1841	9.6	285	2.55	75.7	0.010	0.3	0.023	0.7	392	494
Oct-99	4.25	6684	0.82	82	16139	7.57E-04	0.53	102	5.9	0.45	201	0.07	169	7.8	150	15	532	88	3119	11.1	393	2.33	82.6	0.027	1.0	0.056	2.0	238	420
Nov-99	3.93	8665	0.80	80	28688	2.00E-03	1.39	479	3.8	0.49	219	0.05	67	7.4	161	49	1606	189	6195	26.4	865	2.17	71.1	0.012	0.4	0.132	4.3	371	597
Dec-99	4.19	10993	0.85	74	28704	6.00E-04	0.42	144	3.2	0.46	196	0.04	68	7.4	180	70	2446	204	7129	22.5	786	24.6	859.6	0.021	0.7	0.119	4.2	191	684
Average	4.45	6321	0.83	86	17425	1.59E-03	1.10	247	5.1	0.44	212	0.08	88	7.4	130	37	1382	116	4267	15.1	557	5.6	207	0.019	0.7	0.058	2.2	303	468
Minimum	3.56	4146	0.78	74	11296	7.92E-05	0.06	8	2.1	0.34	123	0.04	21	7.2	100	13	386	61	1841	5.9	210	0.6	23	0.009	0.3	0.015	0.6	191	282
Maximum	5.72	10993	0.88	98	28704	5.77E-03	4.01	1141	7.6	0.54	296	0.133	176	7.8	180	79	3018	204	7129	38.2	1523	26.8	1068	0.056	2.2	0.182	7.3	409	684
Jan-00	4.35	7048	0.87	83	24334	6.52E-04	0.45	132	4.8	0.44	150	0.05	65	7.2	148	44	1596	120	4353	13.6	493	3.79	137.5	0.016	0.6	0.058	2.1	251	578
Feb-00	4.54	8077	0.87	85	22700	2.15E-03	1.50	408	5.5	0.42	155	0.05	84	7.2	135	30	1136	90	3408	18.8	712	1.9	71.9	0.010	0.4	0.097	3.7	441	789
Mar-00	4.26	8091	0.84	86	23299	5.31E-04	0.37	103	4.2	0.45	265	0.07	104	7.4	162	32	1137	96	3411	12.5	444	4.39	156.0	0.039	1.4	0.071	2.5	362	724
Apr-00	5.14	9914	0.79	82	23853	1.80E-02	12.48	3575	5.0	0.37	262	0.07	33	7.2	177	28	1200	122	5230	12.6	540	1.17	50.2	0.010	0.4	0.055	2.4	444	703
May-00	5.64	6382	0.77	85	22947	1.60E-02	11.11	3062	6.0	0.34	82	0.04	26	7.2	129	20	941	94	4422	7.8	367	0.32	15.1	0.009	0.4	0.057	2.7	332	591
Jun-00	6.56	6325	0.70	85	19925	1.48E-02	10.29	2462	6.5	0.29	127	0.07	26	7.3	129	26	1422	98	5362	7.6	416	5.49	300.4	0.103	5.6	0.033	1.8	652	883
Jul-00	4.98	8126	0.70	92	17820	2.76E-02	19.14	4096	6.5	0.39	179	0.06	26	7.5	144	23	955	80	3323	5.6	233	0.81	33.6	0.008	0.3	0.044	1.8	413	1047
Aug-00	4.46	6660	0.70	93	23469	2.65E-02	18.41	5189	6.3	0.43	201	0.07	18	7.5	148	22	818	85	3162	10.5	391	1.2	44.6	0.009	0.3	0.050	1.9	277	491
Sep-00	4.65	4284	0.77	88	27835	1.26E-02	8.76	2928	7.7	0.41	166	0.09	19	7.4	129	20	776	75	2909	7.3	283	0.93	36.1	0.006	0.2	0.029	1.1	255	425
Oct-00	3.58	3877	0.78	88	21347	1.45E-02	10.09	2587	7.8	0.54	141	0.07	20	7.4	145	19	567	66	1971	6.5	194	0.65	19.4	0.005	0.1	0.036	1.1	174	189
Nov-00	4.05	4528	0.80	86	17499	1.63E-02	11.35	2385	6.3	0.47	153	0.07	15	7.2	164	73	2466	72	2432	7.7	260	0.66	22.3	0.006	0.2	0.035	1.2	240	285
Dec-00	4.04	4845	0.84	85	19577	9.57E-03	6.65	1562	6.9	0.48	242	0.11	31	7.2	167	29	977	113	3807	11.7	394	7.26	244.6	0.012	0.4	0.040	1.3	346	456
Average	4.69	6513	0.79	87	22050	1.33E-02	9.22	2374	6.1	0.42	177	0.07	39	7.3	148	31	1166	93	3649	10.2	394	2.4	94.3	0.019	0.9	0.050	2.0	349	597
Minimum	3.58	3877	0.70	82	17499	5.31E-04	0.37	103	4.2	0.29	82	0.04	15	7.2	129	19	567	66	1971	5.6	194	0.3	15.1	0.005	0.1	0.029	1.1	174	189
Maximum	6.56	9914	0.87	93	27835	2.76E-02	19.14	5189	7.8	0.54	265	0.11	104	7.5	177	73	2466	122	5362	18.8	712	7.3	300.4	0.103	5.6	0.097	3.7	652	1047
Jan-01	6.04	4030	0.84	81	21461	2.79E-03	1.94	500	5.8	0.32	180	0.14	43	7.7	192	20	1007	60	3022	6.7	338	1.41	71.0	0.007	0.4	0.021	1.1	256	468

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Table 3-8
Secondary System
Operating History

Date	Al Flow (MGD)	Aer Basin TSS mg/l	Aeration Volatile Fraction	Aer Tk Temp °F	R Sludge TSS mg/l	Ave Sludge Wasted MGD	Sludge Wasted gpm	Ave Sludge Wasted lb/day	Basin DO (AE)	Detention Time days	Aer Inf BOD	F/M 1/day	Sludge Age Days	Clar pH (SU)	Clar Alk mg/l	Clar TSS mg/l	Clar TSS #/day	Clar COD mg/l	Clar COD #/day	Clar BOD mg/l	Clar BOD #/day	Clar NH_3-N mg/l	Clar NH_3-N #/day	Clar Tot. CN mg/l	Clar Tot CN #/day	Clar Phenol mg/l	Clar Phenol #/day	Final BOD #/day	Final TSS #/day
Feb-01	6.19	4325	0.82	80	23067	2.45E-02	16.99	4707	7.1	0.31	192	0.14	12	7.4	161	22	1136	59	3046	5.0	258	0.29	15.0	0.007	0.4	0.020	1.0	316	523
Mar-01	5.33	5341	0.82	83	24203	2.58E-02	17.92	5209	5.3	0.36	255	0.13	13	7.2	178	27	1200	64	2845	7.3	325	1.05	46.7	0.012	0.5	0.029	1.3	359	374
Apr-01	5.32	4430	0.80	85	18972	2.34E-02	16.24	3700	4.4	0.36	175	0.11	13	7.6	200	36	1597	114	5058	9.2	408	0.24	10.6	0.012	0.5	0.041	1.8	308	536
May-01	4.30	4227	0.81	90	11400	2.45E-02	17.03	2332	4.7	0.45	173	0.09	19	7.5	155	36	1291	106	3801	6.3	226	3.09	110.8	0.017	0.6	0.037	1.3	174	336
Jun-01	5.11	3697	0.87	92	9241	1.58E-02	10.96	1216	4.7	0.38	201	0.14	22	7.6	149	34	1449	82	3495	8.0	341	0.70	29.8	0.015	0.6	0.039	1.7	168	285
Jul-01	4.01	3872	0.86	96	6478	1.87E-03	1.301	101	4.9	0.48	212	0.11	32	8.0	150	55	1839	103	3445	7.4	247	0.88	29.4	0.015	0.5	0.025	0.8	130	325
Aug-01	5.07	3674	0.83	87	10658	7.65E-03	5.31	680	5.1	0.38	120	0.09	42	8.0	176	17	718.8	56	2368	5.8	245	0.29	12.3	0.008	0.3	0.014	0.6	282	355
Sep-01	3.73	2892	0.88	83	8879	7.44E-03	5.17	551	5.2	0.51	104	0.07	42	7.8	144	18	559.9	47	1462	6.7	208	0.80	24.9	0.021	0.7	0.016	0.5	194	232
Oct-01	4.67	2841	0.82	83	8423	2.29E-02	15.87	1605	7.1	0.36	152	0.15	20	7.8	116	16	623.2	31	1207	5.6	218	0.30	11.7	0.011	0.4	0.007	0.3	144	261
Nov-01	3.32	4722	0.74	84	15205	1.79E-02	12.42	2268	4.9	0.42	205	0.10	27	7.6	128	20	553.8	44	1218	6.4	177	0.80	22.2	0.009	0.2	0.030	0.8	120	222
Dec-01	3.54	4456	0.84	82	12755	2.60E-02	18.09	2771	4.6	0.39	144	0.08	22	7.6	161	18	531.4	59	1742	4.9	145	1.96	57.9	0.016	0.5	0.041	1.2	69	181
Average	4.72	4042	0.83	86	14229	1.67E-02	11.60	2137	5.3	0.39	176	0.11	26	7.6	159	27	1042	69	2726	6.6	261	0.98	36.9	0.013	0.5	0.027	1.0	210	342
Minimum	3.32	2841	0.74	80	6478	1.87E-03	1.30	101	4.4	0.31	104	0.07	12	7.2	116	16	531	31	1207	4.9	145	0.24	10.6	0.007	0.2	0.007	0.3	69	181
Maximum	6.19	5341	0.88	96	24203	2.60E-02	18.09	5209	7.1	0.51	255	0.15	43	8.0	200	55	1839	114	5058	9.2	408	3.09	110.8	0.021	0.7	0.041	1.8	359	536
Jan-02	3.44	3012	0.85	85	10908	1.12E-02	7.8	1022	4.9	0.40	138	0.11	29	7.6	154	22	631.2	53	1521	4.8	138	0.43	12.3	0.015	0.4	0.034	1.0	83	187
Feb-02	4.34	4290	0.83	84	10941	5.04E-03	3.5	460	4.9	0.40	153	0.09	48	7.5	183	27	977.3	109	3945	13.3	481	1.13	40.9	0.022	0.8	0.053	1.9	11.4	1317
Mar-02	5.01	5702	0.84	83	13195	1.67E-02	11.6	1838	5.4	0.35	183	0.09	33	7.45	106	22	919.2	70	2925	9.5	397	0.16	6.7	0.019	0.8	0.034	1.4	5.5	1132
Apr-02	5.29	4389	0.78	82	13906	1.08E-03	0.75	125	5.0	0.33	180	0.12	76	7.6	194	18	794.1	92	4059	6.0	265	1.27	56.0	0.010	0.4	0.022	1.0	5.1	540
May-02	4.96	6330	0.71	84	15574	1.68E-02	11.65	2179	3.0	0.35	128	0.06	34	7.6	153	19	786	65	2689	4.4	182	0.14	5.8	0.009	0.4	0.022	0.9	4.8	413
Jun-02	4.60	4773	0.76	89.5	14147	3.38E-02	23.44	3982	5.4	0.38	194	0.11	16	7.7	229	19	728.9	90	3453	5.8	223	4.25	163.0	0.021	0.8	0.045	1.7	183	961
Jul-02	4.80	5303	0.81	95.2	14888	2.16E-02	15	2682	3.9	0.36	179	0.09	26	7.4	140	15	600.5	75	3002	4.9	196	0.28	11.2	0.007	0.3	0.036	1.4	155	260
Aug-02	4.72	6577	0.79	94	14117	2.16E-02	15	2543	5.0	0.37	119	0.05	33	7.5	155	16	629.8	75	2952	3.1	122	0.15	5.9	0.009	0.4	0.028	1.1	108	468
Sep-02	4.16	6687	0.81	91	14838	1.06E-02	7.34	1308	3.7	0.42	213	0.08	31	7.5	207	63	2186	189	6557	15.1	524	1.44	50.0	0.018	0.6	0.024	0.8	184	365
Oct-02	3.92	6455	0.86	77	14705	1.32E-02	9.18	1621	4.4	0.45	246	0.09	41	7.4	253	28	915.4	129	4217	9.9	324	1.16	37.9	0.024	0.8	0.043	1.4	209	240
Nov-02	3.17	7626	0.78	73	24374	1.73E-02	11.98	3507	5.0	0.55	173	0.04	25	7.5	257	52	1375	133	3516	16.5	436	1.32	34.9	0.014	0.4	0.063	1.7	148	126
Dec-02	3.68	6489	0.73	81	26206	6.67E-03	4.63	1457	3.7	0.48	273	0.09	49	7.6	321	21	644.5	85	2609	13.0	399	17	521.8	0.031	1.0	0.092	2.8	119	44
Average	4.34	5636	0.80	85	15650	1.46E-02	10.16	1894	4.5	0.40	182	0.08	37	7.5	196	27	932	97	3454	8.9	307	2.39	78.9	0.017	0.6	0.041	1.4	101	504
Minimum	3.17	3012	0.71	73	10908	1.08E-03	0.75	125	3.0	0.33	119	0.04	16	7.4	106	15	600	53	1521	3.1	122	0.14	5.8	0.007	0.3	0.022	0.8	5	44
Maximum	5.29	7626	0.86	95	26206	3.38E-02	23.44	3982	5.4	0.55	273	0.124	76	7.7	321	63	2186	189	6557	16.5	524	17	521.8	0.031	1.0	0.092	2.8	209	1317
Jan-03	4.51	8026	0.80	82	21444	2.96E-02	20.53	5287	2.9	0.31	229	0.09	20	7.3	183	32	1204	108	4062	10.8	406	1.99	74.9	0.026	1.0	0.049	1.8	213	548
Feb-03	4.40	4587	0.87	83	10274	1.58E-02	10.96	1352	2.4	0.40	237	0.13	8	7.8	186	200	7339	462	16954	61.7	2264	1.36	49.9	0.024	0.9	0.067	2.5	348	792
Mar-03	5.03	4446	0.85	85	7482	3.61E-03	2.51	226	3.6	0.35	145	0.09	30	7.6	140	52	2181	133	5579	12.9	541	0.62	26.0	0.027	1.1	0.046	1.9	367	816
Apr-03	4.95	5147	0.82	85	11955	9.81E-03	6.81	978	2.9	0.35	166	0.09	25	7.6	131	56	2312	112	4624	14.3	590	0.74	30.5	0.012	0.5	0.052	2.1	269	525
May-03	5.79	5882	0.82	85	16577	1.24E-02	8.62	1716	1.0	0.30	172	0.10	26	7.75	177	39	1883	108	5215	11.6	560	5.15	248.7	0.009	0.4	0.035	1.7	316	657
Jun-03	4.62	4297	0.84	87	21025	6.08E-03	4.22	1066	4.9	0.38	186	0.11	32	7.5	115	28	1079	84	3237	6.0	231	2.72	104.8	0.021	0.8	0.033	1.3	209	477
Jul-03	5.64	3600	0.78	89	14868	2.16E-02	15	2678	4.7	0.31	108	0.10	18	7.5	98	10	470	57	2681	9.7	456	0.27	12.7	0.020	0.9	0.011	0.5	238	492
Aug-03	5.61	6191	0.62	91	20576	2.16E-02	15	3707	4.3	0.31	158	0.08	24	7.6	118	9	421	44	2059	3.7	173	0.18	8.4	0.009	0.4	0.013	0.6	227	242
Sep-03	4.16	6980	0.78	88.4	13846	2.37E-02	16.47	2739	3.7	0.42	180	0.06	21	7.5	149	78	2699	143	4961	8.2	286	0.32	11.1	0.012	0.4	0.036	1.2	231	199
Oct-03	4.18	6995	0.77	91	14023	2.81E-02	19.53	3289	3.5	0.42	183	0.06	19	7.5	144	79	2751	146	5078	7.6	264	0.34	11.9	0.015	0.5	0.037	1.3	208	363
Nov-03	4.19	6624	0.77	81.8	14116	7.56E-03	5.25	890	3.5	0.42	230	0.08	48	7.32	98	38	1314	97.2	3397	6.0	210	5.1	178.2	0.031	1.1	0.049	1.7	225	509
Dec-03	4.79	8889	0.77	82.2	9212	8.63E-03	5.99	663	2.6	0.37	239	0.07	28	7.5	169	111	4434	184	7351	22.7	907	16.24	648.8	0.010	0.4	0.146	5.8	259	487
Average	4.82	5972	0.79	86	14617	1.57E-02	10.91	2049	3.3	0.36	186	0.09	25	7.5	142	61	2341	140	5433	14.6	574	2.92	117.2	0.018	0.7	0.048	1.9	259	509
Minimum	4.16	3600	0.62	82	7482	3.61E-03	2.51	226	1.0	0.30	108	0.06	8	7.3	98	9	421	44	2059	3.7	173	0.18	8.4	0.009	0.4	0.011	0.5	208	199
Maximum	5.79	8889	0.87	91	21444	2.96E-02	20.53	5287	4.9	0.42	239	0.13	48	7.8	186	200	7339	462	16954	61.7	2264	16.24	648.8	0.031	1.1	0.146	5.8	367	816
Jan-04	4.51	6019	0.79	83.2	18502	4.41E-03	3.06	680	2.9	0.38803	154	0.07	41	7.6	149	45	1693	92	3460	8.11	305	4.93	185.4	0.02	0.6	0.056	2.1	165	523
Feb-04	5.86	5267	0.83	82.4	11211	1.02E-03	0.71	96	5.7	0.29863	154	0.10	43	7.5	129	38	1857	97	4741	7.6	371	0.14	6.842	0.01	0.5	0.023	1.1	221	530
Mar-04	5.72	5585	0.78	82.8	16681	1.04E-02	7.24	1450	5.1	0.30594	138	0.08	36	7.6	185	21	1002	63	3005	3.65	174	0.12	5.725	0.01	0.5	0.024	1.1	214	548
Apr-04	5.69	4390	0.82	85.6	11885	1.54E-02	10.7	1527	4.8	0.30756	215	0.16	28	7.6	166	21	996.5	68	3227	4.1	195	0.072	3.417	0.01	0.5	0.029	1.4	217	448
May-04	5.42	5629	0.82	84.7	16214	1.59E-02	11.01	2144	4.4	0.32288	167	0.09	28	7.6	153	25	1130	67	3029	3.88	175	0.134	6.057	0.017	0.8	0.034	1.5	219	467
Jun 04	5.99	4801	0.84	84	21148	3.24E-03	2.25	571	4.5	0.29215	128	0.09	59	7.7	148	15	739.4	49	2448	2.5	125	0.113	5.645	0.011	0.5	0.02	1.0	210	657
Jul-04	5.18	3559	0.79	90.7	14657	1.41E-02	9.8	1725	4.7	0.33784	132	0.11	22	7.6	140	19	820.8	54.4	2350	2.8	121	0.069	2.981	0.005	0.2	0.024	1.0	212	426
Aug-04	4.56	5764	0.71	88	14870	1.13E-02	7.86	1404	5.1	0.38377	101	0.05	41	7.6	120	22	836.7	53	2016	3.6	137	0.099	3.765	0.007	0.3	0.033	1.3	237	507
Sep-04	4.09	5837	0.72	88	14678	2.58E-02	17.92	3159	5.1	0.42787	144	0.06	23	7.6	114	28	955.1	64	2183	5.2	177	0.372	12.69	0.005	0.2	0.037	1.3	176	410
Oct-04	3.95	5683	0.78	83	16327	2.09E-02	14.51	2845	3.9	0.44304	164	0.07	13	7.5	158	126	4151	143	4711	8.1	267	8.62	284	0.014	0.5	0.09	3.0	144	362
Nov-04	4.44	5754	0.78	74	20892	1.60E-02	11.1	2785	5	0.39414	184	0.08	24	7.6	181	28	1037	108	3999	3	111	26	962.8	0.006	0.2	0.054	2.0	221	660
Dec-04	5.98	7807	0.72	80.8	20920	3.40E-02	23.6	5929	5.9	0.29264	143	0.06	17	7.6	144	25	1247	74	3691	4.7	234	6.84	341.1	0.0067	0.3	0.047	2.3	248	627

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Table 3-8
Secondary System
Operating History

10/8/2007

Date	Al Flow (MGD)	Aer Basin TSS mg/l	Aeration Volatile Fraction	Aer Tk Temp °F	R Sludge TSS mg/l	Ave Sludge Wasted MGD	Sludge Wasted gpm	Ave Sludge Wasted lb/day	Basin DO (AE)	Detention Time days	Aer Inf BOD	F/M 1 day	Sludge Age Days	Clar pH (SU)	Clar Alk mg/l	Clar TSS mg/l	Clar TSS #/day	Clar COD mg/l	Clar COD #/day	Clar BOD mg/l	Clar BOD #/day	Clar NH_3-N mg/l	Clar NH_3-N #/day	Clar Tot. CN mg/l	Clar Tot CN #/day	Clar Phenol mg/l	Clar Phenol #/day	Final BOD #/day	Final TSS #/day
Average	5 116	5508	0 78	84	16499	0 0143712	9 98	2026	4 8	0.35	152	0 084	31	7.59	149	34	1372	77 7	3238	4 77	199	3 959	151 7	0 01	0 42	0 039	1 596	207	514
Minimum	3 95	3559	0 71	74	11211	0.0010224	0 71	96	2 9	0 29	101	0 046	13	7 5	114	15	739 4	49	2016	2 5	111	0 069	2 981	0 01	0 17	0 02	0 999	144	362
Maximum	5 99	7807	0 84	91	21148	0 033984	23 6	5929	5 9	0 44	215	0 159	59	7 7	185	126	4151	143	4741	8.11	371	26	962 8	0 02	0 77	0 09	2 965	248	660
Jan-05	6 4	6446	0 63	80 3	22088	3 40E-02	23 6	6260	4 5	0 27	152	0 086	14	7 2	117	22	1153	69	3683	4.5	240	2 53	135	0 007	0 4	0 043	2 3	225	391
Feb-05	5.83	3170	0 79	77 2	19996	4.54E-03	3 15	756	3 5	0 30	188	0 198	29	7 3	87	21	1021	69	3355	6 6	321	0 361	18	0 007	0 3	0 034	1 7	245	391
Mar-05	5 47	4715	0 78	78 2	15129	1 56E-02	10 8	1962	4 7	0 32	171	0 113	22	7 5	101	32	1460	75	3421	7 34	335	0 358	16	0 007	0 3	0 031	1 4	214	341
Apr-05	6.31	5704	0 79	82 1	15352	1 64E-02	11 4	2102	5 0	0.28	148	0.094	19	7 6	114	50	2631	105	5526	5 35	282	0 211	11	0 0032	0 2	0 047	2 5	179	357
May-05	4 26	6620	0 76	88 4	17692	1 11E-02	7 68	1632	4 1	0.41	199	0 073	53	7 7	124	11	373	64	2274	3.28	117	0 242	9	0 0045	0.2	0 031	1 1	186	516
Jun-05	4 9	6518	0 76	92 9	16301	3 93E-03	2.73	534	3 6	0.36	182	0 078	28	7.7	118	77	3147	116	4740	3 5	143	0 27	11	0.016	0 7	0.04	1 6	164	472
Jul-05	5 5	9652	0 71	92 3	20796	2 48E-02	17.2	4296	3 4	0.32	185	0.06	31	7 7	163	14	651 4	81	3715	2 6	119	6.48	297	0.0045	0 2	0.03	1 4	157	243
Aug-05	4.67	7284	0.78	92 9	19952	1 77E-02	12 29	2945	3 9	0.37	187	0 069	31	7 5	106	22	856 9	92	3583	3.53	137	3 98	155	0 0039	0 2	0 051	2 0	117	288
Sep-05	4 15	7370	0.78	88 2	23445	1 77E-02	12 29	3460	4 3	0.42	188	0.06	28	7 5	113	21	726.8	157	5434	3.53	122	5.52	191	0 0068	0.2	0.062	2.1	124	310 0
Oct-05	4 01	7101	0 77	82 8	22032	1.27E-02	8 81	2331	5 9	0.44	158	0 051	10	7.7	167	257	8595	313	10468	7	234	10 4	348	0.067	2 2	1 75	58 5	143	317.0
Nov-05	2 67	7400	0 59	84 7	31055	2 36E-02	16.4	6117	6 1	0 66	164	0.034	17	7 8	174	30	668	98	2182	3	66 8	10.39	231	0 007	0 2	0 046	1 0	106	230 0
Dec-05	5 24	6548	0 73	83	20351	1 70E-02	11 8	2884	3.67	0.33397	173	0 079	26	7 4	94	25	1093	109	4763	4.53	198	2 75	120	0 009	0 4	0 072	3 1	110	319 0
Average	4.95	6544	0.74	85 3	20349	1 66E-02	11 5	2940	4 4	0.37	175	0 083	26	7 6	123	48	1865	112	4429	4 56	193	3 624	128.5	0.0119	0 4499	0 186	6 566	164	348
Minimum	2.67	3170	0.59	77.2	15129	3 93E-03	2 7	534	3 4	0.27	148	0.034	10	7 2	87	11	373	64	2182	2.6	66.8	0 211	8.598	0 0032	0 1519	0 03	1.024	106	230
Maximum	6.40	9652	0 79	92 9	31055	3 40E-02	23 6	6260	6.1	0.66	199	0.198	53	7 8	174	257	8595	313	10468	7.34	335	10.4	347.8	0.067	2 2407	1 75	58 53	245	516
Jan-06	5 67	6512	0 79	84 6	18272	1.77E-02	12 3	2,699.1	5 2	0.31	179	0.089	27	7.4	108	26	1229	98	4634	4 6	218	5 3	250 6	0.025	1 1822	0.05	2 364	162	329
Feb-06	5 45	6760	0.75	83 8	22045	3 01E-02	20 9	5,533 3	4 9	0 32	169	0 078	14	7 7	151	45	2045	116	5273	4 3	195	9.7	440.9	0.041	1 8636	0 088	4 0	220	378
Mar-06	5 68	6364	0 71	80 3	22652	1.63E-02	11 3	3,074.1	4 7	0.31	121	0.062	19	7 6	133	49	2321	205	9711	4	189	12.28	581.7	0.006	0.2842	0.1	4.7	131	310
Apr-05	5 63	5963	0.79	85 9	20813	1.92E-02	13 3	3,324 4	4 5	0 31	126	0.068	21	7 5	125	25	1174	90	4226	4.4	207	6 24	293	0.004	0 1878	0.054	2 5	141	400
May-06	4 94	5719	0 80	86 9	19387	2.48E-02	17 2	4.004.7	4	0 35	212	0 105	19	7.4	136	20	824	92	3790	11 4	470	7.5	309	0.003	0.1236	0 053	2 2	147	423
Jun-06	4.91	7597	0 70	89 8	25322	3 21E-02	22 3	6,781 6	4 6	0 36	173	0 064	17	7 5	123	11	450 4	79	3235	4 4	180	0 31	12.69	0 003	0 1228	0 03	1.2	194	357
Jul-06	4 73	8282	0.77	94 1	24102	5.16E-02	35 8	10,362 5	3.3	0.37	188	0 061	12	7.7	163	14	552 3	81	3195	2.6	103	6 49	256	0 005	0.1972	0 03	1.2	141	219
Aug-06	5 38	9373	0 76	92.7	21490	2.84E-02	19 7	5,084.3	4 5	0 33	165	0 054	25	7 48	106	22	964.7	93	4173	3 5	157	3 98	178.6	0.004	0 1795	0.051	2 3	122	245
Sep-06	6 11	7650	0 78	83.7	17907	5 34E-02	37 1	7,978 6	3 9	0 29	166	0 076	14	7 5	118	19	968 2	78	3975	4.7	239	0.46	23.44	0 004	0 2038	0 038	1 9	161	356
Oct-06	5 22	6117	0.76	81 4	22660	3.79E-02	26 3	7,157 2	3 7	0 34	136	0 066	12	7 7	173	16	687 8	74 5	3243	8 5	370	0 405	17.63	0.002	0.0871	0 023	1.0	217	309
Nov-06	4 48	6232	0 68	81 1	30574	2.74E-02	19 05	6,994 8	4	0 39	232	0.095	13	7 8	226	12	429 7	76.5	2858	8 1	303	0.337	12.59	0.0089	0 3325	0.02	0 8	197	109
Dec-07	6 7	5728	0.70	78 2	21826	7.78E-03	5 4	1,415.5	4 8	0.26	182	0.122	41	7 9	149	15	842 1	49 2	2749	3.19	178	0 181	10.11	0 01	0 5588	0 022	1.2	114	259
Average	5 41	6858	0 75	85.2	22254	2 89E-02	20.1	5368	4 3	0 33	171	0.078	19	7 6	143	23	1041	94.4	4255	5 31	234	4 432	198 9	0.0097	0 4436	0 047	2 12	162	308
Minimum	4.48	5719	0 68	78 2	17907	7 78E-03	5 4	1415	3.3	0.26	121	0 054	12	7 4	106	11	429.7	49 2	2749	2 6	103	0.181	10.11	0 002	0 0871	0.02	0 751	114	109
Maximum	6 70	9373	0.80	94.1	30574	5.34E-02	37.1	10363	5 2	0.39	232	0.122	41	7 9	226	49	2321	205	9711	11.4	470	12.28	581.7	0 041	1.8636	0.1	4.737	220	423
Jan-07	5.7	6972	0.7	81 2	18653	0 021888	15.2	3405.029	3 5	0 30702	256	0 12	23	7 6	212	31	1450	77	3660	7 04	335	0 65	30 9	0 007	0 3328	0 051	2 424	172	319
Feb-07	5 1	6885	0.74	83 6	18451	0 027792	19 3	4276 6702	5 5	0.34314	186	0 079	17	7 6	144	56	2382	140	5955	6 37	271	0 6	25 52	0 066	2 8072	0 028	1 191	126	478
Mar-07	6 52	6569	0 79	84 2	17289	0 020736	14 4	2989.9292	3 7	0.2684	82	0.047	13	7 6	153	92	5003	229	12452	9 4	511	1 41	76 67	0 007	0 3806	0 21	11.42	169	468

As a first step in evaluating the performance of the treatment plant, the secondary treatment plant data was compared to the discharge criteria. Table 3-9 summarizes the calculated BPT and BAT limits, the IEPA general effluent standards (contained in Section 304 of the Illinois regulations) and the current NPDES limits for the refinery. These calculated BPT/BAT limits were used in the recent July 2006 renewal of the NPDES permit.

A comparison of the regulatory limits (Table 3-10) with the treatment plant performance and final effluent quality indicates that the treatment system has consistently achieved an effluent quality which is significantly better than the applicable limits. The system has performed excellently in terms of effluent quality and pollutant removal. The final effluent has consistently complied with the mass based final effluent ammonia limitations contained in the NPDES permit and is achieving significantly better performance than that required by the BAT/BPT guidelines.

3.4 REVIEW OF LONG TERM AMMONIA REMOVAL PERFORMANCE

The Refinery has continued to maintain an excellent long term ammonia nitrogen removal program. This has been achieved in spite of an increasingly more difficult environment for operating a petroleum refinery.

Changes in environmental regulations have required CITGO to undergo a major expenditure to add a FCCU wet gas scrubber/selective catalytic reduction unit which has resulted in an additional ammonia source. The refinery has added a new physical-chemical wastewater treatment system to process this waste stream.

The demand for refined material has resulted in production near design capacities and use of heavier crudes. These factors have resulted in increased loadings to the wastewater treatment plant. The data shows that the refinery has made exceptional strides under difficult circumstances. The annual average ammonia discharge to the Canal over the last 5 years has averaged 102.4 pounds per day, with a net ammonia discharge of 76.2 pounds per day.

TABLE 3-9

BPT & BAT LIMITATIONS AND IEPA/NPDES LIMITATIONS

Parameter	BPT/BAT Limits[1]		Illinois Regs[2]		NPDES Permit Limits			
	Monthly Avg. lb/day	Daily Max lb/day	Monthly Avg. lb/day	Daily Max lb/day	Monthly Avg. lb/day	Daily Max lb/day	Monthly Avg. mg/l	Daily Max mg/l
BPT (40CFR419.22)								
BOD	1,843.8	3,318.9	1,189	4,996	1,008.8	2,472.32		
CBOD							20	40
TSS	1,475.1	2,313.2	1,489	6,247	1,475.10	2,313.23	25	50
O&G	536.4	1,005.7	891.7	3,747	536.40	1,005.75	15	20
BAT (40CFR4192.23)								
COD	12,873.4	24,808.2			12,873.6	24,808.50		
NH3-N	1,005.7	2,212.6	559.8	3,247	1,005.75	2,212.65	9.4	26.0
Sulfide	9.72	21.79			9.72	21.79		
BAT Settlement Agreement (40CFR419.23)								
Phenol	12.07	24.81	17.8	74.9	10.28	42.37	0.3	0.4
Chromium, Tot.	29.5	50.29	59.5	249.8	11.99	34.51	--	1.0
Chromium, Hex.	1.88	4.02	5.94	37.47	.99	2.2	0.1	0.3
Fluoride			2,288.7	3,747	756.6	2,161.7	15	28.6
Cyanide			5.94	25	5.04	14.41	0.1	0.2

(1) Calculated based on July 2006 renewal of NPDES permit.

(2) Calculated from concentration based effluent standards and an average flow of 7.13 MGD and a daily maximum flow of 14.98 MGD.

TABLE 3-10

SUMMARY OF MONTHLY AVERAGE EFFLUENT BOD, TSS AND AMMONIA

JANUARY 2006 – OCTOBER 2007

Month	Effluent BOD (lb/day)	Effluent TSS (lb/day)	Effluent Ammonia (lbs/day
January 2006	162	329	250
February	220	378	403
March	131	310	287
April	141	400	284
May	147	423	241
June	194	357	26
July	141	219	75
August	122	245	15
September	161	356	26
October	217	309	16
November	197	109	18
December	114	259	21
January 2007	172	319	61
February	126	478	68
March	169	468	76
April	429	723	148
May	466	645	95
June	359	335	138
July	558	578	140
August	463	620	202
September	200	466	57
October	212	384	43
NPDES Permit (lbs/day) Monthly Average	1008.8	1475.1	1005.75

Approximately, 25 percent of the ammonia nitrogen discharge is due to background conditions in the Canal.

The refinery has continued to maintain an excellent long term ammonia nitrogen removal program. This has been achieved in spite of an increasingly more difficult environment for operating a petroleum refinery.

The Lemont refinery has processed heavier crudes over the last 3 to 4 years. The use of heavier crudes has resulted in higher solids and COD loading to the wastewater treatment plant. This has made it exceedingly more difficult to maintain biological nitrification and nitrogen removal. Since the year 2002, the chemical cost for pretreatment (TSS and oil and grease removal) has risen by 500% and has become a significant expenditure of the treatment plant operating budget. Also, because of the changes in the crude quality, a daily regiment to optimize chemical addition to maintain the optimum performance of the treatment plant is required.

The higher solids loadings to the biological treatment plants have compounded and complicated the maintenance of an adequate sludge age for biological nitrification. In spite of considerable difficulties, the refinery treatment program has maintained consistent compliance with effluent criteria and has maintained a very high quality effluent. A review of the data shows that changes in crude quality have resulted in an increase in the effluent nitrogen discharge. A summary of these data is presented in Figure 3-3. In spite of these difficulties, the refinery wastewater treatment plant operating program has maintained compliance with the effluent criteria and has consistently produced a BAT quality effluent.

The refinery has expanded its optimization program to handle problems related to changes in production. This has included projects to optimize the induced gas floatation system, to further improve solids removal, and to conduct pilot studies to evaluate alternatives for additional solids removal.

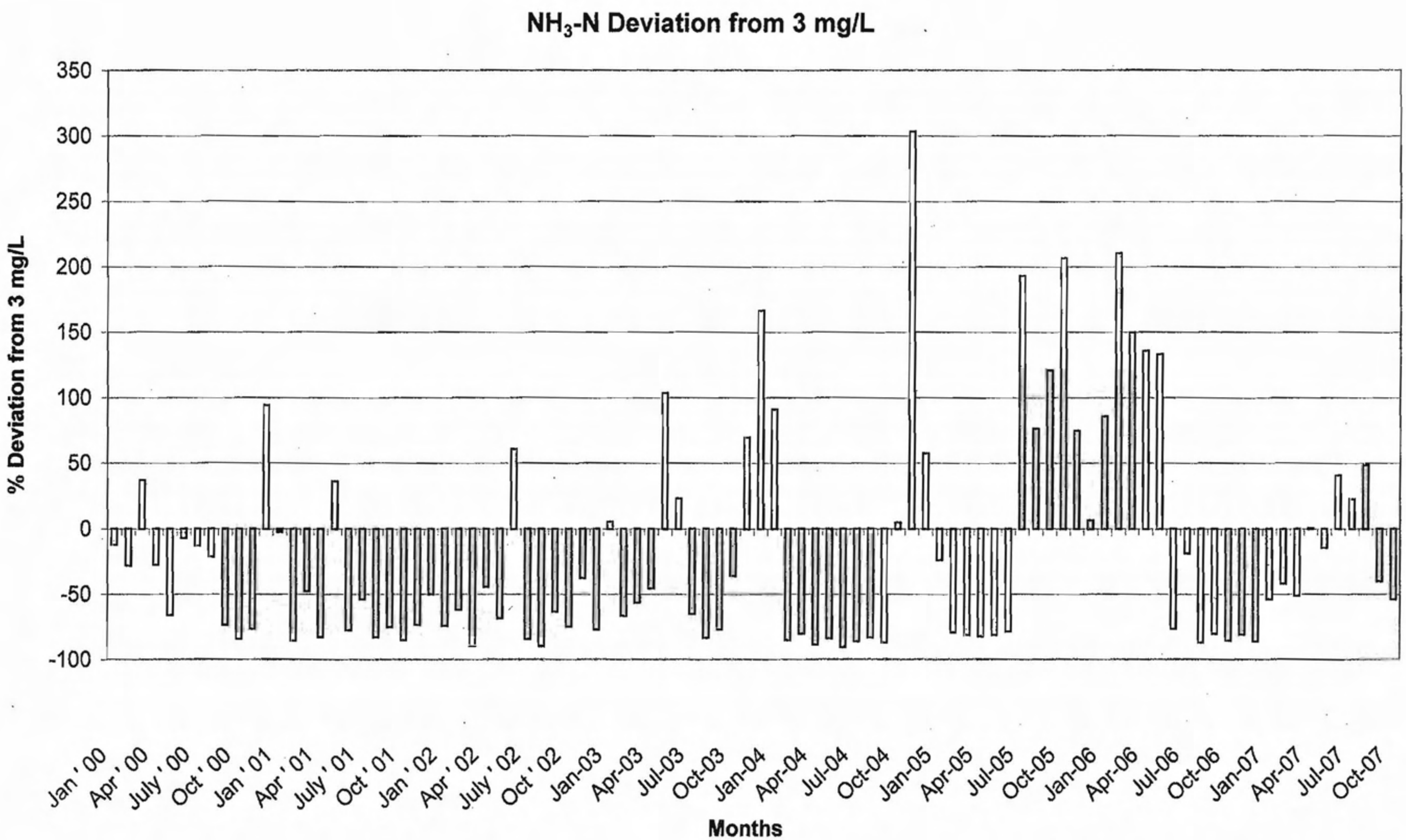


Figure 3-3
Variability of Effluent Ammonia Nitrogen as compared to Proposed 3 mg/L Limitation

In addition, the refinery is a sponsor of a research effort being conducted by the Petroleum Environmental Research Forum. Lemont in combination with BP, Conoco Phillips, Marathon Ashland, ExxonMobil, Shell Global, Repsol and Total are conducting research studies to access the performance of solid removal systems when processing heavy crude oils. This technology evaluation is designed to analyze treatment options which could be used to pretreat or handle crude solids. Revealing a viable solid removal technology would benefit the ammonia removal optimization program as it would reduce the COD, oil and grease and TSS loads which have increased with processing heavier crudes.

In light of the problem created because of changes in crude supply and processing heavier crudes, the wastewater treatment program has been diligent and has continued to provide excellent wastewater treatment plant operations. However, consistently meeting the 3.0 mg/l ammonia nitrogen standard has not been achieved. This inconsistency is attributed in large part to the inherent variability in refinery wastes. To determine other potential causes of the higher effluent ammonia concentrations, the factors which affect ammonia removal were reviewed and are discussed in the following section.

3.5 PARAMETERS WHICH CONTROL NITRIFICATION

In order to review the ability of the wastewater treatment system to provide biological nitrification it is necessary to evaluate the plant operation with regard to those parameters which control biological nitrification. The primary factors which affect nitrification in a biological treatment system include F/M (food-to-microorganism ratio), sludge age, aeration basin pH, aeration basin temperature, availability of alkalinity, and the aeration basin dissolved oxygen (D.O.) concentration. The facility operating data for these parameters are included in Table 3-8. The operating ranges for these parameters which have generally been found to provide optimum nitrification performance in activated sludge systems are summarized in Table 3-11. This table includes a comparison with the operation of Lemont Refinery treatment system. This shows that the facility has operated the system under the conditions which are conducive to biological nitrification. The specific parameters are discussed below.

TABLE 3-11

TYPICAL OPERATING RANGES FOR NITRIFICATION

Parameter	Optimum Range	Lemont Refinery Operation[2]
F/M, lb BOD_5/lb MLVSS-day	Less than 0.3	0.034 – 0.159
Sludge Age, days	$\geq$ 10	10 - >100
D.O., mg/l	2.0[1]	2.1 – 7.8[3]
pH	7.2 – 9.0	7.1 – 8.0
Temperature, ºF	68 – 100	73 – 98

NOTES:

(1) Average D.O. should be $\geq$ 2.0 mg/l.
Minimum D.O. should be $\geq$ 1.5 mg/l.

(2) Based on monthly average data.

(3) In May 2003, the D.O. averaged 1 mg/l; however, the effluent ammonia averaged 5.15 mg/l. This is thought to have been a probe problem with actual D.O. levels being higher.

The F/M level, expressed as lb of BOD applied per day per lb mixed liquor volatile suspended solids (MLVSS), is an important indicator of conditions suitable for nitrification to occur. The lower F/M ratios normally provide an improved environment for nitrification to occur. The F/M has been maintained at less than 0.16 lb BOD_5/lb MLVSS-day over the last ten years. The BOD loading over the last ten years has been lower than in previous years and provides an improved condition to achieve biological nitrification.

These F/M ratios should provide an excellent opportunity for the system to achieve nitrification. However, there still is periodic variability of the effluent ammonia concentrations. This data indicates that F/M ratios do not appear to be a factor limiting nitrification.

Sludge age represents the average length of time the biomass remains in the treatment system. The greater the sludge age the better the chance for nitrifying organisms to grow and for biological nitrification to occur. Sludge ages of 10 days or more are generally adequate for nitrification. During this period of operation, the increase in influent TSS levels due to heavier crudes has made the control of sludge age difficult. However, the sludge age has consistently been maintained at greater than 10 days and has typically been maintained at 20 to 100 days. This is an indication of good wastewater treatment plant operation. The data indicates the occurrence of elevated effluent ammonia concentrations, even at long sludge ages. Therefore, sludge age does not appear to be a factor which limits nitrification.

The desired minimum dissolved oxygen concentration for biological nitrification is an average D.O. of 2 mg/l with a minimum D.O. of 1.5 mg/l. Nitrifying bacteria are extremely sensitive to D.O. concentrations. Adequate aeration is extremely important to ensure that D.O. levels are adequate at all times throughout the aeration basins. The average aeration basin dissolved oxygen concentration has been excellent over the 1997 through 2007 time period. The D.O. has averaged in excess of 4.5 mg/l over the last three (3) years. The aeration system includes ceramic fine bubble diffusers which are distributed uniformly over the entire aeration basin floor. The aeration system provides consistently adequately D.O. levels throughout the basins and provides a very uniform mixing pattern. Based on this, D.O. does not appear to be a factor limiting nitrification.

Optimal nitrification performance occurs in the pH range between 7.2 and 9.0 and in the temperature range between 68 and 100ºF. Aeration basin pH and temperature have remained within acceptable ranges throughout the period under review. The refinery has provisions to add steam to maintain the aeration basin temperature above 70ºF. This is a very desirable feature for maintaining optimum treatment and nitrification performance. The lowest monthly average temperature over the period evaluated was 73ºF in November 2002 and over the last two (2) winters the average aeration basin temperatures has been 80ºF or above. This data indicates that the pH and temperature have been maintained well within the optimum range for nitrification.

The nitrification reaction consumes 7.1 mg/l of alkalinity (as calcium carbonate) per 1 mg/l of ammonia nitrogen removed. Inadequate alkalinity can result in sharp decreases in pH which can upset the treatment system. The system has had adequate alkalinity available based upon residual alkalinities and pH in the effluent. Alkalinity has consistently been available in the influent, and supplementary alkalinity is added when needed to maintain an effluent residual. Therefore, alkalinity is not a factor limiting nitrification.

In summary, the Lemont Refinery wastewater treatment system has consistently operated at F/M, sludge age, DO, alkalinity, pH and temperature levels normally found to be satisfactory for single-stage biological nitrification.

3.6 SUMMARY

An analysis of the Lemont Refinery wastewater collection and treatment system was conducted to determine if the system continues to be a BAT facility. The results of this analysis indicate that the refinery has a state-of-the art wastewater treatment system which exceeds BAT criteria and allows compliance with all U.S. EPA refinery discharge regulations and with the current NPDES permit for the facility. The wastewater treatment system has been operated under conditions which are optimum to achieve biological nitrification. However, the system has been unable to consistently achieve biological nitrification. The data has demonstrated that the wastewater treatment system is not able to consistently provide biological nitrification to meet the 3.0 mg/l ammonia nitrogen standard as required in the Illinois regulations.

Lemont Refinery has an ongoing program to optimize the wastewater treatment system and to address problems caused by use of heavier crudes. This appears to be the proper direction for improving wastewater treatment plant performance.

SECTION 4.0
ANALYSIS OF ALTERNATIVES

An alternative procedure for Lemont Refinery to assure sufficient ammonia removal is the utilization of additional treatment technologies. The additional treatment technologies would have to comply with an effluent ammonia nitrogen level of 3 mg/l or less on a consistent basis. AEI conducted an analysis of these treatment technologies for application at the refinery based on technical and economic feasibility. AEI also reviewed the treatment technologies employed at the other Illinois refineries to determine if they were employing treatment approaches which differed from the Lemont system.

4.1 SELECTED TECHNOLOGIES FOR EVALUATION

There are a number of technologies which have been reported to be applicable for providing ammonia removal. A large number of technologies were considered and the following technologies and variations were deemed appropriate for evaluation at Lemont Refinery:

1. Biological Treatment Technologies/Adaptations
   a. Single-stage activated sludge.
   b. Single-stage activated sludge with the supplement of specialized bacteria.
   c. Single-stage activated sludge with a powdered activated carbon supplement.
   d. Single-stage activated sludge membrane bioreactor.
   e. Two-stage activated sludge.
   f. Two-stage biological treatment using activated sludge for the first stage and a fixed media system for the second stage.

2. Land Treatment

3. Wetlands Polishing

4. Physical – Chemical Technologies
   a. Ion exchange.
   b. Air stripping.

c. Steam stripping.
d. Breakpoint chlorination.

Based on a review of available literature, previous studies on Lemont Refinery wastewater, and our personal experience with similar wastewaters, this list of technologies was reduced to the four with the greatest potential for achieving the Illinois 3.0 mg/l ammonia nitrogen standard on a consistent basis. The four technologies selected for consideration at Lemont Refinery are:

1. Activated sludge with powdered activated carbon addition (PACT);
2. Activated sludge with a fixed media system;
3. Activated sludge with membrane bioreactor; and
4. Activated sludge with breakpoint chlorination and dechlorination.

Process designs were developed for each of the four selected ammonia nitrogen removal technologies. The process designs presented in this chapter were developed to treat the design waste loadings presented in Table 3-4. The advantages and disadvantages for each alternative are summarized in Table 4-1.

This section will focus primarily on a presentation of the actual design parameters, the required modifications to the treatment system to implement these technologies, and a comparative cost estimate for each design alternative. The assumption in this discussion is that the selected alternatives will work and be reliable. However, it is not certain that the refinery can consistently comply with the 3.0 mg/l ammonia nitrogen standard even with implementation of one of these technologies.

The alternatives presented in this report utilize end-of-pipe processes. Each design has been developed as a complement to the existing WWTP. Each addition to the existing WWTP is designed to improve the existing WWTP's nitrification capabilities, and add reliability and dependability to the system.

TABLE 4-1

SUMMARY OF POTENTIAL TECHNOLOGIES

Method	Advantages	Disadvantages
Powdered Activated Carbon System	Removes toxic compounds; Enhances nitrification; Aids solids settling; Removes color.	Increased quantity of sludge produced; High operating cost; Abrasion to mechanical equipment; May require expensive sludge disposal and carbon regeneration facilities; No proven process reliability for this type of application.
Fixed Media System	Media provides a good growth mechanism for nitrifying organisms; Easier and less costly to operate than PAC or membrane bioreactor; Low heat loss.	Chemical incompatibility with the refinery wastewater may limit media life; No proven process reliability for this type of application; Based on a biological process.
Membrane Bioreactor	Allows operation at longer sludge ages; Potential for water reuse.	Relatively new technology application; Fouling of membrane; Potentially short membrane life; Increased extracellular polymeric substance generation; No long term experience of this application (fouling and foam).
Breakpoint Chlorination and Dechlorination	Low capital cost; Easy process control.	High operating cost; Potential for formation of toxic chlorinated hydrocarbons; Handling large quantities of chlorine; Requires dechlorination; State of Illinois (IEPA) is against use of chlorination for organic wastewaters; creates by-products in the treated water which have greater water quality concern than the ammonia being treated.

4.2 ACTIVATED SLUDGE WITH POWDERED ACTIVATED CARBON ADDITION

The activated sludge process with the addition of powdered activated carbon provides an enhancement of the treatment system by providing removal of biologically resistant organics. The mechanism for powdered activated carbon to enhance biological nitrification appears to be through removal of inhibitory compounds rather than enhanced nitrifier growth on the surface of suspended solids. In this process, powdered activated carbon is added to the aeration basin mixed liquor. The system includes a wet air oxidation process which allows for recovery of the powdered activated carbon (PAC).

Design information for the single-stage activated sludge system incorporating powdered activated carbon addition is shown in Table 4-2. A simplified process flow diagram is presented in Figure 4-1, utilizing the existing WWTP. The system will require the construction of a third secondary clarifier to handle both the additional solids loading from the powdered carbon and the slower settling nitrifying bacteria, and addition of a wet air regeneration system.

An average F/M ratio of 0.1 lb BOD_5 applied/lb MLVSS-day is assumed for this design, with an average MLVSS concentration of 6,750 mg/l. The design sludge age is 12 days based on the average flow rate of 6.64 MGD. PAC will be added at a rate of 100 mg/l. These conditions should enable the system to nitrify, and the PAC could provide adsorption of any inhibitory substances to the biological nitrification process which may be present.

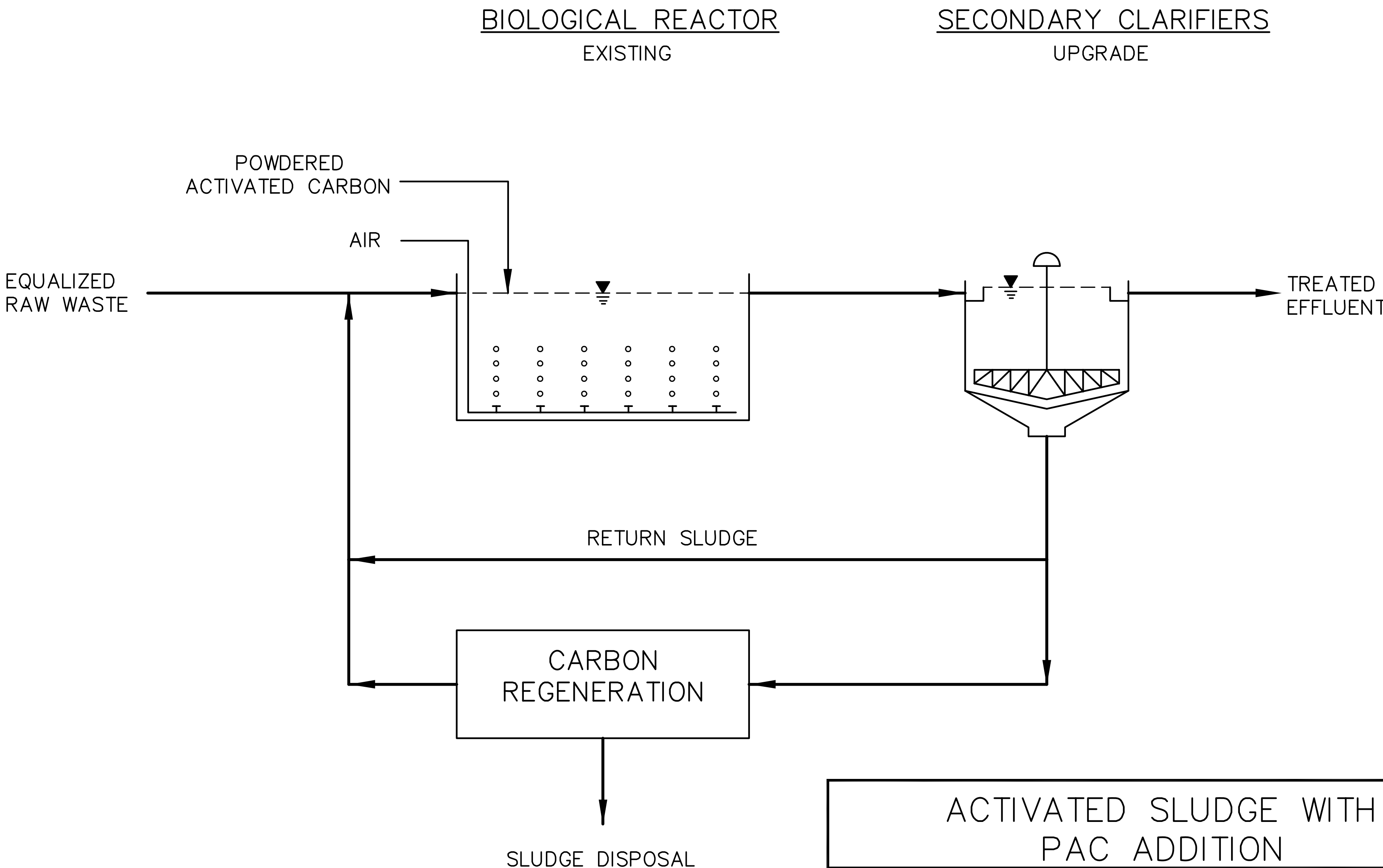
The carbon will be mixed in slurry form and pumped into the WWTP. The PAC would be regenerated on-site in a wet air regeneration system. This will provide a ninety (90) percent PAC recovery. The remaining portions of the system would remain intact, with the addition of a third secondary clarifier and a gravity thickener for thickening spent PAC prior to wet air regeneration. Some upgrading of the existing system may be necessary to handle the increased abrasion due to the presence of the PAC, but no costs are included in our estimate for this upgrade.

The cost estimate for this option includes facilities for carbon regeneration and sludge disposal. It is assumed that continuation of the present sludge disposal practices will not be possible

TABLE 4-2

PROCESS DESIGN SUMMARY FOR ACTIVATED SLUDGE WITH PAC

Parameter	Units	Design Value
BOD Load	lb/day	10,050
NH3 Load	lb/day	1,065
Flow	MGD	6.64
Aeration Basin		
Average F/M (BOD)	lb/lb-day	0.1
Average MLSS	mg/l	6,750
Total Hydraulic Retention Time	days	0.29
Total Required Volume	MG	1.92
Number of Aeration Basins		3
Average Waste Sludge	lb/day	9,000
Oxygen Requirements	lb/day	16,400
Carbon Addition	mg/l	100
	lb/day	5,540
Secondary Clarifier		
Overflow Rate	gpd/sq ft	300
Total Clarification Area	sq ft	22,100
Number of Clarifiers		3
Selected Clarifier Diameter (existing)	ft	2@ 100
(new)	ft	1 @ 100
Average Underflow Concentration	mg/l	10,000
Average Recycle Flow	MGD	3.32
Average Recycle Rate	%	50



ACTIVATED SLUDGE WITH PAC ADDITION		
LEMONT REFINERY LEMONT, ILLINOIS		
SCALE NOT TO SCALE	APPROVED BY :	DRAWN BY: DAO / JKS
DATE OCTOBER 2007	DESIGNED BY :	REVISED
PROJECT NUMBER N356-06	AWARE ENVIRONMENTAL INC	DRAWING NO. FIGURE 4-1

October 10, 2007 2:43:25 p.m.
Drawing: 35606P03.DWG.DWG

because of the presence of the PAC in the waste sludge. Construction of the new facilities will cost approximately $14,800,000, with an annual operating cost of $1,424,000. The annualized cost for this alternative is $3,630,000 per year, assuming a capital recovery factor for 10 years at 8 percent interest.

Although it is anticipated that powdered activated carbon process can improve biological nitrification, there is no assurance that it will provide compliance with the 3 mg/l ammonia nitrogen criteria. The powdered activated carbon may not be able to adsorb the compounds which limit nitrification at Lemont Refinery, and there is the possibility that compounds adsorbed onto the activated carbon can deadsorb, under certain conditions. This could increase inhibition of the nitrifying organisms.

Additional concerns include increased sludge production and higher operating costs. The addition of the carbon can be abrasive to the mechanical components of the treatment plant. Overall, there is no proven process reliability that the technology will achieve continuous compliance with the 3.0 mg/l ammonia nitrogen effluent criteria.

4.3 ACTIVATED SLUDGE WITH A FIXED MEDIA SYSTEM

The operation of an activated sludge system with a fixed media system can provide a mechanism for improving biological nitrification. In this process the activated sludge system provides a suspended growth biological system for removal of the organic components in the wastewater. This is then followed by a fixed media rotating biological contactor (RBC). The RBC consists of large diameter closely spaced circular discs, with corrugated plastic media mounted on a horizontal shaft placed in a concrete tank. The discs are submerged in the wastewater and slowly rotate through the wastewater. The surface of the discs provide an ideal mechanism for nitrifying organisms to grow. Since the activated sludge process provides organic removal, this limits competition on the disc surface between the organisms which remove carbon and the nitrifying organisms.

The design parameters and process flow diagram for the fixed media attached-growth rector system are presented in Table 4-3 and Figure 4-2, respectively. This would be operated as an aerobic process. A tertiary clarifier would be required following the reactors, since there will be some sludge sloughing and additional solids discharging into the RBC system.

The current activated sludge system with the addition of a third secondary clarifier would provide the first stage of the process. The RBCs utilized for the nitrification stage contain a total of 6.64 million sq ft of media area. This would be split into three or four stages to achieve low effluent ammonia nitrogen concentrations. Twelve foot diameter, high-density media is specified to minimize the total number of shafts and cost. The use of this media is possible due to the low organic removals which will take place in this treatment step. The hydraulic loading rate used for this design is 1.0 gpd/sq ft. This corresponds to 6235 sq ft/lb of influent ammonia nitrogen. The design overflow rate of the third clarifier is 600 gpd/ft^2.

The total capital cost of installing an RBC system following the existing treatment plant is estimated to be approximately $13,500,000. Operation and maintenance costs were estimated to be approximately $1,220,000 per annum. The total annual cost is $3,220,000/year.

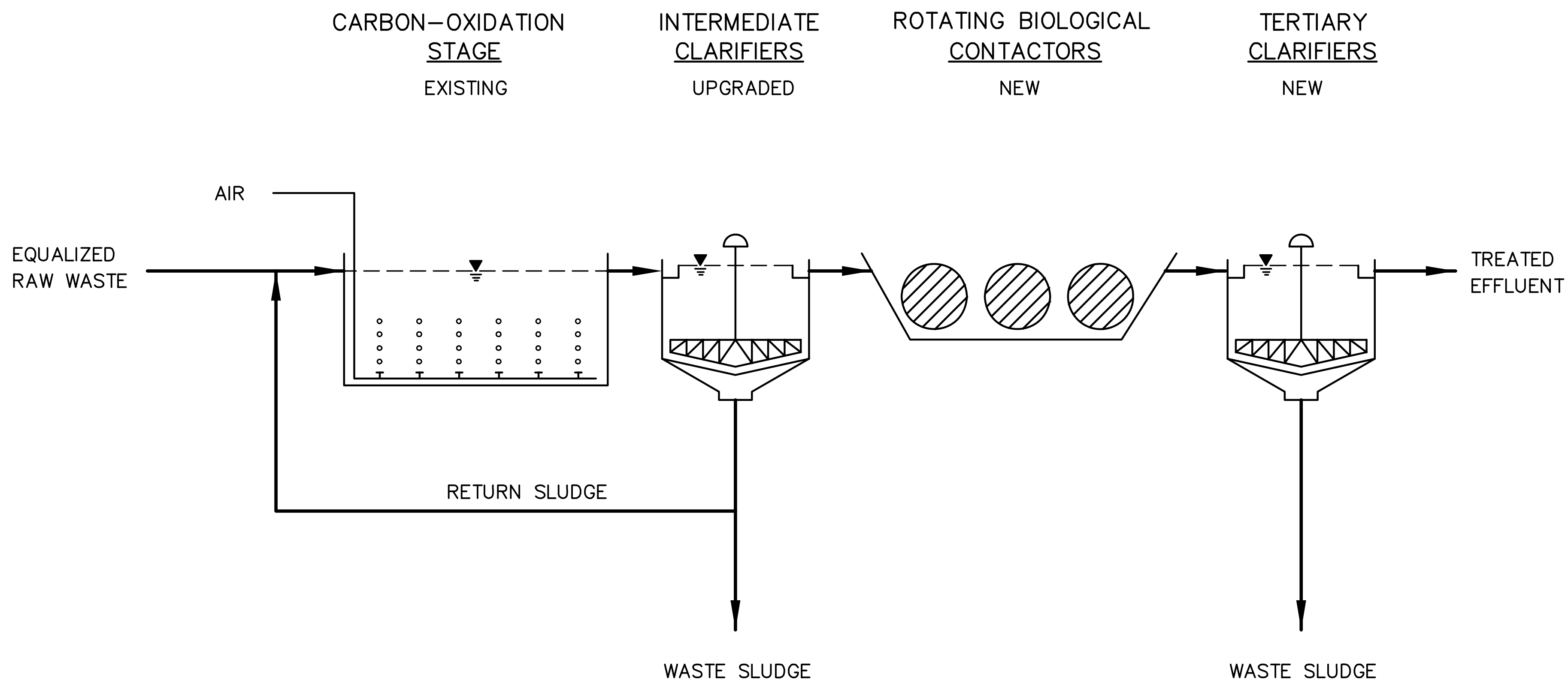
There are potential problems associated with a fixed film nitrification process. The nitrifiers are sensitive to a number of compounds and this can inhibit biological nitrification. There is a potential of chemical incompatibility with the refinery wastewater. This can result in premature failure of the RBC media. RBC units have been plagued with shaft failure problems caused by structural design problems, metal fatigue and excessive biomass accumulation. Because of these problems there is no assurance that this technology can consistently comply with the 3.0 mg/l ammonia nitrogen criteria.

4.4 ACTIVATED SLUDGE WITH MEMBRANE BIOREACTOR

A membrane bioreactor (MBR) is a system which couples the activated sludge process with membrane separation of the treated effluent from the mixed liquor. This separator eliminates the

TABLE 4-3
PROCESS DESIGN SUMMARY FOR ACTIVATED SLUDGE WITH A FIXED MEDIA SYSTEM

Parameter	Units	Design Values
Fixed Media System		
Type		Rotating biological contractor (RBC)
Diameter	ft	12
Hydraulic Loading Rate	gpd/sq ft	1
Area Requirement	sq ft/lb NH_3-N	6235
Total Media Surface Area	10^6 sq ft	6.64
Media Type		High Density
No. of Stages		3-4
Additional Secondary Clarifier		
Type		Circular
Number		1
Diameter	ft	100
Side Water Depth	ft	16
Tertiary Clarifier		
Type		Circular
Number		1
Diameter	ft	120
Side Water Depth	ft	16



ACTIVATED SLUDGE WITH A FIXED MEDIA SYSTEM		
LEMONT REFINERY LEMONT, ILLINOIS		
SCALE NOT TO SCALE	APPROVED BY :	DRAWN BY: J.K.S.
DATE OCTOBER 2007	DESIGNED BY :	REVISED
PROJECT NUMBER N356–06	AWARE ENVIRONMENTAL INC	DRAWING NO. FIGURE 4–2

October 10, 2007 2:44:14 p.m.
Drawing: 35606P02.DWG.DWG

need of a separate secondary clarifier since the membrane section can be added directly to the aeration basins. The advantage of the MBR process is mainly due to the fact that high MLVSS levels and sludge ages can be maintained in the aeration basin. This is a relatively new technology and there is limited experience in applying this technology to the petroleum refining industry for nitrogen removal.

There are several advantages associated with the MBR which makes this an alternative for consideration. The MBR process allows retention of suspended matter and most soluble compounds within the bioreactor thus leading to a good quality effluent and provides very good control with regard to sludge age since the system can be operated with a higher biomass concentration.

The design of the system is based on a minimum sludge age of 20 days with a minimum MLSS of 5,800 mg/l. In this alternative, the existing secondary clarifiers would be converted to sludge thickeners. Each basin would be equipped with 320 membrane modules of Siemens (or equivalent) B2OR, poly vinylidinedifluoride (PVDF). These modules would incorporate filtrate and air supply header integrally.

Table 4-4 presents the design information for the membrane bioreactor system. Figure 4-3 presents the process flow diagram for the membrane bioreactor activated sludge system.

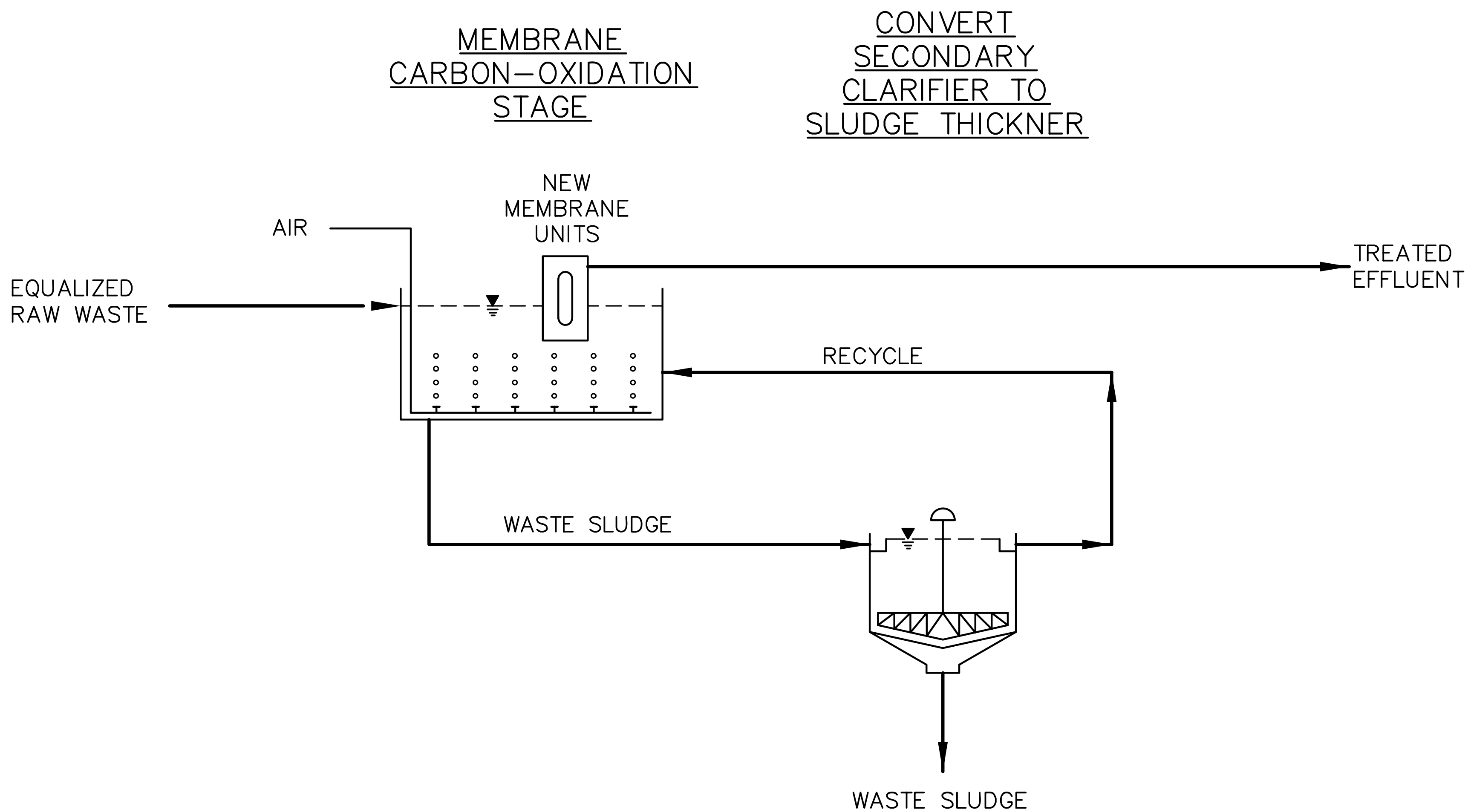
The total capital cost including aeration tank equipment, membrane modules, air scouring and filtrate water distribution equipment is estimated to be $54,700,000. The annual operating cost for this system is $3,280,000. The total annualized cost for the membrane bioreactor alternative is $11,400,000.

There is limited data on the utilization of MBR systems for biological nitrification applications in the refining industry. The membrane process allows operation at high MLVSS levels; however, since the membrane retains low molecular weigh compounds it may be possible to build up a concentration of inhibitory compounds. Full scale MBR systems have experienced problems

TABLE 4-4

PROCESS DESIGN FOR MEMBRANE BIOREACTOR ACTIVATED SLUDGE

Parameter	Design Value
Aeration Basins	
Number	3
Volume (MG per basin)	1.92
MLSS (mg/l)	5800
Membrane Units	One per basin
Number of Modules per unit	320 per basin
Module Type	Siemens or equivalent - B3OR poly vinylidinediflouride
Related Equipment	Filtrate and air supply header
Membrane Cleaning	Air souring



MEMBRANE BIOREACTOR
ACTIVATED SLUDGE

LEMONT REFINERY
LEMONT, ILLINOIS

SCALE NOT TO SCALE	APPROVED BY :	DRAWN BY: J.K.S.
DATE SEPTEMBER 2007	DESIGNED BY :	REVISED
PROJECT NUMBER N356-06	AWARE ENVIRONMENTAL INC	DRAWING NO. FIGURE 4-3

October 10, 2007 2:45:04 p.m.
Drawing: 35606P01.DWG.DWG

with foaming and fouling of membranes. This necessitates expensive cleaning and replacement operations. This process has a very high capital cost and if the membranes need to be replaced, the operating costs would increase significantly. In addition, the process may not be able to provide consistent compliance with the 3.0 mg/l ammonia nitrogen criteria.

4.5 ACTIVATED SLUDGE WITH BREAKPOINT CHLORINATION/ DECHLORINATION

Activated sludge with breakpoint chlorination/dechlorination utilizes a physical chemical process for nitrogen removal following the activated sludge system. Specifically, the wastewater with nitrogenous compounds is chlorinated with a sufficient dosages of chlorine to produce a free chlorine residual. The hypothetical breakpoint curve is based on a 9:1 $Cl:NH_3$ ratio. The end products of the breakpoint reaction are primarily nitrogen gas (N_2) and secondarily, nitrate-nitrogen (NO_3^-). Any residual chlorine is removed using a dechlorination agent (usually a reduced sulfur compound).

Breakpoint chlorination provides chemical destruction of the ammonia nitrogen. This alternative is the simplest of the proposed alternatives in terms of operation and equipment requirements. Table 4-5 and Figure 4-4 present the design parameters and the flow diagram for this process alternative.

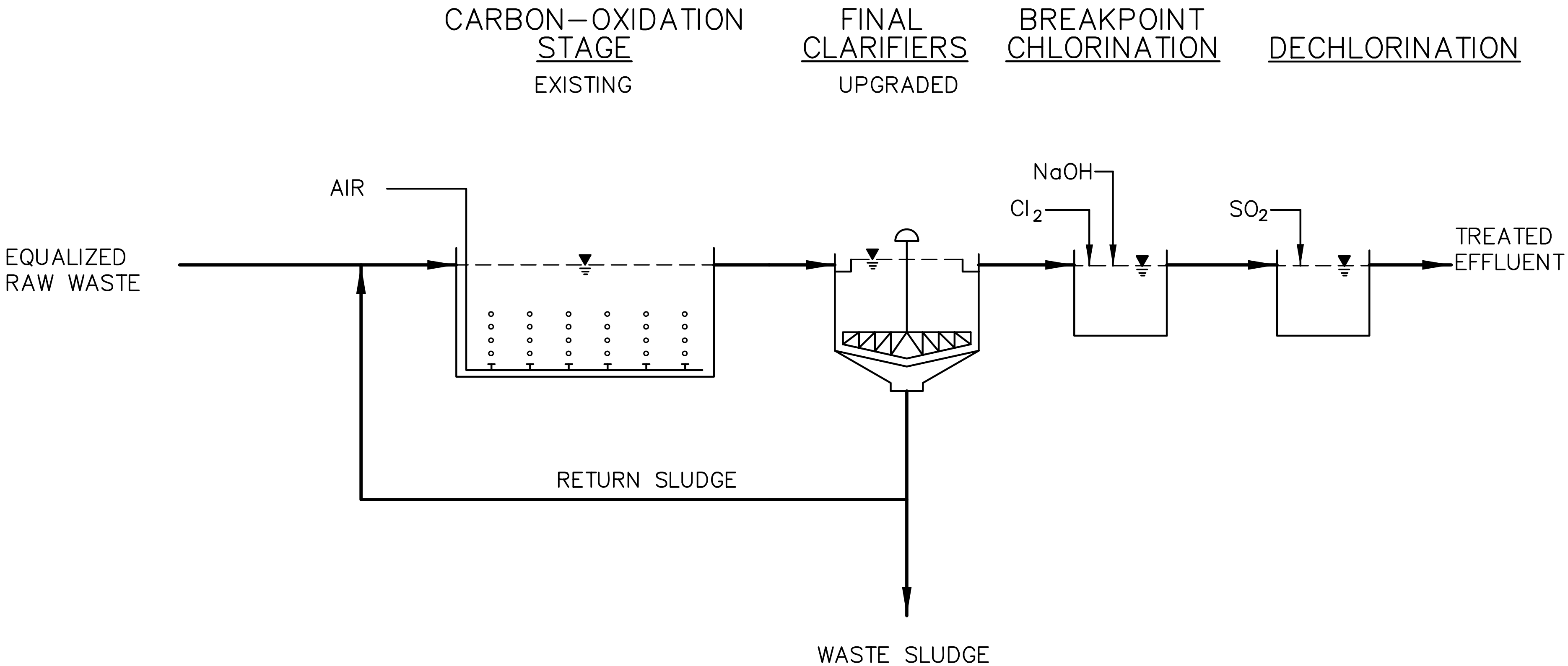
A chlorine contact chamber with a 20 minute detention time, and facilities to add a maximum of 10,710 lb/day of chlorine are included. Chlorine is fed at a 8:1 to 10:1 chlorine-ammonia nitrogen ratio. Caustic is added to offset the pH reduction which occurs when the reaction converts ammonia to hydrochloric acid and nitrogen gas. The caustic requirement is estimated at 10,850 lb/day.

Dechlorination is accomplished by adding sulfur dioxide after the chlorine reaction is completed. A reaction tank volume of approximately 9,700 gallons would be required to provide the 2 minute retention time necessary to complete this second

TABLE 4-5

PROCESS DESIGN SUMMARY FOR ACTIVATED SLUDGE WITH BREAKPOINT CHLORINATION AND DECHLORINATION

Parameter	Units	Design Values
Breakpoint Chlorination		
Max Influent Ammonia Load	lb/day	1,190
$C1_2/NH_3$-N Ratio	lb/lb	9
Max Chlorine Requirements	lb/day	10,710
Caustic Requirements	mg/l	196
	lb/day	10,850
Detention Time	min	20
Reactor Volume	gal	92,000
Dechlorination		
$C1_2$ Residual	mg/l	5
	lb/day	277
$SO_2/C1_2$ Ratio	lb/lb	1
SO_2 Requirement	lb/day	277
Dechlorination Time	min	2
Reactor Volume	gal	9,700



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ACTIVATED SLUDGE WITH BREAKPOINT CHLORINATION−DECLORINATION

LEMONT REFINERY
LEMONT, ILLINOIS

SCALE NOT TO SCALE	APPROVED BY :	DRAWN BY: JKS
DATE OCTOBER 2007	DESIGNED BY :	REVISED
PROJECT NUMBER N356−06	AWARE ENVIRONMENTAL INC	DRAWING NO. FIGURE 4−4

reaction. This reaction is fast enough that in-line dechlorination can be considered, but for estimating purposes, a reaction tank is included. Assuming a 5 mg/l chlorine residual, approximately 280 lb/day of sulfur dioxide will be required.

Capital construction costs for the feed equipment, the reaction tanks, and the third secondary clarifier are estimated at $1,400,000. The annul operating cost is estimated to be $3,332,000. The estimated total annualized cost is $3,640,000 for the chlorination/dechlorination system.

The chlorination/dechlorination process can remove ammonia. However, there are potential downside risks of this option. Chlorine as well as chlorinated organic by-products are generally toxic to fish as well as harmful to aquatic biota even at low concentrations. The use of dechlorination removes residual chlorine but does not remove chlorinated organics which are byproducts of the chlorination process.

The use of chlorine for water and wastewater disinfection is of concern for regulatory authorities in the treatment of organic wastewaters. In the wastewater treatment field, chlorine is known to react with organic matter to form disinfection byproducts such as trihalomethanes. These are carcinogens and can be toxic to aquatic species. Due to the higher organic content of wastewaters as compared to drinking water, wastewater chlorination can result in the production of a much greater quantity and a much wider range of organic compounds. These chlorinated organic compounds exhibit acute toxicity, bioaccumulation and/or sublethal affects and have come under increasing scrutiny and regulation around the world.

Numerous organizations have proposed the prohibition of the use of chlorine and chlorine containing compounds for treatment of organic wastewaters because of the toxicity of chlorinated organic by-products. The Illinois Pollution Control Board has eliminated chlorination as a requirement for disinfection in many municipal wastewater treatment plant discharges, where it had previously been required. The trend is away from the use of chlorine for treatment of organic wastewaters. Because of these concerns, the use of breakpoint chlorination/dechlorination is not a justifiable treatment technology on organic containing wastestreams for Lemont Refinery.

Breakpoint chlorination/dechlorination is being used to remove ammonia in the PTU. However, this is an inorganic wastewater and will not produce chlorinated organic by-products. The dechlorination process will remove the residual chlorine.

4.6 ANALYSIS OF TECHNOLOGIES UTILIZED AT ILLINOIS REFINERIES

In conjunction with the review of alternative technologies to upgrade the Lemont Refinery, a review of the treatment technologies in place at other Illinois refineries was conducted. The refineries included:

Conoco-Phillips	Roxana, IL
Exxon-Mobil	Joliet, IL
Marathon	Robinson, IL

A summary of this analysis is presented in Table 4-6.

This analysis indicated that the treatment technologies at all the Illinois refineries are very similar. All have preliminary oil separation followed by an additional oil-water separator using a gas flotation process. The biological treatment process is activated sludge. The overflow rates on the secondary clarifiers are similar. The only difference in the treatment systems appears to be the activated sludge retention time. The Conoco-Phllips and Marathon refineries have a longer retention time than the Lemont Refinery. The Exxon-Mobil and Lemont Refinery have similar activated sludge retention times. The activated sludge is followed by polishing ponds at all refineries except Marathon which has final filters.

4.7 CONCLUSIONS

The treatment process at the Lemont Refinery is similar to that at the other Illinois refineries. All of the refineries employ the activated sludge process for nitrogen removal.

TABLE 4-6

COMPARISON OF WASTEWATER TREATMENT AT ILLINOIS REFINERIES
AEI JOB NO. N356-01

System	Refinery			
	Conoco Phillips	**Exxon Mobil**	**Lemont**	**Marathon**
Initial Oil and Solids Removal	Oil/Water Separator	API Separator	Two-4.6 MG Process Separation Tanks	API Separator
Additional Oil and Solids Removal	Dissolved Nitrogen Flotation	Air Flotation	Induced Gas Flotation	Dissolved Nitrogen Flotation
Biological Treatment	Activated sludge with 1.31 days detention time and 450 gpd/ft^2 clarifier overflow	Activated sludge with 10.9 hrs detention time (upgrading to 19.4 hrs). Clarifier overflow 392 gpd/ft^2	Activated sludge with 7.7 hrs detention time and 382 gpd/ft^2 clarifier overflow	Activated sludge with 1.54 days detention time and 227 gpd/ft^2 clarifier overflow
Tertiary Treatment	Polishing ponds 5.4 MMgal	Polishing pond 4.9 MMgal	Polishing in treated water basin (polishing pond) 16 MMgal	Final filtration

Estimated costs for the four most viable alternatives to upgrade the Lemont wastewater treatment system are presented in Table 4-7. The least expensive of these technologies is the fixed media biological treatment unit. Additional ammonia removal may be achievable by upgrading the treatment plant with additional treatment steps such as a fixed media biological treatment unit. However, this would be at significant cost, and it is uncertain that the upgraded system would achieve consistent compliance with the 3.0 mg/l ammonia nitrogen standard. Therefore, upgrading the treatment system with additional treatment technologies for ammonia removal is not justified.

The ongoing optimization program at Lemont Refinery has resulted in improved ammonia nitrogen removal. The Refinery has participated in pilot studies and research programs to address problems because of higher solid loadings. It is anticipated that the refinery will be able to improve treatment plant performance based on research through the Petroleum Environmental Research Forum. In addition, improved performance is anticipated in conjunction with continued optimization. However, the capability of any system is limited in large part due to the inherent variability in refinery wastes.

We recommend that Lemont Refinery continue its ongoing wastewater treatment improvement programs. These efforts should be directed toward obtaining the maximum possible ammonia removal on a consistent basis. Continued development of operational data under the varying conditions inherent with refinery wastes will help to improve the performance of the system, and will allow the maximum ammonia removal capability of the system to be achieved.

35606r003

TABLE 4-7

SUMMARY OF PROJECT COST ESTIMATE
AEI JOB NO. N356-01

CASE	CASE 1	CASE 2	CASE 3	CASE 4
CASE DESCRIPTION	ACTIVATED SLUDGE & POWDERED ACTIVATED CARBON	ACTIVATED SLUDGE WITH A FIXED MEDIA SYSTEM	MEMBRANE BIOREACTOR ACTIVATED SLUDGE	ACTIVATED SLUDGE, BREAKPOINT CHLORINATION/ DECHLORINATION
Major Processes Cost	$9,264,600	$8,487,000	$35,710,000	$468,000
Site Work, Pumps and Piping	$592,400	$492,000	$492,000	$248,000
Electrical	$1,000,000	$945,000	$4,016,000	$127,000
Engineering	$1,480,000	$1,341,000	$5,432,000	$209,000
Contingency	$2,463,000	$2,235,000	$9,050,000	$348,000
Total Project Cost	$14,800,000	$13,500,000	$54,700,000	$1,400,000
Major O&M Cost (annual)	$1,424,000	$1,220,000	$3,280,000	$3,332,000
Equivalent Annual Cost (a)	$3,630,000	3,220,000	$11,400,000	$3,640,000

(a) Based on a Capital Recovery Factor for 10 years @ 8% interest.

APPENDIX A

CALCULATION OF EFFLUENT CRITERIA

Received, Clerk's Office August 1, 2008

Load Limit Calculations
Based on Federal Regulations - 40 CFR419
168,626 barrels of crude oil processed per day

Process	**Capacity M bbl's**	Capacity Relative to Throughput	**Weighting Factor**	**Processing Configuration**
Crude: Design	168.626			
Desalt	168.626	1.000		
Atmos Dist.	168.626	1.000		
Vac. Dist.	82.807	0.491		
		2.491	1	2.491

Process	Capacity M bbl's	Capacity Relative to Throughput	Weighting Factor	Processing Configuration
Cracking:				
FCC	69.098	0.410		
Delayed Coker	40.326	0.239		
Needle Coker	6.413	0.038		
		0.687	6	4.122

Process	Capacity M bbl's	Capacity Relative to Throughput	Weighting Factor	Processing Configuration
Asphalt				
Prod.	4.329	0.026		
Emul	10.935	0.065		
		0.091	12	1.092
			TL	7.705

Refinery Processing Configuration 7.705

Size Factor	1.41	Paragraph 419.22 (b) (1)
Process Factor	1.41	Paragraph 419.22 (b) (2)
# of 1000 Bbl's of Feed	168.626	
Multiplication Factor C	335.25	

Go to BPT Parameters Tab

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BPT Parameters [419.22a]

Parameter	Average			Maximum		
	419.22a factor	Proc Config factor	#'s		Proc Config factor	#'s
BOD	5.5	335.25	1843.8	9.9	335.25	3318.9
TSS	4.4	335.25	1475.1	6.9	335.25	2313.2
COD	38.4	335.25	12873.4	74	335.25	24808.2
O & G	1.6	335.25	536.4	3	335.25	1005.7
Phenol	0.036	335.25	12.07	0.074	335.25	24.81
NH3-N	3.0	335.25	1005.7	6.6	335.25	2212.6
Sulfide	0.029	335.25	9.72	0.065	335.25	21.79
Cr Tl	0.088	335.25	29.50	0.15	335.25	50.29
Cr +6	0.0056	335.25	1.88	0.012	335.25	4.02

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BAT Parameters [419.23 (a)]

Parameter	Average			Maximum		
	419.22a factor	Proc Config factor	#'s		Proc Config factor	#'s
COD	38.4	335.25	12873.42	74	335.25	24808.2
NH3-N	3.0	335.25	1005.7	6.6	335.25	2212.6
Sulfide	0.029	335.25	9.72	0.065	335.25	21.79

167.139

BAT Effluent Calcs (419.23(c)(1)(I) (Phenol, CrTI, Cr+6)

Refinery Processes

Crude	M Bbls	**Cracking, Coking, Product Hydrotreating**	M Bbls	**Asphalt**	M Bbls	**Reforming**	M Bbls
Distillation	168.626	FCC	69.098	Prod	4.329	U-16	25.182
Desalting	168.626	Delayed Coking	40.326	Emul	10.935	U-23	14.545
Vac Dist	82.807	Needle coking	6.413				
		U-25 Hyd Trt	35.32				
		U-15 Hyd Trt	14.34				
		U-102 Hyd Trt	41.7				
Group Totals	420.059		207.232		15.264		39.727

Phenol

		Average		Maximum	
	Totals	419(c)(1)(I) factor	#'s	419(c)(1)(I) factor	#'s
Crude	420.059	0.003	1.260177	0.013	5.460767
Cracking, etc	207.232	0.036	7.460352	0.147	30.463104
Asphalt	15.264	0.019	0.290016	0.079	1.205856
Reforming	39.727	0.032	1.271264	0.132	5.243964
Totals			**10.28**		**42.4**

Total Cr

		Average		Maximum	
	Totals	419(c)(1)(I) factor	#'s	419(c)(1)(I) factor	#'s
Crude	420.059	0.004	1.680236	0.011	4.620649
Cracking, etc	207.232	0.041	8.496512	0.119	24.660608
Asphalt	15.264	0.022	0.335808	0.064	0.976896
Reforming	39.727	0.037	1.469899	0.107	4.250789
Totals			**11.98**		**34.5**

Hex Cr

		Average		Maximum	
	Totals	419(c)(1)(I) factor	#'s	419(c)(1)(I) factor	#'s
Crude	420.059	0.0003	0.126018	0.0007	0.2940413
Cracking, etc	207.232	0.0034	0.704589	0.0076	1.5749632
Asphalt	15.264	0.0019	0.029002	0.0041	0.0625824
Reforming	39.727	0.0031	0.123154	0.0069	0.2741163
Totals			**0.983**		**2.21**

Stormwater Credits 8/29/2007

Stormwater Credit 419.23(f)(2) and 419.24 (e)(2)

Parameter	Average	Maximum
Phenols	0.0014	0.0029
CrTI	0.0018	0.005
Cr+6	0.00023	0.00052
COD	1.5	3
BOD	0.22	0.4
TSS	0.18	0.28
O & G	167.139	0.13

Multiply the above factor times the number of 1000 gallons of stormwater flow

e.g.) Dry weather flow = 2400 gpm Wet weather flow = 4000 gpm

COD 1600 gpm : # of 1000's gal = 2304

38.50 = 2304 (1.5) = 3456 #'s
Maximum = 2304 (3.0) = 6912 #'s

Concentration Limits - Section 304.124 Title 35 - Subtitle C - Chapter I

Title 35 - Subtitle C - Chapter I Regulations
Average Flow = 4950gpm (6-93) Maximum Flow = 10400gpm (7-96)

	GPM	MGD
Ave flow	4950	7.128
Max Flow	10400	14.98

	167.139		#'s	
	Average	Max	Average	Max
TSS	25	50	1486.2	6245.0
BOD	20	40	1189.0	4996.0
Cr+6	0.1	0.3	5.94	37.47
CrTI	1.0	2.0	59.45	249.8
O & G	15	30	891.7	3747.0
NH3-N	9.4	26.0	558.8	3247.4
Fluoride	38.50	30	2288.7	3747.0
Phenol	0.3	0.6	17.8	74.9
Cyanide	0.1	0.2	5.94	25.0
CBOD	20	40		

Load Limits Comparison 8/29/2007

Load Limits Comparison

	BAT & BPT		Chapter I Regulations	
Parameter	Average	Maximum	Average	Maximum
TSS	1475.1	2313.2	1486.2	6245.0
COD	12873.4	24808.2	-----	-----
BOD	1843.8	3318.9	1189.0	4996.0
Cr+6	0.983	2.21	5.94	37.5
CrTl	11.98	34.5	59.4	249.8
O & G	536.4	1005.7	891.7	3747.0
NH3-N	1005.7	2212.6	558.8	3247.4
Fluoride	----	----	2288.7	3747.0
Phenol	10.28	42.4	17.8	74.9
CN	----	----	5.94	25.0
Sulfide	9.72	21.8	----	----

Outfall 001 Effluent Limits

	Concentration Limits (mg/l)		Load Limits (#'s/day)		Site Specific		
Parameter	Average	Maximum	Average	Maximum	Average	Maximum	
BOD	----	----	1189.0	3318.9			
TSS	25	50	1486.2	2313.2			
COD	----	----	12873.4	24808.2			
O & G	15	30	536.4	1005.7			
Phenol	0.3	0.6	10.28	42.4			
NH3-N	9.4	26	~~967.5~~	~~2212.6~~	749.19	1648.21	USEPA supported from 1994 issued permit
Sulfide	----	----	9.72	21.8			
CrTl	1	2	11.98	34.5			
Cr+6	0.1	0.3	0.983	2.21			
CN	0.1	0.2	5.94	25.0			
Fluoride	38.5	30	2288.7	3747.0			
CBOD	20	40	----	----			

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APPENDIX B
STATISTICAL DATA ANALYSIS

46 8000

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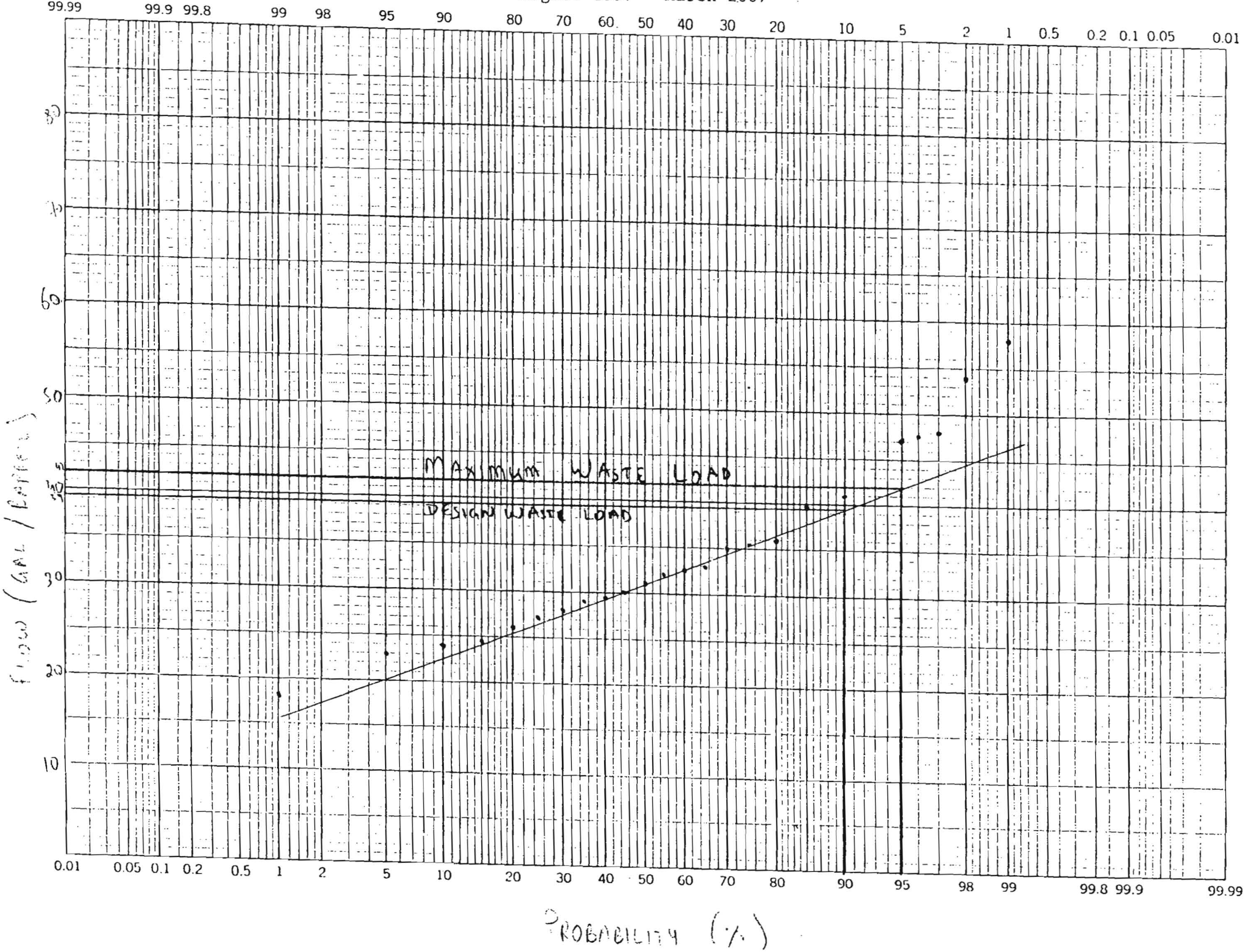
DESIGN = 39

Average Monthly Aeration Influent Flow
August 1997 - March 2007



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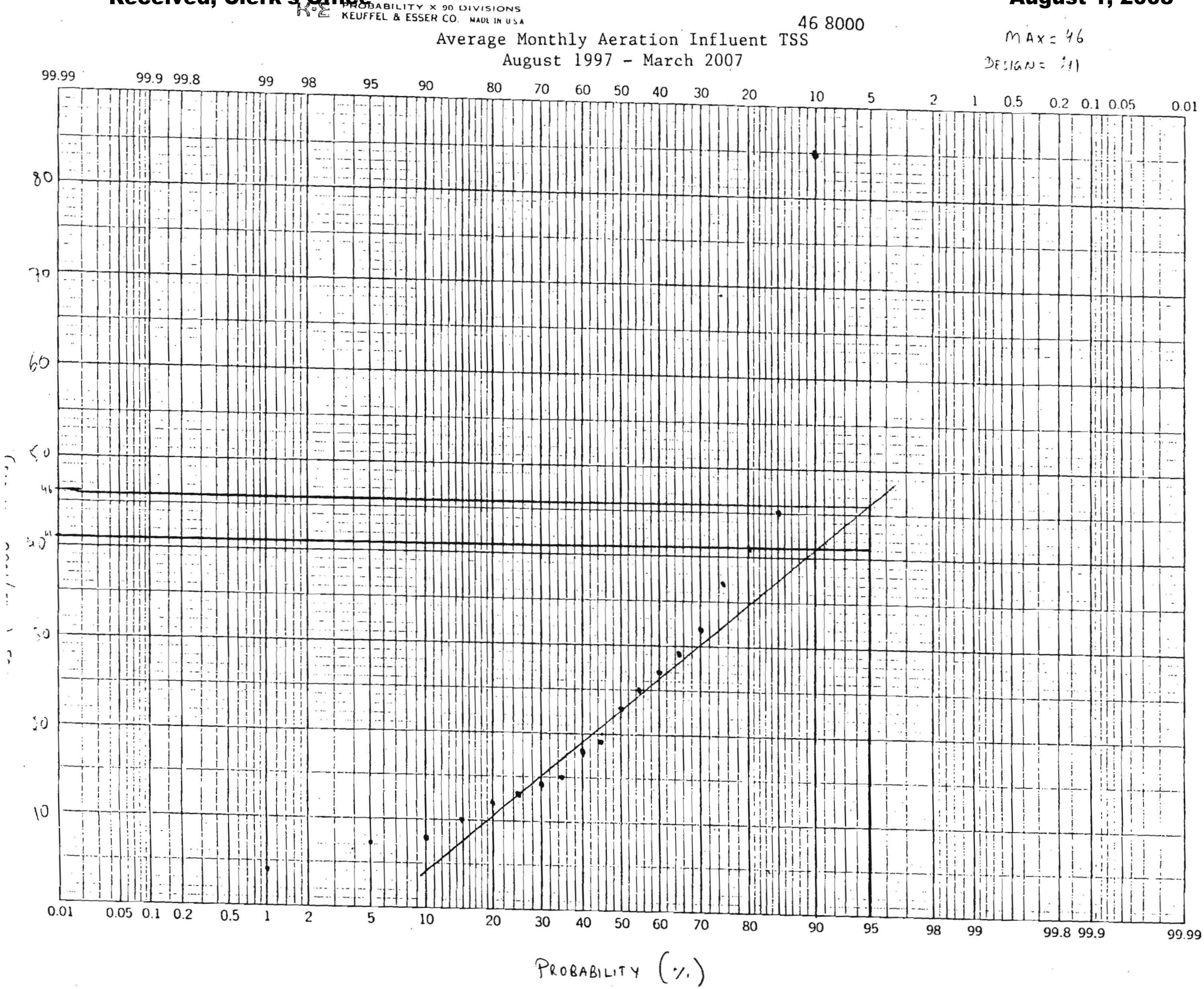

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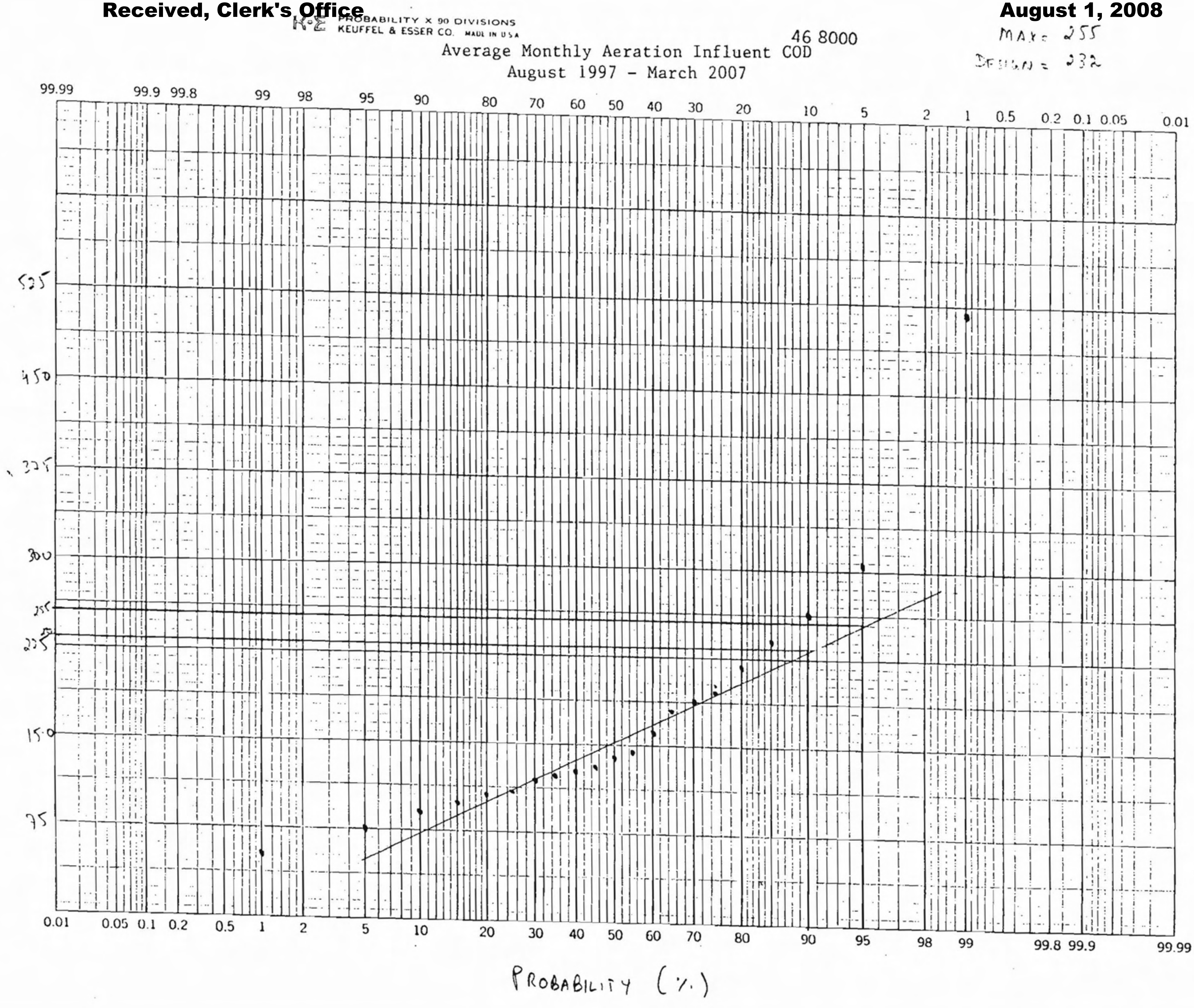
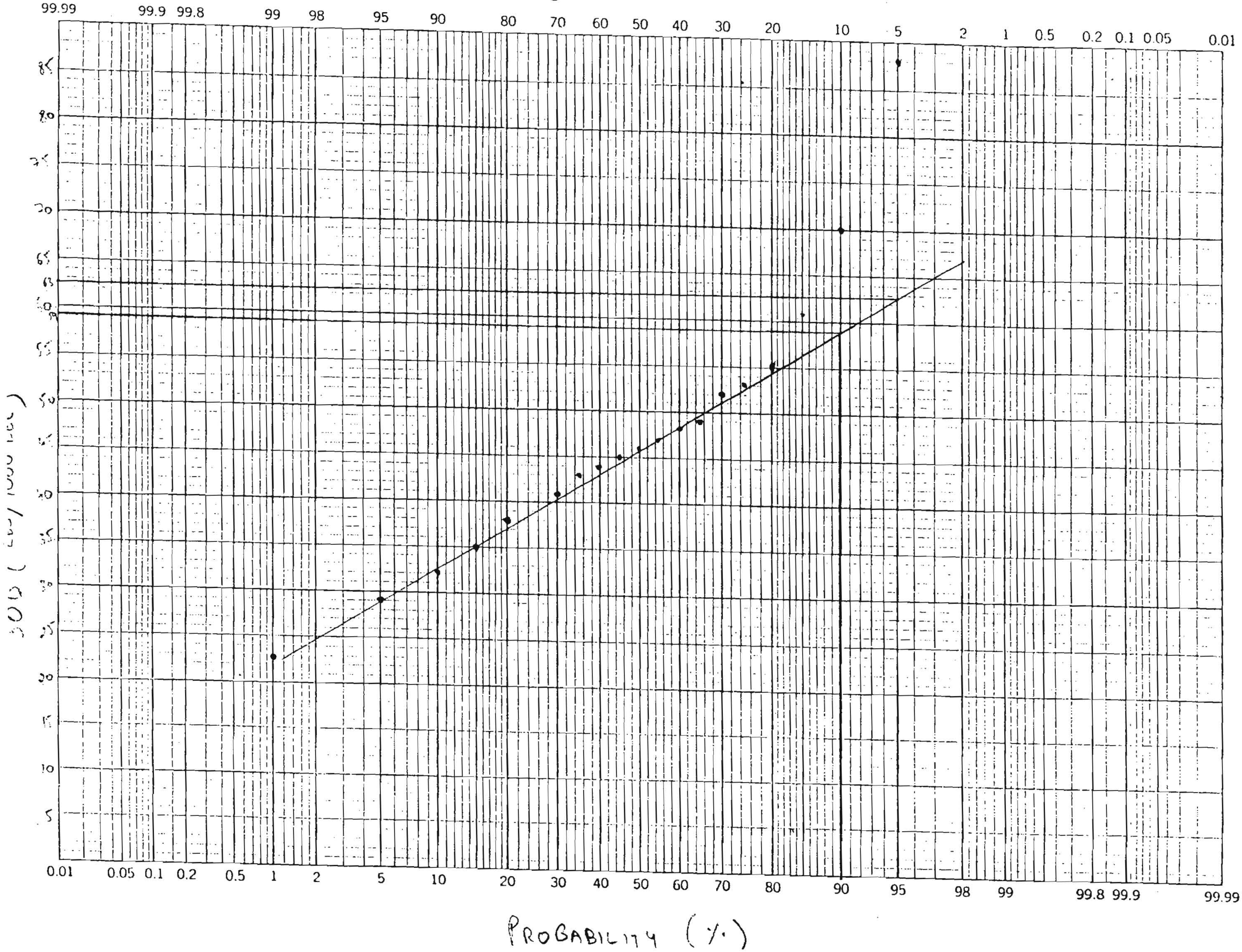


Received, Clerk's Office August 1, 2008

46 8000

DESIGN = 59

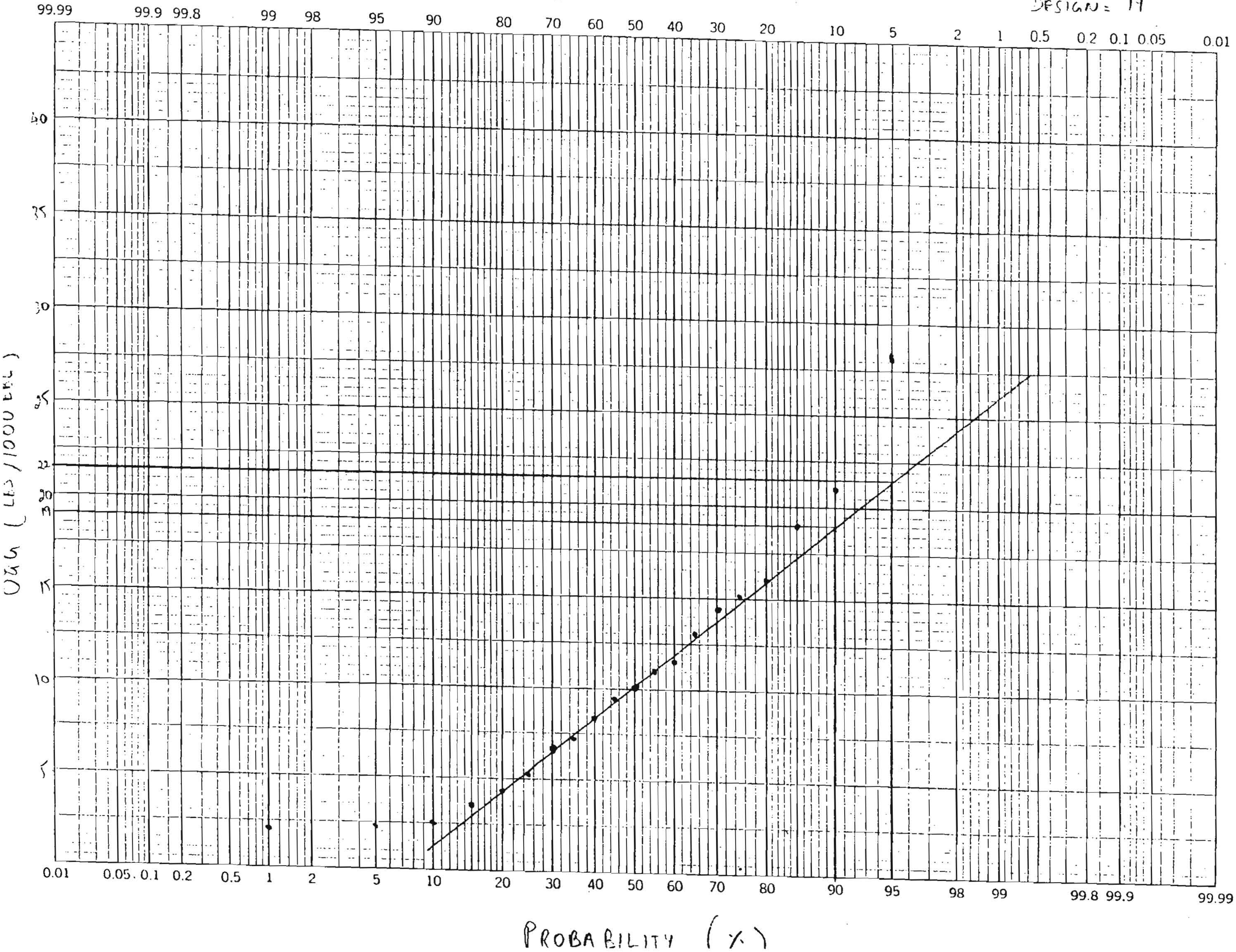
Average Monthly Aeration Influent BOD
August 1997 - March 2007

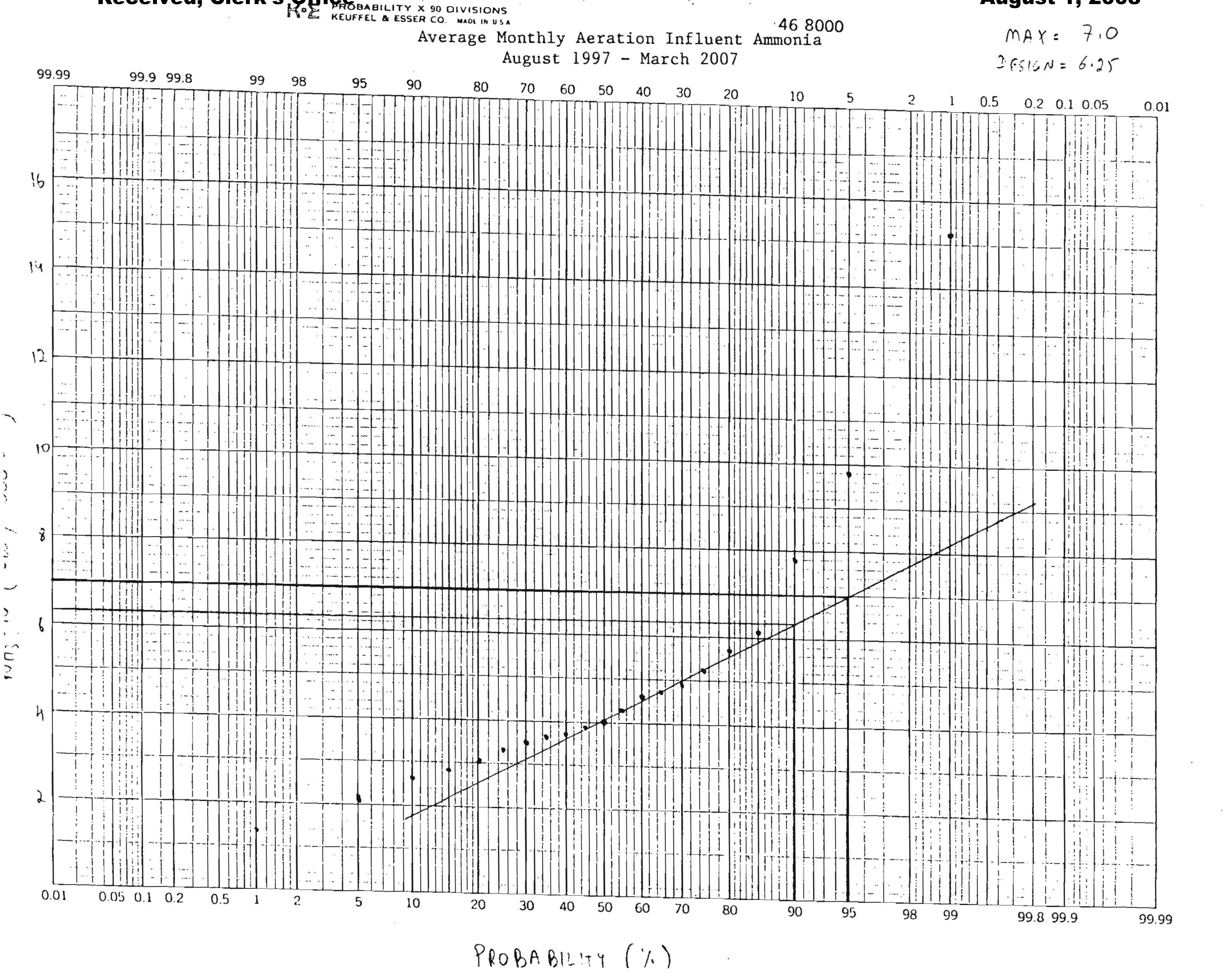


K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 8000

Average Monthly Aeration Influent Oil and Grease
August 1997 - March 2007

MAX = 22
DESIGN = 19



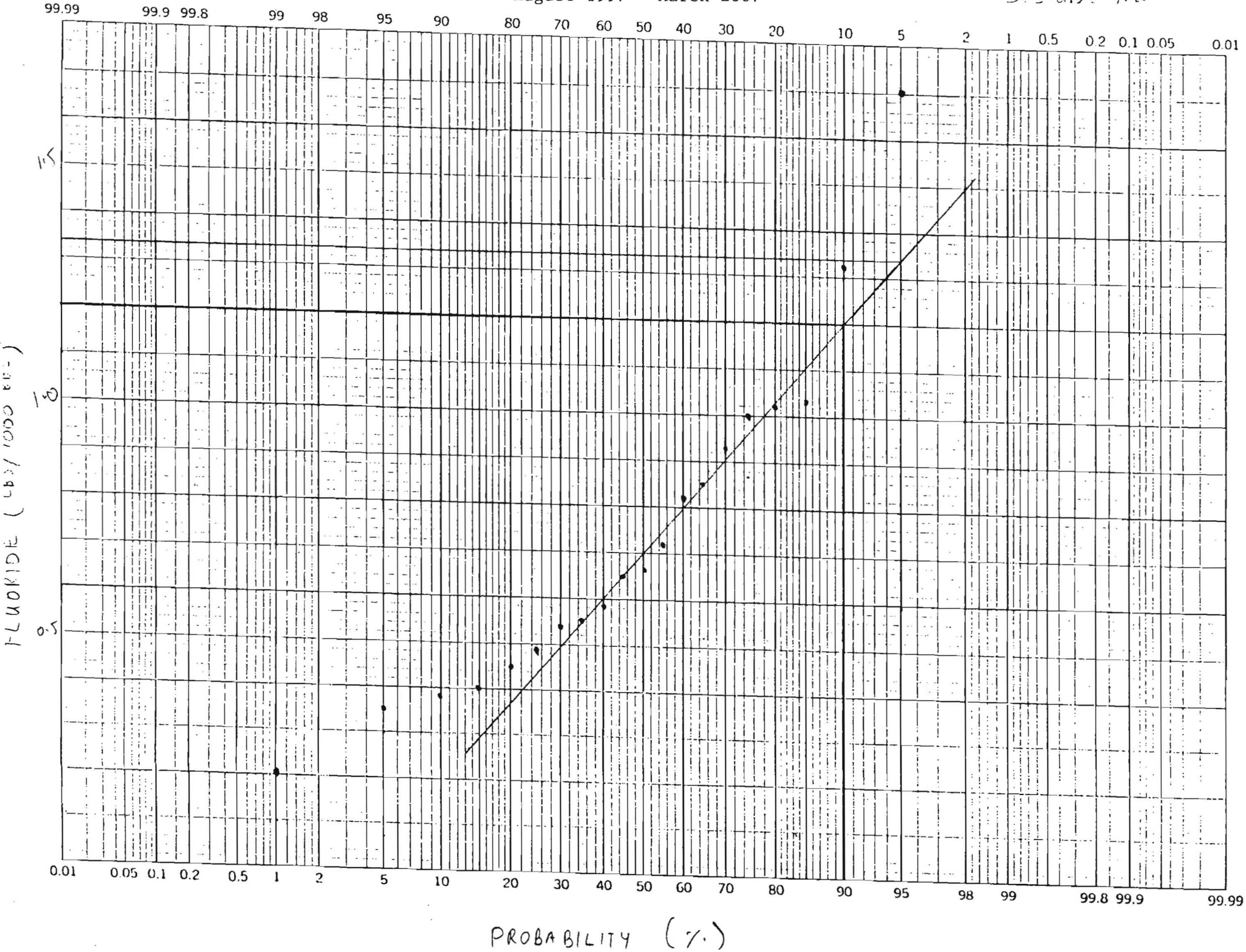

K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 8000
Average Monthly Aeration Influent Ammonia
August 1997 - March 2007
MAX: 7.0
DESIGN = 6.25
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
16
14
12
10
8
6
4
2
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
PROBABILITY (%)

K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

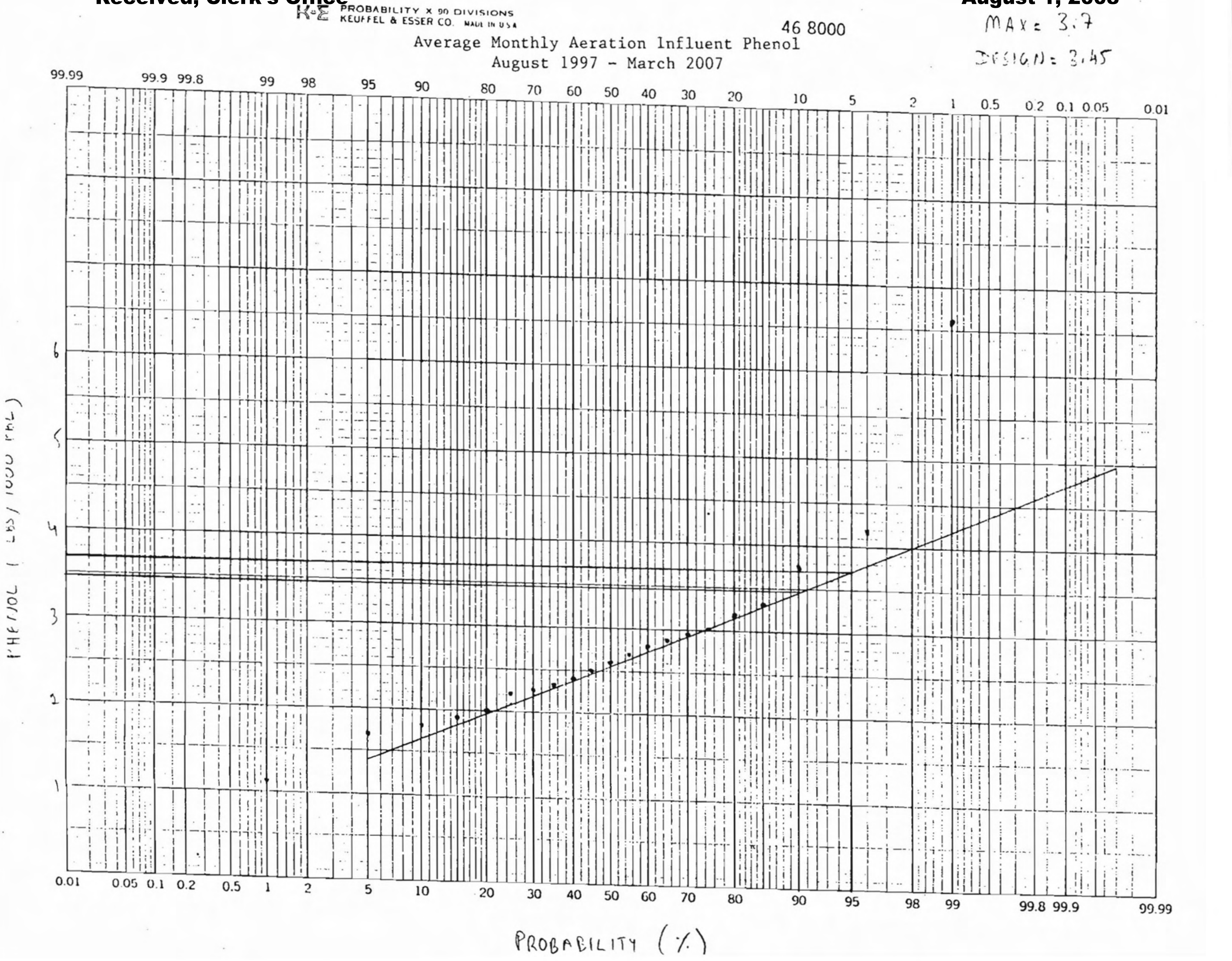
46 8000

Average Monthly Aeration Influent Fluoride
August 1997 - March 2007

MAX: 1.34
DESIGN: 1.2



Received, Clerk's Office August 1, 2008



K&E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 8000

Average Monthly Aeration Influent Sulfide
August 1997 - March 2007

MAX: 0.71
DESIGN: 0.6