Ozone Qualifications, Services and Experience

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Resume - Kerwin L. Rakness

EXPERIENCE:
Mr. Rakness has specific experience in the following areas: ozone equipment performance testing, ozone system start-up and optimization training and assistance, and wastewater treatment plant evaluation, optimization and start-up assistance. He was author of the ozone book titled "Ozone in Drinking Water Treatment: Design, Operation and Optimization that was published by the American Water Works Association. He was project manager for the "Ozone Energy Optimization Project" that was co-sponsored by the AWWA Research Foundation and Electric Power Research Institute Community Environmental Center. Mr. Rakness was a contributing author of the AWWARF ozone book titled "Ozone in Water Treatment: Application and Engineering" and was primary author for the ozone section of the "EPA Disinfection Design Manual" for wastewater treatment. He has conducted several ozone design and operations seminars for the AWWA, University of Wisconsin, University of Alberta, and private clients.

Mr. Rakness has evaluated or assisted in start-up and optimization training in over four-dozen ozone systems for drinking water treatment. He has evaluated or provided technical assistance at over 100 wastewater treatment plants, including activated sludge and fixed-film wastewater treatment plants. He has conducted research studies in the areas of high-purity oxygen activated sludge, biological aerated filter, and activated bio-filter wastewater treatment processes and in the area of ozone for water and wastewater treatment.

Mr. Rakness has presented and published several technical papers, and he was presented with the International Ozone Association's "Best Paper Award" for a paper on ozone transfer efficiency. He is Chairman of the IOA Standardization Committee, a member of the "Ozone Science and Engineering" editorial review board, and chairman of Task Group 4300-Ozone of "Standard Methods for the Examination of Water and Wastewater." He was chairman of the Personnel Advancement Committee of the Rocky Mountain Water Pollution Control Association (RMWPCA), was trustee of the RMWPCA, and received the RMWPCA Distinguished Service Award.

EDUCATION:	M.S. Sanitary Engineering, 1970, South Dakota State University B.S. Civil Engineering, 1968, South Dakota State University
REGISTRATION:	Professional Engineer - Colorado, California, Indiana, Pennsylvania, South Dakota, and Utah
ORGANIZATIONS:	International Ozone Association, Water Environment Federation, Rocky Mountain Water Environment Association
EMPLOYMENT HISTORY:	Process Applications, Inc., Fort Collins, CO (3/82 - Present)
	M & I, Inc., Consulting Engineers, Fort Collins, CO (4/75 - 3/82)
	FMC Corporation, Englewood, CO (3/74 - 4/75)
	USEPA, Region VIII, Denver, CO (4/72 - 3/74)

Resume - Glenn F. Hunter

EXPERIENCE:

Mr. Hunter has specific experience in the following areas: Ozone system process training, ozone startup assistance, ozone performance testing, ozone process optimization, water and wastewater treatment process design, water system master planning, water main and sewer design, water pumping station renovation, water storage tank sizing and site design, water system computer modeling and hydraulic analysis. While working for a water utility he managed the consultant design of a 52 MGD ozone water disinfection facility. He also assisted operations and maintenance staff with the start-up and optimization of this facility.

Mr. Hunter has served as a project manager on many water system design and renovation projects. He has prepared engineering reports and contract documents for construction of water and wastewater treatment projects. He has conducted ozone process evaluation, training and optimization at many water treatment facilities and presented workshops and seminars on utilizing ozone in water treatment.

EDUCATION: B.S. Civil Engineering, 1978, University of Maine

REGISTRATION: Professional Engineer – Colorado, Maine, Maryland. Michigan

ORGANIZATIONS: International Ozone Association, American Water Works Association

EMPLOYMENT HISTORY:

Process Applications, Inc., Fort Collins, Colorado
(8/97 to present)

Portland Water District, Portland, Maine
(7/86 - 8/97)

Greenhorne & O'Mara, Inc., Greenbelt Maryland
(4/84 - 7/86)

Misco, Inc., Dundalk, Maryland
(9/83 -4/84)

Self -Employed
(8/82 -9/83)

Camp Dresser & McKee, Inc., Boston, MA & Detroit, MI
(6/78 - 8-82)

Ozone Process Training, Technical Assistance and Optimization

Process Applications, Inc. (PAI) has provided technical assistance and operation and optimization training services through activities in the areas listed below. Selected, specific projects and client contact persons are shown in Table O-2.

a) ozone facility evaluations,
b) ozone design review (from an operations and maintenance perspective),
c) ozone process training,
d) ozone facility technical assistance and
e) ozone process optimization.

TABLE O-2. Summary of Ozone Process Training and Technical Assistance Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
2005	R.L. Sherard WTP Cheyenne, WY	920	Developed ozone data monitoring program and trained plant staff on its use.	Bud Spillman (307) 632-9890
2004 - 2005	John J Carroll WTP Massachusetts Water Resources Authority Boston, MA	7,500	Providing start-up training and optimization assistance for ozone process including development of an ozone simulator, data-monitoring program and residual meter calibration spreadsheet, to meet SWTR disinfection performance objectives. Assisted plant staff with developing ozone system operating guidelines.	Dave Coppes (508) 872-4388
2004-2005	Joseph Jensen WTP Metropolitan Water District of So. Calif. Riverside, CA	14,800	Providing start-up ozone process training and optimization assistance for raw water ozone system including development of an ozone simulator, data-monitoring program and residual meter calibration spreadsheet, to meet SWTR disinfection performance objectives. Assisted plant staff with developing ozone system operating guidelines.	Sajal Mitra (213) 217-5671
2003 – 2005	Passaic Valley Little Falls WTP Clifton, NJ	3,600	Conducting ozone process start-up training and optimization assistance for the 110 MGD Little Falls WTP. Ozonation of settled water is employed to achieve SWTR disinfection performance objectives. Assisted plant staff with developing ozone system operating guidelines. Developed ozone system simulator program and other spreadsheets to assist plant staff with ozone data monitoring, trending, disinfection reporting, and ozone residual analyzer calibration.	Laura Cummings Phil Roosa Linda Pasquariello (973) 237-2020
1999 – 2005	Southern Nevada Water Authority Las Vegas, NV	12,000 AMS 4,000 RM	Conducted ozone design review/process control workshops, ozone process start-up training, technical assistance and optimization assistance for the AMSWTF and RMWTF operating staff. Pre-ozonation is employed to achieve enhanced disinfection of 2-logs *cryptosporidium* oocyst inactivation credit. Assisted plant staff with developing ozone system operating guidelines. Developed control and automation guidelines, ozone simulator, residual meter calibration, and ozone data monitoring spreadsheets.	Ron Zegers (702) 564-7697
2004	Arcadia Lake WTP City of Edmond, OK	650	Conducted ozone process training and optimization workshop for staff at the 12 MGD Arcadia Lake WTP. Ozonation of settled water is employed for disinfection, taste and odor control, and microflocculation. Developed spreadsheets to assist plant staff with ozone disinfection credit calculations and ozone residual analyzer calibration. Identified optimization	Fred Rice 405-216-7690 J. Dan Shannon (CDM, Inc.) 817-332-8727

TABLE O-2. Summary of Ozone Process Training and Technical Assistance Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
			opportunities associated with ozone residual sampling and measurement.	
2004	Energy Conservation Products Portland, ME	<10	Provided technical assistance to help resolve ozone laundry system operation and maintenance problems.	Thomas Tobiassen (207) 775-5666
2000 – 2004	H.J. Mills WTP Metropolitan Water District of So. Calif. Riverside, CA	6,000	Conducted ozone process training, technical and optimization assistance at this 170 MGD WTP using raw water ozonation to provide 1-log Giardia disinfection. Assisted plant staff with developing ozone system operating guidelines. Developed ozone simulator, residual meter calibration, and ozone data monitoring spreadsheets to assist plant staff meet SWTR and MWD disinfection performance objectives.	Sajal Mitra (213) 217-5671 Ric Johnston 951-776-2702
2001 – 2004	Burlington WTP Region of Halton Oakville, Ontario	2,400	Conducted ozone process design review, start-up training and optimization assistance for the 79 MGD Burlington WTP. Ozonation of settled water is employed to achieve enhanced disinfection of 2-logs *cryptosporidium* oocyst inactivation credit. Assisted plant staff with developing ozone system operating guidelines. Developed ozone system simulator program and other spreadsheets to assist plant staff with ozone data monitoring, trending, disinfection reporting, and ozone residual analyzer calibration.	Bill Mundy (905) 825-6123 ext. 7727
1997-2004	Portland Water District Portland, ME	1,300	Provided ozone system technical assistance to plant staff at the 52 MGD Sebago Lake WTF for evaluating ozone process operating data trends and optimization. Developed ozone system spreadsheets to assist plant staff with ozone data monitoring, trending, and ozone residual analyzer calibration. Identified optimization opportunities associated with ozone residual sampling, equipment design, and control strategies.	Jim Wallace Joel Anderson (207) 774-5961
2003	Pierce Burch & John Kubala WTPs Arlington, TX	Both plants 5,150	Provide ozone optimization technical assistance and training, including development of ozone simulator program and automation control guidelines for 76 MGD and 60 MGD plants.	Chuck Vokes 817-457-7550 Travis Andrews (817) 459-6604
2003	North Andover WTP North Andover, MA	150	Conducted ozone facility evaluation (OFE) at the North Andover WTP. The OFE identified optimization opportunities associated with contactor design, ozone residual sampling, control strategy, and maintenance program.	Dennis Bedrosian 978-688-9574
2002 – 2003	Lake Ray Roberts WTP City of Denton, TX	1,200	Provided design review assistance, start-up training and technical assistance for pre and intermediate ozone process to meet SWTR disinfection performance objectives. Provided ozone simulator, training sessions, residual meter calibration spreadsheet, and ozone data monitoring spreadsheet.	Tim Fisher (940) 349-7190 Randy Markham (940) 349-7526 David Jackson (Freese & Nichols) (214) 217-2257
2001 - 2003	R.M. Levy WTP Helix Water District La Mesa, CA	5,400	Provided start-up training and optimization assistance at this intermediate ozone system installed to meet SWTR disinfection performance objectives. Developed ozone simulator, residual meter calibration, and ozone data monitoring spreadsheets.	Larry Lyford (619) 443-1031
2000 –2002	A.H. Weeks Water Treatment Plant Windsor Utilities Comm. Windsor, Ontario	1,450	Provided ozone process control, process monitoring review, start-up training, and optimization assistance for raw water ozonation used for *cryptosporidium* disinfection and taste and odor control. Developed ozone simulator, residual meter calibration, and ozone	Saad Jasim 519-379-0187 Glenn Bondy 519-255-2785

TABLE O-2. Summary of Ozone Process Training and Technical Assistance Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
			data monitoring spreadsheets.	
2001	Vail WWTP Vail, CO Eagle River Water & Sanitation District	250	Prepared and presented ozone optimization workshop. Developed ozone system simulation model for the air-fed ozone system used for wastewater treatment.	Jim Edwards (970) 476-7480
2001	Avon WTP Avon, CO Eagle River Water & Sanitation District	250	Prepared and presented ozone optimization workshop. Developed ozone system simulation model for the air-fed ozone system used for water treatment.	Steve Wilson (970) 476-7480
2001	City of Fort Worth North Holly WTP Fort Worth, TX	4,400	Provided ozone system design review from O&M perspective for this 80 MGD conventional WTP. Developed ozone system simulation program for assistance in set-up of ozone process control strategy.	David Sloan (817) 735-7277
2001	Upper Trinity WTP Upper Trinity Regional Water District Lewisville, TX	2,800	Provided design review workshops, start-up training and optimization assistance for this intermediate ozone system installed to meet *Crypto* disinfection performance objectives. Developed ozone simulator, residual meter calibration, and ozone data monitoring spreadsheets.	Hector Ortiz (972) 436-2379 Darryl Corbin, MWH (214) 360-9929
2001	Haworth WTP Harrington Park, NJ	2,700	Conducted ozone facility operability and optimization review study.	Bob Raczko (201) 634-4232
1999	Mill Creek WTP City of Walla Walla, WA	600	Conducted start-up ozone process training in coordination with the design engineer, CH2M Hill (Seattle). Ozone is used for *Cryptosporidium* inactivation without filtration at this 12 MGD facility.	Tom Krebs (509) 522-3758 Robert Gordon (509) 527-4380
1998-99	John Kabala WTP Arlington, TX	2,060	Provided start-up training, including an ozone data monitoring program for pre- and intermediate-ozone process control at this 32-MGD Water Treatment Plant to meet disinfection objectives.	Chuck Vokes 817-457-7550 Ron Joost, Carollo (602) 263-9500
1998-99	Pierce Burch WTP Arlington, TX	3,090	Provided start-up training, including an ozone data monitoring program for pre- and intermediate-ozone process control at this 75-MGD Water Treatment Plant to meet disinfection objectives.	Travis Andrews (817) 459-6604 Ron Joost, Carollo (602) 263-9500
1997-99	Canal Road WTP, Bound Brook, NJ	6,000	Provided ozone optimization assistance for the WTP staff. Result was an approximate 40 percent reduction in operating cost.	Oleg Kostin (908) 654-1234, X125
1998	Bollman WTP Contra Costa Water District Concord, CA	2,040	Provided start-up ozone process training, ozone data monitoring program and technical assistance at this 80 MGD Water Treatment Plant with intermediate ozonation.	Pat Panus (925) 688-8305 Paul Prewitt (925) 688-8157 Scott Dittman, CDM (925) 296-8015
1998	Howard Avenue Water Treatment Plant Milwaukee, WI	2,400	Assisted Black & Veatch in preparing and presenting ozone training workshops prior to start-up of ozone facilities.	Dan Welk (414) 286-2690
1998	Linnwood Water Treatment Plant Milwaukee, WI	6,200	Assisted Black & Veatch in preparing and presenting ozone training workshops prior to start-up of ozone facilities.	Lonnie Lamb (414)-365-0787
1998	Eagle Mountain WTP Fort Worth, TX	1,112	Conducted ozone residual monitor study to support City of Fort Worth in obtaining authorization to use on-line	Jerry McMillion (817) 238-9977

TABLE O-2. Summary of Ozone Process Training and Technical Assistance Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
	Elm Fork WTP Dallas, TX	13,000	meter readings to report disinfection compliance and City of Dallas in determining which residual monitors work best for their unique water quality. Study was conducted as part of an AWWARF and EPRI-CEC-sponsored research project.	Gamaliel Guzman (972) 389-6012
1998	Harwoods Mill and Lee Hall WTPs Newport News, VA	HM 1,275 LH 1,500	Provided O&M design review assistance and workshops for the Harwoods Mill and Lee Hall WTPs in Newport News, VA. Design Engineer was Montgomery Watson.	Mike Hotaling (757) 867-6990 David Wilkes (703) 478-3400
1998	Seal Harbor, ME Northeast Harbor, ME	SH 9 NEH 17	Reviewed design memos and specs and drawings for upgrade of two small ozone water disinfection facilities using sidestream injection and pipeline contactors. Provided comments regarding operability and maintenance issues to assist Woodard & Curran with final design.	Ron Hidu (207) 945-5492
1997	Mesa Consolidated Water District Costa Mesa, CA	500	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with ozone generator maintenance and design.	Bill Johnson 714-574-1000
1997	Delaware River Water Treatment Plant New Jersey American Water Company Delran, NJ	3,150	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with generator operation, contactor operating strategy, and contactor baffle design.	Eva Ibrahim 609-764-4905
1996 - 1997	Mannheim WTP Regional Municipality of Waterloo Kitchener, Ontario	600	Provided OFE and follow-up technical assistance to develop and implement an optimized strategy for changing ozone treatment objective from taste and odor control to *crypto* disinfection. Project activities included development of a contactor simulation model that assisted in determining benefit of proposed contactor modifications and ozone data monitoring program for tracking *crypto* inactivation credit and associated cost of operation.	Franklyn Smith (519) 571-6206
1996	Worcester, MA	1,200	Provided process control training including an ozone data monitoring program and conducted ozone system performance tests.	Bob Hoyt, Worcester (508) 799-1513 Carol Ashe, CDM (617) 621-2565
1996	Delaware River Water Treatment Plant Delran, NJ	3,000	Assisted New Jersey American Water Company with developing an optimized ozone system start-up approach. Ozone system is medium frequency and pre-ozonation is utilized.	Eva Ibrahim (609) 764-4905
1996	Eagle Mountain Water Treatment Plant, Fort Worth, TX	1,112	Conducted OFE for this low pressure air-fed ozone system with supplemental LOX feed gas. Two ozone contactors were originally included in the plant expansion design. Based on results of this study, one contactor was removed from the design providing $6.75 million savings for the City of Fort Worth.	Ronnie Hyde 817-871-8293 Melvyn Ludwig 817-238-9977
1996	Mannheim Water Treat-ment Plant, Regional Municipality of Waterloo Kitchener, Ontario	600	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with air compressor operation and ozone concentration monitoring.	Brian Pett 519-571-6203 Franklyn Smith

TABLE O-2. Summary of Ozone Process Training and Technical Assistance Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
				519-571-6206
1996	Charles-J. DesBaillets Filtration Plant Montreal, Quebec	9,500	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with generator and contactor operation and off-gas destruct design.	Michel Gagne 514-872-3414
1996	Paul M. Neal Water Treatment Plant, Central Lake Co. Joint Action Water Agency Lake Bluff, IL	1,000	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with air preparation equipment operation and compressor design.	William Koepsel, Jr. 847-295-7788
1994-1996	Portland Water District Portland, ME	1,300	Provided ozone process training and technical assistance with developing an optimized approach to achieve CT disinfection compliance at this 52 MGD water treatment plant.	Jim Wallace (207) 774-5961
1995	Elm Fork Water Treatment Plant Dallas, TX	13,200	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with air preparation equipment operation and compressor design.	Ted Kilpatrick 214-670-8585
1995	Waterman Water Treatment Plant Fairfield, CA	500	Conducted OFE as part of AWWARF/EPRI ozone optimization project. LOX-fed system with medium frequency ozone generators (ozone concentration %wt of 6.0). The OFE identified optimization opportunities associated with generator maintenance.	Tony Sicre 707-428-7595 Ken Briltz 707-428-7680
1995	Metropolitan Water District of So. California Los Angeles, CA	16,000	Prepared an over/under baffled bubble diffuser ozone contactor design sizing model which estimates ozone, oxygen, and nitrogen gas transfer; residual ozone concentrations; and CT disinfection compliance for user-selected operating conditions.	Dave Henry (818) 440-3266
1995	Metropolitan Water District of So. California Los Angeles, CA	16,000	Prepared ozone generation system unit sizing and estimated power demand model for air-fed, oxygen-fed, or oxygen-recycle ozone systems using various equipment options such as PSA, VSA, cryogenic or LOX oxygen sources, or medium or low frequency ozone generators.	Dave Henry (818) 440-3266
1994	Upper San Leandro Water Treatment Plant EBMUD Oakland, CA	1,500	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with air preparation equipment operation and compressor design.	M. K. Carpenter 510-254-8357
1994	Alameda Co. Water District Fremont, CA	770	Conducted OFE as part of AWWARF/EPRI ozone optimization project. The OFE identified optimization opportunities associated with air preparation equipment and contactor operation and chiller and compressor design.	Karl Stinson 510-659-1970
1994	Fleming Hill Water Treatment Plant Vallejo, CA	1,875	Conducted start-up training for entire plant, including the ozone system. Assisted staff with operations during modifications to existing plant.	Ex Ganding (707) 648-4305
1994	Forest Park Water Chalfont, PA	600	Conducted start-up training for the entire plant, including the ozone system. Training included workshops and the development of operating guidelines to prepare staff for start-up.	Jeff Pifer (215) 822-5950
1993	Eagle Mountain Water Treatment Plant Fort Worth, TX	1,112	Evaluated CT disinfection compliance strategy and provided technical assistance to assist plant staff with optimizing ozone system performance.	Gerry McMillion (817) 238-9978
1993	Travis Air Force Base Vallejo, CA	145	Conducted ozone system start-up training to prepare	Glenn Galtere (707) 437-3381

TABLE O-2. Summary of Ozone Process Training and Technical Assistance Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
			operating staff to efficiently operate their ozone system.	
1992	Alameda County Water District Fremont, CA	770	Conducted ozone system start-up training to prepare operating staff to efficiently operate their ozone system.	Susan Teefy (510) 659-1970
1992	Randall-Bold Water Treatment Plant Contra Costa Water Dist, Concord, CA	1,200	Conducted start-up training and ozone system performance testing to assist staff with efficiently operating their ozone system.	Karl Voigt (510) 625-6501
1991	Metropolitan Water District of S. California Los Angeles, CA	150	Water plant is a 5.5 MGD Oxidation Demonstration Plant with multiple ozone generation flexibility including: LOX-fed; air-fed; and oxygen recycle at low, mid, and high ozone concentrations and multiple ozone contacting flexibility including: injector, eductor, over/under baffled bubble diffuser, and serpentine baffled bubble diffuser (designer: James M. Montgomery Consulting Engineers, Inc.).	Carol Tate (818) 568-6264
1991	Waterman Water Treatment Plant Fairfield, CA	500	Conducted ozone system start-up training to prepare operating staff to efficiently operate their ozone system.	Niles Fleege (707) 428-7680
1990	North Bay Regional Water Treatment Plant Fairfield, CA	1,000	Conducted start-up training for the entire water treatment plant, including the ozone process. Training included workshops and development of operating guidelines.	Ken Briltz (707) 428-7680
1990	Los Angeles Advanced Oxidation Plant Los Angeles, CA	200	Hydrogen peroxide and ozone are used to remove TCE and PCE from this groundwater source. Project included developing data monitoring spreadsheets and operator training.	Gary Stolarik (213) 481-3163
1990	Los Angeles Aqueduct Filtration Plant Los Angeles, CA	7,900	Project addressed developing a practical, cost effective CT disinfection compliance strategy and included development of data monitoring spreadsheets, ozone residual sampling procedures, and ozone demand and decay testing techniques for their drinking water treatment plant.	Gary Stolarik (213) 481-3163
1989	Waterman Water Treatment Plant Fairfield, CA	500	Water plant with 3-stage pre-sedimentation bubble diffuser contactor (designer: James M. Montgomery Consulting Engineers, Inc.).	Jim Borchardt (510) 933-2250
1989	Metropolitan Water District of Southern California Los Angeles, CA	150	Conducted ozone system start-up training to prepare operating staff to operate their ozone system with a high degree of system quality control checks to ensure that reported data was accurate for their drinking water ozone system tests.	Brad Coffey (909) 392-5045
1988	Hagerstown, MD	1,000	Wastewater plant with pressure swing adsorption (PSA) oxygen separation equipment and 3-stage bubble diffuser ozone contactors (designer: James M. Montgomery Consulting Engineers, Inc.).	Ron Appleton (510) 933-2250
1988	Palm Beach Co. Plant No. 8 Palm Beach, FL	1,050	Water plant with post-sedimentation diffuser ozone contactor used for color removal (designer: James M. Montgomery Consulting Engineers, Inc.).	Glenn Dunkleburger (407) 586-8830
1986 - 1988	Indianapolis, IN	6,380	Conducted training to improve process control to maintain permit compliance of the wastewater ozone disinfection system (reduced energy cost by about $5,000 per month).	Kevin Corsaro (317) 327-2481
1987	Indianapolis, IN	6,380	Wastewater plant with cryogenic oxygen separation equipment and 4-stage bubble diffuser ozone contactors. Project involved cooling system modifications to	Mike Taylor (502) 423-0034

TABLE O-2. Summary of Ozone Process Training and Technical Assistance Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
			existing ozone equipment (designer: Camp, Dresser & McKee, Inc.).	
1987	North Bay Regional Water Treatment Plant Fairfield, CA	1,000	Water plant with 2-stage pre-sedimentation and 3-stage post-filtration ozone contactors (designer: James M. Montgomery Consulting Engineers, Inc.).	Jim Borchardt (510) 933-2250
1985	Avon, CO	170	Water plant with pre- and post-sedimentation bubble diffuser contactors (designer: RBD, Inc., Consulting Engineers).	Brian Janonis (970) 482-5922

Ozone Performance Test Services

Process Applications, Inc. (PAI) has provided independent oversight of ozone performance testing for several clients. The purpose was to provide reassurance that the installed ozone system meets the specified ozone production and energy efficiency requirements. Typical services have included:

a) Developing a performance testing protocol based on specified requirements,
b) Facilitating a pre-test meeting to coordinate test activities and responsibilities,
c) Developing spreadsheets used to evaluate test data,
d) Supervising data collection to ensure that the performance test is conducted fairly and to the satisfaction of all parties,
e) Facilitating a meeting at the end of the test to communicate results to all involved parties, and
f) Completing the final test report.

In addition to documenting compliance with the specifications, testing activities have been used, in many cases, as an opportunity for additional practical training for plant staff. When possible, PAI involves plant staff in testing activities. The goal is to clearly explain to the staff how the tests are conducted and how the results might be used to support optimization practices during follow up ozone system operation. Then, considerations for optimization are documented in the performance test report. The following client testimonial summarizes the PAI approach to ozone performance testing:

"(1) PAI is very experienced at performance testing- they have data sheets and spreadsheets prepared to calculate results as the test data comes in; they are well versed in the test equipment; they know different methods to simulate the higher production runs if the WTP is not able to accept applying that high an ozone dose. (2) They have all of the test protocol written for use – we have had problems getting acceptable protocol from the suppliers. (3) They are so well known and respected by the vendors that there is less likelihood that there will be disputes. If there are disputes I think they are able to facilitate a compromise among all parties. (4) If there are opportunities for testing to assess different performance aspects, PAI will seize the opportunity and document the results."

TABLE O-1. Summary of Ozone Performance Test Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
8/05	John J. Carroll WTP Mass – Water Resources Authority Marlborough, MA	13,500	Conducted ozone performance testing for four ozone generators. Design ozone concentration was 10 %wt. Required specific energy was 4.5 kWh/lb. Evaluated cooling water temperature was 60^{o}F.	Dave Coppes, MWRA (508) 872-4388 Stephen Martin, CDM (617) 452-6563
7/05	Jensen WTP Metro. Water Dist. Of S.California Granada Hills, CA	18,750	Conducted ozone performance testing for five ozone generators. Design ozone concentration was 8.6 %wt. The ozone generator specific energy was about 3.8 kWh/lb at the evaluated cooling water temperature of 74^{o}F.	Robert Valazquez (213) 217-6722 Sajal Mitra, MWD (213) 217-5671
7/05	Shoal Creek WTP Gwinnett Co. Dept. of Public Utilities Buford, GA	4,980	Conducted ozone performance testing for three ozone generators. Design ozone concentration was 12 %wt. Required specific energy was 5.0 kWh/lb. Evaluated cooling water temperature was 86^{o}F.	Neal Spivey, GCDPU (770) 904-3204 Laurie Gilmore, CDM (770) 952-8643
6/05	Dallas East Side WTP Dallas, TX	36,000	Conducted ozone performance testing for nine ozone generators and two, 30 ton/day, VSA oxygen systems. Design concentration was 10 %wt. Total ozone and oxygen system specific energy was about 6.0 kWh/lb at the evaluated cooling water temperature of 90^{O}F.	Joe Huang, CDM (916) 567-9900

TABLE O-1. Summary of Ozone Performance Test Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
1/05	Little Falls WTP Passaic Valley Water Commission Little Falls, NJ	3,600	Observed and monitored data collection and evaluation for ozone performance testing conducted by others for three ozone generators. Design ozone concentration was 12 %wt. Required specific energy was 4.9 kWh/lb. Evaluated cooling water temperature was 80^{o}F.	Laura Cummings 973-237-2039 Philip Roosa 973-237-2070
7/04	Burlington WTP Region of Halton Burlington, Ontario	1,650	Conducted ozone performance testing for two ozone generators. Design ozone concentration was 10 %wt. Required specific energy was 5.0 kWh/lb. Evaluated cooling water temperature was 28^{o}C.	Bill Mundy 905-825-6123 ext 7648
11/03	River Mountain WTF Las Vegas, NV	6,000	Conducted ozone system performance testing for three ozone generators and two 25 ton/day VPSA oxygen systems. Design ozone concentration was 9%wt and evaluated cooling water temperature was 21 ^{o}C.	Ron Zegers, SNWA (702) 567-2001 Pat Russell, SNWA (702) 567-2020
11/03	Alfred Merritt Smith WTF Las Vegas, NV	20,000	Conducted ozone system performance testing for five ozone generators and two 50 ton/day VPSA oxygen systems. Design ozone concentration was 9 %wt and evaluated cooling water temperature was 21 ^{o}C.	Ron Zegers, SNWA (702) 567-2001 Pat Russell, SNWA (702) 567-2020
11/03	Arcadia Lake WTP Edmond, OK	1,300	Conducted ozone system performance test for two ozone generators. Design ozone concentration was 10 %wt, required specific energy was 4.7 kWh/lb, and evaluated cooling water temperature was 95 ^{o}F.	Danny Shannon, CDM (817) 332-8727 Fred Rice, City of Edmond (405) 216-7696
8/03	Lake Ray Roberts WTP Denton, TX	1,200	Conducted ozone system performance testing for two 600 lb/day medium frequency, high concentration ozone generators at 10 %wt and 72^{0}F cooling water temp.	Timothy Fisher (940) 349-7190 Randy Markham (940) 349-7526 David Jackson, Freese & Nichols (214) 217-2257
5/03	H. J. Mills WTP MWD of So. Calif. Riverside, CA	9000	Conducted ozone system performance testing for three 3000 lb/day medium frequency, high concentration ozone generators at 10 %wt and 85^{0}F cooling water temp.	Robert Valazquez (213) 217-6722 Sajal Mitra (213) 217-5671
4/03	Rolling Hills WTP Fort Worth, TX	8,000	Conducted ozone system performance test at this 150 MGD WTP which has five ozone generators each with a capacity of 1,600 lb/day at 10 %wt ozone concentration. Required specific energy was 4.5 kWh/lb at 10 %wt and 95 ^{o}F cooling water temp.	Billy Haynes, Eagle Contracting (817)-379-1897 Danny Shannon, CDM (817) 332-8727 Milburn Shenewerk, City of Fort Worth (817) 238-9978
3/03	R.M. Levy WTP Helix Water District	3,600	Conducted ozone system performance test at this 100 MGD WTP. LOX/Oxygen feed-gas to three	Mark Umphries, Larry Lyford,

TABLE O-1. Summary of Ozone Performance Test Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
	Lakeside CA		medium frequency ozone generators with the following design criteria for each generator: 675 lb/day at 12 %wt, 5.0 kwh at 87°F cooling water temperature, 1,800 lb/day at 7 %wt, 3.7 kwh at 87°F cooling water temperature.	Helix Water District (619) 699-4118 (619) 443-1031
9/02	Cary/Apex WTP Cary, NC	4,500	Conducted ozone system performance test at this 40 MGD WTP. Three ozone generators were tested, each with a capacity of 1,500 lb/day at 10 %wt ozone concentration. Required specific energy was about 4.5 kWh/lb at 90°F cooling water temperature.	William Mason, CDM (919) 787-5620 Kelvin Creech, J.D. Arnold, Perry Joiner, Town of Cary (919) 362-5502
7/02	Lake Ray Roberts Water Treatment Plant, Denton, TX	600	Observed and monitored factory test of medium-frequency, high-concentration ozone generator.	Larry Eckersley (817) 735-7348
11/01	Upper Trinity Reg. WTP Lewisville, TX	2,800	Conducted ozone system performance test at this 70 MGD WTP. LOX/Oxygen feed-gas to two medium frequency ozone generators with the following design criteria for each generator: 1,400 lb/day at 10%wt, 4.7 kwh/lb at 80°F cooling water temperature.	Hector Ortiz, UTRWD (972) 436-2379 Darryl Corbin, MWH (214) 360-9929
4/01	Osage WTP Amarillo, TX	600	Conducted ozone system performance test at this 70 MGD WTP. LOX/Oxygen feed-gas to two medium frequency ozone generators with the following design criteria for each generator: 300 lb/day at 10 %wt, 4.5 kwh/16 at 70°F cooling water temperature.	Emmet Autrey, City of Amarillo (806) 378-4277 Christopher Kolkhorst, MWH (214) 360-9929
3/01	Ngau Tam Mei WTP Water Supply District Hong Kong, China	2,080	Conducted ozone system performance testing for VPSA oxygen-fed ozone system (design concentration is 7.5 %wt) with medium frequency, high concentration ozone generators and 5-ton/day and 10-ton/day VPSA units.	Chris Chen, CDM (852) 2428 2332 Chris Schultz, CDM (617) 452-6000
3/01	Eagle Mountain WTP City of Fort Worth Fort Worth, TX	2,600	Conducted ozone system performance testing for LOX-fed ozone system at 95 F (design concentration is 12 %wt) with medium frequency, high concentration ozone generators.	Danny Shannon, CDM (817) 332-8727 Milburn Schenewerk (817) 238-9978
8/99	Bollman WTP Contra Costa Water Dist. Concord, CA	2,040	Conducted ozone system performance testing for LOX-fed ozone system (design ozone concentration is 10 %wt) with medium frequency, high concentration ozone generators.	Scott Dittman, CDM (925) 296-8015 Paul Prewitt (925) 688-8157
12/98	Lanier Filter Plant Gwinnett County Buford, GA	1,500	Conducted ozone system performance testing for LOX-fed ozone system (design ozone concentration is 8.5 %wt) with medium frequency, high concentration ozone generators.	Dieter Franz Denise Funk (770) 952-8643
2/97	Worcester Water	660	Conducted ozone system performance testing. Low	Carol Ashe

TABLE O-1. Summary of Ozone Performance Test Projects

Date	Ozone Facility	Installed Capacity (lb/day)	Description	Contact
	Filtration Plant Worcester, MA		pressure air-fed system (ozone conc. 2.0 %wt) with low frequency ozone generators. Identified optimization opportunities with compressor and generator operation.	(617) 252-8708
1997	Canal Road WTP Bound Brook, NJ	6,000	Conducted ozone system performance testing for air-fed ozone system (ozone concentration 1.8 %wt) with medium frequency ozone generators.	Oleg Kostin (908) 654-1234 X125
12/94	Forest Park Water Water Treatment Plant Chalfont, PA	600	Conducted ozone system performance testing. Low pressure air-fed system (ozone concentration %wt of 1.5) with low frequency ozone generators.	Jeff Pifer (215) 822-5950
11/94	Lincoln, NB	700	Conducted ozone system performance testing. Low pressure air-fed ozone system (ozone concentration %wt of 1.1) with low frequency ozone generators.	Bob Hulsey (913) 339-3441
2/94	Portland Water District Portland, ME	1,300	Conducted ozone system performance testing. Low pressure air-fed ozone system (ozone concentration %wt of 1.5) with low frequency ozone generators.	Jim Wallace (207) 774-5961
4/93	Contra Costa Water Dist. Randall-Bold Water Treatment Plant Concord, CA	1,000	Conducted ozone system performance testing. LOX-fed system (ozone concentration %wt of 10.0) with medium frequency, high concentration ozone generators.	Karl Voigt (510) 625-6310
12/92	San Andreas Water Treatment Plant San Francisco, CA	2,176	Conducted ozone system performance testing. Low pressure air-fed ozone system (ozone concentration %wt of 1.8 and 5.0) with medium frequency ozone generators. Generators could also be fed with oxygen supplied by a LOX tank.	Greg Lindstadt (510) 933-2910
2/92	Metropolitan Water District of S. California Los Angeles, CA	150	Conducted ozone system performance testing. Low pressure air-fed ozone system (ozone concentration %wt of 1.5, 2.5, 6.0, 10.0) with low frequency ozone generators. LOX-fed ozone system with medium frequency, medium concentration ozone generators. LOX-fed ozone system with medium frequency, high concentration ozone generators. Oxygen recycle ozone system with both low and medium frequency ozone generators.	Dave Henry (213) 217-7140
10/91	North Bay Regional Water Treatment Plant Fairfield, CA	1,000	Conducted ozone system performance testing. Low pressure air-fed ozone system (ozone concentration %wt of 2.5) with medium frequency ozone generators.	Ken Briltz (707) 428-7680
10/87	Los Angeles Aqueduct Filtration Plant Los Angeles, CA	7,900	Conducted ozone system performance testing. Cryogenic oxygen-fed ozone system (ozone concentration %wt of 6.0) with medium frequency, medium concentration ozone generators.	Gary Stolarik (213) 481-3163
7/85	Indianapolis, IN	6,380	Conducted ozone system performance testing. Cryogenic oxygen-fed ozone system (ozone concentration %wt of 2.2) with dual-cooled high frequency ozone generators.	Kevin Corsaro (317) 327-2481
2/83	Vail, CO	500	Conducted ozone system performance testing. Low pressure, air-fed ozone system (ozone concentration %wt of 1.0) with low frequency ozone generators.	Mike Poeckes (303) 476-4089

Ozone Presentations, Publications and Research Projects

Process Applications, Inc. (PAI) projects in the table below include ozone presentations, publications and research projects

TABLE O-3. Summary of Ozone Presentations, Publications and Research Projects

Date	Agency or or Authors	Description	Contact
2005	Kerwin L Rakness	"Ozone in Drinking Water Treatment: Process Design, Operation, and Optimization" This book is intended to help the reader gain insight into the application, design, operation, control, and optimization of ozone facilities in drinking water treatment plants. The target audience includes water utilities using or considering ozone as a treatment process, design engineers involved with ozone system planning and design, laboratories and researchers involved with bench- or pilot scale ozone testing, and regulatory agencies responsible for enforcement, design review, and inspections of plants that use ozone.	American Water Works Association (www.awwa.org) International Ozone Association (www.int-ozone-assoc.org)
2005	Rakness, K.L.	"*Giardia* Virus and *Cryptosporidium* Log Inactivation Calculations" Published in Proceedings of International Ozone Association Pan American Group Annual Conference, Lake Lanier, Georgia (October 2005).	N/A
2005	Rakness, K.L.	"Ozone Process Control and Monitoring" Published in Proceedings of International Ozone Association Pan American Group Annual Conference, Lake Lanier, Georgia (October 2005).	N/A
2005	Mitra, S., R. Johnston, B. Clay, G. Hunter, and K. Rakness	"Ozone Operating Experiences and Results at MWD Mills Filtration Plant" Published in Proceedings of International Ozone Association Pan American Group Annual Conference, Lake Lanier, Georgia (October 2005).	N/A
2005	Hunter, G.F.	Presented ozone operations workshop at the Shoal Creek WTF as part of the International Ozone Association Pan American Group Annual Conference, Lake Lanier, Georgia (October 2005). Included presentation of "Overview of Ozone in Water Treatment, Equipment and Safety" and "Ozone Process and Disinfection Calculations Workshop."	N/A
2004	Rakness, K.L., I. Najim, M. Elovitz, D. Rexing, and S. Via	"On-Site VPSA Oxygen and Ozone Generation Equipment Performance Testing Results at Las Vegas" Published in Proceedings of International Ozone Association Pan American Group Annual Conference, Windsor, Ontario (September 2004).	N/A
2004	Rakness, K.L., G. Hunter, T. Pickle, R. Zegers, and C. Bromley	"Cryptosporidium Log Inactivation Calculation Methods" Published in Proceedings of International Ozone Association Pan American Group Annual Conference, Windsor, Ontario (September 2004).	N/A
2004	Hunter, G.F.	Presented ozone operations workshop at the A.H. Weeks WTP as part of the International Ozone Association Pan American Group Annual Conference, Windsor, Ontario (September 2004). Included presentation of "Overview of	N/A

TABLE O-3. Summary of Ozone Presentations, Publications and Research Projects

Date	Agency or or Authors	Description	Contact
		Ozone in Water Treatment, Equipment and Safety" and "Ozone Process and Disinfection Calculations Workshop."	
2003	Najim, I., K. Rakness, D. Rexing, and S. Via	"Theory of Segregated Flow Analysis for Calculating Inactivation Credit" Published in Proceedings of International Ozone Association – 16th World Conference, Las Vegas, Nevada (September 2003).	N/A
2003	Rakness, K.L., I. Najim, M. Elovitz, D. Rexing, and S. Via	"Implementing Segregated Flow Analysis for Cryptosporidium Inactivation" Published in Proceedings of International Ozone Association – 16th World Conference, Las Vegas, Nevada (September 2003).	N/A
2003	Rakness, K.L., G. Hunter, P. Russell, and R. Zegers	"Ozone Process Control and Monitoring at Las Vegas" Published in Proceedings of International Ozone Association – 16th World Conference, Las Vegas, Nevada (September 2003).	N/A
2003	Hunter, G.F. and K. Rakness	Presented ozone operations workshop at the River Mountains WTP as part of the International Ozone Association 16th World Conference, Las Vegas, Nevada (September 2003). Included presentation and "hands-on" workshop for "Ozone Residual Grab Sampling and Analyzer Calibration."	N/A
2002	Rakness, K.L., & G. Hunter	"Ozone Equipment Performance Testing Experiences and Results" Published in Proceedings of International Ozone Association – Pan American Group Annual Conference, Raleigh, North Carolina (May 2002).	N/A
2002	Hunter, G.F., & K. Rakness	"Considerations for Successful Operation and Calibration of On-Line Ozone Residual Analyzers" Published in Proceedings of International Ozone Association – Pan American Group Annual Conference, Raleigh, North Carolina (May 2002).	N/A
1988 - 2002	American Water Works Assoc. Denver, CO	AWWA-sponsored seminar, "Ozone Essentials: Equipment, Process Control and Optimization" Presented over twenty 1- and 2-day Application of Ozone in Water Treatment seminars throughout the U.S. and Canada.	Mayme Larson Robert Renner (303) 794-7711
2001	Hunter, G., K.L. Rakness, P. Russell, and G. Gifford	"Optimizing Ozone Disinfection Credit Calculations to Enhance Process Control," Published in Proceedings of International Ozone Association Pan American Group Annual Conference, Newport Beach, California (May 2001).	N/A
2001	Rakness, K.L., G. Gordon, B. Bubnis, D.J. Rexing, E.C. Wert, and M. Tremel	"The Impact of Underestimating Dissolved Ozone Residual Using Standard Methods 4500-Ozone and Outdated Indigo," Published in Proceedings of International Ozone Association Pan American Group Annual Conference, Newport Beach, California (May 2001).	N/A
2001	Rakness, K.L., & G. Hunter	"Monitoring and Control of Ozone Disinfection for Crypto, Giardia and Virus Inactivation" Published in Proceedings of International Ozone Association – 15th World Conference, London, U.K. (September 2001).	N/A
2001	American Water Works Assoc. Denver, CO	Prepared and presented ozone information and participated in the panel discussion at the AWWA teleconference held on March 8, 2001.	Mayme Larson Robert Renner (303) 794-7711
2000	Rakness, K.L., P. Russell, G. Gifford,	"Ozone Control at Las Vegas to Obtain On-Peak, Off-Peak Energy Savings," Published in Proceedings of	NA

TABLE O-3. Summary of Ozone Presentations, Publications and Research Projects

Date	Agency or or Authors	Description	Contact
	R. Zegers, and G.F. Hunter	International Ozone Association World Congress in Orlando, Florida (October 2000).	
2000	Rakness, K.L., G.F. Hunter, and L.D. DeMers	"Drinking Water Ozone Process Control and Optimization," Presented at the International Ozone Association Symposium in Toulouse, France (March 2000).	NA
1999	Rakness, K.L. and D. Henry	"Gas Flow Measuring in Ozonation Practice," Published in Proceedings of International Ozone Association World Congress in Dearborn, MI (August 1999).	NA
1999	Rakness, K.L. and G.F. Hunter	Advancing Ozone Optimization During Pre-Design, Design and Operation, Sponsored by Electric Power Research Institute Community Environmental Center and AWWA Research Foundation. Published by AWWA Research Foundation, Denver, CO (1999).	NA
1999	Rakness, K.L. and G.F. Hunter	"Ideas for Simplifying and Improving LOX-Ozone Automation," Published in Proceedings of International Ozone Association World Congress in Dearborn, MI (August1999).	NA
1999	EPRI-CEC St. Louis, MO Public Service Electric & Gas Co. Newark, NJ	Documented key elements for successful implementation of on-line ozone residual analyzers to promote efficient energy use and optimization of ozone process control. Project activities were conducted at the Delaware River Regional WTF in Delran, New Jersey, operated by the New Jersey American Water Company.	Karin Lukas-Cox (EPRI) (914) 644-8358 Eva Ibrahim (NJA) (856) 764-3603
1999	AWWARF Denver, CO EPRI-CEC St. Louis, MO	Conducted a five-year ozone energy optimization research project that was jointly sponsored by the American Water Works Assoc. and Electric Power Research Institute – CEC. Final report was "Ozone Optimization During Pre-Design, Design, and Operation."	Elizabeth Kawczynski (303) 347-6106 Ray Ehrhard (314) 935-8590
1999 Phase 3	AWWARF Denver, CO EPRI-CEC St. Louis, MO	The Phase 3 effort followed up on findings from Phases 1 and 2 and included special studies into key optimization areas of on-line ozone residual monitoring, process control and automation, and effect of ozone demand/decay on ozone system sizing.	Elizabeth Kawczynski (303) 347-6106 Keith Carns (314) 935-8590
1998 Phase 2	AWWARF Denver, CO EPRI-CEC St. Louis, MO	Conducted 10 Ozone Facility Evaluations. Determined and documented factors impacting optimization and results of optimization case studies. Document titled "Ozone Facility Optimization Research Results and Case Studies" is available from sponsoring agencies.	Elizabeth Kawczynski (303) 347-6106 Keith Carns (314) 935-8590
1996 Phase 1	AWWARF Denver, CO EPRI-CEC St. Louis, MO	Developed ozone facility evaluation and optimization protocol for drinking water treatment. Document titled "Ozone System Energy Optimization Handbook" is available from sponsoring agencies.	Elizabeth Kawczynski (303) 347-6106 Keith Carns (314) 935-8590
1998	Casper College Casper, WY	Presented a one-day ozone seminar at Wyoming Water Quality and Pollution Control Association Rocky Mountain Education Conference.	Bill Mixer (307) 268-2670
1998	Rakness, K.L. and L.D. DeMers	Ozone Facility Optimization Research Results and Case Studies, Sponsored by Electric Power Research Institute Community Environmental Center and AWWA Research Foundation. Published by AWWA Research Foundation, Denver, CO (1998).	N/A
1998	Rakness, K.L., D. Henry, and B. Langlais	"Validation of Gas Flow Measurement During Ozone Generator Performance Testing," Published in Proceedings of International Ozone Association Annual	N/A

TABLE O-3. Summary of Ozone Presentations, Publications and Research Projects

Date	Agency or or Authors	Description	Contact
		Conference in Vancouver, B.C. (October 1998).	
1998	Rakness, K.L., G.F. Hunter, T. Andrews, G. Guzman, and G. McMillion	"Solutions for Effective On-Line Ozone Residual Monitoring for Disinfection Compliance," Presented at AWWA WQTC Conference, San Diego, CA (November 1998).	N/A
1997	Rakness, K.L., L.D. DeMers, E. Kawczynski, and K. Carns	"Water Quality Benchmark for Ozone Optimization," Presented at AWWA WQTC Conference in Denver, CO (November 1997).	N/A
1997	Rakness, K.L., L.D. DeMers, E. Kawczynski, and K. Carns	"Defining Ozone System Optimization," Presented at International Ozone Association Pan American Committee Meeting in Lake Tahoe, NV (August 1997).	N/A
1996	Blank, B.D., K.L. Rakness, L.D. DeMers, M. Gagne, M. Letourneau, and M. El-Kindi	"Ozone System Optimization – Evaluation Process and Findings in Montreal," Published in Proceedings of International Ozone Association Conference in Ottawa (September 1999).	N/A
1996	DeMers, L.D., K.L. Rakness, and B.D. Blank	Ozone System Energy Optimization Handbook, Sponsored by Electric Power Research Institute Community Environmental Center and AWWA Research Foundation. Published by AWWA Research Foundation, Denver, CO (February 1996).	N/A
1996	Rakness, K.L.	"Recent Advances in Application and Optimization of Ozonation Systems," Presented at 1996 Engineering and Construction Conference, Denver, CO (March 1996).	N/A
1996	Rakness, K.L., L.D. DeMers, and B.D. Blank	"Benchmarking Ozone System Energy Use," Published in AWWARF Newsletter (March 1996).	N/A
1996	Rakness, K.L., L.D. DeMers, and B.D. Blank	"Ozone System Fundamentals for Drinking Water Treatment," Published in AWWA OpFlow, Vol. 22, No. 7 (July 1996).	N/A
1996	Rakness, K.L., L.D. DeMers, B.D. Blank, and D.J. Henry	"Gas Phase Ozone Concentration Comparisons From a Commercial UV Meter and KI Wet-Chemistry Tests," Published in Ozone Science & Engineering, Vol.18, pp.231-249 (April 1996).	N/A
1996	Rakness, K.L., G. Gordon, B. Langlais, W. Masschelein, N. Matsumoto, Y. Richard, C.M. Robson, and I Somiya	"Guideline for Measurement of Ozone Concentration in the Process Gas From an Ozone Generator," Published in Ozone Science & Engineering, Vol. 18, pp.209-229 (April 1996).	N/A
1995	Cranor, J.C. J.S. Pifer, and L.D. DeMers	"Start-Up and Operation of Ozonation Processes at the Forest Park Water Treatment Facility," Proceedings International Ozone Association Pan American Group Conference, Cambridge, MA (November 1995).	N/A
1995	DeMers, L.D., K.L. Rakness, and B.D. Blank	"Ozone System Optimization," Presented at IOA Pan American Group Ozone for Drinking Water Treatment Conference, Cambridge, MA (November 1995).	N/A
1994	Hunter, G.F. and	"Start-Up and Optimization of the Ozone Disinfection	N/A

TABLE O-3. Summary of Ozone Presentations, Publications and Research Projects

Date	Agency or or Authors	Description	Contact
	K.L. Rakness	Process at the Sebago Lake Water Treatment Facility," Published in Ozone Science & Engineering, Vol. 19, pp.255-272 (September 1994).	
1993	Yorkshire Water Services, LTD Bradford, England	Provided training on ozone system operation and control and on conducting CCP activities. Yorkshire Water is a large operating company that manages and operates several hundred water and wastewater facilities in England.	Gordon Wheale 011-44-274-692357
1992	International Ozone Association Stamford, CT	Presented a half-day workshop on Design and Operations Considerations for Ozone System Equipment at the IOA European Committee-sponsored ozone seminar in London, England.	N/A
1992	DeMers, L.D. and R.C. Renner	"Alternative Disinfection Technologies for Small Drinking Water Systems," AWWA Research Foundation, Denver, CO (1992).	N/A
1991	Rakness, K.L., et. al.	Chapter IV. Engineering Aspects, Chapter V. Operating an Ozonation Facility, Chapter VI. Economics of Ozone Systems: New Installations and Retrofits, and Appendix A of Ozone in Water Treatment - Application and Engineering; B. Langlais, D.A. Reckhow, and D.R. Brink, ed., AWWA Research Foundation, Lewis Publishers, Inc., Denver, CO (1991).	N/A
1991	Rakness, K.L., G.F. Stolarik, and J.D. Christie	"Operating Strategy to Meet SWTR Disinfection Regulations at the Los Angeles Aqueduct Filtration Plant," Presented at the International Ozone Association Pan American Committee Conference in Toronto, Ontario (September 1991).	N/A
1991	Virginia American Water Works Association Newport News, VA	Presented a paper, "Ozone in Water Treatment - The Importance of Staff Ownership in Start-Up" at a 2-day seminar entitled "The Future of Water Treatment: New Regulations and New Technologies."	N/A
1991	American Water Works Research Foundation Denver, CO	Participated in the preparation of ozone reference book titled "Ozone in Water Treatment: Application and Engineering", edited by Langlais, B., D.A. Reckhow, and D.R. Brink.	Debbie Brink (303) 347-6109
1990	International Ozone Association Pan American Committee Stamford, CT	Participated in the preparation of Design Guidance Manual for Ozone Systems, which was coordinated by the International Ozone Association Pan American Committee and edited by M. A. Dimitriou.	Mike Dimitriou (804) 756-7600
1990	Palm Beach County, Plant No. 8 Palm Beach, FL	Conducted two operator training workshops to introduce the operating staff to priority issues regarding operation and maintenance of their drinking water ozone system.	Jack Holden (407) 686-2664
1990	Barber, J.B., K.M. Corsaro, and K.L. Rakness	"Developing a Control Strategy for Ozone Disinfection," WPCF Operations Forum (August 1990).	N/A
1990	Renner, R.C., K.L. Rakness, and B.A. Hegg	"Getting Ozone Facilities On-Line," Presented at the AWWA Annual Conference and Exposition, Cincinnati, OH (June 1990).	N/A
1989	Rakness, K.L., R.C. Renner, and B.A. Hegg	"Design Considerations in Alternative Ozone Feed-Gas Systems," Presented at the International Ozone Association and Pan American Committee Spring Conference, New York, NY (February 1989).	N/A

TABLE O-3. Summary of Ozone Presentations, Publications and Research Projects

Date	Agency or or Authors	Description	Contact
1989	Hagerstown, MD	Conducted one operator training workshop to introduce the operating staff to priority issues regarding operation and maintenance of their wastewater disinfection ozone system.	Rick Thomas (301) 790-3200
1989	Metropolitan Water District of S. California Pasadena, CA	Presented two 1-day seminars, "Design Considerations in Using Ozone" and "Operational Aspects of an Ozone Process."	Gordon Johnson (818) 440-3266
1988	Rakness, K.L. and G.F. Stolarik	"Power Evaluation of the Los Angeles Oxygen-Fed Ozone System," Presented at the International Ozone Association Pan American Committee Spring Conference, Monroe, MI (April 1988).	N/A
1988	Rakness, K.L., R.C. Renner, B.A. Hegg, and A.G. Hill IV	"Practical Design Model for Calculating Bubble Diffuser Contactor Ozone Transfer Efficiency," Presented at the International Ozone Association Pan American Spring Conference, Perrysburg, OH (Apr 1986). Also published in IOA Journal, Vol. 10, No. 3 (1988).	N/A
1988	Rakness, K.L., R.C. Renner, D.B. Vornehm, and J.R. Thaxton	"Start-Up and Operation of the Indianapolis Ozone Disinfection Wastewater Systems," Presented at the 59th Annual Water Pollution Control Federation Conference, Los Angeles, CA (October 1986). Also published in IOA Journal, Vol. 10, No. 3, (1988).	N/A
1987	Rakness, K.L., R.C. Renner, and B.A. Hegg	"Ozone System Design for Water and Wastewater," Presented at the International Ozone Association, Second International Conference, The Role of Ozone in Water and Wastewater Treatment, Edmonton, Alberta (April 1987).	N/A
1986	Rakness, K.L.	Ozone Section of EPA Design Manual, U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH, Pub. No. 625/1-86/021 (October 1986).	N/A
1986	Rakness, K.L., B.A. Hegg, and R.C. Renner	"Ozone Disinfection Equipment Sizing," Presented at the 59th Annual Water Pollution Control Federation Conference, Preconference Workshop, Los Angeles, CA (October 1986).	N/A
1985	Rakness, K.L., B.A. Hegg, and E.L. Stover	"Determination of Ozone Dosage for Wastewater Disinfection," Presented at International Ozone Association Conference, The Role of Ozone in Water and Wastewater Treatment, London, England (November 1985).	N/A
1984	Rakness, K.L., E.L. Stover, & D.L. Krenek	"Design, Start-Up, and Operation of an Ozone Disinfection Unit," WPCF Journal (Nov 1984).	N/A
1984	Vail, CO	Conducted training to optimize energy usage while achieving permit compliance with their wastewater ozone disinfection system.	Mike Poeckes (303) 476-4089
1982	Rakness, K.L.	"Design and Operations Considerations for Wastewater Ozone Disinfection Systems," Presented at the 2nd National Symposium on Municipal Wastewater Disinfection, Orlando, FL, Sponsored by the Municipal Environmental Research Laboratory, Cincinnati, OH (January 1982).	N/A
1980	Rakness, K.L. and B.A. Hegg	"Full Scale Ozone Disinfection of Wastewater at the Upper Thompson Sanitation District AWT Facility," Presented at 51st WPCF Convention, Anaheim, CA (Oct 1978). Published in WPCF Journal (March 1980).	N/A

TABLE O-3. Summary of Ozone Presentations, Publications and Research Projects

Date	Agency or or Authors	Description	Contact
1979	Rakness, K.L. and B.A. Hegg	"Field Scale Evaluation of Wastewater Disinfection by Ozone Generated From Air," Presented at National Symposium on Wastewater Disinfection, Cincinnati, OH (September 1978). Also published in Water and Wastewater Engineering (July 1979).	N/A
1977	Hegg, B.A., L.E. Stanton, and K.L. Rakness	"Ozone Disinfection of Wastewater at the Upper Thompson Sanitation District Advanced Wastewater Treatment Facility," Presented at the IOA/EPA Seminar on the State of the Art of Ozone Treatment in Water and Wastewater (September 1977).	N/A