Albuquerque's Constructed Wetland Pilot Project for Wastewater Polishing

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Abstract—The City of Albuquerque has funded the Constructed Wetland Pilot Project (CWPP) since 1995 at the City's Southside Water Reclamation Plant (SWRP). Results from CWPP and other wetland treatment projects indicate that appropriately designed surface-flow wetlands could increase the cost-efficiencies of wastewater treatment, as well as help the City meet present and future discharge limits for nitrate, ammonia, organic nitrogen, various metals, biological oxygen demand, and total suspended solids, among other constituents. Results from CWPP also support the option to construct a 5-acre or larger demonstration-scale treatment wetland that would provide increased realism for evaluating the effectiveness of wetland polishing and potential habitat benefits.

The City of Albuquerque City Council and the City's Public Works Department have funded the Constructed Wetland Pilot Project (CWPP) located at the City's Southside Water Reclamation Plant (SWRP). The CWPP started July 1, 1995 to provide a pilot-scale evaluation of constructed treatment wetland effects and potentials to provide cost-effective "polishing" (i.e., enhanced treatment) to improve the quality of the City's wastewater discharges. Present and future design-flow capacities for the SWRP are, respectively, 60- and 76-million gallons-per-day (mgd). This study has been assessing alternative wetland treatment strategies that may help the City meet National Pollutant Discharge Elimination System (NPDES) discharge limits to address increasingly stringent water quality standards for the Rio Grande. These standards are established by the New Mexico Water Quality Control Commission and by the Pueblo of Isleta, located five miles downstream from Albuquerque. The initial goal of the CWPP was to use the information collected to help decide whether to conduct a larger demonstration-scale study and/or begin construction of a full-scale wetland treatment facility for the "polishing" of SWRP's effluent.

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Constructed wetlands have been found to provide viable alternative treatment components to conventional "concrete-and-steel" wastewater treatment systems (U.S. EPA 1988). These wetlands include *free-water surface* (open-water) systems, with surface flows through shallow water depths, and *subsurface flow* systems, with water flowing laterally through sand and gravel. Constructed wetlands provide cost-effective treatment to meet wastewater discharge requirements for many municipal discharges and for other discharges across the U.S. and around the world (Albuquerque-Bernalillo Constructed Wetlands Study Group Report 1993, Hammer 1989, Kadlec and Knight 1996, Moshiri 1993, and U.S. EPA 1988). Because of the construction and operation cost savings possible, the number of municipalities benefitting from constructed wetland treatment technologies has increased. In the Southwest, for example, only four constructed wetlands treating municipal wastewater existed in Arizona during 1990 and 15 existed in 1994. By 1997 Arizona had 26 municipal and onsite constructed wetlands operating, with an additional 24 wetlands either awaiting approval or under construction (Anonymous 1997, Gelt 1997).

Natural wetlands, which include swamps, bogs, sloughs and marshes, are often described as "nature's kidneys" to characterize the water quality improvements produced in waters flowing through these systems (Mitsch and Gosselink 1986). Constructed wetlands are similar to natural wetlands. Both involve communities of wetland plants, associated microorganisms, and chemical reactions in the water and soil substrates to purify water. Also, constructed wetlands are similar to conventional wastewater treatment facilities. Both are technologically-based designs that strive to enhance natural processes to cleanup wastewater. But, because constructed wetlands rely much less on concrete and steel (and more on land surface area), construction and operation costs are often much lower for wetland facilities having comparable treatment capabilities. For example, compared to the $360 to $625 million that officials estimated as needed to upgrade Phoenix's 91st Avenue Wastewater Treatment Plant, the projected cost of developing the existing $3.5-million Tres Rios Constructed Wetland Pilot Project into a full-scale facility was an additional $80 million (Gelt 1997, Greeley and Hansen 1996). That is, upgrading the wetland treatment system was projected to cost only 13 to 22 percent of the cost for a concrete and steel upgrade to the plant to meet the same water quality goals.

Beyond treatment benefits, constructed wetlands also generally provide significant additional economic and societal benefits by enhancing a diversity of tourist, recreation, education, and wildlife habitat attributes associated with the wetland. Some benefits documented for the 150-acre Arcata Marsh and Wildlife Sanctuary include use by water birds, estimated at 1,492,253 use days per year, and waterfowl, 98,689 use days per year. Estimates for picnicking, relaxing, birdwatching, nature studies, jogging, walking, education, fishing, photography and art, vary from 5 to 80 people per day, at 2 to 4 hours per visit. This open-surface constructed wetland system was developed between 1985 and 1989, and treats 2.6 mgd of municipal wastewater from Arcata, CA (Gearheart and Higley 1993). Similarly, development plans for the 800-acre Tres Rios constructed wetland project in Phoenix include accommodations for more than a half-million visitors annually expected to access the recreational and educational features of the project (Tres Rios Recreation Technical Committee 1997).

Design and Methods

Albuquerque's CWPP facility includes 12 individual open-water (surface-flow) wetland treatment cells, each is 102-feet long and 40-feet wide (fig. 1). The constructed wetland cells cover about 1.1 acres. Four wetland plant species were planted in duplicated plantings across six pairs of these cells to monitor effects by these communities on

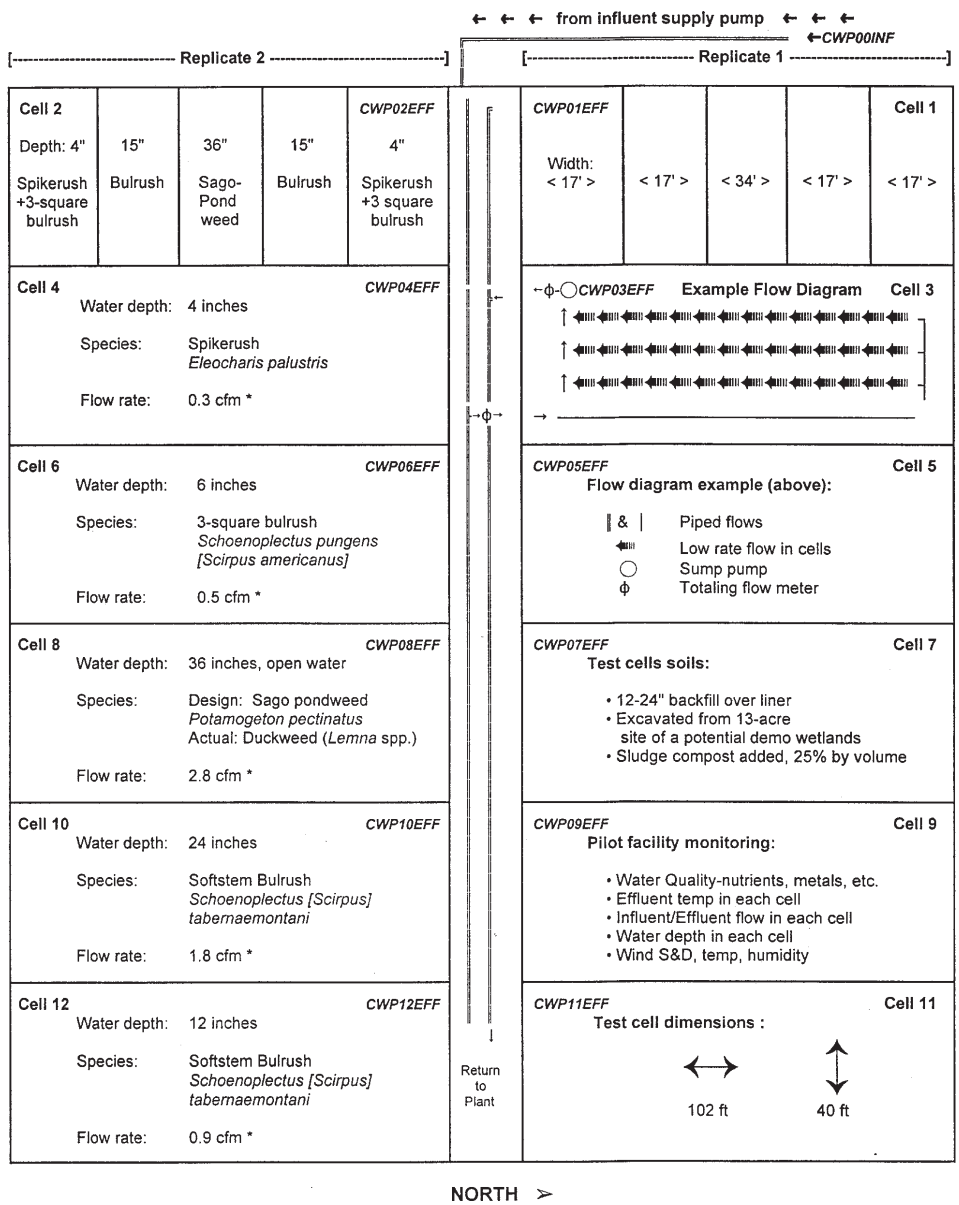

Figure 1—Schematic diagram of the facility design for the City of Albuquerque's Constructed Wetland Pilot Project. (Note: Flow rates assume 72-hour retention time in each cell; diagram shows locations for sample collections for wetland influent (*CWP00INF)* and for wetland effluents (*CWP01EFF-CWP12EFF)* included on various subsequent figures in this report).

water quality, water loss through evapotranspiration, and incidental habitat attributes. The water source for the wetland is treated, dechlorinated SWRP effluent, which is diverted to the wetland shortly upstream from the conveyance structure carrying SWRP effluent to the Rio Grande. The SWRP effluent is then distributed to the surface of the wetland cells. For most of the study, wetland flows were single-pass, through the length of the cells, before being discharged at the ends opposite from the inflows through a French-drain located along the bottom of the cells. Final effluents from most wetland cells are recycled back into the SWRP's treatment waters.

Starting in March 1997, the effluents from Cells 9 and 11 were directed into Cell 7, and the effluents from Cells 10 and 12 were directed into Cell 8. This was done, not to address specific treatment issues, but to allow greater latitude to increase flow volumes to Cells 9 through 12. The effluent flows from 7 and 8 are then recycled back into the SWRP. Operation of the wetland facility has focused on maintaining a 3-day target hydraulic retention time in each of the cells, with water depths ranging from 6 to 36 inches, as appropriate for the plant species inhabiting each wetland cell. Under the target hydraulic retention time, total target flow to the wetland facility was approximately 115 gallons-per-minute (gpm), 0.17 mgd, and 185 acre-feet per year.

Sampling was conducted from June 1996 through May 1998 to assess the removal efficiencies in each wetland cell for parameters of potential concern for future NPDES discharge limits. Of particular concern, ammonia, nitrate plus nitrite, total organic nitrogen, biological oxygen demand, and total suspended solids samples were collected every two weeks for analyses. Every four weeks, metals samples were collected to assess silver, aluminum, and arsenic removals. All analyses were conducted at the City of Albuquerque, Public Works Department, Water Quality Laboratory.

Treatment wetlands generally include a series of wetland cells, rather than the parallel, single-pass wetland flows studied in the CWPP. Each cell in the series typically has different vegetation types, water depths, and hydraulic retention times to produce different environmental conditions that sequentially address different water quality restoration issues. Selection of vegetation types used in these sequenced wetland cells often includes consideration of the potential ecological benefits of the plant communities to both aquatic and terrestrial animals.

In a simplified example, treatment wetlands constructed to address nitrogen removal commonly hold a community of larger emergent plants (for example, bulrush) in the first treatment cell. These cells commonly contain very low to no oxygen in the shallow waters surrounding the plants to aid nitrate removal. Such conditions also aid the breakdown of organic materials, converting organic nitrogen to ammonia. The second community in the treatment series is often a deeper, open-water, often pond like area, where ammonia discharged from the previous wetland cells is converted into nitrate. Next, a second emergent community often serves largely as a filter to remove suspended algae and other material, before the wetland water is discharged. The discharge structure for the wetland can produce additional water quality effects. Figure 1 provides an expanded but still simplified characterization of water quality effects possible through a series of wetland cells having different vegetation and treatment characteristics.

When reviewing and assessing the results from the CWPP, it is very important to understand that the design and operation of this facility have produced conditions that test effects on water quality produced by alternative wetland communities that might be used as the first wetland treatment component, as described in figure 2. In a full scale wetland facility, effluents from wetland cells, which had been designed and operated like the CWPP cells, would commonly discharge into a series of subsequent wetland cells for additional treatment, very commonly through sequenced oxic (oxygen containing) and anoxic (oxygen lacking) water conditions. Thus, the water quality effects reported in the following sections represent example results from a range of water quality changes obtainable with passage through *only* the first wetland cells from a possible series of additional wetland communities. Because the CWPP cells represent, in effect, only the first part of what could be some potentially larger treatment wetland design, their results are best characterized as likely representing the low to average range of the treatment benefits possible for SWRP effluents using wetland polishing. The water quality conditions in effluents from the CWPP cells reported here cannot be extrapolated to represent either the best or final water quality results obtainable for SWRP effluents using constructed wetland treatment.

Results and Discussion

Hydrology Characteristics in the Wetland Cells

Hydraulic flow regimes in the wetland cells were relatively consistent during 1997, reasonably approaching target 3-day retention times. During 1996, hydraulic consistency and integrity of the wetland cells were compromised due to problems with the wetland's influent delivery system and holes in the liners of the wetland cells caused by muskrats that colonized the facility. The improved 1997 results occurred, first, because of improvements to the influent plumbing that were installed and maintained by the wetland staff. Second, removal and exclusion of muskrats from the facility allowed successful patching of holes in the wetland liners.

Water Quality Changes in Routine SWRP Discharges

Focusing on the period from March to November 1997, the observations and results from this project show the following:

Silver concentrations in SWRP effluents and CWPP influents for 1997 both averaged 0.6 μg/l (fig. 3). During this period, average effluent concentrations from wetland Cell 5 (3-square bulrush) were less than the potential 30-d average NPDES limit of 0.21 μg/l for a 76-mgd discharge. Statistical analyses indicate that Cell 3 (spikerush), Cell 5, and Cell 7 (open-water/ duckweed) produced effluent silver concentrations that were significantly less than influent concentrations. Greatest variability in silver effluent concentrations occurred in Cell 4 (spikerush), Cell 8 (open-water/duckweed), and Cell 1 (mixed species), respectively. (Recall that effluents from Cells 9 - 12 provided the influents to Cells 7 and 8.) Statistical analyses also indicate there was no significant difference in net removal of silver among the wetland cells, i.e., no cell was particularly better at removing

EMERGENT MARSH 1:	**FREE-WATER SURFACE:**	**EMERGENT MARSH 2:**	**DISCHARGE (NPDES):**
Bulrush, cattails Anaerobic/reducing water Water depth - 4 to 8 inches (ave.) 1 to 2 feet (max)	Pond - submerged plants Aerobic/oxidizing water Water depth - 30-60 inches (ave. to max.)	Bulrush, cattails Anaerobic/reducing water Water depth - 4 to 8 inches (ave.) 1 to 2 feet (max)	Open-water/cascade Aerobic/oxidizing water Water depth - 2-12 inches (ave. to max.)
Concentration Reductions:	***Concentration Reductions:***	***Concentration Reductions:***	***Concentration Reductions:***
BOD/COD Dissolved oxygen Suspended Solids (TSS) Pathogens NO_3^- (plant uptake; denitrification ---> $N_2 + N_2O$) Complex Organics (ammonification ---> NH_3) Many/Most Metals (sulfide ppt., filtration)	NH_3 (volatilization; nitrification ---> NO_3^-) NO_3^- (plant uptake) Complex Organics (oxidation and photo-decomposition) BOD/COD Some Metals (Sorption)	Suspended Solids (TSS - algae and duckweed) NO_3^- (plant uptake; denitrification ---> $N_2 + N_2O$) Complex Organics (ammonification ---> NH_3) BOD/COD Dissolved Oxygen Pathogens Additional Metals (sulfide ppt., filtration)	NH_3 (volatilization; nitrification ---> NO_3^-) NO_3^- (plant uptake) H_2S Complex Organics (volatilization, oxidation and photo-decomposition)
Concentration Increases:	***Concentration Increases:***	***Concentration Increases:***	***Concentration Increases:***
NH_3 H_2S (Chlorination, optional)	NO_3^- algae & duckweed Wildlife habitat value and use (Non-human pathogens may increase)	NH_3 H_2S	Dissolved Oxygen (Chlorination, UV, or Ozonation)

Figure 2—Common design components (cells) and typical functions for a free-water surface constructed treatment wetland.

silver than another cell. The variability for silver in CWPP effluents suggests that some recurring analytical interference or sample contamination problem (for example, entrained particles) may have produced high concentration spikes.

Aluminum in SWRP effluents and CWPP influents averaged 82.6 and 98.6 µg/l, respectively (fig. 3). Average effluent concentrations from all wetland cells, excluding Cell 3 (spikerush), produced effluent concentrations that averaged less than the pending 30-d average low flow NPDES discharge limit of 60 µg/l for aluminum during 76-mgd discharges. Statistical analysis indicated that all cells during this period, except Cell 3, produced effluent aluminum concentrations that were significantly less than wetland influent concentrations. Greatest variability in aluminum effluent concentrations occurred in Cell 3. Statistical analyses also indicate that no cell was significantly better at removing aluminum than another cell.

Arsenic concentrations in SWRP effluents and CWPP influents averaged 7.0 and 7.1 µg/l, respectively (fig. 3). Both values are less than the existing 30-d average limit for arsenic of 13.7 µg/l. Cell 5 (3-square bulrush) produced the minimum average effluent arsenic concentrations. This effluent averaged 5.1 µg/l, which is markedly greater than a potential 30-d average NPDES discharge limit of 0.031 µg/l for low-flow 76-mgd discharges. Statistical analysis of the wetland effluent arsenic concentrations indicated that effluents only from Cells 5 and 6 (both 3-square bulrush cells) were significantly less than concentrations in wetland influents. Statistical analysis also indicated that positive net removal of arsenic by Cell 5 was significantly better than occurred in Cells 1 and 2 (mix species), Cell 3 (spike rush), Cell 7 (open-water/duckweed), and Cells 9 and 10 (deepwater plantings of softstem bulrush); no other significant differences in net removal of arsenic were indicated.

Ammonia concentrations in SWRP effluents and CWPP influents, averaged 4.5 mg/l and 6.9 mg/l, respectively (fig. 3). Average concentrations in effluents from wetland cells averaged 4.1 in Cell 5 (3-square bulrush) to 7.2 in Cell 12 (shallow plantings of softstem bulrush), reflecting the anoxic water quality conditions maintained in these cells, as discussed above. Average concentrations in the SWRP effluent and all CWPP effluents exceeded the pending 30-d average low-flow NPDES limit of 1.0 mg/l. Wetland discharge likely could meet permit limits through construction of a direct injection of air or turbulent producing outlet structure or to enhance nitrification and volatilization.

Nitrate plus nitrite concentrations in SWRP effluents and CWPP influents averaged 10.6 and 8.9 mg/l, respectively (fig. 3). Average concentrations in effluents from wetland cells averaged 0.3 and 0.5 mg/l in Cell 3 and 4 (spikerush cells) to 3.3 in Cell 10 (deep plantings of softstem bulrush). Average concentrations in effluents from all wetland treatments cells were less than the pending 30-d average low-flow NPDES limit of 9.0 mg/l.

Total Kjeldahl Nitrogen (TKN) or organic nitrogen in SWRP effluents and CWPP influents in 1997, averaged 9.6 and 8.9 mg/l, respectively (fig. 3). Average concentrations in wetland effluents ranged from 6.7 mg/l in Cell 5 (3-square bulrush) to 9.1 mg/l in Cell 8 (open-water/ duckweed). The NPDES permit contains no limit for TKN.

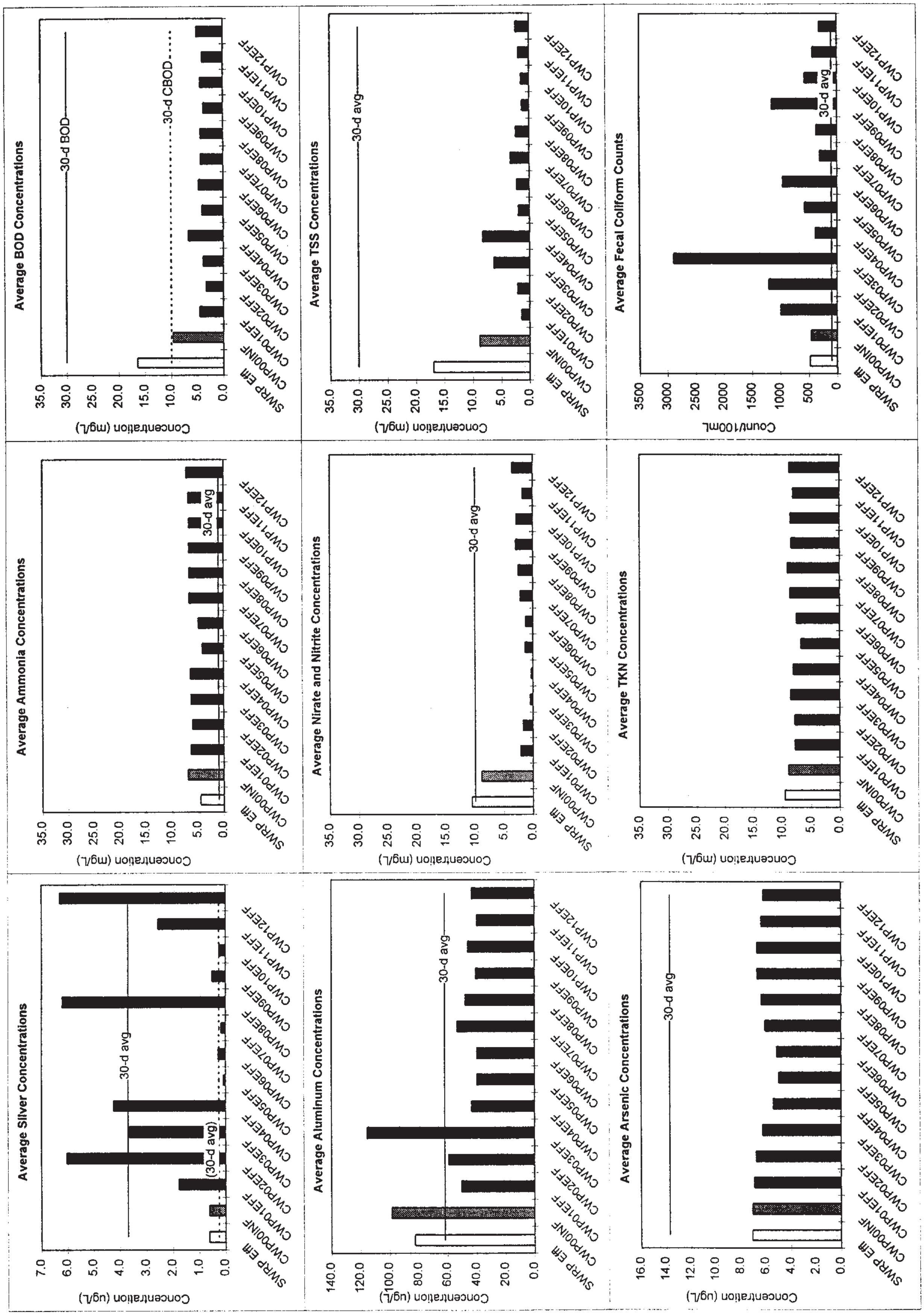

Figure 3—Average Concentrations, March-November 1997, in effluent from SWRP, influent to CWPP, and effluents from CWPP Cells 1-12 (showing present and potential future NPDES discharge permit limits).

Biological Oxygen Demand (BOD) averaged 16.4 mg/l in the SWRP effluent and 9.7 mg/l in the wetland influent (fig. 3). Average concentrations in effluents ranged from 3.3 to 5.1 mg/l for all wetland cells, with the exception of Cell 4, which averaged 6.8 mg/l. The 30-d average BOD under the existing NPDES limits is 30 mg/l; the pending 30-d low-flow CBOD limit is 10 mg/l.

Total Suspended Solids (TSS) during 1997, averaged 17.0 mg/l in the SWRP effluent and 8.9 mg/l in wetland influent (fig. 3). For wetland effluents, average TSS ranged from 1.3 to 3.4 mg/l in all but two wetland cells; average TSS from Cells 3 and 4 (the two spikerush cells) averaged 6.3 and 8.3 mg/l. The present and pending low flow 30-d average NPDES limit for TSS limit is 30 mg/l.

Fecal Coliform averaged 480 counts/100 ml in the SWRP effluent and 460 counts/100 ml in the CWPP influent (fig. 3). Across the CWPP effluents, fecal coliform ranged from 386 counts/100 ml in Cell 4 to 2896 counts/100 ml in Cell 3 (the two spikerush cells). The 30-d average fecal coliform limit under the present NPDES permit is 500 MPN/100 ml and the pending limit is 100 counts/100 ml. For the wetland effluents there were 79 cases where fecal coliform exceeded 100 counts/100 ml.

Fecal streptococci (FS) have been used with fecal coliform (FC) to differentiate human fecal contaminations from that of other warm blooded animals. In editions of *Standard Methods for the Examination of Water and Wastewater* previous to the 17th edition (American Public Health Association 1989), it was suggested that the ratio of fecal coliform to fecal strep could provide information on the source of contamination. A ratio greater than four was thought to indicate human fecal contamination, whereas a ratio of less than 0.7 suggested contamination from non-human sources. In the 19th edition (American Public Health Association 1995), however, the reliability of these ratios is questioned due to poor survival rates for certain fecal strep groups in the environment (which would tend to increase FC/FS ratios) and for other analytical-based reasons (which could decrease these ratios). Consequently, these ratios are no longer considered dependable for use in differentiating between bacterial contamination sources. Nevertheless, lacking another suitable alternative, it may be instructive to note that of the 79 FC exceedances recorded in the wetland effluents, only five effluents held FC/FS ratios greater than four, which may indicate human source contamination. Four of these events occurred during, and the fifth shortly after, the July-August 1997 SWRP upset, which is described in the next section. Of the remaining 74 exceedances, 45 cases (i.e., 60 percent) held FC/FS ratios less than 0.7, potentially indicating non-human bacterial sources.

Variability in analytical results for monitored water quality parameters produced marked differences between corresponding averages for some analyzed water quality parameters in the SWRP effluent and the CWPP influent concentrations, as noted above. These differences may be attributable to unquantified differences due to sampling times, sampling frequency, sample collection or handling, possible wetland piping effects, or other causes. For example, 24-hour composite samples are used to characterize most constituents in the SWRP effluent. In contrast, analyses to characterize CWPP influents and effluents are based on individual grab samples. Despite differences in the sampling approaches used, comparisons between overlapping sampling intervals indicate that the results from the CWPP influent samples for most analytes are reasonably representative of conditions in the SWRP effluent samples. In turn, analyte results for grab sample collections of CWPP effluents are assumed to be generally representative of the range of potential discharge conditions for the individual wetland cells. Questions remain, however, as to the cause of occasionally high concentration spikes for individual constituents in the CWPP effluents. Specifically, questions exist on whether these concentration spikes would have appeared if composited samples had been use to characterize the CWPP effluents.

Water Quality Benefits of the Wetland During Treatment Failure

During late July and early August 1997, the construction upgrade activities at the SWRP adversely affected the microbial flora in activated sludge treatment tanks, leading to treatment failure. During this period, SWRP effluents were ineffectively treated with multiple and recurring NPDES permit violations for total suspended solids, biological oxygen demand, and fecal coliform. Water quality data collected during this period clearly show the relatively high effectiveness of wetland treatment to buffer downstream receiving waters from many adverse effects during periods of treatment facility failure.

TSS and BOD concentrations that violated NPDES permit limits for the SWRP effluent showed significant improvements after flowing through the CWPP. TSS concentrations detected during this upset in SWRP effluents ranged over 180 mg/l, while effluent from all wetland cells were 19.0 mg/l or less, with most less than 4.0 mg/l; all TSS in all of the CWPP effluents were less than the 30-d average NPDES limit of 30 mg/l for a 76 mgd discharge. BOD concentrations detected in SWRP effluents during this upset ranged over 160 mg/l. Concurrent effluent BODs from all wetland cells ranged between 4 and 16 mg/l, all less than the present 30-d average NPDES limit of 30 mg/l.

Benefits of the CWPP were observed in metals removal through the course of this upset. Silver concentrations detected in SWRP effluent and CWPP influent ranged to 0.51 μg/l, while concentrations of silver in effluents from all wetland cells were at the minimum reporting limit for silver, 0.05 μg/l. Aluminum concentrations detected in the CWPP influent approached 110 μg/l; concentrations in effluents in wetland Cells 5, 6, 8, 9, 10, and 11 (including all wetland vegetation species, except spikerush) were at or near the minimum reporting value for aluminum, 0.40 μg/l. Arsenic concentrations in the SWRP effluent approached 6 μg/l, while concentrations in effluents from the wetland cells range from 3.1 to 4.5 μg/l.

Nitrogen components were generally removed over the course of the treatment plant upset. Ammonia concentrations in SWRP effluents and CWPP influents ranged over 19 mg/l, compared to effluent from wetland Cells 5 and 6 (3-square bulrush cells), where ammonia concentrations were less than 12 mg/l, despite the severely anoxic conditions existing in these cells. Nitrate plus nitrite nitrogen concentrations in SWRP effluents ranged over 3.5 mg/l, compared to average concentrations in all wetland cell effluents of 0.2 mg/l, i.e., the minimum reporting value for these analytes. TKN in SWRP effluents approached 32 mg/l, compared to concentrations between 13 and 16 mg/l found in effluents discharged from six (i.e., 50 percent) of the wetland cells.

Additional Considerations

Assessments of relative evapotranspiration rates (ET), sediment metals accumulations, bioaccumulation of metals, and the economics of wetland development and treatment, have been used to evaluate the effectiveness of wetland operation. Additionally, these evaluations aid in assessing whether to expand on the pilot project technology by constructing a 5-acre or larger demonstration scale, or full-scale treatment wetland.

Relative ET rates were assessed using an independent estimate produced for the City. Potential water loss through wetland evapotranspiration was determined for a 450-acre wetland facility. The assessment revealed that ET could reduce discharge volumes from the SWRP by, perhaps, 1,800 to 2,250 acre-feet/year (i.e., four to five feet of water per year over each acre of wetland).

Sediment metals accumulations were investigated by research cooperators from the USGS BRD. Sediment samples were collected from CWPP cells on February 19, 1997. Concentrations were below or near the minimum reporting values for total silver (<1 mg/kg), aluminum (<2 mg/kg), arsenic (<5 mg/kg), and selenium (<5 mg/kg) in both the inorganic and organic fractions assessed for all samples. Typical environmental sediment concentrations were detected for iron, manganese, mercury, and zinc.

The uptake of metals by organisms is termed *bioaccumulation*. USGS BRD researchers assessed concentrations of silver, aluminum, arsenic, mercury, and selenium in plant stems and roots, and benthic macroinvertebrate tissues collected from CWPP cells and in bryophytes incubated in wetland cells during August 25-28, 1997. Silver was not detectable in any of the tissues. Root concentrations for aluminum, arsenic, and mercury ranged from nearly equal to 10-times or greater than the stem concentrations. Root concentrations for selenium were often less than stem concentrations for the CWPP plants sampled. Greatest root concentration of aluminum, arsenic, and mercury occurred in spikerush, with nearly equivalent concentrations found in the roots of softstem bulrush. Concentrations of aluminum, arsenic, mercury and selenium were generally similar for bryophytes incubated at CWPP cells and the Nature Center (a natural wetland located upstream from the CWPP, which acted as reference samples for this assessment). With individual exceptions, concentrations of these four metals in macroinvertebrates were variable, but generally similar among samples collected from both CWPP and the Nature Center.

An economic evaluation of wetland operation was considered in a 1997 draft benefit-cost analysis from the University of New Mexico (Holmes and Blackwell 1997). The evaluation was conducted for a potential 500-acre treatment wetland facility considered by the City. The analysis gave a benefit-cost ratio of 1.17 for the conservatively short estimated project life of 15 years for a 500-acre constructed wetland facility (typical operational durations projected for constructed wetlands range 20 or more years). Similar analysis and results from other locations reveal that constructed wetland treatment facilities often pay for themselves through cost saving and usage benefits after relatively short periods of operation.

Conclusions and Recommendations

Results from the pilot study offer support for constructing a 5-acre or larger demonstration-scale treatment wetland, which would enable increased realism to evaluate the effectiveness of wetland polishing. These results also support the option to purchase available land and begin construction of a full-scale treatment wetland facility to provide beneficial polishing of Albuquerque wastewater, with concurrent wildlife and recreational benefits. The CWPP results indicate that a wetland treatment system, if constructed using the appropriate wetland plant communities in an appropriately sequenced flow configuration, can produce significant benefits for polishing metals, nitrogen compounds, BOD, and TSS in wastewater discharged by the SWRP. Potential issues related to bacteria and ammonia can be remedied relatively cost effectively.

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