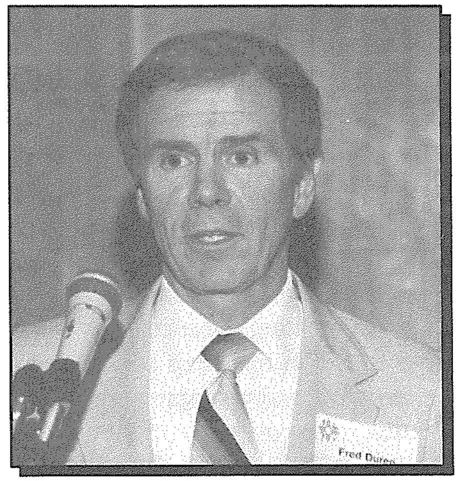
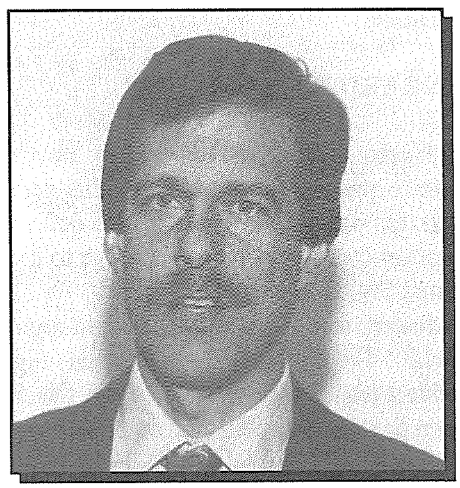
Fred Duren is the Southwest Water Resources Director for Montgomery Watson. He has 24 years experience in water resources and water supply engineering, encompassing evaluations of surface and groundwater supplies and including overall responsibility for large water resources projects. He is a registered engineer and geologist having B.S. degrees in Civil Engineering and Geology from the University of Notre Dame and an M.S. in Geology (water resources major) from the University of Nevada at Reno. He is currently serving as project co-director for the Las Cruces Water Resources Management Plan study, which is evaluating water supply and wastewater treatment/disposal alternatives for Las Cruces through 2035.



Charles Leder has been a specialist in wastewater collection, treatment, and disposal for 17 years and has practiced as a consulting engineer in New Mexico for the past 12 years. During this time, he has worked on master planning and facilities design of several discharge wastewater treatment facilities in the state, including those which had effluent reuse for crop/landscape irrigation or reuse at industrial facilities. Charles has a B.S. in Engineering Science from John Hopkins University and an M.S. in Sanitary Engineering from Georgia Tech. He currently is responsible for the wastewater evaluation for the Las Cruces Water Resources Management Plan study, including analyses of several zero discharge options.



ZERO DISCHARGE: A DUAL SOLUTION TO WASTEWATER DISPOSAL AND WATER SUPPLY PROBLEMS

Fred K. Duren, Jr.
Montgomery Watson
6245 N. 24th Parkway, Suite 208
Phoenix, AZ 85016

Charles Leder
Molzen-Corbin & Associates
2701 Miles Road SE
Albuquerque, NM 87106

INTRODUCTION

This paper provides a general overview of zero discharge as a means for: (1) eliminating costly wastewater treatment upgrades in response to increasingly stringent discharge regulations and (2) providing additional water supplies. The concept of zero discharge is relatively new, having been prompted primarily by updated discharge regulations for wastewater treatment plants which can mandate additional, expensive plant modifications. As planners evaluate the costs of complying with stringent new discharge regulations, attention has been drawn to eliminating these costs by removing the discharge from the receiving stream and utilizing it for alternative, water supply purposes.

In addition to the overview of zero discharge, which is covered in the first half of the paper, a discussion also is provided of zero discharge in New Mexico and the potential for this concept to become a significant component of water resources planning in the state.

WHAT IS ZERO DISCHARGE?

Since zero discharge is relatively new, it is appropriate to present a definition of this concept. As used in this paper, zero discharge is defined as: the elimination of a wastewater discharge to a water of the United States.

Discharges to waters of the U.S. are regulated by the U.S. Environmental Protection Agency (EPA), which issues National Pollution Discharge Elimination System (NPDES) permits to those who operate discharging facilities. Additionally, state health departments typically issue state stream standards, which also regulate wastewater discharges. By implementing a zero discharge program, thereby removing the discharges from waters of the U.S., a plant owner can avoid being constrained by an NPDES permit and by state stream standards applicable to the particular receiving stream. However, discharges to other locations (e.g., for irrigation) also require acquisition of permits, so implementation of a zero discharge project does not typically result in avoidance of the need to acquire permits.

FACTORS PROMOTING ZERO DISCHARGE PROJECTS

There are two significant factors that have tended to promote consideration of zero discharge projects. First, NPDES permits and state stream standards are reissued on a regular basis by the EPA and the state health department, respectively. With successive updates of these permits and standards, more stringent discharge regulations have typically resulted. Thus, the treatment processes needed to comply with a current NPDES permit or to meet a current set of stream standards may not be adequate to comply with the regulations contained in the subsequent permit or standard. In some instances, substantial improvements to wastewater treatment plant facilities are required to meet very stringent restrictions in the discharge regulations in a new NPDES permit or an updated state stream standard.

Beneficial uses are used in developing NPDES permits and determining applicable stream standards. The selection of beneficial use of a particular water has significant impact on the facilities required at a wastewater treatment plant. An example is given below of objectives defined in the California Inland Surface Water Plan for two defined beneficial uses, Human Health and Aquatic Habitat:

Table 1. California Inland Surface Water Plan

Constituent	Example Objective (µg/l)	
	Human Health	Aquatic Habitat
Chromium	50	11
Copper	1,000	57
Lead	50	4
Nickel	600	206

As indicated in this table, discharge standards can be set at a level much more stringent than required for human health to meet an alternative beneficial use. An additional factor leading to increased costs for wastewater discharges in the desert Southwest is the occurrence in some instances for stream standards for dry stream beds to be set based on aquatic habitat beneficial uses.

The second factor that tends to promote consideration of zero discharge projects is the need for additional water supplies. Areas of the country that are limited in the available options to augment existing water supplies, such as the desert Southwest, are prompted to consider zero discharge as a means for increasing water supplies.

Zero discharge projects can be utilized in several ways to augment an existing water supply. These include: (1) groundwater recharge; (2) irrigation; (3) industrial uses; (4) indirect potable use; and, in the future, (5) direct potable use. Any of these methods, either alone or in combination, are viable means of augmenting a water supply, except for direct potable use, which will require additional time for water supply needs and public acceptance to reach the necessary level for implementation.

BARRIERS TO ZERO DISCHARGE

The above discussion has pointed out the benefits to implementing a zero discharge project. There are, however, barriers which present obstacles to zero discharge projects. These include: (1) water rights; (2) cheaper alternative water supplies; (3) established riparian areas; (4) public concerns; and (5) impairment of local water quality.

Water rights can impact zero discharge projects in that elimination of a discharge can reduce surface water supplies for which rights have been established. New Mexico communities along the Rio Grande are effected by this consideration as a result of the elimination of return flow that would occur. Cheaper alternative water supplies also can tend to discourage zero discharge projects because the expense of developing a supply from a treated wastewater discharge can exceed that for an alternative water supply. Costs for reclaimed water projects can vary significantly; however, typical projects range from a minimum of about $400 per acre-foot to more than $1,500 per acre-foot.

Environmental-related barriers in implementing a zero discharge project include the last three listed above. Riparian areas established as a result of a wastewater discharge that has existed for many years can be an obstacle to stopping the discharge if that would cause the riparian area to be destroyed. Public concerns about introducing treated wastewater into the water supply also can sidetrack a zero discharge project. Lastly, the potential impairment of local water quality resulting from introducing a lower water quality into the local water resources can occur from a zero discharge project. For example, recharge of reclaimed water into a groundwater system containing higher quality water would tend to discourage this final use of treated wastewater as part of a zero discharge project.

CURRENT PLANNING FOR ZERO DISCHARGE PROJECTS

Numerous zero discharge projects are in the planning or implementation stages. A few that are located in the western U.S. are described below.

Phoenix 91st Avenue Wastewater Treatment Plant

For the past four years, the Sub-Regional Operating Group that provides wastewater to this 150 million-gallon-per-day (mgd) wastewater treatment plant (WWTP) has been investigating zero discharge to remove the plant's effluent from the Salt River bed. Extensive testing related to treatment and disposal criteria necessary to recharge all current and future discharged effluent to the local groundwater system is underway. It is estimated that the construction cost of complying with proposed State Navigable Water Quality Standards and anticipated NPDES permit requirements will be $368 million. The zero discharge project, which would involve a 3,200-acre recharge site, is estimated to cost $200 million. Two environmental barriers will require consideration in implementing the project: (1) the establishment of a riparian area along the previously dry Salt River bed and (2) concern by local water agencies in the vicinity of the recharge project to potential degradation of their groundwater supplies.

Los Angeles Terminal Island WWTP

This 20-mgd WWTP, which discharges to Los Angeles Harbor, is being investigated to eliminate or mitigate its discharge to the harbor. An outfall extension, estimated to cost $60 million, is one alternative being investigated. A second alternative involves upgrading treatment at the plant to allow all of the effluent to eventually be used for urban landscape irrigation and industrial uses. This alternative is estimated to cost $55 million, resulting in a savings in capital cost in addition to providing a revenue source through the sale of reclaimed water.

Kingman, AZ, Hilltop WWTP

Kingman's 2-mgd Hilltop WWTP utilizes a wetlands to provide additional treatment downstream of aerated lagoon secondary treatment facilities prior to ultimate discharge of the treated wastewater effluent.

Oxnard, CA, WWTP

The City's 20-mgd secondary WWTP currently disposes of effluent to an ocean outfall. With anticipated, more stringent regulations in the California Ocean Plan, the City may be required to upgrade its plant by a $50 million outfall extension. Based on a Water Reclamation Master Plan developed by the City, up to 50,000 acre-feet per year of treated wastewater effluent could be used for agricultural irrigation with non-irrigation season discharge to the groundwater basin.

San Francisco Bay Export Project

Studies starting in 1981, with followup work done in 1991, have investigated the potential for removing all wastewater discharges to San Francisco Bay. Earlier investigations developed two alternatives, including use of effluent for Delta salinity control and for agricultural irrigation in the southern San Joaquin Valley. The 1991 study found that the original alternatives were not feasible due to changes in the regulatory and institutional environment and due to unit costs in excess of $1,500 per acre-foot. This recent study recommended a different alternative involving use of effluent for providing up to 400,000 acre-feet per year for agricultural irrigation in the northern San Joaquin Valley. The preliminary cost for this updated alternative ranged between $1,100 and $1,400 per acre-foot.

Las Cruces WWTP

A study currently is underway to evaluate zero discharge opportunities for the City's WWTP. These studies, which are part of the Water Resources Management Plan project, are discussed in some detail later in this paper.

ZERO DISCHARGE IN NEW MEXICO

Communities in southern and eastern New Mexico were among the first in the state to use zero discharge systems for wastewater treatment and disposal. These systems were zero discharge for the simple reason that there was no body of water into which to discharge renovated effluent. Most of these systems used crop irrigation as an expedient method for treated wastewater disposal. With an increased awareness of effluent's larger water resource role in arid climates, zero discharge projects are now being seen as a combined water supply/ wastewater disposal method which conserves limited fresh water supplies. The following project examples exhibit this overall pattern.

Clovis

The City of Clovis (pop 31,000) has historically used agricultural irrigation for wastewater disposal. Currently, the city's wastewater treatment plant generates 4,500 acre-feet per year of denitrified effluent of which 3,960 acre-feet per year is used to irrigate grain and forage crops. The remaining 10 percent is used for wetlands habitat maintenance in Williams Playa. Discharge to the playa provides a handy way to dispose of off-season surplus irrigation flows.

Hobbs

The City of Hobbs (pop 29,000) also uses crop irrigation to dispose of 3,100 acre-feet per year of secondary wastewater effluent. Mild winters in this region of New Mexico enable the city to dispose of nearly all of its 3 mgd average daily flow in this manner even during cold weather. The City further treats 300 acre-feet per year by filtration and sells this volume to an oil production company for use in water-flood recovery operations.

Alamogordo

This community of 25,000 persons recently completed the first phase of an effluent reuse project which substitutes denitrified effluent for potable water at an 18-hole golf course, 4 city ballfield complexes, a high school ballfield, and other landscape areas. This project cost $1,000 per acre-foot to implement including treatment plant renovations and the first part of an effluent distribution system including two booster pump stations, 26,000 feet of effluent lines, and a 9-hole golf course irrigation system. The City conserves an estimated 1,700 acre-feet per year of potable water through effluent reuse. Off-season surplus flows are disposed via spray irrigation of native vegetation. In a community where water supplies and water rights are both in short supply, the ability to reuse effluent for irrigation was a key factor in letting the city expand its golf course from 9 to 18 holes.

Las Campañas de Santa Fe

This golf course resort community adjacent to Santa Fe will use zero discharge to treat and dispose wastewater from 1,720 residences and associated clubhouse and shopping facilities. As in the previous three examples, there was no available water body into which treated effluent could be discharged. At buildout, Las Campañas will be able to use denitrified effluent to supply 100 percent of irrigation needs for its 210 acres of turf area. This project will eventually include 90 acre-feet of storage for effluent collected during the irrigation off-season.

PERMITTING ZERO DISCHARGE IN NEW MEXICO

Both the New Mexico Environment Department (NMED) and the State Engineer Office (SEO) are involved in permitting zero discharge projects in New Mexico. The permitting responsibilities of these two agencies are described below.

New Mexico Environment Department Permits

All zero discharge projects in New Mexico will require a Ground Water Discharge Permit issued by the NMED's Ground Water Protection and Remediation Bureau. These permits include an acceptable Operation and Monitoring Plan specifically developed to assure that groundwater beneath an application site will not become contaminated. One of the principal elements of the Plan is control of nitrogen discharges. NMED's policy is to allow essentially unrestricted effluent application if its Total Nitrogen (TN) level is < 10 ppm and there are no other concerns about aquifer degradation through toxic pollutants or Total Dissolved Solids. This TN standard assures that any effluent which ever migrates to groundwater will not cause the background level to exceed 10 ppm.

This policy presents an interesting challenge to communities considering zero discharge via irrigation. An obvious disadvantage of reducing effluent Total Nitrogen content to < 10 mg/L is that some fertilizer value is lost. On the other hand, commonly used biological denitrification systems can produce better quality effluents which contain fewer suspended solids. In turn, better quality effluent is less likely to foul spray irrigation equipment often used for urban landscape irrigation.

For projects which apply an effluent with TN > 10 ppm, NMED typically requires more rigorous tracking of application rates, effluent quality, and groundwater quality beneath application sites. In addition, with TN > 10 ppm, NMED usually requires all effluent storage ponds in the distribution system to be lined.

New Mexico State Engineer Office Permits

The SEO requires permits for all storage facilities, including effluent storage ponds, which hold ≥ 10 acre-feet or which have an embankment ≥ 10 feet tall. These permits are to assure that the SEO's dam safety criteria are included in storage facility design. There also are a number of water rights issues the SEO will review and consider before a community's zero discharge project can be implemented; however, these issues are beyond the scope of this paper.

SURPLUS FLOWS DURING THE IRRIGATION OFF-SEASON

One of the key design issues in developing zero discharge irrigation projects is how to address the imbalance between wastewater effluent flows which essentially stay constant and monthly crop irrigation demands which vary throughout the year. Figure 1 illustrates the case for the City of Alamogordo which shows that even by increasing the off-season irrigation rate to 0.5 inches per week, there would still be an off-season surplus of 405 acre-feet for every 1,200 acre-feet (1.07 mgd) of available effluent. The City now disposes of this surplus by irrigating 180 acres of native desert vegetation.

The Las Campañas de Santa Fe zero discharge project is more typical of landscape irrigation in

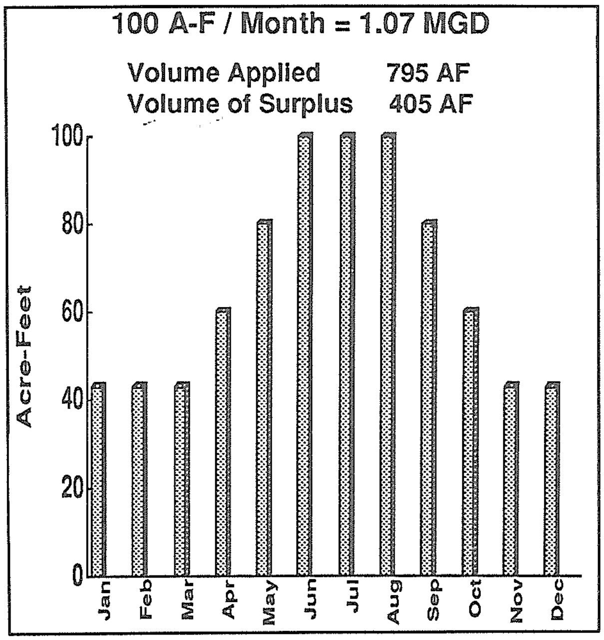


Figure 1. City of Alamogordo monthly irrigation demand for 120 acres of grass (based on 6.6 ft/yr application rate).

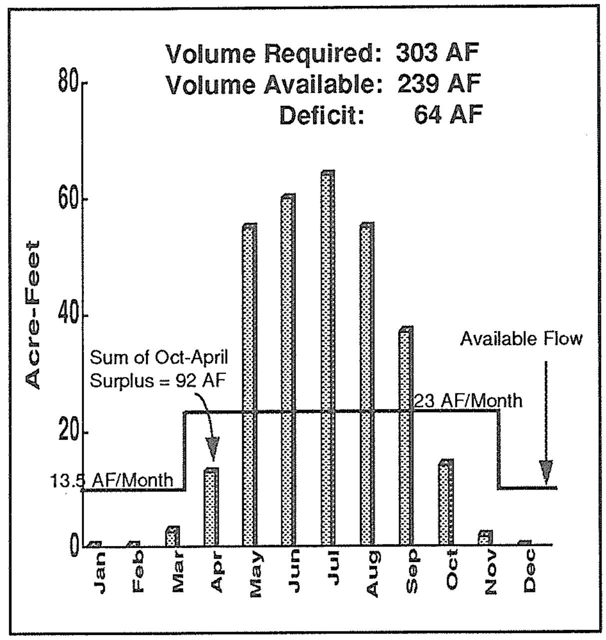


Figure 2. Las Campañas de Santa Fe monthly irrigation demand for 210 acres of grass (based on 1.4 ft/yr application rate).

northern New Mexico. Figure 2 shows that with irrigation rates set according to consumptive demand rather than maximum possible rate to enhance effluent disposal, the variation in monthly irrigation demand is even more pronounced. For this one project, off-season storage of surplus flows became a necessary project element to satisfy basic irrigation requirements as well as keep the project "zero discharge." Lined storage facilities, such as used in this project, may cost on the order of $12,000-16,000/acre-foot including costs for revegetation, liner, and fencing.

ZERO DISCHARGE AND WATER RESOURCES PLANNING FOR LAS CRUCES

Recent population estimates for the City of Las Cruces project a utility service population of 293,000 persons by the year 2035 with an equivalent need for 75,000 acre-feet per year of diversions for water supply and 31 mgd of wastewater treatment capacity. The City will soon complete a Water Resources Management Plan that looks at the benefits and disadvantages of three zero discharge concepts for wastewater treatment within the context of:

- possible water supply benefits
- possible relief from federal and state requirements for discharge to the Rio Grande

The balance of this paper describes conceptual frameworks for these three options and preliminary findings to date.

Zero Discharge via Aquifer Storage and Recovery

This option calls for renovating wastewater so that it could be reinjected into a drinking water aquifer and eventually recovered for potable use. This option could potentially give the City access to 35,000 acre-feet per year of water supply. Unlike crop irrigation schemes, an Aquifer Storage and Recovery (ASR) system is not impacted by changes in seasonal irrigation demand. If implemented, this would be the first example of ASR in New Mexico.

Detailed scans of the effluent for toxic substances shows it is relatively free of chemical contamination and can be renovated prior to reinjection through a series of 40 wells using a process train designed to reduce TN to < 10 ppm and remove Total Organic Carbon, suspended solids, and pathogens. This advanced wastewater treatment system would be similar to that used by El Paso's Fred Hervey Reclamation Plant which is a 7-year old ASR project in the Hueco Bolson. The desire to have positive control over recharge water withdrawals, requires the reinjection site to be located in an undeveloped area. Candidate sites meeting this requirements are 400 feet uphill from the City's treatment plant and will thus entail substantial pumping energy costs. The capital costs of this option are expected to be on the order of $7.00 per gallon of capacity, including facilities for treatment, transmission, and reinjection.

Zero Discharge via Crop Irrigation

This option follows more traditional New Mexico zero discharge schemes by substituting effluent for current crop irrigation water supplies. Ideally, the City would be able to receive one gallon of irrigation water or its equivalent in surface or groundwater diversions for its water supply system for each gallon of effluent it furnishes. Pecans are perhaps the most water-intensive crop that is extensively farmed in the area with irrigation demands approaching 6 feet per year for old, established orchards. Those orchards with access to both groundwater and Elephant Butte Irrigation District project rights typically get 3 feet per year from each source. With pecan irrigation, the City could dispose of an effluent volume in half the acreage otherwise required for turf grass irrigation which, on average, consumes 3 feet per year in Las Cruces net of natural rainfall.

Effluent quality data show the City's effluent meets New Mexico Water Quality Control Commission (NMWQCC) irrigation standards and has salinity and Sodium Absorption Ratio values comparable to that of water now used for irrigation. The effluent would be denitrified to < 10 ppm TN, filtered, and disinfected prior to distribution on pecan orchards. This process train follows the latest EPA effluent reuse guidelines for nuts and similar crops which can be eaten raw. The potential surplus effluent volume during the off-season is projected at 16,000 acre-feet per year. Short of implementing an off-season ASR treatment and recharge system described for the previous option, it will probably be necessary to discharge the surplus to the Rio Grande. In this case, the City will not be getting any relief from NPDES program requirements. It should also be noted that the most onerous NPDES permit conditions for the City are those requiring elimination of effluent ammonia toxicity during winter when ammonia removal is more difficult to achieve and historic dilution flows in the Rio Grande are least.

Zero Discharge via Constructed Wetlands

This option is essentially a way to dispose of 35,000 acre-feet per year of effluent via evaporation. The City's effluent would now just receive primary treatment to remove settleable solids before transfer to a series of constructed wetland cells. A facility on the order of 9,000-10,000 acres in size is projected including space for site buffer areas, dikes, and access roads.

The West Mesa area 12 miles southwest of the City, which is undeveloped and has extremely limited groundwater resources, is one potential site for this wetland facility. Given the remote possibility of contaminating groundwater supplies, especially for sites west of a geologic fault, it could be possible to eliminate bottom liners typically required at these facilities. One definite drawback to a site in this area is the pumping energy required to overcome a 500-foot lift from the treatment plant. The project element could include crop irrigation to support wildlife forage. Although this option provides an opportunity for wildlife habitat creation and related tourist activity, the City would also lose some 35,000 acre-feet per year in return flow credits. Additionally, future discharge and soil waste disposal requirements could significantly increase the cost of this option.

CONCLUSION

Zero discharge provides a means to reduce the cost of wastewater disposal and at the same time provide additional water supplies. Because of these two significant benefits, it is expected that zero discharge will continue to increase in popularity as a water resources management option, especially across the desert Southwest including New Mexico. Although barriers to implementation of zero discharge projects do exist, the attractiveness of these projects relative to solving the two pressing water resources problems of wastewater discharge permitting and scarcity of water supplies should result in additional planning and implementation of zero discharge projects in the future.