Domestic Wastewater Treatment Plants In Florida

David York and Elsa Potts

Domestic wastewater management in Florida can be characterized by a multitude of small facilities, and by a small number of large facilities that represent the majority of the total permitted capacity in the state. Based on a 1993 review of DEP records, there are about 3,500 permitted, domestic wastewater treatment facilities in Florida. The total permitted capacity of these facilities is about 2,180 mgd.

The predominance of small package treatment facilities is striking. Figure 1 presents the distribution of the 3,500 domestic wastewater treatment facilities by size. The distribution of permitted capacities of these facilities also is shown in Figure 1. About 80 percent of Florida's treatment facilities have capacities less than 0.1 mgd. However, these small facilities account for only about three percent of the total permitted capacity in the state. There are slightly more than 3,200 domestic wastewater treatment facilities having capacities less than 1.0 mgd (about 92 percent of the total number of facilities). Facilities less than 1.0 mgd account for only about 10 percent of the total permitted capacity in Florida.

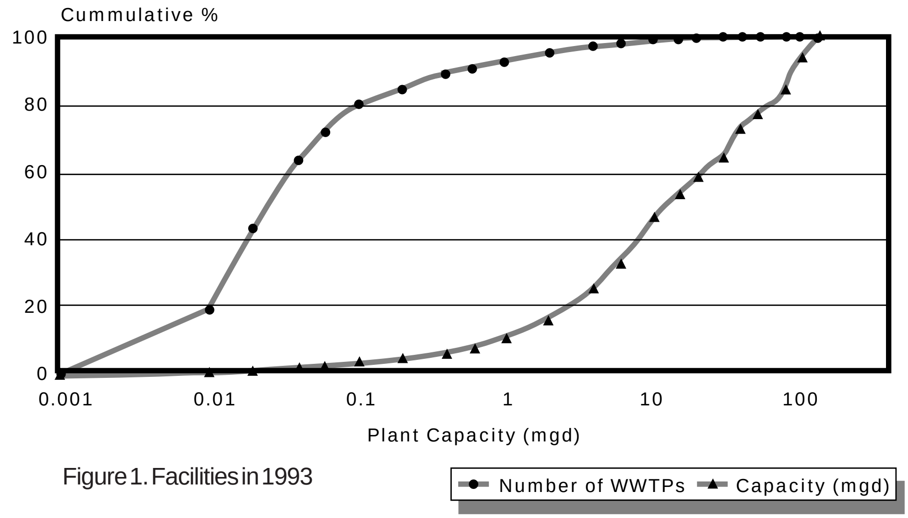

Figure 1. Facilities in 1993

Obviously, the larger facilities in Florida contribute the vast majority of the state's permitted capacity. Domestic wastewater treatment facilities over 5.0 mgd constitute less than 3 percent of the state's facilities but they represent about 70 percent of the total permitted capacity. There are 42 facilities having permitted capacities of 10 mgd or more. These 42 facilities represent only about 1.2 percent of the total number

Table 1. Florida's Largest Treatment Facilities in 1993

Treatment Facility	County	Level of Treatment	Capacity (mgd)	Primary Reuse/ Disposal Method
Miami-Dade-Central District	Dade	Secondary	133.0	Ocean Outfall
Miami-Dade-North District	Dade	Secondary	100.0	Ocean Outfall
Tampa-Hookers Point	Hillsborough	AWT (a)	96.0	Surface Water
Broward County-North	Broward	Secondary	80.0	Ocean Outfall
Miami-Dade-South District	Dade	Secondary	75.0	Deep Wells
Jacksonville-Buckman St.	Duval	Secondary	52.5	Surface Water
Hollywood	Broward	Secondary	42.0	Ocean Outfall
Orlando-Iron Bridge	Seminole	AWT(a)	40.0	Reuse (Wetlands) & Surface Water
West Palm Beach-East Central	Palm Beach	Secondary	40.0	Deep Wells
Ft. Lauderdale-G.T. Lohmeyer	Broward	Secondary	38.0	Deep Wells
Bay County Regional	Bay	Secondary	37.0	Surface Water
Port St. Joe	Gulf	Secondary	34.8	Surface Water
Orange County-Sand Lake Rd.	Orange	Secondary(a)	30.1	Reuse (Conserv-II)
Tallahassee-T.P. Smith	Leon	Secondary	27.5	Reuse (Spray Irrigation)
Orlando-McLeod Rd.	Orange	Secondary(a)	25.0	Reuse (Conserv-II)
Pinellas County-South Cross Bayou	Pinellas	Secondary	24.5	Deep Wells
Boynton-Delray-South Central	Palm Beach	Secondary	24.0	Ocean Outfall
Pensacola-Main Street	Escambia	AWT	20.0	Surface Water
St. Petersburg-Northwest	Pinellas	Secondary(a)	20.0	Reuse
St. Petersburg-Southwest	Pinellas	Secondary(a)	20.0	Reuse
Orange County-Easterly	Orange	AWT	19.0	Wetlands & Reuse
Manatee County-Southwest	Manatee	Secondary(a)	18.0	Reuse
Boca Raton	Palm Beach	Secondary	17.5	Ocean Outfall & Reuse
St. Petersburg-Northeast	Pinellas	Secondary(a)	16.0	Reuse
Largo	Pinellas	AWT(a)	15.0	Reuse
Palm Beach County-Southern Region	Palm Beach	Secondary	15.0	Deep Wells & Reuse
Reedy Creek Improvement District	Orange	AWT(a)	15.0	Reuse
Total			**1074.9**	

Notes: (a) Provides High-level disinfection. (b) Source: 1993 DEP data.

of facilities, yet their capacities (about 1,240 mgd) represent about 57 percent of the state total. Table 1 lists the 27 largest facilities in Florida (having capacities of at least 15 mgd), which account for less than 1 percent of the number of facilities and about 50 percent of capacity. While these large facilities are very important to domestic wastewater management in Florida, they are relatively small in comparison to the largest facilities in several of the nation's metropolitan areas, the largest of which have capacities over 1,000 mgd.

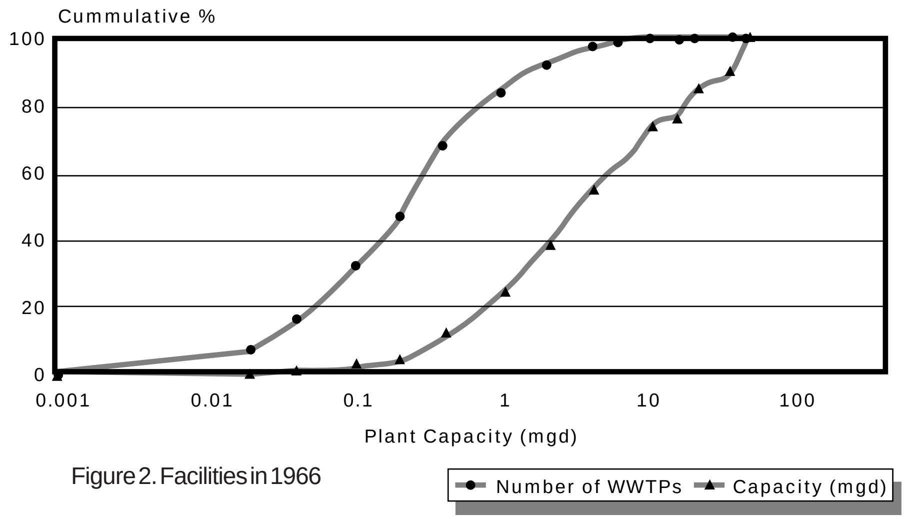

Figure 2. Facilities in 1966

Implications for Reuse

Sections 403.064 and 373.250, Florida Statutes (F.S.), establish the encouragement and promotion of reuse of reclaimed water as formal state objectives. Reflecting these objectives, the DEP and the water management districts have implemented a reuse program. In response to state program and other factors, reuse continues to grow in popularity in Florida. The *1992 Reuse Inventory* (DER, 1992) identified nearly 300 reuse projects using about 300 mgd of reclaimed water for beneficial purposes. Projects included in the 1992 inventory had reuse capacities totaling about 600 mgd, which is about 30 percent of the state's total permitted capacity for all domestic wastewater treatment facilities. Reuse has become an important part of wastewater management in Florida.

Inspection of Table 1 reveals that a number of Florida's largest facilities have implemented reuse. However, several of the largest facilities, which are located in designated Water Resource Caution Areas (formerly known as Critical Water Supply Problem Areas), continue to rely on disposal methods such as ocean outfalls, other surface water discharges, and deep well injection. Several of these facilities are beginning to implement reuse for a portion of their flows. Of note is the City of Tampa's proposed, large-scale, indirect potable reuse project.

Treatment facilities having capacities less than 0.1 mgd currently are precluded by Chapter 62-610, Florida Administrative Code, from implementing any form of public access reuse. This chapter also eliminates the possibility of residential irrigation or irrigation of edible food crops using reclaimed water from facilities having capacities less than 0.5 mgd. (Ongoing efforts to revise the reuse rules may result in the lowering of this minimum system size requirement to 0.1 mgd.) These size constraints eliminate several of the most attractive reuse activities from consideration by owners of the vast majority of domestic wastewater facilities in the state of Florida. Recognizing these constraints, the 1994 Florida Legislature exempted facilities heaving capacities less than 0.1 mgd from the reuse feasibility study requirements in Section 403.064, F.S.

As noted previously, the large facilities in Florida account for a large percentage of the state's total permitted capacity. To achieve a significant increase in the level of reuse in Florida, additional reuse activity will be needed from the larger facilities. Unfortunately, several of the very large facilities face difficulties in converting to reuse. Some facilities located near the coast experience infiltration of brackish water into the collection system. This results in increased salinity in the reclaimed water, which may significantly reduce the potential use for landscape or agricultural irrigation. Frequently, the larger facilities are located near the coast. Transmission of reclaimed water back across miles of heavily developed infrastructure to reach developing residential areas and agricultural areas greatly adds to the cost of reuse conversion. For facilities in the 1.0 to 5.0-mgd range, golf courses, which typically use about 0.5 mgd, can be important parts of the reuse system. However, for a 50-mgd facility, golf courses, parks, and residential properties become less attractive, largely due to the very large numbers of customers needed to use the entire

Table 2. Florida's Largest Treatment Facilities in 1966

Treatment Facility	**County**	**Level of Treatment**	**Capacity (mgd)**	**Primary Reuse/ Disposal Method**
Miami	Dade	Secondary	47.0	Ocean Outfall
Tampa	Hillsborough	Primary	36.0	Surface Water
St. Petersburg-Albert Whitted	Pinellas	Secondary	20.0	Surface Water
Jacksonville	Duval	Primary+	17.5	Surface Water
North Miami	Dade	Preliminary	15.0	Ocean Outfall
Daytona Beach	Volusia	Secondary	10.0	Surface Water
Lakeland	Polk	Secondary	9.0	Surface Water
Pensacola	Escambia	Secondary	9.0	Surface Water
Ft. Lauderdale-Plant B	Broward	Secondary	8.0	Surface Water
Orlando-Bennett Rd.	Orange	Secondary	8.0	Surface Water
St. Petersburg-Northeast	Pinellas	Secondary	8.0	Surface Water
St. Petersburg-Southwest	Pinellas	Secondary	7.2	Surface Water
Hollywood	Broward	Secondary	6.5	Surface Water
West Palm Beach	Palm Beach	Secondary	6.0	Surface Water
Total			**207.2**	

Source: Florida State Board of Health, 1966.

reclaimed water supply. Other options, such as ground water recharge and indirect potable reuse, may hold more potential for implementation of large-scale reuse at these large facilities, particularly in Water Resource Caution Areas.

A Look Back

A 1966 inventory of domestic wastewater facilities in Florida (Florida State Board of Health, 1966) identified 593 treatment facilities. This inventory included both public and investor-owned utilities. However, the report notes that an unknown number of small systems (such as some schools, motels, etc.) were not included. The total permitted capacity was only 512 mgd in 1966. The distributions of numbers of facilities and capacities are shown in Figure 2. Facilities with capacities less than 0.1 mgd accounted for about 31 percent of all facilities, but for only about 1.7 percent of the total state capacity. About 83 percent of the facilities had capacities less than 1.0 mgd, and these facilities accounted for about 24 percent of the total capacity in Florida. The largest 14 facilities are listed in Table 2. These 14 facilities represented only about 2 percent of all facilities, yet they accounted for about 40 percent of the total state capacity. It is interesting to note that none of the facilities in Table 2 provided treatment beyond secondary (several provide less than full secondary) and all involved some form of surface water discharge.

Department of Environmental Regulation records noted the existence of about 4,250 domestic wastewater facilities in 1986 (Smith, et al., 1986). As shown in Figure 3, the distributions of numbers of facilities and treated flows were similar to those for 1993. About 82 percent of the facilities had capacities less than 0.1 mgd. These small facilities treated about 4 percent of the total flow. Facilities less than 1.0 mgd represented about 95 percent of all facilities and accounted for about 10 percent of the total treated flow. Facilities having capacities greater than 10 mgd represented only about 1 percent of all facilities, but accounted for about 60 percent of the total flow.

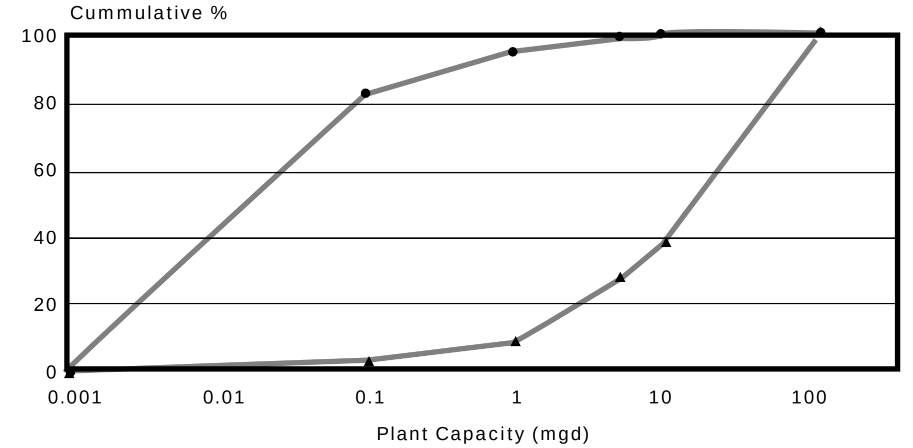

Figure 3. Facilities in 1986

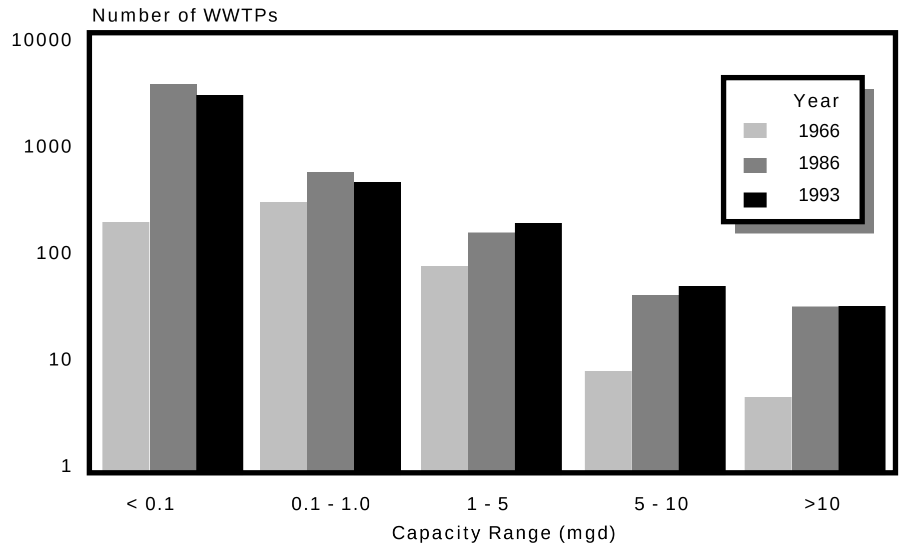

Figure 4. Numbers of Treatment Facilities

Figure 4 compares the numbers of facilities in 1966, 1986, and 1993. While differences in the three data sets exist, the rapid increase in numbers of facilities between 1966 and 1986 is striking, particularly for the small facilities. It is interesting to note that the total number of domestic wastewater facilities decreased by about 750 facilities between 1986 and 1993. This decrease is attributable primarily to the decrease in the number of facilities having capacities less than 0.1 mgd. Regionalization efforts in several counties eliminated many of these small facilities.

Summary

Wastewater management in Florida continues to be dominated by a very large number of small facilities, which represent a small percentage of the total capacity in the state. In addition, a relatively small number of large facilities dominates the total permitted capacity. During the 1966 to 1986 period, a significant increase in the number of facilities was observed. From 1986 to 1993, an 18-percent reduction in the number of facilities was observed, probably reflecting the trend toward regionalization of facilities. During the last decade a move toward reuse has been observed. However, the need for large-scale reuse at the state's largest facilities continues to pose challenges to the utilities and their engineers.

References

1. Florida Department of Environmental Regulation, *1992 Reuse Inventory*, Florida Department of Environmental Regulation, Tallahassee, Florida, 1992.
2. Florida State Board of Health, *Inventory of Public Sewerage Systems in Florida - 1966*, Florida State Board of Health, Bureau of Sanitary Engineering, Jacksonville, Florida, 1966.
3. Smith, R.W., D.J. O'Lone, and D.W. York, "Florida Wastewater Disposal Experience,"*Proceedings: Water and Wastewater Issues in the North Central Gulf Coast*, Mobile, AL, 1986.

David W. York, Ph.D., P.E., is reuse coordinator and Elsa Potts is administrator, domestic wastewater, Department of Environmental Protection, Tallahassee.

Effects of Recreational Vehicle Wastes on the Treatability of Domestic Wastewater

William Thomas

The impact of recreational vehicle (RV) wastewater on domestic wastewater treatment facilities has received little attention. This type of wastewater is typically not identified as a problematic contributor, however flow consisting of approximately 25 percent or more of RV wastewater may present problems to a domestic treatment plant in obtaining specified effluent quality limits[1].

RV wastewater is generated through the use of water closets, baths, sinks, and cooking in RVs. Chemical additives are typically introduced into holding tanks of RVs to mask or eliminate odors, but incidentally affect the biological characteristics and biodegradation process of the wastewater. These changes in characteristics can cause problems at treatment facilities not intended to treat considerable quantities of RV wastewater. Typical characteristics of RV wastewater found to cause operational and treatability problems primarily include low BOD and high COD concentrations as compared to typical domestic wastewater[1].

Analyses of RV and domestic wastewater was performed in northeast Polk County to determine comparable characteristics and the treatability of the two wastewaters. An RV resort consisting of transient residents was selected as the source of RV wastewater, and a nearby subdivision consisting of only single-family homes was selected as the source of domestic wastewater. In addition to wastewater analyses, a survey of holding tank additives was conducted in the Polk County area to identify active ingredients of these additives and recommended concentrations within RV holding tanks.

Wastewater Characteristics

Approximately 90 percent of all RV holding tank additives surveyed have formaldehyde (CH_2O) or a form thereof (i.e., paraform, formalin, or glutaraldehyde) as the active ingredient. Other active ingredients include cellulase, (a proteinaceous enzyme, whose composition was unobtainable due to proprietary rights) and bronopol (a preservative common in European cosmetic make-up products)[2]. Of the additives surveyed, the formaldehyde content ranged from 10 to 35 percent with dosing rates of four to eight ounces per 40 gallons of RV holding tank waste. These recommended dosing rates equate to concentrations of 156 to 273 mg/l of the active ingredient. Enzyme and cellulase content were unavailable, but, according to the Thetford Corporation[2], bronopol content is less than 10 percent of the additive by volume. Dosing rates of enzyme, cellulase, and bronopol-based additives were comparable to that of formaldehyde-based additives.

Formaldehyde is a reducing agent used as a disinfectant, germicide, and fungicide, but it is primarily used as a preserving fluid for biological specimens and as an embalming fluid. Therefore, RV holding tank additives containing formaldehyde suspend biological degradation activity and preserve the state of the organic constituents of the wastewater until removal of the formaldehyde can be accomplished.

By definition, formaldehyde and bronopol can be classified as volatile organic compounds (VOCs), but are nonoxidizing (reducing) biocides[3, 6, 8, 14, 15, 16]. Nonoxidizing VOCs can be removed from a wastewater stream by physical operations or chemical adsorption. The most economical and common methods of removing these VOCs in a wastewater environment are air stripping and preaeration prior to biological treatment of the wastewater stream. Typical values of preaeration hydraulic retention times (HRTs) for removal of VOCs range from one-half to two hours, depending on the concentration of the VOCs present in the waste stream[3 6,15].

Two 24-hour composite samples of raw wastewater were taken in the RV and residential developments using ISCO samplers. One sample was taken from a lift station collecting wastewater from the RV park and the other from a lift station collecting wastewater from single-family homes. Both wastewater streams are treated at a 0.6 MGD contact-stabilization facility. The samples were analyzed for BOD, COD, Total Nitrogen (TN) as Nitrogen (N), Ammonia-Nitrogen (NH_4-N), Total Kjeldahl Nitrogen (TKN), Organic N, Nitrite-Nitrogen (NO_2 -N), Nitrate-Nitrogen ($N0_3$-N), Total Phosphorus (TP) as Phosphorus (P), Total Suspended Solids (TSS), Alkalinity as Calcium Carbonate ($CaCO_3$), pH, and Formaldehyde. Due to limited funding, concentrations of proteinaceous enzymes and bronopol were not obtainable. Results of the analyses are presented in Table 1.

Table 1. Wastewater Characteristics RV and Domestic Comparison

Parameter/Unit	*RV*	*Domestic*
BOD_5, mg/l	201	223
COD, mg/l	504	333
TN as N, mg/l	96.5	50.5
NH_4-N, mg/l	58.1	26.4
Organic N, mg.l	38.3	23
NO_2-N, mg/l	BDL	0.02
NO_3-N, mg/l	0.11	1.12
TP as P, mg/l	8.17	6.68
TSS, mg/l	124	134
Alkalinity as $CaCO_3$, mg/l	208	205
pH	7.8	7.8
Formaldehyde, mg/l	100.1	BDL

BDL=Below Detectable Limits

The oxygen demand and inhibitory effects of formaldehyde are noteworthy. Comparison of the BOD and COD concentrations of the RV waste to those of the domestic waste are the best indicators for such effects. The reason for these differences is that the formaldehyde concentration found in the RV waste places an additional oxygen demand on the treatment system; whereas, the domestic waste has no formaldehyde and, therefore, no additional oxygen demand. The 100.1 mg/l formaldehyde concentration found in the RV wastewater has a COD concentration of 106.8 mg/l. Furthermore, the biological inhibitory effects of formaldehyde are noted in the difference between the COD and BOD values of the RV waste. If biological degradation were not inhibited, the BOD and COD concentrations would be closer, like those of the domestic wastewater. The preserving effects of formaldehyde prevent biological activity from occurring during the BOD test, which results in a low BOD concentration. However, the COD test analyzes biodegradable and non-biodegradable oxygen demand, and this is a more realistic measure of the true oxygen demand of the wastewater.

Formaldehyde occurs naturally and is used in organic synthesis, but at extremely low concentrations. Formaldehyde can be biologically removed from a waste stream, given the proper conditions. As with any type of wastewater, bacteria removing a particular constituent from a waste stream must first be acclimated to it.

Summary and Conclusions

Removal of formaldehyde, or other nonoxidizing VOCs, can be achieved after screening and/or grit removal through preaeration of the wastewater before entering the biological treatment train[9, 16, 21]. The required preaeration HRT is dependent upon the VOC concentrations present in the waste stream, but typical HRTs range from one-half hour to two hours[3, 6, 15].

A comparison of the two wastewater types presented in Table 1 clearly indicated RV wastewater to have a greater oxygen demand than domestic wastewater. The low nitrite and nitrate concentrations in the RV wastewater indicated that nitrification was inhibited, whereas, the domestic wastewater was beginning to nitrify. Notably, the COD, BOD_5, TKN, and TP values support the argument that RV waste requires greater treatment efforts than domestic waste and should be considered when undertaking design of a wastewater treatment facility that may serve RVs.

In this particular study, the bacteria cannot survive and satisfactorily remove the intermittent (seasonal) formaldehyde loadings from RVs. If the formaldehyde content was maintained all year at a fairly consistent concentration, the bacterial population might become acclimated to the formaldehyde. Realistically, a possible solution to the intermittent loadings would be to pretreat the RV wastewater with ozone or by preaeration at a convenient location within the collection system, for example a lift station. Further studies should be conducted to help identify the threshold of toxicity that formaldehyde has on domestic wastewater streams.

References

1. Alexander, Gaines, Chief WPC Operator, Polk County Utilities Division—Wastewater Facilities Operations, Polk County, Florida, May, 1994.
2. Burrows, Mary, Chief Chemist, Thetford Corporation, Ann Arbor, Michigan, April, 1994.
3. Cagwin, Dale J. and Lager, John A., "Volatile Organic Carbon Emission - Control Systems," *Water Environment & Technology,* June, 1990.
4. Carrio, Luis A., Sharpe, Russ, Bizzarri, Ronald E. and Wilson, Tom El, "Room for Advancement," *Water Environment & Technology,* December, 1993.
5. Converti, Attilio, et al., "Influence of Nutrient Concentration on New Operating Criteria for Biological Removal of Phosphorus from Wastewaters," *Water Resources Journal*, Vol. 27, No. 5, pp. 791-798, 1993.
6. Corbitt, Robert A., *Standard Handbook of Environmental Engineering*, pg. 5.152, McGraw-Hill, New York, 1990.
7. Daigger, Glen T., et. al., "Enhanced Secondary Treatment Incorporating Biological Nutrient Removal," *Journal WPCF*,, Vol. 60, No. 10, October, 1988.
8. Eckenfelder, Jr., W.W., *Industrial Water Rollution Control*, 2nd Ed., pp. 136, 146, McGraw-Hill, New York, 1987.
9. Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers, *Recommended Standards for Wastewater Facilities*, 1990 Ed., pp. 60-1 - 110-5, Health Education Services, New York, 1990.
10. Kerrn-Jespersen, Jens Peter and Henze, Mogens, "Biological Phosphorus Uptake Under Anoxic and Aerobic Conditions," *Water Resources Journal*, Vol. 27, No. 4, pp. 617-624, 1993.
11. Lekevin, Craig C., et al., "Wetlands Put to the Test," Water Environmental & *Technology,* February, 1994.
12. Lessard, P. and Beck, M.B., "Dynamic Modeling of the Activated Sludge Process: A Case Study," *Water Resources Journal*, Vol. 27, No. 6, pp. 963-978, 1993.
13. Maiti, S.K., Gupta, S.K. and Joshi, S.G., "Nutrients Removal and Conservation by Activated Algae in Oxidation Ditch," *Journal WPCF*, Vol.. 60, No. 12, December, 1988.
14. McGhee, Terence J., *Water Supply and Sewerage*, pg. 238, McGraw-Hill, New York, 1991.
15. Metcalf and Eddy, Inc., *Wastewater Engineering: Treatment, Disposal, and Reuse,* 3rd Ed., pp. 68-70, 287-292, McGraw-Hill, New York, 1991.
16. Okoniewski, Bradley A., "Remove VOCs from Wastewater by Air Stripping," *Chemical Engineering Progress,* February, 1992.
17. Pisano, William C., Thibault, Nelson and Forbes, Gene, "The Vortex Solids Separator," *Water Environment & Technology,* May, 1990.
18. Price, Joanne Kirkpatrick, *Applied Math for Wastewater Plant Operators,* Technomic Publication Co., Inc., Pennsylvania, 1991.
19. U. S. Environmental Protection Agency, *Design Manual: Phosphorus Removal*, EPA/625/1-87/001, September, 1987.
20. U. S. Environmental Protection Agency, *Design Manual: Municipal Wastewater Disinfection*, EPA/625/1 -86/021, October, 1986.
21. Van Durme, Gayle P., "Capping Air Emissions from Wastewater," *Pollution Engineering,* September, 1993.

William C. Thomas IV, E.I., is with Polk County Utilities Engineering, Bartow and a student at the University of South Florida. This was a student paper at USF.

Alternative Project Delivery Approaches for Public Works Owners

Douglas Smith

If you are like most public works owners who have undertaken a major capital improvement project in the past few years, chances are you have dealt with cost overruns, schedule delays, contractor claims, and perhaps even a lawsuit. The project that was launched in the euphoria of teamwork and high hopes may have ended up on the rocks: late, over budget, and entangled in settlement negotiations that ultimately cost everybody something. Such is the nature of the prevailing lump-sum, low-bid approach to public works contracting.

To counteract this trend, design professionals have created thicker and thicker contract documents intended to clearly define the responsibilities of the parties. All too often, however, the successful low bidder has not read — or has read but failed to fully consider — the fine print of the contract documents. When a dispute arises, the public works owner is faced with litigating (or arbitrating) an issue—or settling with the contractor to avoid litigation costs. During the dispute resolution process, the design professional's judgment is questioned in the bright light of 20/20 hindsight and everyone suffers.

What can be done to break out of this conundrum created by competitive bid laws and the current economic pressures on general contractors to win bids at any cost? The good news is that there are several options available to public works owners that can improve on the lump-sum, take-it-or-leave-it approach that is currently practiced.

One major advancement in the traditional project delivery arena that has achieved considerable success in the past few years is "partnering." The partnering process establishes working relationships among the parties through a mutually developed, formal strategy of commitment and communications. It is a process that attempts to create an atmosphere of trust and teamwork, a hierarchy for dispute resolution, and a cooperative bond for everyone's benefit. But like all forms of partnership, the success of partnering depends on the commitment of the partners. When owners, contractors, and design professionals approach the process in the adversarial manner to which they've grown accustomed, partnering, too, is doomed to failure.

Some owners have chosen an alternative, design-build approach, inextricably linking the contractor and design professional in a joint relationship. In the design-build approach, the owner retains a consultant who prepares a preliminary design document that establishes the scope of the project and the general standard for project quality. The owner and consultant pre-qualify design-build teams or organizations capable of bidding on the work and the job is awarded to the team or entity that submits the lowest lump-sum bid.

This method of contracting can be very effective when the owner has a clearly defined project scope. Schools, jails, and hotels are often produced on a design-build basis because an easily followed pattern has been established. Projects that require a high level of owner involvement, such as water and wastewater treatment plants, do not lend themselves to the typical design-build approach. One drawback is that design professionals are not eager to enter into relationships that require a significant front-end at-risk investment to prepare design drawings on which a contractor can price the work. After the bid, the designer is subordinated to the contractor because of the relative size of their respective contracts. This unequal relationship can create problems for the designer and, ultimately, the owner.

These and other project delivery approaches are available to owners who are willing to take control of the process and create the kind of teamwork required to have successful projects. This article describes possible approaches along with their advantages and disadvantages.

Traditional Approach

The traditional approach to public works contracting is the design-bid-build approach, in which the owner secures separate contracts for design and construction. Designers are selected on the basis of qualifications (usually through some competitive process) and contractors are selected based on the lowest responsive and responsible bid. The general contractor builds the project with oversight by the owner and designer for conformance to contract. Persuasive arguments for the traditional process include its management simplicity, cost security, and adherence to competitive bid laws. Current practice, especially during economically hard times, is that most projects end in some kind of dispute regarding cost, quality, and/or schedule. Each of the three parties to the contract, two of whom do not have a contractual relationship with each other, have different interests to protect and little to gain by expending effort to protect the other party's interest.

In an effort to bridge these gaps between contracting parties, the U.S. Army Corps of Engineers developed a process called partnering. The partnering process establishes working relationships among the parties through a formal strategy of commitment and communication. The parties mutually develop a project mission statement and hierarchy of dispute resolution and also participate in regular team-building activities that nurture the personal relationships so critical to project success.

Consider two recent projects in which the partnering process was employed. These projects involved the same owner and engineer but different contractors. One project was an immense success: all parties were satisfied and the project was completed on schedule and with minimum changes. The second project, however, was rife with conflicts, claims, and criticism and, but for partnering, would have resulted in all-out litigation. Partnering requires a significant altruistic effort by all parties and relies much more heavily on the social contract than the project contract. Some parties — owners, engineers, and contractors alike — are simply unwilling or unable to make that change and the process fails. But for those owners who prefer the traditional approach, partnering should be investigated and incorporated into major projects on a regular basis.

Design-Build

"Design-build" can replace the traditional project delivery approach of awarding separate contracts for design and construction. Under the design-build approach, a single entity provides all of the services necessary to both design and construct the project. This "single point of responsibility" fundamentally distinguishes design-build from other forms of project delivery.

On a design-build project, the designer and the contractor work as a team, designing and constructing the project to satisfy the owner's needs. This results in improved cooperation between the participants who work together toward achieving the most beneficial project results. It is an approach that has been widely and successfully used in the world of private architecture.

The benefits of design-build to the owner are summarized as follows:

Reduced Claims through Single Source Responsibility - The design-build approach establishes a single point of responsibility for all design and construction activity.

Reduced Project Delivery Time - The design-build approach reduces the total project delivery time from inception to completion. Construction documents are not as extensive as those typically prepared for conventionally structured projects. Project delivery time can be reduced by 10 to 30 percent.

Innovative Design - The design and construction professionals work together more creatively to solve various design and construction problems. As actual team members, the various parties work for their mutual benefit from project inception through construction.

Reduced Project Cost - The design-build approach can result in a lower project cost. Savings can accrue through a reduction in delivery time, design and construction efforts, and claims. The cost benefits of the design-build approach are particularly obvious at the beginning of the project, when on-site activities begin earlier because of staged construction packages and pre-purchased equipment.

In a typical procurement process for design-build services for public works projects, the owner prepares a detailed Request for Proposals that defines the project scope. Design-build teams are short-listed based on qualifications, then the short-listed teams develop and submit lump-sum bids based on the RFP. Quality control is provided by the owner.

Weaknesses inherent in many design-build projects lie with the designer-constructor relationship. Because of the relative size of the contracts, the contractor often takes the lead and subcontracts with the designer. Such an arrangement tends to be unhealthy for both the designer and owner. A more appropriate relationship would be a project-specific partnership or joint venture. Such an association makes the designer and contractor mutual stakeholders who work together to meet the owner's requirements.

Another potential disadvantage of this approach is that the design-build team members are in an arms-length contractual relationship with the owner. Although stakeholders themselves, the designer and the contractor may seek to maximize profit at the owner's expense. Although the balance provided by the competing interests of the design-build team members mitigates against this occurrence, it does not eliminate the possibility.

Construction Management

Under the construction management approach, the construction manager assumes the role of the general contractor in coordinating the work. Frequently, this approach is used to "fast track" a project by phased construction. The construction manager works on the owner's behalf to provide professional services during the bidding and negotiating of each contract in sequence as the project proceeds.

Construction management services offer the owner the potential for speed, quality, and reduced cost for delivering a project. The owner, design professional, and construction manager work together to control the cost, quality, and time from inception to completion of the project. The construction manager's primary concern is strict adherence to schedule and budget — with the designer focusing on quality. During the design phase, the construction manager addresses such issues as constructibility, cost, schedules, and work packaging.

The construction manager may take one of two distinct roles: agent or vendor. As an agent, the construction manager acts on the owner's behalf for a fee, with the owner normally holding the contracts for construction. Other construction-related services and supplies are procured on a competitive basis. As an agent, the construction manager does not guarantee the construction cost or schedule. However, completing the project within the estimated budget and schedule helps the construction manager get selected for future jobs.

The construction manager in the vendor (at-risk) role provides the owner a guaranteed price to complete the project. The firm in this role normally holds the construction contracts and assumes the financial and legal liabilities as a general contractor, but performs no work. The advantage is a guaranteed price and schedule. The disadvantage is that the owner has less control and flexibility. Public bid laws typically require competitive bidding for all subcontracts in this situation. Because construction management is a professional service, the construction manager should be selected based on qualifications and experience.

Design-Construction Management/General Contractor

In the past few years, a new project approach has emerged in response to some of the problems described in the preceding sections. The design-construction management/general contractor approach is an attempt to synthesize the positive elements of each of the previously described approaches. This has been done by uniting the design professional and general contractor on a single team offering design and construction management services on a negotiated-fee basis but with a guaranteed maximum price (GMF) that is agreed upon at the beginning of the project.

This approach maintains the unique feature of the typical design-build approach: single point of responsibility for design and construction. The integration of design and construction from project inception fosters coordination and efficiency, reduces the potential for claims and disputes, and enhances the opportunity to "add value" to the constructed project. The design-construction management/general contractor serves as the owner's agent, providing professional design-build services on a cost-plus-fee basis. Construction contracts and equipment purchases are awarded by competitive bid as public bidding laws require. The owner has the benefit of a guaranteed price and schedule, but also has a direct hand in determining the style and quality of the project.

The D-CM/GC initially prepares a Basis of Design Report to establish and communicate to the owner the scope of the project including the GMF and schedule. This work is performed for a negotiated fixed fee.

The GMF method of compensation with limited self performance of work is used to assure fair pricing. The fee for overhead and profit is fixed prior to proceeding; all work is performed at cost plus this fee. The D-CM/GC performs construction management and competitively bids the construc-

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Brackish Water Supply Enhancing Fresh Water Availability for Dunedin

Dave Wiley and Robert Brotherton

Brackish water may be the answer for meeting current and future water needs for residents of Dunedin. Like other municipalities along Florida's Gulf Coast, Dunedin has been experiencing drinking water shortages and water quality degradation problems that are expected to worsen over time. Unlike other areas, however, Dunedin is taking a long-term approach to the problem, including development of brackish groundwater that can be treated and used to supplement available fresh water.

The program in this innovative undertaking is twofold: (1) test existing wells with the goal of developing a future well-field management program, and (2) find and develop a brackish groundwater supply within the city.

Dunedin is on a peninsula that is surrounded by salt water. Pumping from existing fresh water wells tends to draw the salt water vertically into the fresh water zone of the aquifer, especially during droughts. The purpose of the testing program is to determine the cause and effect relationship between chloride concentrations and pumpage and to establish a plan for reducing salt-water upconing in the future.

As part of the process, zones of brackish water are being delineated—water with a salinity between that of fresh and ocean water that can be pumped, mixed with fresh water, and treated by the city's reverse osmosis plant to increase the overall amount of potable water.

A New Pumping Strategy

The emerging plan involves keeping underground fresh and brackish water zones separate through an improved pumping strategy. Over pumping a fresh water well pulls brackish water up from deeper zones. The well-field management plan being developed calls for replacing or modifying existing wells to pump fresh water from the shallower aquifer, and accessing the brackish water zone with new, deeper wells. The water from both zones can then be mixed and treated at the RO plant.

The city's RO plant has been used since 1992 to remove iron, magnesium and other minerals from the water. But the membrane softening facility was also built for treatment of brackish water and to address future water quality requirements of the Safe Drinking Water Act.

Water quantity has become a critical issue, with more people moving to the Tampa Bay area every day. The RO plant not only solves current water quality problems, but provides a means to supplement fresh water supply when the need arises without placing additional burdens on currently stressed regional water supply sources.

Blending fresh water with brackish water before processing makes RO treatment extremely cost-effective. If salt water were being treated alone, it would have to be run through the membrane at a relatively high pressure. Diluting salt water with available fresh water requires less pressure, which means less power and reduced costs. Treating water for current future Federal State Drinking Water Act requirements was also a key factor in selecting the process.

In fact, the current cost of treating blended fresh and brackish water is relatively low. The cost of chemicals, manpower and power to treat 1,000 gallons of water is less than eighty cents, whereas piping water into Dunedin from inland areas would be totally cost-prohibitive. This cost includes an annual sinking fund to replace membranes on a five year life cycle, as well as other major components of the treatment plant. The capital outlay was $11 million for the 9.5 mgd facility, or slightly more than $1.00 per gallon daily capacity.

Locating Brackish Water

Quantifying the availability and quality of brackish water resources in the city is an extremely important task. LBG has worked with the U.S. Geological Survey (USGS) and the Southwest Florida Water Management District (SWFWMD) to install a test production well and a test monitoring well on the RO plant site to delineate local supplies and therefore minimize piping costs. Through the use of lithologic logs, geophysical logs, packer tests and pumping tests, a brackish water zone was identified at depths ranging from 230 to 385 feet. Water quality in that interval was fairly consistent and acceptable for the RO process.

A computer model has been developed to assist in preparing a well-field management plan for the city. Initial use of the model will show how pumping fresh water from various locations at various depths affect the overall ground-water flow system. Because brackish water is denser than fresh water it has the tendency to seek lower elevations in the ground-water regime, but this characteristic can be overridden if the direction of vertical flow is upwards due to extensive pumping. The degree of upward flux between the two water-producing zones depends upon several interacting well-field characteristics which were taken into account by the model.

Information from the brackish water well study was added to this model to determine the effects of brackish-water development on the shallower fresh-water producing zones. Preliminary results indicate that the effect will be a positive one, with the new, deeper wells reducing the potentiometric head in the brackish water zone, which helps to maintain downward flow in the aquifer and prevent upconing of poorer quality water. Once all the data are available, the model will be used to determine the best well locations and pumpage rates for preserving freshwater zones while utilizing brackish water supplies.

The city will begin pumping water from the test well to the RO plant in the Fall of 1994. The effect on potable water supply is expected to be dramatic: The one well is expected to increase potable water supplies by 10 percent. or 0.5 million gallons a day. As additional brackish water wells are added, the pumping of fresh water will decrease and/or allow better rotation of well pumpage. Some fresh water will always be blended with brackish water for cost effective water treatment.

The highly mineralized water that is rejected at the RO plant is now discharged to the city's wastewater treatment plant through a direct discharge pipe. There it is processed with wastewater (which dilutes it to an acceptable salinity) and is distributed through the city's reclaimed water system for irrigation purposes. As additional brackish water supplies are developed, some reject water (RO concentrate) will be by-passed and blended with the wastewater plant discharge prior to entering the receiving salt water body. This piping system is already installed but will require permit modifications for the wastewater plant prior to opening the valve.

Dunedin's wastewater plant is a new AWT facility designed for the build-out population of the city. The limits of 5 mg/l BOD, 5 mg/l SS, 3 mg/l nitrogen, and 1 mg/l P is accomplished with the A20 process and deep bed de-nite filters. This allows for a permit to discharge to the salt water bay 24 hours per day, 365 days per year. The city's reclaimed water system is 100% dedicated for the purpose of aquifer recharge and elimination of irrigation demands on the potable water aquifer. The treatment and reuse of the RO concentrate is, therefore, desirable to maximize the recycle potential of this valuable water resource.

Dunedin's water supply plan in notable not only for its use of state-of-the-art technology, but for its farsightedness. It promises to provide a long-term, dependable solution to water supply problems in a region noted for water supply shortages.

Dave Wiley is an associate with Leggette Brashears & Graham, Inc., Tampa. Robert H. Brotherton, P.E. is director of public works and utilities, Dunedin, Florida.

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tion work and the procurement of major equipment items. The advantages of competition are realized because the actual construction is subcontracted on the basis of competitive bidding.

The author has been heavily involved in two water treatment plant projects with a D-CM/GC approach. In one case, the plant was delivered just 11 months after the contractor was able to begin work — 17 months after the design work started; a previous plant for the same owner under the traditional (design-bid-build) approach took three-and-a-half years. The other project -of roughly the same size, at $8 million — required six months to gain owner approval and is scheduled to deliver water 12 months later. Both owners are very pleased with the project delivery approach.

The primary differences between the D-CM/GC approach and the typical design-build approach are as follows:

Selection of the contractor (D-CM/GC) is based on professional qualifications, which results in greater quality control. The owner and the contractor work together to develop the project scope, which yields greater quality and cost control.

The contractor uses the construction management concept, subcontracting the majority of the work via competitive bids - which keeps project costs down.

The owner shares in savings under the GMP concept, so the incentive to save money is inherent in the approach.

Because cost savings are shared, there is an increased potential for "value added" services — and improved project efficiency.

Under the D-CM/GC approach, the owner has a guaranteed price and set schedule. The selection of the D-CM/GC firm is based on the "professional service" method. One integrated team furnishes professional design and construction management services and competitively bids the actual construction work in place. The team "designs in" quality during project design, and "designs out" cost during procurement and construction. As part of the team, construction professionals control costs and time by assisting with project layout, material/equipment specifications, and procurement procedures, and by performing constructibility reviews and value analyses. Overall costs are reduced through efficient design, savings in construction time, and a decreased potential for disputes over change orders and subcontractor claims.

Summary

Public owners are no longer faced with taking the lowest lump-sum bid on their public works projects and making the best of the situation. There are many options available today that provide the owner greater control over the qualifications of the construction team and the integration of design and construction activities. Partnering with general contractors is one option. But owners can go much further in making the designer and general contractor part of a single team — their team — through use of the design-build or the design-construction management/general contractor approach. The key is to select the designer-constructor team on the basis of qualifications and work with that team on a professional services basis. That way, the owner not only gets a guaranteed price and set schedule, but also a team that can be counted on to deliver.

Douglas G. Smith, P.E., J.D. is partner-in-charge of project development, Black & Veatch, Tampa.