COMPARATIVE COSTS
OF
IMPLEMENTING A WASTEWATER REUSE PROJECT
IN COLORADO

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ABSTRACT

This paper presents a comparison of the estimated construction costs to implement a wastewater reuse system in the City of Westminster, City of Broomfield, and the Woodmoor Water & Sanitation District near Monument, Colorado. The authors have compared three facility studies which had been prepared to determine the cost effectiveness of implementing wastewater reuse systems for irrigation purposes. The studies also evaluated annual operation and maintenance costs for each system.

The studies demonstrate that wastewater reuse can be cost effective compared to potable water use for irrigation purposes. In each locale the large initial capital investment has delayed implementing the plans until funding sources are obtained. In a move towards ultimate implementation, the City of Westminster has begun to install reuse transmission mains with ongoing street improvement projects.

As potable water demands for irrigation purposes increase, wastewater reuse will become a more attractive alternative, versus the development of additional raw water resources. In Colorado, irrigation water demands are typically a large part of the total demand on the potable water system from the spring through the fall months. Large scale irrigation users identified in the studies as offering a good potential for irrigation reuse included golf courses, schools, parks, greenbelts, office parks and campuses.

Reuse system costs are partially driven by State Health Department requirements for additional treatment of secondary effluent, availability of
reuse water versus use as augmentation water for water right purposes, fluctuating seasonal demand for reuse water which dictates system sizing and storage requirements, the number of large irrigation demand users within a system, and adaptation to existing irrigation systems.

The Westminster system evaluated was for a 3,500 gallons per minute (gpm) to 4,800 gpm production rate and involved seven miles of transmission pipeline. The Broomfield system evaluated was for a 960 gpm to 1,930 gpm production rate and included five miles of transmission pipeline. The Woodmoor system evaluated was for a 300 gpm to 600 gpm production rate and involved five miles of transmission pipeline.

One of the authors was also involved in the evaluation and implementation of the use of raw water (ditch water source) for irrigation purposes at three public school sites. These systems required the construction of conveyance, storage, pumping, and piping of the raw water to the existing irrigation system. The cost for these systems was used to identify costs associated with the adaptation of a new water source to an existing irrigation system.

INTRODUCTION

The front-range of Colorado has experienced surges of rapid growth over the past 15 years. With the difficulty and expense of developing raw water sources to increase potable water supplies, wastewater reuse has been identified as a method to off-set some of the raw water and potable water needs of a community by supplying water to large irrigation water users such as parks, greenbelts and golf courses.

Several front-range communities have already implemented effluent reuse programs for irrigation of parks and golf courses. These communities include the City of Colorado Springs, City of Aurora, Parker Water and Sanitation District, and the Castle Pines and International Golf Courses which are supplied by the Plum Creek Wastewater Authority.

The Colorado Department of Health (CDH) has developed draft wastewater reuse regulations entitled "Slow-rate Land Application of Treated Wastewater." The draft regulation contains treatment limits which have been adapted from wastewater reuse regulations that other states have implemented, primarily California. The limits are divided into four categories which cover the majority of municipal reuse type projects.

- Individual residential areas
- Bodily (primary) contact areas
- Greenbelt and other secondary contact areas
- Impoundments
Effluent reuse projects are regulated first by the State Site Application process and then by the Colorado Discharge Permit System (CDPS).

BACKGROUND

The purpose of each of the reuse studies was to examine the economic and technical feasibility of implementing a wastewater effluent reuse project. The studies evaluated effluent availability, additional treatment required, conveyance requirements, and the operation and maintenance costs required for a wastewater reuse system. The studies identify potential irrigation sites and estimated water quantities required at each site.

CASE STUDIES

City of Westminster

The City of Westminster is a city of approximately 80,000 people located in the north metropolitan Denver area. The City has been studying wastewater reuse for a number of years and has begun partial implementation of their plan.

The City's objective is to install a reuse forcemain from the Big Dry Creek Wastewater Treatment Plant to a large golf course along a route which will also provide reuse to many other parks and golf courses along the alignment. The City has established a policy to install reuse forcemain piping in conjunction with City street improvement projects. By supplying these parks and golf courses with reuse irrigation water the City will benefit from the exchange of some existing water rights, a decrease of the maximum day potable water demands on the water system, and help to provide City parks with a water rate lower that the existing City potable water rate.

The City has found that it now costs approximately $6,500 to $10,000 per acre-foot to develop new raw water sources. The availability of raw water sources in this cost range is not unlimited and in fact will likely continue to increase in cost dramatically. A comparative cost to develop 2,510 acre-feet of effluent reuse was estimated to be approximately $3,700 per acre-foot.

The reuse system identified to be the most feasible is presented on Table 1. The reuse system would supply most of the identified sites with a pressurized water supply capable of directly supplying existing irrigations systems. Several of the larger users will be required to have on-site storage and separate pumping facilities. These additional user costs have not been included in the above costs. Two of the golf courses already have on-site storage and pumping facilities which are required for their use of ditch (raw) water for irrigation purposes.
City of Broomfield

The City of Broomfield is a city of approximately 30,000 located in the north metropolitan Denver area. The City has studied the possibility of reuse in the past but the need to supply water to a new golf course and office park has spurred the City to examine the economic viability of reuse with renewed interest.

In order to meet the irrigation water needs of the new golf course and office park a wastewater reuse system was analyzed. City parks that are adjacent to the proposed forcemain could also be connected to the system depending on the final design of the system.

Development of 600 to 1,200 acre-feet of effluent reuse supply was estimated to cost approximately $5,700 to $3,400, respectively. This amount is also considerably less than the costs for development of other raw water sources available to the City.

The reuse system identified to be the most feasible is presented on Table 2. Additional costs, not included in the above costs, will be incurred to construct on-site storage and pumping facilities but these items will be incorporated into the overall golf course and business park development project.

Woodmoor Water & Sanitation District

The Woodmoor Water & Sanitation District is located approximately 45 miles south of Denver, along Interstate 25 east of Monument, Colorado. The District primarily serves a residential population of about 4,500 along with two public schools and a limited amount of commercial development. The District contains a golf course which has historically been irrigated from a surface water source.

The District obtains all of its water for potable use from deep wells. The existing golf course has recently experienced difficulty in obtaining sufficient quantities of irrigation water from their raw water sources. Recent development in the area has required the local school district to expand the existing high school facilities and build a new middle school. Future development plans identify a second golf course in the southern portion of the District.

The District has found that meeting irrigation water demands from the potable water system can severely strain the system and has required substantial capital improvements to be made. The District has studied reuse as an alternative to meeting or supplementing irrigation demands of the golf courses and meeting irrigation demands from the schools.

The reuse system identified to be the most feasible is presented on Table 3. On-site storage and pumping is available at the existing golf course, but some
sites may require in-line booster pumping to overcome insufficient pressure for the irrigation system.

**WASTEWATER REUSE TREATMENT LIMITS**

Each of the projects evaluated included irrigation of parks, golf courses, schools, office parks and other areas where bodily contact is likely to occur. Because of the mixed uses in each project, it was determined that the reuse systems should be able to meet the treatment limits set for bodily contact areas as defined by CDH. Although treatment limits for secondary contact areas such as greenbelts and golf courses are less restrictive and therefore less costly to implement, it did not make economic sense to eliminate these other viable users from the projects.

Each of the wastewater plants currently treat wastewater to discharge limits of 30 mg/l BOD₅ and 30 mg/l TSS. Each plant has historically performed much better than these limits and normally discharge BOD₅ and TSS below 10 mg/l and 10 mg/l, respectively.

The treatment limits for bodily contact areas that were used in these studies are shown on Table 4.

**ADDITIONAL TREATMENT REQUIREMENTS**

The wastewater treatment process proposed to be added at each facility to achieve the additional treatment required for bodily contact includes:

- Filter Influent Pumping
- Polymer Feed System
- Mixed Media or Continuous Backwash Deep-bed Filters
  - Backwash Pumping (may not be required)
  - Backwash Surge Tank (may not be required)
- Backwash Waste Sump and Pumping (if gravity flow is not feasible)
- Chlorinator
- Clearwell / Chlorine Contact Tank / Pump Wetwell
- Additional Treated Effluent Storage (optional)
- Effluent Reuse High-service Pumping

A schematic of the proposed effluent filtration process is shown on Figure 1.

**COMPARATIVE COSTS**

Capital and annual operation and maintenance costs were compiled for each project for the recommended alternative as shown in Table 5. The capital costs have been broken down into two areas: 1) piping, pumping and on-line storage costs, and 2) treatment system costs. Project capital costs are listed in Table 5 and shown on Figure 2. The project capital cost based on an annual per acre-foot basis is shown on Figure 3. The estimated annual
operation and maintenance (O&M) costs include labor for maintenance, electric power, sampling and testing, and chemicals. Administrative costs for permit administration, meter reading and account billing have not been included in the O&M costs. Annual O&M costs and capital recovery plus annual O&M costs per 1,000 gallons delivered are shown on Figure 4. Figure 4 also shows the current bulk potable water rates per 1,000 gallons charged by the various entities. Water rights costs for modification of augmentation plans or for the leasing of additional water rights have not been included in the project costs. Other costs, such as on-site storage ponds, pumping facilities, and backflow prevention devices are also not included.

MODIFICATION TO EXISTING SITES FOR EFFLUENT REUSE

Each effluent reuse site must adapt existing irrigation systems to the new water supply. Supply of reuse water at the equivalent pressure and flow that each system requires is not always feasible. The reuse systems are typically not as extensive as the corresponding potable water distribution system. Therefore, each site must be examined on a case by case basis to determine what modifications or improvements are needed.

One of the authors was involved in a project to connect raw water (ditch water supply) sources to three existing public school sites in Jefferson County, Colorado. Ditch water is raw water diverted from a stream or river and normally conveyed to a site by an irrigation ditch. Most of the irrigation ditch water systems in Colorado were originally built for irrigation of farm crops. Each of the schools used potable water for 100 percent of their irrigation water needs. A predesign study identified that each school needed on-site storage, a pump station, and connecting waterlines.

Project construction costs to provide the needed on-site storage, pumping, and waterlines ranged in cost from $44,000 to $70,000 per site in 1991. The installed systems included approximately 3 days of irrigation water storage capacity, a booster pump and wetwell, waterline connections to the existing irrigation system, and a backflow prevention device on the potable water service connection.

As stated above, each irrigation site will have different irrigation system requirements. Most golf courses already have on-site storage and pumping facilities and therefore will only require minimal improvements. Sites that currently rely on the potable water system for their irrigation water may require the most extensive modifications and improvements if reuse water can not be supplied at sufficient pressure and flow.

PROJECT IMPLEMENTATION

Each of the entities involved has recognized effluent reuse as a viable water resource that should be further developed when proven to be needed by the
community and as a cost effective alternative to increased potable water supplies.

The following project implementation approaches are being taken at this time by the various entities.

**City of Westminster**

The City recently completed a cost estimate comparison of two alternative alignments for an upcoming pipeline installation project. The City plans to install approximately 5,000 feet of 16-inch to 20-inch pipe in conjunction with a street widening project this summer.

**City of Broomfield**

The City plans for implementation phasing of the reuse project is subject to the outcome of final negotiations with the developer of the business park/golf course.

**Woodmoor Water & Sanitation District**

The District is evaluating installation of a part of the reuse forcemain while constructing a planned outfall sewerline project. Depending on costs the District will determine if funds are available to start the installation of a reuse forcemain with this project.

Each entity has found it difficult to fully implement an effluent reuse program because of funding limitations. With a phased approach it is possible to achieve a reuse system at a lower capital cost by combining system improvements with other capital improvement projects. The only drawback to this approach may be the length of time it may take to complete each reuse project. In the future, if reuse standards become more stringent it will become more expensive and difficult to implement a reuse program. In addition, the public's perception and knowledge about effluent reuse must continue to be enhanced through education and dissemination of information.
TABLE 1
CITY OF WESTMINSTER
EFFLUENT REUSE PROJECT

• 7.0 MGD PROCESS EXPANSION AT WWTP

• 7.0 MGD HIGH-SERVICE PUMP STATION

• 40,000 FEET OF FORCEMAIN

• REUSE SUPPLY TO 17 SITES WITH A TOTAL OF 1,100 ACRES

• ANNUAL REUSE SUPPLY OF 2,510 ACRE-FEET
<table>
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| CITY OF BROOMFIELD  
EFFLUENT REUSE PROJECT |

- 2.8 MGD PROCESS EXPANSION AT WWTP
- 2.8 MGD HIGH-SERVICE PUMP STATION
- 27,300 FEET OF FORCEMAIN
- REUSE SUPPLY TO BUSINESS PARK AND GOLF COURSE AND UP TO 15 CITY PARKS WITH A TOTAL OF 735 ACRES
- ANNUAL REUSE SUPPLY OF 1,200 ACRE-FEET AND FUTURE SUPPLY OF UP TO 1,900 ACRE-FEET
TABLE 3
WOODMOOR WATER & SANITATION DISTRICT
EFFLUENT REUSE PROJECT

- 0.9 MGD PROCESS EXPANSION AT WWTP
- 0.9 MGD HIGH-SERVICE PUMP STATION
- 28,000 FEET OF FORCEMAIN
- REUSE SUPPLY TO 6 SITES WITH A TOTAL OF 139 ACRES
- ANNUAL REUSE SUPPLY OF 325 ACRE-FEET
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<tr>
<td>TSS (MG/L)</td>
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<td>MAXIMUM DELIVERY FLOW RATE (GPM)</td>
<td>CAPITAL TRTMT. COST ($M)</td>
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NOTES: TRTMT. = TREATMENT
(1) BASED ON A CAPITAL RECOVERY OF 20 YEARS, 8% INTEREST AND CONTINUOUS COMPOUNDING
FIGURE 1    EFFLUENT FILTRATION SCHEMATIC

Rothberg, Tamburini & Winsor, Inc.
FIGURE 2

Rothberg, Tamburini & Winsor, Inc.
FIGURE 3

Rothberg, Tamburini & Winsor, Inc.
FIGURE 4

Rothberg, Tamburini & Winsor, Inc.