Engineering Report

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FEASIBILITY STUDY
SEWAGE EFFLUENT REUSE
THUNDERBIRD PASEO

City of Glendale
Glendale, Arizona
Project No. Y867026

April 1987
Project No. 0756-03-1

MALCOLM PIRNIE

ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

CITY OF GLENDALE, ARIZONA

FEASIBILITY STUDY
SEWAGE EFFLUENT REUSE
THUNDERBIRD PASEO
PROJECT NO. Y867026

APRIL 1987

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CITY OF GLENDALE, ARIZONA

FEASIBILITY STUDY
SEWAGE EFFLUENT REUSE
THUNDERBIRD WASH
PROJECT NO. Y867026

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1. INTRODUCTION

Background

The City of Glendale (City) is considering the feasibility of developing a wastewater reclamation system in Thunderbird Paseo, part of the Arizona Canal Diversion Channel (ACDC), to provide water for irrigation of planned greenbelts and parks within the Paseo. The feasibility of providing reclaimed water to users outside the Paseo is also being considered.

Thunderbird Paseo is a portion of the ACDC, a major flood control project being designed and built by the U.S. Army Corps of Engineers (COE). Located between 51st and 75th Avenues, the Paseo will comprise approximately 200 acres and will include recreational facilities and landscaped areas. The recreational facilities and landscaping will be designed and built by COE. Maintenance, however, will be provided by the City and Maricopa County Flood Control District (MCFCD).

Initially, it was planned to use potable water to irrigate the landscaped areas of the Paseo. City staff recognized that providing potable water for this project would have a negative impact on its efforts to attain the water consumption reductions required by the Arizona Department of Water Resources (DWR). Using reclaimed wastewater for the Thunderbird Paseo project, however, would conserve the City's potable supplies while providing irrigation water for recreational and landscape areas which will benefit the City's residents. Thus, the concept for the Thunderbird Paseo wastewater reclamation project emerged.

Purpose

In September 1986, the City retained Malcolm Pirnie, Inc: to perform a feasibility study regarding the potential development of a wastewater reclamation system in Thunderbird Paseo. The purposes of the study are to:

- o Investigate, develop and evaluate alternative arrangements for a wastewater reclamation project.
- o Identify any modifications to the planned irrigation system for the Paseo if reclaimed water is used.
- o Determine the estimated costs and benefits of the project.
- o Make conclusions and recommendations concerning the technical and economic feasibility of the project and develop a preliminary plan for implementation.

Scope

The scope of services for this feasibility study generally includes:

1. Pre-study consultation with City staff to open communications and review and/or modify the approach to and objectives of the project.

2. Assembly and review of all available pertinent information required to develop the components of the project. Determination of the additional information needed and development of the programs to obtain it.

3. Identification and characterization of the water reuse potential taking into consideration the following:

   - o Quantity and quality of available wastewater,
   - o Long-term water requirements for the Paseo and potential uses of reclaimed water in the vicinity of the Paseo, and
   - o Reclaimed water demand characteristics including reuse classification and seasonal quantity variations.

4. Development of project concept alternatives including facility locations, treatment processes, effluent storage, noise and odor control and site aesthetics.

5. Preparation of a financial analysis of the project concept alternatives. This will include cost estimates for construction of facilities and operation and maintenance; economic benefits with regard to present wastewater treatment costs,

alternative water sources, revenues from sale of effluent, and fertilizer cost savings; possible participation of private developers.

6. Review of project concept alternatives and financial analysis with City staff.

7. Preparation of a report including the information developed above and a description of the recommended plan and implementation program.

2. STUDY AREA DESCRIPTION

Proposed Thunderbird Paseo Development

Thunderbird Paseo is the approximately 4-mile stretch of the ACDC from Cactus Road to Skunk Creek. The ACDC parallels the Arizona Canal between Cudia City Wash and Skunk Creek. The ACDC is designed to intercept and direct 100-year flood-flows within its reach in order to aid in alleviating flood-flow discharges into the Phoenix metropolitan area resulting from overflows of the Arizona Canal.

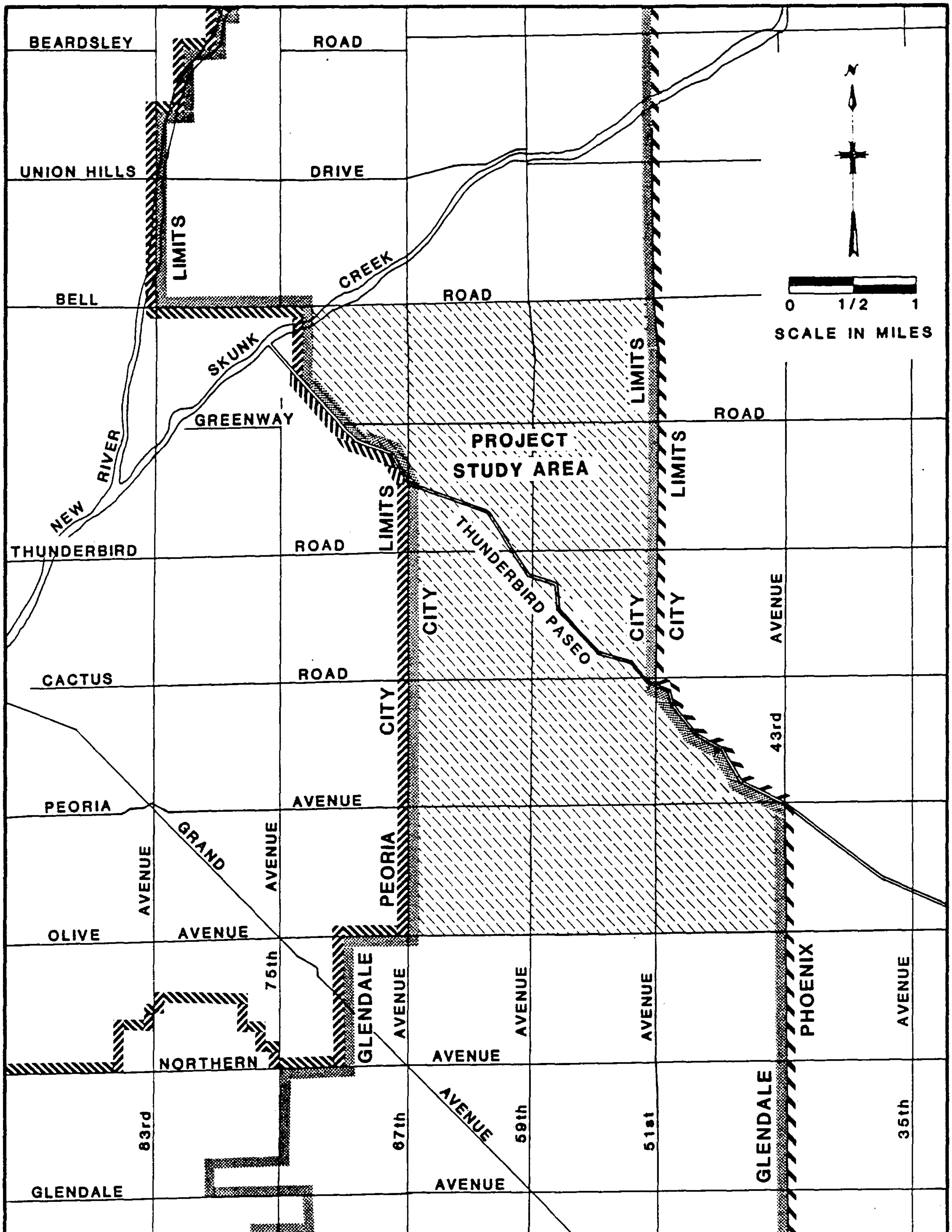
Thunderbird Paseo is being developed as a recreational parkway with activity areas linked by a system of hiking, jogging, bicycling and equestrian trails. The recreational facilities in the parkway will include picnic sites shaded by ramadas and other shading structures, an informal gathering area for nature appreciation and other programs, multipurpose paved courts and multipurpose turf athletic fields. Also planned are restroom facilities, parking areas, children's play lots, physical fitness courses and an area for target archery. The side slopes of the channel will be landscaped throughout the Paseo; landscaping for nonrecreational areas will consist of native grasses.

The maintenance and landscape irrigation of the Paseo will be provided by the City and MCFCD. The City will provide maintenance and irrigation for the recreational facilities and related landscaping in specific portions of the Paseo, while MCFCD will be responsible in other areas.

Figure 1 shows the location of Thunderbird Paseo and the limits of the study area for consideration of other potential uses of reclaimed water.

Adjacent Areas

The area surrounding Thunderbird Paseo has been zoned and development is nearly completed. There are areas along Bell Road which are presently undeveloped or in the process of being developed. These areas



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FEASIBILITY STUDY - SEWAGE EFFLUENT REUSE
THUNDERBIRD PASEO
REGIONAL SETTING

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FIGURE 1

are zoned for single and multifamily residential and general commercial development. The majority of the existing development is residential (both single and multifamily) in nature. There are several pockets of commercial development throughout the study area. Also, there are a few areas presently zoned agricultural-residential. It is anticipated that the agricultural areas eventually will be developed for residential and/or commercial use.

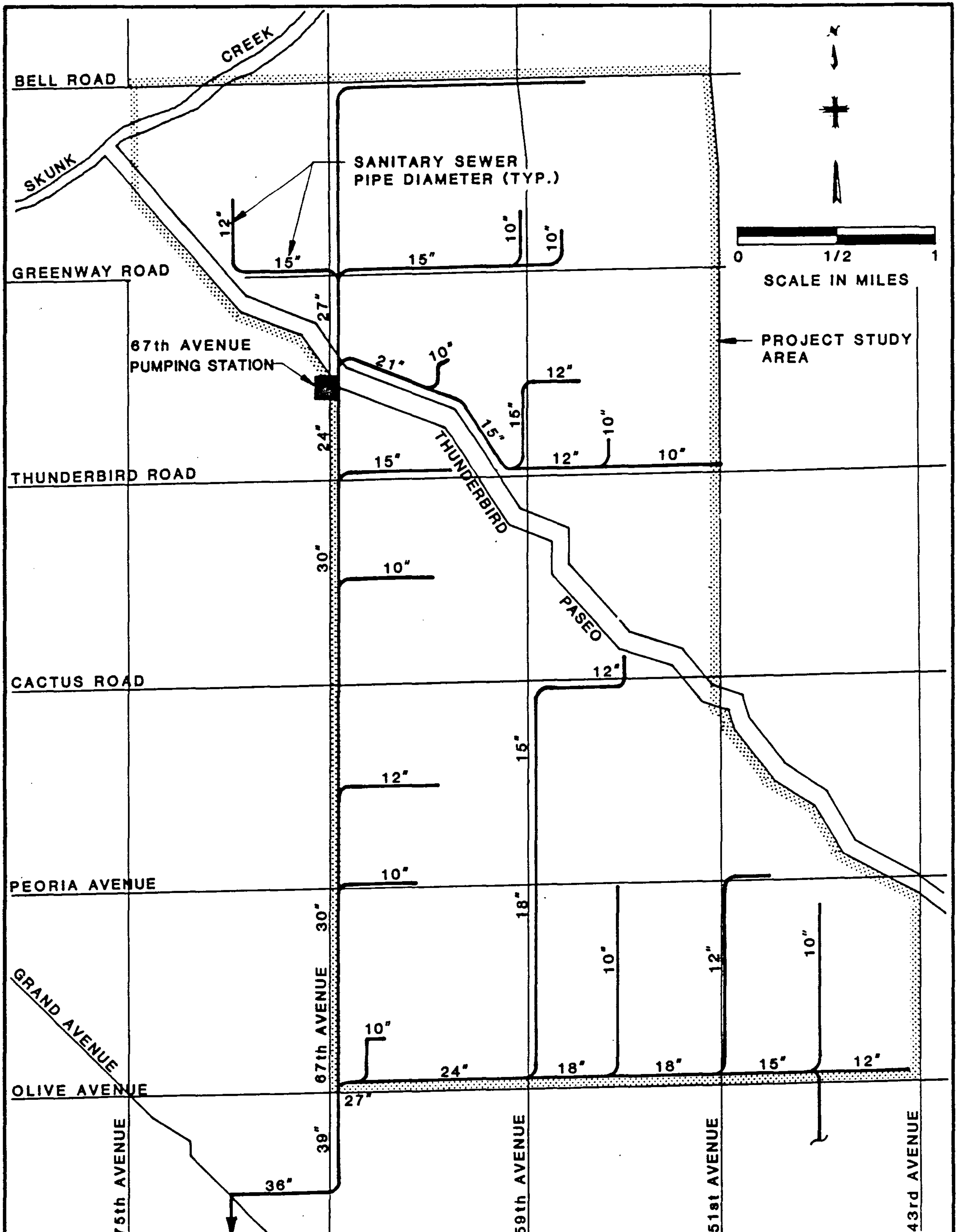
Water Supply System

The potable water supply for those portions of the study area south of the Arizona Canal is provided by City-owned wells and by the City's Cholla Water Treatment Plant which treats surface water from the Salt River Project (SRP) Arizona Canal. Irrigation water for some parcels of property south of the Arizona Canal (including schools and parks) is provided directly from the SRP irrigation distribution system.

Areas north of the Arizona Canal, which include Thunderbird Paseo, do not have SRP water rights (off-project) and currently are supplied potable water from City-owned wells. In the future, the potable water supply will be supplemented with water from the Pyramid Peak Water Treatment Plant which will treat water from the Central Arizona Project (CAP) Canal. Potable water is the primary source of irrigation water for areas north of the Arizona Canal. In addition, there are some parcels irrigated with water from private wells.

Wastewater System

The major components of the wastewater system within the study area are shown in Figure 2. The major trunk sewer for the area is the 24-to 30-inch diameter sewer in 67th Avenue. This sewer includes the 67th Avenue Pumping Station which lifts the sewage after passing beneath the Paseo. It is anticipated that wastewater for reclamation would be withdrawn from the system at the 67th Avenue Pumping Station. Existing and projected wastewater flows available for possible reclamation are presented and discussed in Chapter 4.



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THUNDERBIRD PASEO

EXISTING WASTEWATER COLLECTION SYSTEM

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FIGURE 2

Wastewater Characteristics

The wastewater contribution to the system upstream of the 67th Avenue Pumping Station is primarily residential and commercial in nature. The following are the results of analyses of the wastewater through August 1986:

Parameter	Concentration (mg/l)
Biochemical Oxygen Demand, 5-day (BOD_5)	160
Chemical Oxygen Demand (COD)	480
Suspended Solids	160
Oil and Grease	24
Total Nitrogen (as N)	30
Ammonia Nitrogen (as N)	21
Nitrate Nitrogen (as N)	0.3

These values are typical for medium strength sewage. Wastewater characteristics are not anticipated to change significantly as the area continues to develop because zoning for undeveloped parcels within the study area is also residential and commercial.

3. WATER RECLAMATION CONCEPTS

Potential Reuse Methods

Existing wastewater treatment technology can produce an effluent suitable for many purposes. Potential reuse methods for the Thunderbird Paseo study area can be grouped into the following major categories:

1. Landscape Irrigation and Recreational Uses - Included in this category is irrigation of turf and plantings in schools, parks, stormwater retention/diversion basins, golf courses or other areas including residential and commercial developments. Use of the reclaimed water to fill artificial lakes for recreational or aesthetic purposes also is included in this category.

2. Nonpotable Water Uses - This category includes uses such as industrial cooling, toilet flushing and fire protection. Much of the study area already is developed, as such, potential nonpotable water uses are already connected to the existing potable water system, and it would be difficult and costly to convert to a separate nonpotable system. Consequently, nonpotable reuse does not appear to be a feasible alternative for the study area.

3. Groundwater Recharge - The reclaimed wastewater can be used to replenish groundwater supplies either through infiltration from the ground surface or direct injection into the aquifer. The use of reclaimed wastewater for aquifer recharge has received much attention in recent years. This use of reclaimed water has potential for storing large quantities of water for future use or for replenishing depleted aquifers. However, a thorough evaluation of the feasibility of this option is beyond the scope of this investigation. Nevertheless, the use of effluent for this purpose is a possible future option which should be considered.

4. Agricultural Irrigation - Irrigation of agricultural crops with reclaimed wastewater is included in this category. While there remain a few agricultural parcels within the study area, long-term reuse by agricultural irrigation is unlikely. It is anticipated these agricultural parcels will eventually be developed for commercial or residential use.

Based on existing and planned development within the study area, the most feasible reuse method appears to be landscape irrigation and recreational uses. Demands for reclaimed water are discussed further in Chapter 4.

Regulatory Requirements

Regulations for the reuse of wastewater were adopted in April 1985 by the Arizona Department of Health Services (ADHS) and are contained in Arizona Rules and Regulations, R9-20-400. These regulations cover:

- General requirements and management practices for the reuse of wastewater,
- Specific water quality standards and monitoring requirements,
- Storage requirements,
- Permitting for the reuse of wastewater, and
- Enforcement policies

Of particular importance is the section of specific standards which dictates the minimum water quality requirements for various reuse options. Table 1 presents a summary of the requirements for landscape irrigation and recreational lakes. Specific requirements for in-building nonpotable uses and groundwater recharge are not listed in Regulation R9-20-400. These would be determined by ADHS and Maricopa County Health Department (MCHD) on a case-by-case basis.

ADHS (1978) in Engineering Bulletin No. 11 - Minimum Requirements for Design Submission of Plans and Specifications of Sewage Works, interprets the rules and regulations for design of effluent reuse systems. For domestic irrigation and irrigation of golf courses where children may play (unrestricted, or open access), ADHS requires secondary treatment and some form of tertiary treatment and disinfection.

TABLE 1

WATER QUALITY REQUIREMENTS FOR SPECIFIC REUSE METHODS

Constituent or Criteria	Open Access Landscape Irrigation	Recreational Lakes: Incidental Body Contact	Recreational Lakes: Full Body Contact
pH (units)	4.5 - 9	6.5 - 9	6.5 - 9
Fecal Coliform (CFU/100 mL)[1]			
Geometric mean	25	1000	200
Single sample not to exceed	75	4000	800
Turbidity (NTU)[2]	5	5	1
Enteric Virus (PFU/40 liters)[3]	125	125	1
Entamoeba Histolytica	--[4]	--	ND[5]
Giardia Lamblia	--	--	ND
Ascaris Lumbricoides (roundworm eggs)	ND	ND	ND
Common Large Tapeworm	--	--	--
Trace Substances (mg/L)			
Arsenic	2.0	--	0.05
Barium	--	--	1.0
Boron	1.0	--	--
Cadmium	0.05	--	0.01
Chromium	1.0	--	0.05
Copper	1.0	--	--
Lead	10.0	--	0.05
Manganese	10.0	--	--
Mercury	0.002	--	0.002
Selenium	0.02	--	0.01
Silver	--	--	0.05
Zinc	10.0	--	--
Cyanides	--	--	0.2
Phenolics	--	--	0.005
Sulfides	--	--	--

Notes:

1. CFU - denotes colony forming unit
2. NTU - denotes nephelometric turbidity units.
3. PFU - denotes plaque forming unit
4. -- = No standard
5. ND = None detectable

Under these regulations, the following limits are placed on effluents used for the above purposes:

BOD_5	10 mg/L
SS	10 mg/L
Fecal Coliform	200 CFU/100 mL (based on the arithmetical mean of 5 analyses over a 15-day period)

As a minimum, a wastewater reclamation facility must reliably produce water meeting the quality standards of ADHS. Other requirements which may be imposed by aesthetic or functional needs of the users include:

- <u>Additional oxidation beyond BOD removal</u> - This would mainly involve nitrification of ammonia to produce a more stable effluent and eliminate the effects of this process occurring in the elements of the reuse system.

- <u>Phosphorus reduction</u> - Reduction in phosphorus level would aid in controlling algae growths in aesthetic lakes.

- <u>Additional turbidity removal</u> - This would improve the visual appearance of the effluent.

In addition to water quality standards, ADHS and MCHD dictate that certain management practices be employed in effluent reuse systems. The most significant of these are:

1. Control of irrigation systems for residential reuse must be by approved agency or "water master," not individual users.

2. In most cases, irrigation areas must be arranged so that the 10-year, 24-hour storm is retained on site.

3. Marking and signage requirements for wastewater reuse areas.

The specific management requirements are developed and contained in reuse permits issued by ADHS for each project.

Bulletin No. 11 also outlines specific guidelines for setback requirements of treatment facilities from adjacent property depending on the size of the facilities and the environmental controls provided. These guidelines are summarized below:

Minimum Setback vs. Treatment Plant Size

	Setback Distance (feet)		
Plant Size 10^3 GPD	No Controls	Aesthetic, Noise & Odor Control or Signature	Enclosure with Noise & Odor Control or Signature
5 - 25	250	100	25
25 - 100	350	200	50
100 - 500	500	300	100
500 - 1000	750	500	*
) 1 MGD	1000	750	*

* Will be reviewed on each project.

As will be discussed in Chapters 4 and 5, effluent storage will be required to some degree and the Paseo area is a likely candidate for such storage.

Approval from MCFCD and COE will be required if storage facilities are located in the Paseo. In addition, a National Pollutant Discharge Elimination System (NPDES) Permit would be required if storage facilities are designed as open reservoirs whose content would become part of the flow in the Paseo during a storm event. This permit would be issued by ADHS.

The ADHS groundwater quality permitting program also is applicable to wastewater reclamation projects. For facilities constructed and operated at the surface, requirements generally are not significant. An exception is that wastewater and effluent storage facilities must meet minimum specifications for leakage. Any proposal to discharge effluent into the ground will involve much closer scrutiny by ADHS to determine potential impacts on groundwater quality.

For possible future groundwater recharge with effluent, key quality concerns include the nitrogen, total dissolved solids and trace organic concentrations of the effluent, in addition to the parameters listed in Table 1.

A wastewater reclamation facility may also require an amendment to the Maricopa Association of Governments (MAG) Areawide Water Quality Management 208 Plan.

Table 2 summarizes the regulatory agencies and their potential role in developing a wastewater reclamation project.

Wastewater Treatment

Various treatment processes can be utilized to produce wastewater effluent meeting the reuse requirements discussed above. However, reliability, ease of maintenance and economic feasibility will narrow the selection of the most appropriate treatment process.

To meet the ADHS water quality requirements for the applicable reuses, the wastewater reclamation facility will need to include the following processes:

- Wastewater Diversion - To divert wastewater from the existing sewer to the treatment facility.
- Bar Racks - To remove all large objects from the wastewater and prevent possible damage to downstream equipment.
- Raw Wastewater Pumps - To lift the wastewater to permit gravity flow through subsequent treatment units.
- Screening - To remove smaller objects from the wastewater which could possibly damage downstream equipment. Either coarse bar screens or fine screens may be utilized. Screenings may be disposed of by discharging back to the sewer downstream of the diversion chamber or land disposal.
- Comminution - An alternative to screening, to chop up solids that pass through the bar racks.
- Grit Removal - To remove grit (sand, gravel, coffee grounds, seeds and other materials) to protect downstream equipment from abrasion and abnormal wear (may not be necessary if fine screens are used).

Table 2

PLANNING ENTITIES
REGULATORY/PLANNING ROLES

Level	Agency	Primary Importance	Secondary Importance
FEDERAL	Environmental Protection Agency (EPA)		Regulates potential discharges to surface water courses. Sets industrial pretreatment standards for sewer system Enforces regulations pertaining to its construction grants program
	Department of the Army, Corps of Engineers		Manages flood control in Thunderbird Paseo
STATE	Department of Health Services (ADHS)	Establishes design standards for treatment facilities (Bulletin 11) Sets and enforces quality standards and management practices for the reuse of wastewater	Sets surface water quality standards Issues groundwater disposal permits
	Department of Water Resources (ADWR)		Implementation of Groundwater Management Act Approves of permits to drill new wells
REGIONAL	Multi-City Sub-Regional Operating Group [SROG (Phoenix, Mesa, Tempe, Scottsdale, Youngtown and Glendale)]		Performs coordination, detailed planning, grants management and operation responsibilities for facilities serving all members
	Central Arizona Water Conservation District (CAWCD)		Operates and maintains Central Arizona Project
	Maricopa Association of Governments (MAG)		Plans for regional water resource management

Table 2
(Continued)

PLANNING ENTITIES
REGULATORY/PLANNING ROLES

Level	Agency	Primary Importance	Secondary Importance
COUNTY	Maricopa County Health Department	Review and approval of treatment facility design Enforcement of treatment facility operations requirements	
	Flood Control District of Maricopa County	Performs regional flood control and stormwater management, owns portions of the Paseo	
MUNICIPAL	City of Glendale		
	Engineering Department	Performs overall water resources planning for City	
	Utilities Department	Operates water supply and distribution systems Operates wastewater collection, treatment and reuse/disposal systems.	
	Planning Department	Controls zoning, land use and building permits for potential project sites	Develops land use and population projections
	Finance Department	Arranges financing for City projects Acquires land for City projects	
	Parks and Recreation Department	Plans, developes and operates parks and open spaces	

- Flow Measurement - To measure and record wastewater flow to the plant. Several methods of measurement are available.

- Organic Removal - Either chemical or biological treatment can be used to remove organic material from wastewater. Of these, the most proven and cost effective is biological treatment which includes: conventional extended aeration, activated sludge, trickling filter, biotower, rotating biological contractors (RBC's), oxidation ditch, contact stabilization.

- Secondary Clarification - To remove excess settleable material.

- Filtration (Tertiary Treatment) - To remove suspended solids and reduce the wastewater turbidity.

- Disinfection - Required to destroy pathogenic agents in the effluent prior to use. The three principal methods to disinfect wastewater are chlorination, ultra violet radiation and ozonation.

Treatment Facility Design Consideration

As discussed in Chapter 2, the study area is heavily developed and it is likely that any available site for the treatment facility will be in proximity to residential or commercial development. If a reclamation project is implemented, it is, therefore, imperative that the facility have a positive impact on the surroundings and that the day-to-day operations do not interfere with the community lifestyle.

Siting

The City has proposed utilizing the site of the 67th Avenue Pumping Station and adjacent property to be acquired from MCFCD for the wastewater reclamation facility. This site is conveniently located adjacent to the Paseo, one of the potential primary users of the effluent. The existing pumping station can be incorporated into the design to serve as the diversion structure.

Architecture

Regardless of the site selected, attention should be directed towards maintaining the prevalent architectural surroundings. The visible parts of the treatment facilities should be designed to be pleasing to the eye and not to conflict or clash with their environment.

Aesthetics

The proposed wastewater reclamation plant should be designed to have a positive impact on the surroundings. All treatment units should be enclosed and designed to be low profile. The control building, housing the major mechanical and some process units, would be built to a height compatible with existing surroundings.

The largest volume of the process units would be placed at or below grade. The architectural design would match or coordinate with the surrounding buildings. Subdued lighting also would be used to avoid drawing attention to the facility.

Odor Control

Septic wastewater inherently has disagreeable odors associated with it. Because of the concern to provide a facility which has a minimal effect on the surrounding community, odor control processes should be used to reliably eliminate any noticeable odors outside the plant site. This will require that the plant layout and process locations be designed with odor control in mind. Odors would be controlled by enclosing all treatment processes prior to effluent filtration and venting the off-gases to odor treatment units. Hydrogen sulfide (rotten egg) typically is the principal odorous compound present in wastewater and can be effectively treated with chlorine. Other odorous compounds will also be oxidized by chlorine.

At this time, it is anticipated that off-gases from treatment process units would be collected and discharged to a packed bed tower. The odorous gases would flow upward through the tower while an oxidating agent would be sprayed into the top of the tower. The odorous compounds would then be oxidized. If abnormally high odors still exist, the gas could pass through a second odor unit, most probably a column filled with activated carbon which would absorb any remaining odorous compounds. Air from the existing pumping station also could be vented to this unit to control odors.

Noise Control

Just as important as odor control is sound attenuation. Therefore, the facility should be designed so that all noise sources are given careful acoustical treatment. Noise levels at the property line should be kept at or below current levels for the surroundings.

4. Wastewater Supply and Effluent Demand

Wastewater Supply

The results of flow monitoring conducted in August and November of 1986, indicate that the average daily wastewater flows at the lift station are approximately 2 million gallons per day (mgd). Current peak daily flows were observed to be approximately two times the average daily flows. It should be noted that peak wet weather flows may be significantly higher.

Based on a 1982 report by John Carollo Engineers entitled Utilities Relocation: Arizona Canal Diversion Channel, the peak projected flows for the 67th Avenue Lift Station for the year 2005 are 7.9 mgd. If the 2.0 peaking factor observed in 1986 is used, the average daily flow in 2005 would be 3.95 mgd. If a more conservative peaking factor of 2.5 is used, the average daily flow in 2005 would be approximately 3.2 mgd. For the purposes of this analysis, a conservative year 2005 average daily flow of 3.2 mgd has been used.

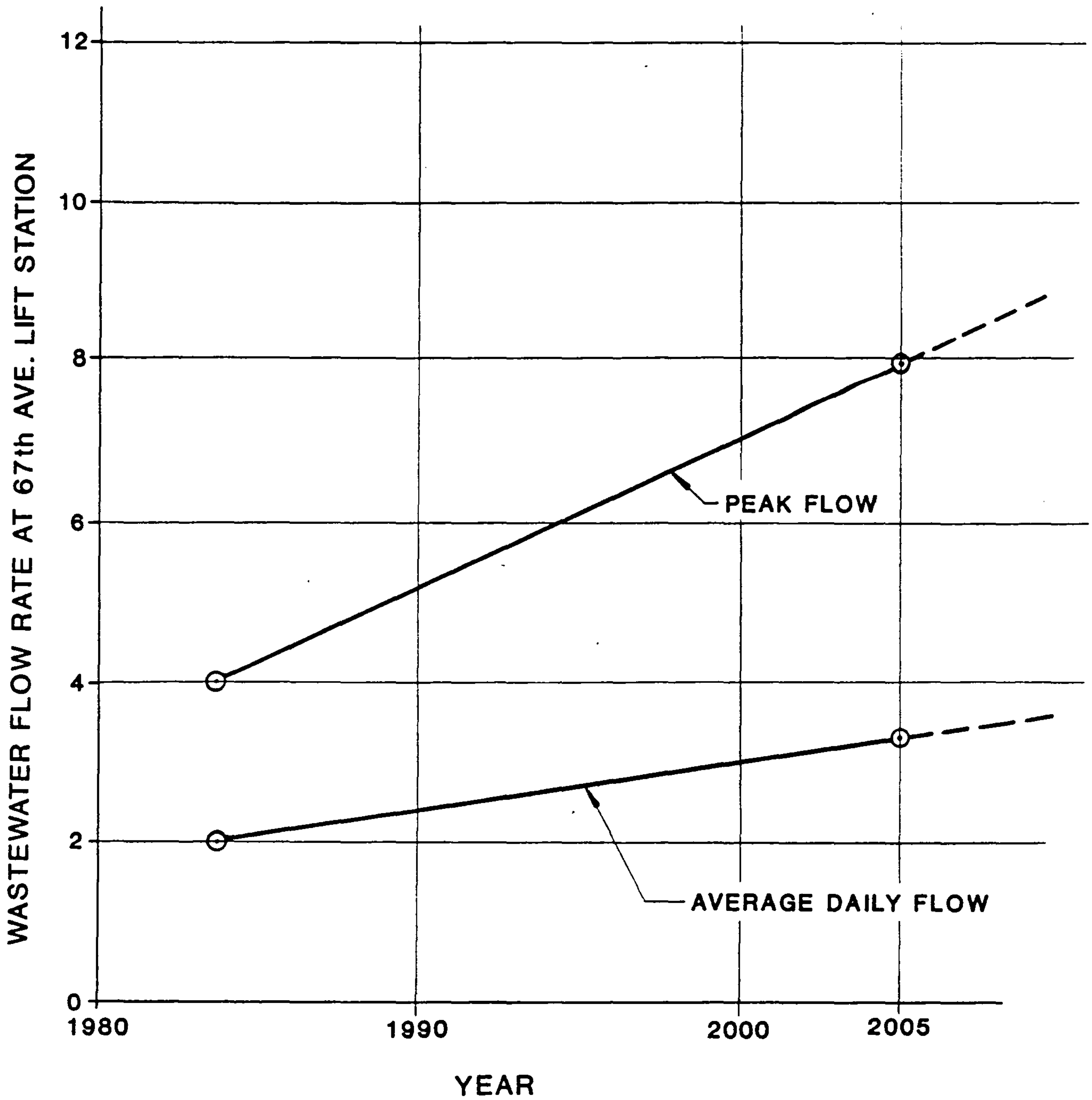
Figure 3 graphically shows the wastewater flow projections.

Potential Reuses

Several potential reuse methods were identified in Chapter 3. The following specific turf irrigation reuses can be further identified:

- Thunderbird Paseo
- Schools
- City Parks
- Private Developments

Figure 4 shows the locations of some of the potential reusers within the study area. The demand characteristics of the potential reusers are discussed in the following sections of this chapter. Water demands generally are based on actual billing or use data obtained from the potential users. Where actual water use data were not available,



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FEASIBILITY STUDY - SEWAGE EFFLUENT REUSE
THUNDERBIRD PASEO

PROJECTED WASTEWATER FLOWS AT 67th AVENUE LIFT STATION

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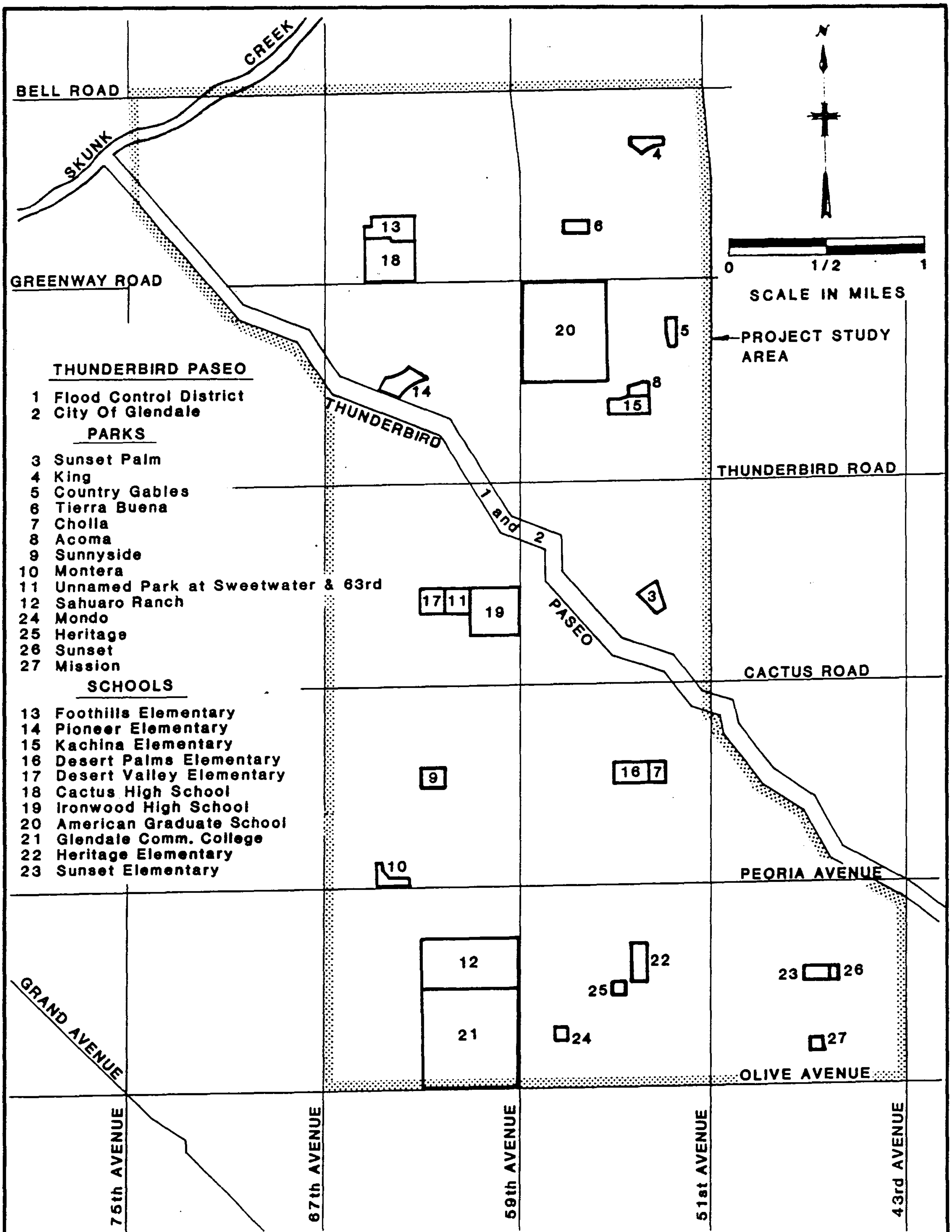
FIGURE 3



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FEASIBILITY STUDY - SEWAGE EFFLUENT REUSE
THUNDERBIRD PASEO

POTENTIAL REUSE SITES

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FIGURE 4

estimates were made from similar types of use. Table 3 summarizes the demand characteristics of the potential reusers.

Thunderbird Paseo - The peak irrigation demand for the Paseo within the study area has been estimated by MCFCD to be 1.0636 ac-ft/day or about 347,000 gallons per day (gpd). This total irrigation demand was broken down to show the demand required for facilities to be maintained by the MCFCD and those to be maintained by the City.

The MCFCD-maintained areas, landscaped with range grasses and plantings, have an estimated peak demand of about 173,000 gpd, or 0.53 ac-ft/day. The estimated peak irrigation demand for the plaza and turf areas to be maintained by the City is 174,000 gpd or 0.53 ac-ft/day. These demands are for the fifth year of operation and beyond. Prior to that, particularly in the first two years, the irrigation demand will be higher because more frequent watering is required to establish the plants and grasses. The irrigation demand for the Paseo presented in Table 2 are based on the above estimates, adjusted for the effects of salt leaching.

The peak and minimum demands are 185 and 19 percent, respectively, of the annual average demand. These relationships are based on information prepared by the designer (The WLB Group) of the proposed landscaping and recreational facilities within the Paseo.

The relationships generally are consistent with irrigation water demands throughout the Phoenix area and are appropriate for use in this study.

Because access to the Paseo will be unrestricted, reclaimed wastewater used for irrigation must meet ADHS water quality criteria for Open Access Landscaped Areas. Specific requirements for this reuse are summarized in Chapter 3.

City Parks - Within the study area there are 14 existing parks with irrigated areas ranging from approximately 3 to 21 acres. The predominant use of water in the parks is turf irrigation. Eight of the parks are flood-irrigated with water from SRP, six are sprinkler-irrigated

TABLE 3
POTENTIAL REUSE DEMANDS

No. 111	Category	Total (Acres	Irrigated (Acres)	Type Vegetation[1]	Irrigation Source[2]	Water Consumption: Winter (ac-ft/ac/yr)	Winter (MGD)	Annual Average (ac-ft/ac/yr)	Annual Average (MGD)	Summer (ac-ft/ac/yr)	Summer (MGD)
	Thunderbird Paseo										
1	Flood Control District			RG,Pl			0.0190		0.102		0.190
2	City of Glendale			T,Pl			0.0191		0.103		0.191
	Subtotal						0.0381		0.205		0.381
	Parks										
3	Sunset Palm	8.0	7.0	BG	Po	0.51	0.0032	2.72	0.017	5.06	0.032
4	King	5.0	4.5	BG	Po	0.41	0.0016	2.20	0.009	4.09	
5	Country Gables	4.0	4.0	BG	Po	0.67	0.0024	3.62	0.013	6.73	
6	Tierra Buena	5.0	4.5	BG	Po	0.66	0.0026	3.58	0.014	6.67	0.026
7	Cholla	5.7	3.5	BG	S	0.80	0.0025	4.29	0.013	7.98	0.025
8	Acoma	3.3	3.0	BG	Po	0.07	0.0002	0.36	0.001	0.67	
9	Sunnyside	8.0	7.5	BG	S	0.62	0.0042	3.34	0.022	6.21	0.042
10	Montera	5.3	4.0	BG	S	0.74	0.0026	4.00	0.014	7.41	0.026
11	Unnamed Park @ Sweetwater & 63rd	7.0	7.0 (est)[3]	BG	S	0.79	0.0049	4.25 (est)	0.027	7.91	0.049
12	Sahuaro Ranch	80.0	21.2 (est)	BG	S	0.77	0.0146	4.15	0.079	7.72	0.146
24	Mondo	5.2	5.2	BG	S	0.72	0.0033	3.86	0.018	7.19	0.033
25	Heritage	3.3	3.3	BG	S	1.13	0.0033	6.05	0.018	11.26	0.033
26	Sunset	3.6	3.6	BG	S	0.78	0.0025	4.17	0.013	7.75	0.025
27	Mission	4.5	4.5	BG	Po	0.88	0.0035	4.70	0.019	8.75	0.035
	Subtotal	147.9	82.8				0.0514		0.277		0.514
	Schools										
13	Foothills Elementary	15.0	10.0	BG	Po	0.41	0.0036	2.20	0.020	4.10	0.036
14	Pioneer Elementary	15.0	10.0	BG	Po	0.41	0.0036	2.20	0.020	4.10	0.036
15	Kachina Elementary	15.0	10.0	BG	Po	0.41	0.0036	2.20	0.020	4.10	
16	Desert Palms Elementary	15.0	10.0	BG	Po,S	0.41	0.0036	2.20	0.020	4.10	0.036
17	Desert Valley Elementary	11.0	5.0	BG	Po,S	0.41	0.0018	2.20	0.010	4.10	0.018
18	Cactus High School	36.0	13.0	BG	Po	0.41	0.0048	2.20	0.026	4.10	0.048
19	Ironwood High School	40.0	25.0	BG	Po,S	0.41	0.0092	2.20	0.049	4.10	0.092
20	American Graduate School	160.0	30.0	BG,R	W	0.41	0.0110	2.20	0.059	4.10	0.110
21	Glendale Comm. College	160.0	52.4 (est)	BG	S	1.40	0.0655	7.52	0.352	14.00	0.655
22	Heritage Elementary	15.0	10.0	BG	Po,S	0.41	0.0036	2.20	0.020	4.10	0.036
23	Sunset Elementary	12.7 (est)	7.2			0.41	0.0026	2.20	0.014	4.10	0.026
	Subtotal	494.7	182.6				0.1129		0.610		1.129
	Future Development										
28	Misc. Undeveloped Parcels	700 (est)	84			0.41	0.0307	2.20	0.165	4.10	0.307
	TOTAL						0.2331		1.257		2.331

Notes:
1. BG = Bermuda Grass, RG = Range Grass, Pl = Plantings, T = Turf, R = Rye
2. Po = Potable, S = SRP, W = Private Well
3. Estimated

with potable water from the City's water supply system. Irrigation demand for the parks presented in Table 3 are based on water usage data furnished by the City Park Maintenance Department and adjusted for salt leaching. The relationships between winter demands, peak summer demands and annual average are the same as for the Paseo. As with the Paseo, access to the parks is unrestricted and would require water quality meeting Open Access Landscape criteria.

Schools - There are seven elementary schools, two high schools and two colleges in the study area with an estimated total of 183 irrigated acres. The irrigated areas for the schools vary in size from approximately 5 to 50 acres.

The irrigation demand for the schools is based on an annual average of 2 ac-ft/ac/year adjusted for the effects of salt leaching which is a conservative value for turf irrigation in the Phoenix area.

The relationship between annual average, peak and minimum demands is the same as for the Paseo. Since access to the schools is primarily unrestricted, reclaimed wastewater would have to meet the requirements for Open Access Landscape areas.

Future Development - There are approximately 700 acres of undeveloped land within the study area with a potential for development that could utilize reclaimed wastewater for irrigation purposes. Utilizing City zoning maps and landscaping requirements, a conservative estimate of 84 acres would require irrigation. Irrigation demands were assumed to be the same as those for schools. Depending on the specific development plans for each parcel, it is anticipated either Restricted Access or Open Access Landscape water quality would be required.

Potential major users of reclaimed water outside the study area include a major development at Bell Road and 75th Avenue and the Outer Loop freeway. WestCor is in the initial planning stages for a 700-acre mixed-use located at Bell Road and 75th Avenue. The development will include a major shopping mall, offices and residential units. Projected potable and nonpotable water demands have not yet been established. The developer indicated that reclaimed water would be considered for landscape irrigation if it was cost-effective.

Another potential reclaimed water demand is landscape irrigation within the right-of-way for the Outer Loop. Arizona Department of Transportation's (ADOT) consultant indicated that there are approximately 26-acres of landscaped area per mile of roadway. Assuming a water usage of 2 acre-feet/acre/year, water usage per mile would average 46,000 gpd. A significant portion of the western leg of the Outer Loop will be located within Glendale or its strip annex. Reclaimed water potentially could be provided for irrigation along this freeway from a Thunderbird Paseo facility, Arrowhead Ranch or a possible future Western Area facility. ADOT's consultant indicated that they would consider using reclaimed water for irrigation if it was not detrimental to the irrigation system.

Summary of Potential Users

The most appropriate use for reclaimed wastewater in the planning area is for landscape irrigation. The potential average annual demand for effluent is 1.257 mgd, ranging from 0.2331 mgd during the winter months to a peak of 2.331 mgd in the summer months. The remaining sections and chapters of the report will focus on the issues of balancing seasonal demand, phasing, costs and benefits of developing a wastewater reclamation project.

Screening of Potential Reuse Areas

In order to determine which potential reuse areas were the most attractive to supply with reclaimed water, the areas were screened to rank them, on a relative economic basis. The screening consisted of comparing the cost of the distribution system required serve a user with the revenue which would result from providing service. The results of screening potential reusers outside the Paseo are summarized as follows:

- The most economically attractive areas are those with the highest demand or are located adjacent to the Paseo, including:

  - Sunset Palm Park
  - Sahuaro Ranch Park
  - Foothills Elementary School
  - Pioneer Elementary School
  - Desert Valley Elementary School
  - Ironwood High School
  - Cactus High School
  - Glendale Community College

- The next category of potential users consisted of outlying areas with low water demands which were practical to serve after the distribution system had been extended to near-by high-demand users. These area include the following:

  - Sunnyside Park
  - Cholla Park
  - Desert Palms Elementary School
  - Montera Park
  - Mondo Park
  - Heritage Elementary School
  - Sunset Elementary School
  - Heritage Park
  - Sunset Park
  - Mission Park

The last category consists of those areas which may not be economically attractive to serve at this time. However, the opportunity to serve these areas should be maintained, if in the future, it becomes more attractive to serve these areas.

Water Balance Conditions

Water balance conditions relate the quantity of raw wastewater available to the demand for effluent. As previously discussed, the average and maximum demands for effluent are estimated to be 1.257 and 2.331 mgd, respectively. A review of current wastewater flows indicate that the average daily flow at the 67th Avenue Life Station is approximately 2 mgd. This supply of sewage is adequate to meet the potential annual average demand (1.257 mgd) for the study area. The potential maximum demand of 2.331 mgd is greater then the current average flow of sewage. However, depending on water balance conditions, discussed below, it may be sufficient to satisfy demand. As shown on Figure 3, the average daily flow at the 67th Avenue Life Station currently is projected to reach 2.3 mgd by 1989.

The size of the reclamation facility depends on the quantity of sewage available, the magnitude and location of effluent demand, and effluent storage capabilities.

Effluent Management Options

As discussed in the previous section of this chapter, there are significant seasonal variations in irrigation demands. An integral part of developing and implementing a reclamation and reuse system is resolving these variations. Several management options are available to achieve a year-round water balance:

1. Size the treatment facilities to meet peak demands and produce less during the winter.
2. Construct large surface storage facilities to store excess effluent produced in winter for use in summer.
3. Size the treatment facilities to meet minimum demand.
4. Store excess effluent underground during winter months and recover it during summer months.

Each of these management options is discussed below.

Meet Peak Demand

This option would involve sizing the reclamation system to meet peak summer demands and operating the system to match supply with demand. Using this option would require reclamation systems with the following capacities to equal the effluent demand of screened reusers categorized as previously discussed, respectively:

Demands	Treatment System Capacity (mgd)
Paseo	0.38
Paseo plus large and/or adjacent users	1.50
All identified users	1.95
All identified plus future users	2.23

The advantage of this approach is that by meeting the peak demands, the use of reclaimed water is maximized and the greatest conservation benefits are realized. Also, maximizing the plant capacity produces certain economies of scale. The main disadvantage of this approach is that during low demand periods, utilization of plant capacity would be low, resulting in inefficient use of facilities. In addition, the ability to vary the throughout of a biological process is limited.

Surface Storage of Excess Production

This approach would involve producing excess water during the winter months and storing it for use during the summer. The advantage of this option is that greater utilization of treatment capacity can be achieved during winter months. Also, treatment capacity can be reduced because peak demands are met, in part, by effluent drawn from storage.

The main disadvantage of this approach is that the large amount of storage required to balance winter and summer demands, limits its economic feasibility. The following summarizes the amount of storage required to balance seasonal demands for a treatment facility sized to operate at a constant rate:

Avg. Ann. Demand and Plant Capacity (mgd)	Peak Summer Demand (mgd)	Storage Volume Required (mil. gal.)
0.21	0.38	21.8
0.90	1.50	34.1
1.10	1.95	34.2
1.30	2.23	34.6

Because the study area is heavily developed, the most feasible location for surface-storage of effluent is in recreational ponds or lakes within the Paseo. Assuming a working depth of 3 feet in the lakes, approximately 1-acre of lake is required for each 1 million gallons of storage. Thus, 21.8 million gallons of storage would require about 22 acres of lakes. The evaporation rate during June and July is about 9.9 inches per month. For 22 acres of water surface, this evaporation rate equates to a water loss of 197,000 gallons per day.

Thus, the capacity of the 0.27 mgd treatment facility would have to be increased by 73 percent just to satisfy the "demand" caused by evaporation from the storage lakes. Because of the significant amount of corporation from lakes, this method of storage may not be feasible for the Thunderbird Paseo project.

Meet Minimum Demands

This option involves sizing the treatment facility to meet the minimum effluent demand and operating the facility at capacity year-round. The advantage of this approach is that it makes maximum use of plant capacity. The following are disadvantages of this option:

- Except during winter months, irrigation demands must be augmented with other supplies.
- Economies of scale possible with larger facilities are not realized.

Store Excess Production Underground

This option involves operating a the treatment facility at a constant rate year-round, and storing or recharging excess production during low demand periods in the aquifer. During periods of high demand the stored water would be recovered with new or existing wells and delivered to the users.

The reclaimed wastewater can be recharged by two methods:

- o Infiltration basins
- o Injection wells

Recharge with infiltration basins involves spreading the water in shallow earthen basins and allowing the water to percolate by gravity into the aquifer. The main disadvantage of infiltration basins is the large areas of land required. As previously mentioned, land availability in the Paseo and study area is limited, and land costs are relatively high. The use of infiltration basins will depend on the amount of water to be recharged and stored, and the local soil and geologic conditions.

The second alternative for recharging the reclaimed wastewater is with injection wells. Injecting the water into the aquifer would involve constructing new injection wells and/or converting existing wells to pump reclaimed water into the aquifer for storage. Minimal land would be required for the injection well system.

Use of the aquifer would be an inexpensive method to store large amounts of effluent. Other advantages to this option include:

- o The treatment facility could operate at or near capacity year-round, resulting in high utilization of capacity.
- o Treatment facility capacity would not be limited by reuse demand.
- o If the supply of reclaimed water is greater than demand, the extra water could be recharged and stored for future use. This also would decrease the long-term decline of the water table in the recharge area.
- o The evaporation losses associated with surface storage in lakes would be reduced.

The following summarizes the main disadvantages of this option:

- o There are many ADHS concerns associated with the recharge of reclaimed wastewater. If the recharge of effluent in the study area would affect any potable supply wells, these ADHS concerns would have to be addressed and resolved.

- There are unresolved legal and water rights issues related to the ownership of the reclaimed water and rights to store and recover this water.

For these reasons, the use of underground storage to achieve a water balance would be difficult to achieve at this time. However, as the health and legal issues concerning recharge and recovery of reclaimed water are resolved, this method of storing reclaimed water is an alternative which could be implemented in the future.

Summary of Effluent Management Options

Based on this review of the basic effluent management options the following conclusions can be made:

- The use of above or below ground storage to achieve year-round water balance does not appear to be practical at this time. However, below-ground storage is an alternative the City may wish to investigate further and implement in the future.

- Sizing the reclamation facility to meet peak demand and then operating the facility during off-peak periods to match demand is not practical because of the resulting low utilization of treatment capacity.

- Sizing the reclamation facility to meet minimum demands is not practical because economies of scale will not be realized which would be possible with a larger facility. Also, the benefits of reclamation and conservation are minimized.

- Maximum size of reclamation facility, recharge excess consider recharge as an alternative.

Consequently, the most feasible approach for achieving a water balance consists of sizing the reclamation and storage facilities as large as is economically practical and balancing production and storage to meet demand. At a minimum, the storage volume provided should be enough to balance the day-to-day variations in production and demand.

The following summarizes the sizing of the facilities under this approach:

Demands	Treatment Capacity (mgd)	Storage Capacity (mil. gal.)
Paseo	0.5	1.5
Paseo plus large and/or adjacent users	1.5	4.5
All identified users	2.0	6
All identified plus future users	2.1	6

5. DEVELOPMENT AND EVALUATION OF ALTERNATIVES

This chapter presents a description of the development of reclamation system alternatives for the Thunderbird Paseo area and an analysis of costs and benefits for these alternatives.

Development of Alternatives

Based on the evaluation of wastewater supply and potential effluent demand presented in Chapter 4, there appears to be two types of reclamation system alternatives:

- A "Phased Project" which would be designed to serve the ultimate demand of the entire study area.
- "Single Capacity Projects" designed to serve a limited portion of the study area.

These system alternatives are developed further in the following sections of this chapter.

Phased Project

Based on the screening of potential reclaimed water demands in Chapter 4, there appear to be four categories or "phases" of demands. These phases are summarized below:

Phase I - Thunderbird Paseo only
Phase II - Major demand areas and smaller demand areas close to the Paseo
Phase III - Smaller demand areas such as small parks and elementary schools
Phase IV - Possible future demands from currently undeveloped areas or unidentified users.

Assuming that all of these demands eventually will be served, a phased project was developed around the four phases of potential demand described above. The initial (Phase I) treatment, storage, and distribution facilities would be sized and designed with the flexibility to accommodate three future expansions to serve demands described for Phases II, III, and IV. The following summarizes the treatment and storage capacity for each of the recognized phases:

Phase	Demand (mgd) Ann. Ave.	Demand (mgd) Maximum	Reclamation Facility Capacity (mgd)	Storage Capacity mil. gal
I	0.21	0.35	0.5	1.5
II	0.90	1.50	1.50	4.5
III	1.10	1.85	2.00	6
IV	1.30	2.10	2.10	6

A preliminary layout of the phased project is shown on Figure 5. A summary of the facilities required for the phased system is presented in Appendix Table A-1.

Single-Capacity Projects

An alternative to the phased project approach is "single capacity projects. Under this approach, a reclamation system would be designed and implemented to serve a limited portion of the study area. The facilities would have only limited flexibility for expansion and would not include multiple process units which are inherit to the phased project approach. Based on the reuse demands presented in Chapter 4, three single capacity projects appear to be feasible:

Alternative 1 - Thunderbird Paseo only.

Alternative 2 - Thunderbird Paseo plus the major reuse areas. The demands for this alternative correspond to those for Phase II of the phased project.

Alternative 3a- Thunderbird Paseo plus all existing reuse areas identified in this study. The demands correspond to those for Phase III of the phased project.

Alternative 3b- Same as 3a with below-ground storage of reclaimed water via recharge and recovery for water balance.

Because of the uncertain nature of potential demands for undeveloped parcels in the study area, a single-capacity project was not developed to include those areas.

The layout of distribution piping for Alternatives 1, 2 and 3 would correspond to that for Phases I, II, and III of the phased project, respectively. These layouts are shown on Figure 5. A summary of facilities required for the single-capacity projects is presented in Appendix Table A-2.

Cost Estimates

Estimated capital and operating and maintenance costs for the phased and single-capacity projects are presented in Table 4. A summary of the basis for these estimates is presented in Appendix Table A-3.

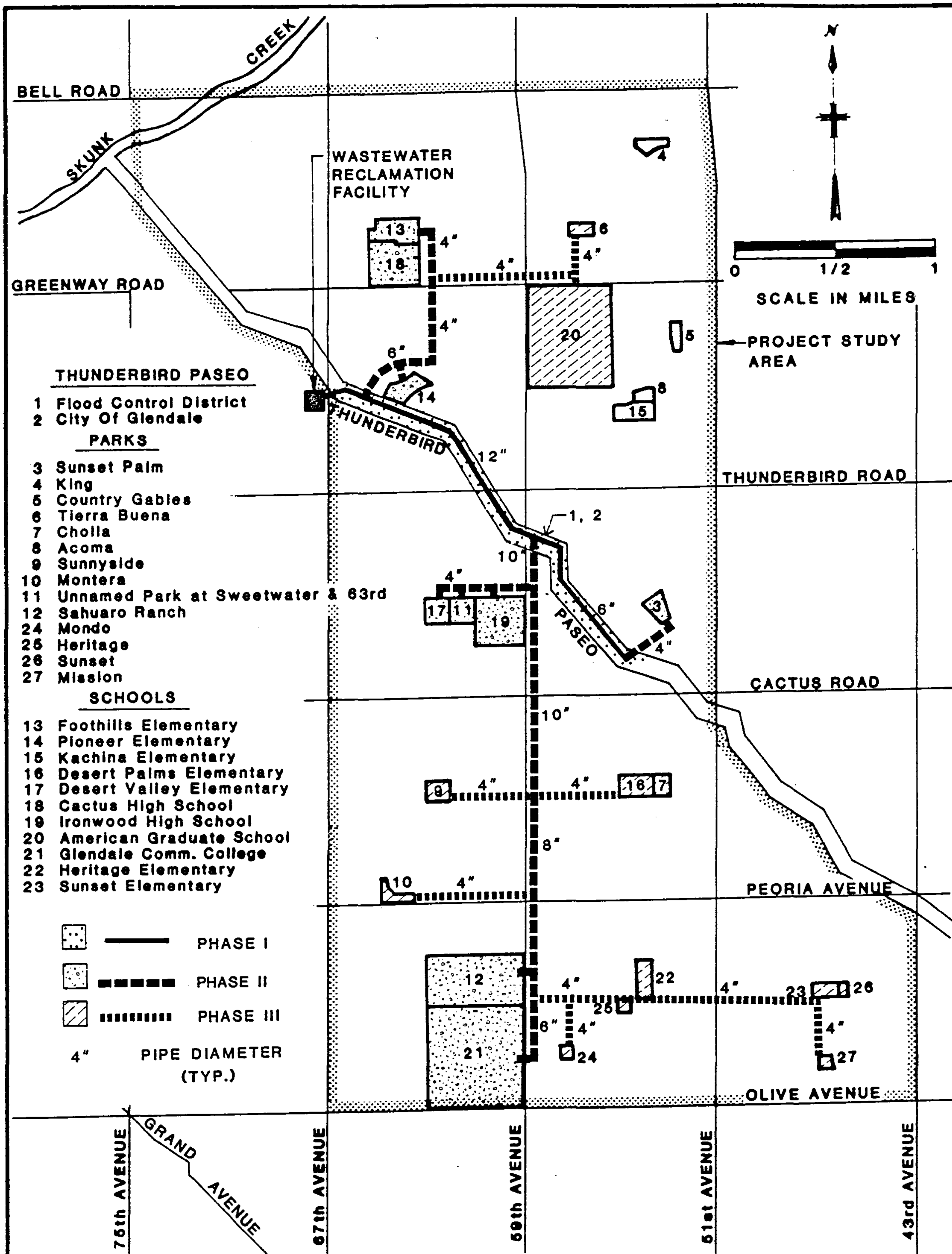
To provide a basis for comparing the cost of the phased and single-capacity projects and to compare the cost of reclaiming water at Thunderbird Paseo to other water supply projects the City is considering, the capital and operating and maintenance costs in Table 4 were converted to unit treatment costs. A summary of the unit costs is presented in Table 5.

A review of these unit costs indicates the following:

- The unit cost for each phase of the phased project ranges from \$4.91 per 1000 gallons (Phase I) to \$2.23 per 1000 gallons (Phase II). The average unit cost over the life of the project is \$2.63 per 1000 gallons.

- For equivalent flow rates, the unit costs of the phased project are greater than those for the single-capacity projects. This premium is due to the cost of flexibility for expansion built into the phased project facilities.

- The cost of Alternative 3 with and without below-ground storage for water balance is about the same.



FEASIBILITY STUDY - SEWAGE EFFLUENT REUSE
THUNDERBIRD PASEO

RECLAIMED WATER DISTRIBUTION SYSTEM

MALCOLM PIRNIE

MALCOLM PIRNIE, INC.

FIGURE 5

TABLE 4

ESTIMATED COSTS
FOR
RECLAMATION SYSTEM ALTERNATIVES

	PHASED PROJECT				SINGLE-CAPACITY PROJECTS			
	Phase I	Phase II	Phase III	Phase IV	Alternative 1	Alternative 2	Alternative 3a	Alternative 3b
Treatment Capacity (mgd)	0.5	1.50	2.00	2.10	0.5	1.50	2.00	1.10
Maximum Production (mgd)	0.35	1.50	1.85	2.10	0.35	1.50	1.85	1.10
Average Annual Flow (mgd)	0.27	0.90	1.10	1.30	0.27	0.90	1.10	1.10
Capital Cost								
Treatment Facility	$2,270,000	$1,850,000	$ 770,000	$ 70,000	$1,560,000	$3,130,000	$3,510,000	$2,620,000
Effluent Storage	160,000	320,000	190,000	0	160,000	480,000	640,000	790,000
Distribution System	520,000	770,000	910,000	130,000	230,000	1,150,000	1,800,000	1,800,000
Subtotal	$2,950,000	$2,940,000	$1,870,000	$200,000	$1,950,000	$4,760,000	$5,950,000	5,210,000
Engineering and Contingencies (30 percent)	885,000	882,000	561,000	60,000	585,000	1,428,000	1,785,000	1,563,000
Total Capital Cost	$3,835,000	$3,822,000	$2,431,000	$260,000	$2,535,000	$6,188,000	$7,735,000	$6,773,000
Operating and Maintenance Cost								
Labor	$ 55,000	$ 78,000	$ 78,000	$ 78,000	$ 55,000	$78,000	$78,000	$ 93,000
Power	55,000	141,000	173,000	204,000	55,000	141,000	173,000	238,000
Chemicals	2,000	7,000	9,000	10,000	2,000	7,000	9,000	9,000
Maintenance Materials and Service	10,000	15,000	23,000	23,000	10,000	15,000	23,000	30,000
Total O&M Cost	$122,000	$241,000	$283,000	$315,000	$122,000	$241,000	$283,000	$370,000

TABLE 5

SUMMARY OF UNIT COSTS

PHASED PROJECT

	Total Capital Cost	Present Worth Capital Cost (1)	Amortized Present Worth (2)	O&M Costs	Total Annual Costs	Average Flow (mgd)	Unit Cost ($/1000 gal)
Phase I	$3,835,000	$3,835,000	$362,000	$122,000	$484,000	0.27	$4.91
Phase II	$3,822,000	$2,725,000	$257,000	$241,000	$860,000	0.90	$2.62
Phase III	$2,431,000	$1,236,000	$117,000	$283,000	$1,019,000	1.10	$2.54
Phase IV	$ 260,000	$ 94,000	$ 9,000	$315,000	$1,060,000	1.30	$2.23

Average Total Annual Cost Over Life of Project	$ 856,000
Average Annual Flow	0.89 mgd
Average Unit Cost	$2.63 per 1000 gallons 857 per acre-ft

SINGLE CAPACITY PROJECTS

	Capital Cost	Amortized Capital Cost (2)	O&M Costs	Total Annual Costs	Total Unit Costs $/1000 gal	Total Unit Costs $/acre-ft
Alternative 1	$2,535,000	$239,000	$122,000	$361,000	$3.66	$1,194
Alternative 2	$6,188,000	$584,000	$241,000	$825,000	$2.51	$819
Alternative 3a	$7,735,000	$730,000	$283,000	$1,013,000	$2.52	$823
Alternative 3b	$6,773,000	$639,000	$370,000	$1,009,000	$2.51	$819

NOTES:

1. Present worth based on interest rate of 7.0 percent. Phasing of system expansions was assumed to be as follows:
   - Phase II 5 years
   - Phase III 10 years
   - Phase IV 15 years

2. Amortization based on 7.0 percent interest rate over 20 years.

Benefit Analysis

A wastewater reclamation system for the Thunderbird Paseo area would yield a number of benefits to the City's water and wastewater utilities and to the City as a whole. The actual cost of implementing a reclamation project can be determined only after comparing the basic costs of a project (presented in Table 4) to the benefits. This section of the report presents a discussion of the potential project benefits and estimates of their value. For the purposes of this analysis, the benefits have been divided into two categories - direct and indirect.

Direct Benefits

The direct benefits of the Thunderbird Paseo reclamation system are those which are related directly to the amount of water reclaimed and can be quantified relatively easily. The potential direct benefits include:

- Benefits to the Wastewater System
  - Collector Sewers
  - Interceptor Sewers and Treatment
  - 67th Avenue Lift Station
- Benefits to the Water System
  - Capital and O&M Costs at Pyramid Peak Water Treatment Plant (WTP)
- Revenue from Sale of Effluent

These benefits and their potential value are discussed below.

Benefits to Wastewater System - A wastewater reclamation system includes elements of wastewater diversion and treatment, and, as such, it is a method for managing municipal wastewater. A reclamation system in Thunderbird Paseo could result in reduced capital and operating costs for the City's wastewater management system. Quantifiable reductions in these costs can be considered benefits of the reclamation system.

The collector sewer system within the study area serves to collect wastewater from individual customers and transports it to the wastewater interceptor system. The capital and operating and maintenance costs associated with the collector system will be the same whether or not a reclamation system is implemented.

As described in Chapter 2, the existing interceptor system serves to carry flows from the collector system in the study area to the 91st Avenue Wastewater Treatment Plant (WWTP). The Thunderbird Paseo reclamation system would reduce flows to the interceptor and treatment system and thus has the potential to produce savings in capital and operating and maintenance costs. To claim this benefit, however, the reclamation system must be able to operate reliably at some minimum flow rate. With existing treatment processes and equipment, it is reasonable to assume that the reclamation system will be able to operate reliably at all times. However, demand for reclaimed water, especially during winter months and wet weather periods, will limit the maximum flow which reliably will be diverted and treated at the reclamation facility. For the purposes of quantifying benefits, it will be assumed that the Thunderbird Paseo reclamation system can reliably divert, treat and use average winter month demands.

The value of the reduced capacity requirements in the existing interceptor and treatment system is estimated to be about $0.43 per 1000 gallons of water treated. This is based on the amortized value of the City's sewer connection fee (approximately $500 per residential unit).

In addition to the savings for capacity in the interceptor and treatment system, there also will be a decrease in the operating and maintenance costs for these facilities for each gallon of wastewater reclaimed. Assuming that waste solids from the reclamation plant will be discharged to the sewer system for processing at the 91st Avenue WWTP, the estimated savings in operating and maintenance costs is about $0.26 per 1000 gallons of wastewater reclaimed. This is based on data provided by City staff on the City's share of costs for transmission and treatment of sewage at the 91st Avenue WWTP.

ACDC REACH I

ESTIMATE OF IRRIGATION REQUIREMENTS

per

JACK DONIS, IRRIGATION DESIGNER AND CONSULTANT

On October 14, 1986 I requested Jack Donis, designer of the irrigation system on ACDC Reach I, to prepare an estimate of the anticipated irrigation water use for the reach. He estimated the following percentage of use for lands managed and maintained by the Flood Control District and those managed by the City of Glendale.

CONSUMPTION PERCENTAGES BY MAINTENANCE AGENCY

<u>YEARS 1 AND 2</u> 1,039,608 gal/day = 3.19 ac/ft/day

Range grass areas + bubbler network (FCD) = 75 to 80%
779,706 to 831,686 gal/day = 2.39 to 2.55 ac/ft/day

Plaza areas + turf areas (City of Glendale) = 20 to 25%
207,922 to 259,902 gal/day = 0.638 to 0.798 ac/ft/day

<u>YEAR 3</u> 831,686 gal/day = 2.5523 ac/ft/day

Range grass areas + bubbler network (FCD) = 40 to 50%
499,012 gal/day = 1.531 ac/ft/day

Plaza areas + turf areas (COG) = 50 to 60%
332,675 gal/day = 1.021 ac/ft/day

YEAR 4 519,804 gal/day = 1.5953 ac/ft/day

Range grass areas + bubbler network (FCD) = 55%

285,892 gal/day = 0.8774 ac/ft/day

Plaza areas + turf areas (COG) = 45%

233,912 gal/day = 0.7179 ac/ft/day

YEAR 5, ONWARD 346,536 gal/day = 1.0635 ac/ft/day

Range grass areas + bubbler network (FCD) = 50%

173,268 gal/day = 0.5318 ac/ft/day

Plaza areas + turf areas (COG) = 50%

173,912 gal/day = 0.5318 ac/ft/day

The logic behind these percentage estimates is based on time required to adequately establish range grasses and estimates relating to periodic 'maintenance' water needed during droughty periods. The establishment period can be as long as two years for these slower growing species. Water, particularly initially, will be applied frequently to guarantee germination and establishment of these grasses for erosion control.

A minor benefit to the wastewater system is reduced power costs at the 67th Avenue Lift Station. Assuming that sewage to be reclaimed will be diverted prior to pumping at the 67th Avenue station, a benefit can be claimed for reduced electricity consumption at the station. This benefit is estimated to be about $0.01 per 1000 gallons of wastewater reclaimed.

In summary, the total direct benefits to the wastewater system are estimated to be $0.70 per 1000 gallons of wastewater reclaimed.

Benefits to Water System

A major advantage of a reclamation system to the City water system is that it is a means to obtain a new water supply. Any savings that can be realized from the resulting need to use less of another supply can be considered a direct benefit of the reclamation system.

As discussed in Chapter 2, the principal source of water supply to the study area, in the absence of a reclamation project, would be the City's Pyramid Peak WTP which utilizes CAP water. Implementation of a reclamation project will reduce capacity requirements at the Pyramid Peak WTP and operating and maintenance costs.

Capital Costs Savings - Assuming that capacity requirements at Pyramid Peak could be reduced by an amount equal to the maximum production flow from the Thunderbird Paseo reclamation plant, the following direct benefits were developed:

	Maximum Production Flow (mgd)	Benefit ($/1000 gal)
Phased Project (avg)	0.89	0.17
Single Capacity Projects		
- Alternative 1	0.35	0.13
- Alternative 2	1.50	0.17
- Alternative 3a	1.85	0.17
- Alternative 3b	1.10	0.17

These benefits are based on the amortized value of the cost for expansion of the Pyramid Peak WTP. The cost for expansion was assumed to be $400,000 per mgd of added capacity.

Operating and Maintenance Cost Savings - For each gallon of water reclaimed, there will be a correspond reduction in operating and maintenance costs at the water treatment plant. City staff has indicated that treatment costs at the Pyramid Peak plant are about $0.81 per 1000 gallons. This reduction in operating and maintenance costs would be a direct benefit of a reclamation system.

Summary of Benefits to Water System - The total direct benefits to the water system are estimated to be $0.94 to $0.97 per 1000 gallons of water reclaimed depending on the project implemented.

Revenue from Sale of Effluent - Revenues would be generated by the reclamation system through the sale of effluent to users in the study area. The amount of revenue generated will be based on:

- Quantity of water sold
- Value of water

The quantity of effluent sold depends on the demand for effluent in the study area. Potential demands for effluent, discussed in Chapter 4, range from an annual average flow of 0.27 to 1.30 mgd.

The value of water is determined by the cost of alternative sources of water supply. Thus, the maximum value of wastewater reclaimed for irrigation in the study area is set by the cost of existing service for irrigation supply. For the Thunderbird Paseo area, the value of water to customers of the City (parks and schools) is set by the cost of City potable water service. The cost of this service is estimated to average about $0.81 per 1000 gallons.

The value of the effluent also is affected by the level of service provided. Effluent provided on an "as needed" basis at a high service pressure will command a higher price than services for which the customer is required to accept some minimum amount of effluent. For the purpose of this study, it will be assumed that a high level of service will be provided and the value of the effluent will be at least equal to that of existing supplies.

Additional sources of revenue beyond that which can be generated through the sale of effluent at current market rates relates to restrictions placed on uses of certain types of water. The regulations of the 1980 Groundwater Management Act, have in essence, reserved certain uses for effluent, such as, artificial lakes. Thus, if a developer desires to incorporate artificial lakes into a development, there may be no other alternatives to effluent for filling the lakes such as at the Ocotillo Development in Chandler. In such a situation, the value of the effluent is far in excess of market rates. Potentially this is an attractive source of revenue for a reclamation system. However, no such opportunities are apparent in the study area at this time.

Summary of Direct Benefits

A summary of the direct benefits from a Thunderbird Paseo reclamation system are summarized below:

	$ per 1000 gallons
Benefits to Wastewater System	
- Collector sewers	0
- Interceptor sewers and treatment	0.69
- 67th Avenue Pumping Station	0.01
Subtotal	$ 0.70
Benefits to Water System	
- Capital and O&M at Pyramid Peak WTP	$ 0.94 - 0.97
Revenue from Sale of Effluent	$ 0.69 - 0.81
TOTAL DIRECT BENEFITS	$ 2.33 - 2.48

Indirect Benefits

In addition to the direct benefits discussed above, the Thunderbird Paseo reclamation project will also yield indirect benefits, such as, conservation and avoided costs for new water supplies. Although clearly benefits of a reclamation project, the value of conservation and avoided costs is not as clearly defined as for the direct benefits. The following sections will further define the indirect benefits and present approaches to quantifying them.

Conservation - A major benefit of the Thunderbird Paseo project is that it will conserve the City's limited supply of potable water by providing reclaimed water for use in its place. This will result in a reduction in the City's ADWR per capita water consumption rate. For 1986, the City's potable water consumption was about 213 gallons per capita per day (gpcd), which is 7 percent higher than the ADWR conservation goal of 199 gpcd. This conservation goal was to be achieved by January 1987. The City is pursuing a number of approaches to reach the conservation goal set by ADWR including:

- Education of the City's residents on conservation
- Landscaping rebates of $100 to homeowners who install "desert-type" landscaping
- Cost rebates ($50) for the installation of timers to control lawn irrigation during off-peak water demand periods
- Installation of low-flow toilets ($300 per unit)

It is the City's objective to reach the ADWR goal as soon as possible and no later than 1990. In 1990, it is anticipated that new water conservation goals will be established. Implementation of a reclamation project could significantly contribute to achieving the City's conservation goal. The City's current use of water is about 28.6 mgd. For every 286,000 gallons per day reclaimed, the City's potable water use would decrease by about 1 percent. If all of the irrigation demands in the study area were served with reclaimed water, the City's consumption of potable water would be reduced by about 4.5 percent.

The conservation benefits of a Thunderbird Paseo cannot easily be quantified. However, it is possible to estimate the cost of other conservation programs the City is implementing. The cost of these programs provides a measure of the value of conservation to the City which would be considered a benefit of the Thunderbird Paseo system, if implemented.

Two of the City's conservation programs were selected to provide a range of potential benefits. Both involve the installation of water-saving plumbing fixtures - low-flow shower heads and low-flow toilets. If the initial cost of the fixtures is amortized and then divided by the volume of water saved, a cost per unit of water saved can be calculated as follows:

	Cost per Unit	Water Saved per Day	$/1000 gal. Water Saved
Showerheads	$ 20	36 gallons	$ 0.14
Toilets	$ 300	36 gallons	$ 2.16

This range of costs can be considered the cost which the City is willing to pay to achieve its conservation goals. In short, it is a measure of the value of conservation.

This is not to imply that the City discontinue its existing conservation program in lieu of a reclamation projects(s). The existing programs will be required to reduce consumption in future years when the more easily implemented conservation measures have been used and additional reductions in consumption become more difficult.

<u>Avoided Costs</u> - Another indirect benefit of the Thunderbird Wash reclamation system is that it would reduce the amount of new supplies

which the City may have to develop to meet future water demands. The City's Water Resource Management Report indicated that water supply deficits will develop for the City's off-project lands. It was recommended that the City pursue several approaches to augment existing supplies including:

- Use of Others' CAP Allocations
- Obtaining Agricultural Water Rights
- Reclaiming Wastewater
- Groundwater Transfers

The Water Resource Management Report identified these alternatives as the most feasible but did not develop cost estimates. Relative cost factors only were used to rank the alternatives.

The City's Water Resources Matrix (November 1985), included an assessment and developed cost estimates for a number of new supply projects involving the acquisition and use of agricultural water rights and groundwater transfers. The costs for these projects ranged from \$114 to \$1,573 per acre-foot (\$0.35 to \$4.31 per 1000 gallons) including land and development of the new supply. The average cost for the alternative considered was \$579 per acre-foot (\$1.78 per 1000 gallons).

Implementation of the Thunderbird Paseo project would reduce the amount of these new supplies which would have to be developed. The resulting cost savings would be an indirect benefit of the reclamation system. For the purposes of this report, an average cost of \$579 per acre-foot will be used.

Summary of Benefit Analysis

Implementation of the Thunderbird Paseo reclamation project potentially will yield a number of important benefits to various City departments and community interest. To be implemented, the benefits of the project must outweigh the costs. Furthermore, the costs of the project must be allocated to users in proportion to the benefits received.

This section has presented a number of direct and indirect benefits which will be used to evaluate the feasibility of the project. A summary of the direct benefits is presented in Table 6.

Comparison of Project Costs and Benefits

The net project cost represents the "bottom line" after project costs have been compared to project benefits. For this project, the costs include:

- Amortized capital costs
- Operating and maintenance costs

The direct and indirect benefits include:

- Wastewater system savings
- Water system savings
- Revenue from sale of effluent

These cost and benefits are summarized in Table 6.

As shown in this Table 6, the net direct project costs range from \$0.09 to \$1.27 per 1000 gallons. If direct costs and benefits only are considered, the project would have to be subsidized to operate on a break-even basis. Based on the City's current population, water rates would have to be raised by \$0.01 to \$0.02 per thousand gallons to cover the net direct costs of the project.

Based on this evaluation of the costs and benefits of this project and other findings of this study, the conclusions and recommendations are presented in Chapter 6.

To determine the economic feasibility of a Thunderbird Paseo project, the net direct cost of the project must be compared to other water supply alternatives the City is considering, such as conservation and acquisition of agricultural water rights. These alterations were

TABLE 6

COMPARISON OF
PROJECT COSTS AND DIRECT BENEFITS

	Phased Project	Single Capacity Projects			
		1	2	3	3b
Project Costs	$ 2.63	$ 3.66	$ 2.51	$ 2.52	$2.51
Direct Benefits					
Wastewater System Savings	$ 0.69	$ 0.69	$ 0.69	$ 0.69	$0.69
Water System Savings	$ 0.97	$ 0.94	$ 0.97	$ 0.97	$0.97
Savings at 67th Avenue PS	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$0.01
Revenue from Sale of Water	$ 0.67	$ 0.67	$ 0.67	$ 0.67	$0.75
Total Direct Benefits	$ 2.42	$ 2.39	$ 2.42	$ 2.42	$2.42
Net Direct Project Cost	$ 0.21	$ 1.27	$ 0.09	$ 0.10	$0.09

previously described in this chapter as indirect benefits. A comparison of these costs is summarized below:

Net Direct Project Cost for Thunderbird Paseo	$ 0.09 - 1.27 per 1000 gal.
Conservation	$ 1.15
Acquire Water Rights	$ 1.78

As shown by this comparison, the net cost of a Thunderbird Paseo project is in the range of other water supply alternatives the City is implementing or considering.

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings and evaluations of this study, conclusions and recommendations are presented in this chapter.

Conclusions

The conclusions for this study relate to the technical and economic feasibility of the Thunderbird Paseo wastewater reclamation project.

Technical Feasibility

Based on the review and evaluation of raw wastewater quality, effluent quality requirements and siting requirements, this project is entirely feasible from a technical perspective.

Well-developed and reliable processes and equipment are available to treat the wastewater to ADHS Open Access Landscape quality standards. Odor and noise can be effectively controlled so as not to be a nuisance. The planned Paseo irrigation system is compatible with the proposed treated water quality and would not require major modifications.

Economic Feasibility

Based on the comparison of costs and benefits of the projects, the direct costs exceed the direct benefits by $0.09 to $1.27 per 1000 gallons. These net costs, however, are comparable to the cost of conservation measures the City is implementing and the cost of new water supplies being considered by the City. Thus, the project appears to be economically feasible also.

Recommendations

The following are the recommendations based on the findings and conclusions of this study:

1. The findings and conclusions of this report should be reviewed in detail by City staff, particularly the viability of the project benefits.

2. If it is determined to proceed with further development of the project, the following should be performed in the next phase of the project:

- Investigate, evaluate and develop the conceptual design for the proposed project.
- Seek and obtain specific letters of interest from potential users of effluent.
- Proceed with acquisition of the proposed treatment plant site or obtain the right to use the site.
- Begin preparation of the permit application required for implementation of the project.
- Gain input from the appropriate City agencies, department and community interests regarding the project and the site.

TABLE A-1

SUMMARY OF FACILITIES
FOR
RECLAMATION SYSTEM

PHASE	MAXIMUM PRODUCTION	TREATMENT CAPACITY	EFFLUENT STORAGE	EFFLUENT DISTRIBUTION
I	0.35 mgd(1)	0.5 mgd	5 mg(2)	- 10,560 LF 12"ACP(3,4)
II	1.50 mgd	1.5 mgd	10 mg	- 10,560 LF 12"ACP - 6,750 LF 10"ACP - 5,300 LF 8"ACP - 2,500 LF 6"ACP - 7,350 LF 4"ACP
III	1.85 mgd	2.0 mgd	15 mg	- 10,560 LF 12"ACP - 6,750 LF 10"ACP - 5,300 LF 8"ACP - 7,500 LF 6"ACP - 25,600 LF 4"ACP
IV	2.10 mgd	2.1 mgd	15 mg	- 10,560 LF 12"ACP - 7,000 LF 10"ACP - 6,000 LF 8"ACP - 8,500 LF 6"ACP - 30,000 LF 4"ACP

Notes:
1. mgd denotes million gallons per day
2. mg denotes million gallons
3. LF denotes linear feet
4. ACP denotes asbestos cement pipe

TABLE A-2

BASIS OF COST ESTIMATES
FOR
TREATMENT SYSTEMS

Cost estimates for the single-capacity treatment systems are based on the following:

Process		Alternative 1
1.	Influent Pumping	- 2 pumps @ 350 gpm each - 6' by 6' by 25' deep wet well - necessary controls and electrical gear for pumps - Access hatches and vents
2.	Primary Treatment	- 1 rotary screen @ 700 gpm - necessary controls and electrical gear for mechanism - piping and installation for sewage routing
3.	Secondary Treatment	- 4-stage RBC with concrete basin and fiberglass covers - 1 clarifier w/sludge mechanism @ 400 gpd/sf - necessary controls and electrical gear for filters
4.	Tertiary Treatment	- Automatic Backwash Sand filters @ 2 gpm/sf - necessary controls and electrical gear for filters
5.	Disinfection	- Chlorine feed system w/contact basin @ 2 hours
6.	Effluent Pumping	- 6' by 6' by 10' wet well - 4 pumping units (2 high head, 2 low head) to meet demand - necessary controls and electrical gear for pumps
7.	Operations Building	- 2,500 sq. ft. building w/ducting
8.	Odor Control	- wet (chlorine) scrubber - blowers to remove gases from op. building - necessary controls and electrical gear for blowers
9.	Sludge Handling	- pumping units to prevent sludge from recycling - necessary controls and electrical gear for pumps
10.	Electrical/Telemetry	- instrumentation and equipment to monitor facility from remote site
11.	Storage Reservoir	- $0.40/square foot for synthetic liner - $2.30/cubic yard for excavation - $5.30/cubic yard for hauling excess fill (assume 75% of fill not used) - Size of reservoir based on 3 days volume at max. production
12.	Distribution System	- 4-inch pipe in wash, 7,920 l.f. @ $12.80/l.f. - 6-inch pipe in wash, 7,920 l.f. $15.8/l.f.

Process	Alternative 2
1. Influent Pumping	- 2 pumps @ 350 gpm each - 2 pumps @ 1,400 gpm each - 12' by 12' by 25' deep wet well - necessary controls and electrical gear for pumps - Access hatches and vents
2. Primary Treatment	- 2 rotary screens @ 700 gpm - necessary controls and electrical gear for mechanism - piping and installation for sewage routing
3. Secondary Treatment	- 4-stage RBC with concrete basin and fiberglass covers - 2 clarifiers w/sludge mechanism @ 400 gpd/sf - necessary controls and electrical gear for filters
4. Tertiary Treatment	- Automatic Backwash Sand filters @ 2 gpm/sf - necessary controls and electrical gear for filters
5. Disinfection	- Chlorine feed system w/contact basin @ 2 hours
6. Effluent Pumping	- 12' by 12' by 10' wet well - 4 pumping units (2 high head, 2 low head) to meet demand - necessary controls and electrical gear for pumps
7. Operations Building	- 5,000 sq. ft. building w/ducting
8. Odor Control	- wet (chlorine) scrubber - blowers to remove gases from op. building - necessary controls and electrical gear for blowers
9. Sludge Handling	- pumping units to prevent sludge from recycling - necessary controls and electrical gear for pumps
10. Electrical/Telemetry	- instrumentation and equipment to monitor facility from remote site
11. Storage Reservoir	- \$0.40/square foot for synthetic liner - \$2.30/cubic yard for excavation - \$5.30/cubic yard for hauling excess fill (assume 75% of fill not used) - Size of reservoir based on 3 days volume at max. production
12. Distribution System	- 4-inch pipe in street, 10,560 l.f. @ \$19.38/l.f. - 4-inch pipe in wash, 3,960 l.f. @ \$12.80/l.f. - 10-inch pipe in street, 14,300 l.f.. @ \$41.08/l.f. - 10-inch pipe in wash, 10,560 l.f. @ \$28.22/l.f.

Process	Alternative 3
1. Influent Pumping	- 4 pumps @ 350 gpm each - 12' by 12' by 25' deep wet well - necessary controls and electrical gear for pumps - Access hatches and vents
2. Primary Treatment	- 2 rotary screens @ 700 gpm - necessary controls and electrical gear for mechanism - piping and installation for sewage routing
3. Secondary Treatment	- 4-stage RBC with concrete basin and fiberglass covers - 2 clarifiers w/sludge mechanism @ 400 gpd/sf - necessary controls and electrical gear for filters
4. Tertiary Treatment	- Automatic Backwash Sand filters @ 2 gpm/sf - necessary controls and electrical gear for screens
5. Disinfection	- Chlorine feed system w/contact basin @ 2 hours
6. Effluent Pumping	- 12' by 12' by 10' wet well - 4 pumping units (2 high head, 2 low head) to meet demand - necessary controls and electrical gear for pumps
7. Operations Building	- 6,000 sq. ft. building w/ducting
8. Odor Control	- wet (chlorine) scrubber - blowers to remove gases from op. building - necessary controls and electrical gear for blowers
9. Sludge Handling	- pumping units to prevent sludge from recycling - necessary controls and electrical gear for pumps
10. Electrical/Telemetry	- instrumentation and equipment to monitor facility from remote site
11. Storage Reservoir	- \$0.40/square foot for synthetic liner - \$2.30/cubic yard for excavation - \$5.30/cubic yard for hauling excess fill (assume 75% of fill not used) - Size of reservoir based on 3 days volume at max. production
12. Distribution System	- 4-inch pipe in street, 32,600 l.f. @ \$19.38/l.f. - 4-inch pipe in wash, 4,500 l.f. @ \$12.80/l.f. - 6-inch pipe in street, 4,650 l.f. @ \$24.76/l.f. - 6-inch pipe in wash, 800 l.f. @ \$15.80/l.f. - 10-inch pipe in wash, 7,500 l.f. @ \$41.08/l.f. - 12-inch pipe in street, 7,000 l.f. @ \$50.10/l.f. - 12-inch pipe in wash, 10,000 l.f. @ \$27.68/l.f.

TABLE A-3

BASIS OF COST ESTIMATES
FOR
RECLAMATION SYSTEM

The following is a summary of the basis for the cost estimates presented in Table 4.

Capital Costs

1. Treatment Facilities include:

Headworks, influent pumping and screening; biological treatment system (rotating biological contactors); secondary clarifier/flocculators; waste sludge handling; effluent filters; extensive odor control and noise control facilities; disinfection (chlorination) facilities; office and laboratory facilities; site work, facility piping; landscaping; and effluent pumping station.

2. Effluent Storage

Effluent storage to balance daily plant flow will be provided as lakes in the Paseo. It has been assumed that the lakes will have a capacity of approximately 7 days flow at the maximum required production.

PHASE	TREATMENT FACILITY CAPACITY	MAXIMUM PRODUCTION RATE	STORAGE CAPACITY
I	0.50 mgd	0.35 mgd	5 mg
II	1.50 mgd	1.50 mgd	10 mg
III	2.00 mgd	1.85 mgd	15 mg
IV	2.10 mgd	2.10 mgd	15 mg

Cost estimate based on synthetically-lined lake with 3-foot constant water depth for aesthetic purposes plus 3-foot working depth and 1-foot of free board.

Lake Excavation	\$2.30/cubic yard (c.y.)
Hauling Excavated Spoil (base on 75 percent of excavated material hauled)	\$5.30/c.y.
Lake Liner	\$0.40/square foot

Include 20 percent on top for Overhead, Profit and Contingencies.

All costs above, excluding lake liner, based on information from "Means Construction Cost Data" and personal communication with Construction Manager responsible for Ocotillo (Chandler, AZ) residential area lake construction project.

4. Distribution System

Piping quantities for distribution systems are presented in Table A-1.

Asbestos Cement Pipe	Unit Cost ($/L.F.)
4"	$19.38
6"	$24.76
8"	$32.14
10"	$41.08
12"*	$27.60

* No street cuts or repairs required for 12" pipe located in Paseo

5. Site Acquisition

Assume no cost associated with site acquisition for treatment system.

Operations and Maintenance Costs

1. Labor Costs

Labor cost for Phase I is based on the following:

a. Treatment Facility and Distribution System

- One Superintendent (1/8 time)	260 hrs. @ $25/hr.
- One Clerk (1/8 time)	260 hrs. @ $13/hr.
- One Operator (1/8 time)	1,095 hrs. @ $21/hr.
- One Laboratory Technician (1 hour/day, 5 days/week)	260 hrs. @ $21/hr.
- One Maintenance Technician (1/4 time)	520 hrs. @ $21/hr.

Labor costs for Phases II, III and IV are based on the following:

a. Treatment Facilty and Distribution System

- One Superintendent (1/8 time)	260 hrs. @ $27/hr.
- One Clerk (1/8 time)	260 hrs. @ $13/hr.
- One Operator (1/4 time)	2,190 hrs. @ $21/hr.
- One Maintenance Technician (1/4 time, 5 days/week)	520 hrs. @ $21/hr.
- One Laboratory Technician (2 hours/day, 5 days/week)	520 hrs. @ $21/hr.

2. Power

Power cost are based on electricity at $0.07 per kilo-watt hour.

3. Chemicals

Chemical Costs based on the following dosages and costs:

Chemical	Dosage (mg/L)	Cost
Chlorine	10	$0.16/lb
Alum	5	$0.10/lb
Polymer	0.5	$1.00/lb

4. Maintenance Materials and Services

Based on 0.5 percent of construction cost for treatment facilities.