Storage and Recovery Technical Program

Feasibility Study

A Report for the

City of Avondale

Prepared by

BCI Geonetics, Inc.

An integrated groundwater technologies company

Post Office Box 2610
Santa Barbara, California 93120

(805) 965-7455
Fax: (805) 965-0343

July, 1993

BCI GEONETICS
AVONDALE WETLANDS WATER TREATMENT FACILITY
FEASIBILITY STUDY

JULY 20, 1993

Registered Professional Engineer (Civil)
CERTIFICATE NO.
27129
STEVEN R.
LIMING
Date Signed 7-20-93
ARIZONA, U.S.A.

Willdan Associates
1717 West Northern Ave., #112
Phoenix, Arizona 85021
(602) 870-7600

CONTENTS

EXECUTIVE SUMMARY

INTRODUCTION 1

WETLANDS TREATMENT PROCESS FEASIBILITY 4
- Introduction 4
- Analysis of Water Conveyance Facilities 6
- Analysis of Water Treatment Facilities 6
  - Description of Water Treatment Process 6
  - Costs of Water Treatment Facility 9
- Analysis of Operating Requirements 11
  - Source Water Treatment 11
  - Flow Measuring and Concentration Monitoring 11
- Analysis of Project Financing 13
  - Overview of Available Financing Mechanisms 13
  - Recommended Funding Method 14
    - Analysis of Improvement District Costs 15
    - Summary of Financing Analysis 15

RECHARGE AREA FEASIBILITY 16
- Surficial Sediment Characteristics 16
- Expected Infiltration Rates 17
- Acreage Required for Spreading Ponds 17
- Expected Impacts on Local Groundwater Regime 18
- Groundwater Quality Considerations 18
- Permitting Considerations 19

RECOMMENDATIONS 20

APPENDICES

A. WOODWARD-CLYDE REPORT

B. MAP SHOWING LOCATION OF WATER CONVEYANCE CANALS

C. WATER QUALITY DATA FOR GRAND CANAL

D. WATER QUALITY DATA FOR AVONDALE WELLS

EXECUTIVE SUMMARY

The City of Avondale currently has a significant allocated quantity of untreated surface water which is essentially unusable without some degree of treatment. The proposed Storage and Recovery Technical Program will utilize this water by treating it in artificial wetlands to reduce nitrate concentrations prior to recharging the water in a series of specially-designed infiltration ponds. Wherever possible, aesthetic design concepts were incorporated into the treatment facility planning to enhance recreation and development potential. The treated water will infiltrate to the groundwater aquifers presently used by the City of Avondale, where it will be available for pumpage from existing wells. Concurrent with this feasibility study, a hydrologic report has been prepared to accompany the application for a Underground Storage and Recovery permit from DWR.

Conceptual engineering design and financial projections have been made in this report. Sufficient flow capacity exists in the canals adjacent to the proposed project site to supply both pilot-scale and potential full-scale projects. Based on work done to date, the wetlands treatment process appears feasible for the typical concentrations of nitrates present in the source water. The basic design of the system involves transferring the water from a turn-out in one or more nearby laterals of the Grand Canal into two sedimentation basins which will allow the suspended solids present in the canal water to precipitate out. The water will be capable of moving from these sedimentation basins in and out of an off-stream equalization basin, which acts to maintain a constant flow rate through the wetlands system. The equalization basin also functions as a short term storage facility which will be used during the annual canal maintenance period.

The artificial wetlands will consist of two parallel stream channels to transport the water through a series of surficial and subsurface aquatic environments containing specially selected plants. This is the primary zone of water treatment. From the treatment streams, the water flows into a polishing pond, which will act as a final wetlands treatment facility. The treated water will then be used to recharge the aquifer through a series infiltration ponds located along the eastern boundary of the Agua Fria River.

CITY OF AVONDALE

STORAGE AND RECOVERY TECHNICAL PROGRAM

FEASIBILITY STUDY

INTRODUCTION

The City of Avondale, which now relies completely on groundwater to meet water demand, has surface water supplies available (Central Arizona Project - CAP - and Salt River Project - SRP) that are not presently usable for potable purposes because of their need for treatment. In lieu of an expensive filtration and treatment plant, the City is considering a treatment procedure that moves the untreated surface water through artificial wetlands, infiltrates the water into the groundwater aquifer through recharge ponds, and extracts the potable water through existing production wells. This technique uses the natural filtering process of plants and soils to substitute for the mechanical and chemical cleaning of typical surface treatment plants.

The Storage and Recovery program is being considered in two phases -- a 2-year pilot project, followed by a larger full-scale project. State permitting standards allow up to 5,000 acre-feet per year (AFY) of recharge during the pilot project. In this feasibility study, we consider both a pilot project of 5,000 AFY and a full-scale project of 40,000 AFY. The following sections include evaluations and design parameters of both the wetlands treatment system and the recharge basins. Particular attention has been given to the potential for "fatal flaws" that would make the project unattractive.

The design of the treatment and infiltration systems utilizes several pioneering concepts in water treatment and supply. The initial pilot-scale phase of the project will test the parameters and techniques presented in the current design and operating plans. Some of these aspects of the system may be modified based on their actual effectiveness and viability determined during the pilot scale testing. Careful monitoring and ongoing analyses of the effectiveness of the various potential techniques will govern the final, full-scale operating and design parameters. In the paragraphs that follow, several aspects of the treatment and

infiltration processes that required special consideration in the design of the system are discussed.

Consideration of source water quality variations -- Throughout the year, the CAP/SRP water present in the Grand Canal has a variety of fluctuations in water quality depending on the relative proportions of CAP, SRP, groundwater (pumped by SRP into the canal for demand considerations), and agricultural/storm drain returns. The water quality of the CAP and SRP waters is relatively constant throughout the year, but the variability of groundwater additions and agricultural/storm drain returns into the canal can have significant effects on the water quality present at the western portion of the Grand Canal near Avondale.

The most critical parameter in terms of treatment considerations is the nitrate concentration. This is largely controlled by both agricultural returns and groundwater additions. Agricultural returns contain varying concentrations of nitrates derived from both fertilizer usage and animal by-products. The groundwater that SRP pumps into the canal to satisfy local demands can also have significant nitrate concentrations. This nitrate is derived from applied water that consists of the same components as the agricultural runoff waters; this applied water percolated down to the water table over time. During certain portions of a given year, the source water introduced into the treatment system will be of sufficiently low nitrate concentration that natural filtration during percolation in the recharge basins will lower the nitrate to acceptable levels. During many parts of the year, however, higher concentrations and occasional spikes up to 20 mg/l (i.e., resulting from widespread irrigation along the Grand Canal) occur which require treatment. Natural wetlands environments are well-documented as being highly effective in reducing nitrate concentrations because of the nitrogen demand of various aquatic plant species. Additional concerns regarding components of the source water necessary to maintain the nitrate-reducing reaction within the wetlands are discussed below.

Consideration of source water chemistry for wetlands operations -- Although wetlands treatment processes are now relatively common alternatives to the traditional municipal treatment plants, these source waters are typically comprised of a much higher percentage of biological material (often because the water is a component of secondary-treated effluent). The biological material contains significant concentrations of carbon which is a critical component in the nitrate-reducing biochemical process of aquatic plants. In Avondale's case, the source water has relatively small concentrations of biological material, and consequently has fairly low carbon content. This creates a concern about the potential for the aquatic plants in the wetlands to effectively reduce the nitrate

concentration. In the proposed system, the growth and eventual break-down of the plant community will provide an in-situ source of carbon to the system which may be sufficient to maintain the nitrate-reducing capacity of the system. During the pilot scale operation of the project, this reaction will be closely monitored to determine the effectiveness of the wetlands. If operation of the pilot project indicates that additional carbon is required, there are several sources possible, including injection of methanol or acetate solutions, or the addition of processed agricultural by-products. The wetlands design allows for introduction of such a carbon source in several portions of the system.

Consideration of annual canal maintenance period -- As part of the standard maintenance of the Grand Canal, SRP shuts down water deliveries for up to a month every year. This created an important consideration for the viability of the wetlands because the plant community must continue to receive water. To allow for this situation, the flow equalization and sedimentation ponds were designed such that during these periods a limited flow could be maintained. This design flow rate is approximately 20% of normal. Higher flow rates during normal periods will be used to account for the limited treatment rates during the maintenance periods.

Consideration of aesthetic aspects -- Because of the large land requirements required for the treatment facility, aesthetic design concepts incorporating a community development project were necessary. By designing the actual wetlands treatment pieces as both functional water treatment and public recreational facilities, the costs of the land are spread across a wider range of benefits.

This report addresses the feasibility of both the wetlands treatment process and the artificial aquifer recharge techniques. The first section deals with the treatment process, costs and financial options. The following section includes an analysis of the artificial recharge of the treated water.

WETLANDS TREATMENT PROCESS FEASIBILITY

INTRODUCTION

The City of Avondale, Arizona has an annual allocation of 4,099 acre feet (1,335 million gallons) of Central Arizona Project (CAP) water from the Central Arizona Water Conservation District (CAWCD). To date, the City has been unable to receive this water due to transportation and treatment requirements.

The City entered into an agreement with BCI Geonetics, Inc. to study the feasibility of an alternative water treatment facility. The following aspects of this facility were identified:

- the facility would utilize existing Salt River Project (SRP) and Grand canals and laterals to deliver water.
- the facility would utilize an innovative wetlands process to provide water treatment.
- the wetlands facility would have conjunctive uses and benefits, such as recreation and development enhancement.
- the wetlands facility would use recharge basins to percolate treated water into underlying groundwater aquifers.

BCI Geonetics entered into an agreement with Willdan Associates to assist in determining the technical, operational, and financial feasibility of this project. Specifically, Willdan Associates was to perform the following:

- investigate existing wetlands processes which were applicable to this project and identify a process which could provide the level of treatment required to not adversely affect groundwater quality by the percolation of treated water.
- conceptually develop the facilities which would utilize the recommended treatment process, including size, configuration and costs.
- develop financing alternatives for the facilities, coordinate these alternatives with City staff and potential developers, and recommend a financing plan for the project.

To assist Willdan Associates with certain elements of the technical investigation of this project, the firm of Woodward-Clyde Consultants was engaged. That firm's report, entitled "Conjunctive Use Water Treatment Facility Plan" is appended in its entirety to this report. References to the Woodward-Clyde report are made in this study and the reader is referred to that report for a description of technical aspects of the initial treatment process concepts. Further analysis and development of the conceptual treatment process resulted in selection of treatment processes not addressed in the Woodward-Clyde report.

This portion of the report is organized into the following sections:

- Analysis of water conveyance facilities
- Analysis of water treatment facilities
- Analysis of operational requirements
- Analysis of project financing
- Appendices:
  - A. Woodward-Clyde Consultants report
  - B. Water Conveyance Canals

ANALYSIS OF WATER CONVEYANCE FACILITIES

Appendix B presents various reaches of the 99th Avenue SRP canal lateral utilized to deliver water to the treatment facility. The capacity of these reaches, as provided by SRP, is as follows:

- Reach 1, extending along 99th Avenue from the Grand Canal to Camelback Road, has a capacity of 397 acre-feet per day.
- Reach 2, which extends from Camelback Road to Indian School Road, has a capacity of 347 acre-feet per day.
- Reach 3, which extends down 99th Avenue from Indian School Road to Thomas Road, has a capacity of 297 acre-feet per day.
- Reach 4, extending from Thomas Road to McDowell Road has a capacity of 283 acre-feet per day.

The greatest bottleneck in the capacity of the 99th Avenue Canal lateral, according to SRP, is reportedly a culvert crossing under Thomas Road. SRP has been requested to provide the capacity of the culvert, but has not done so to date.

SRP and RID canal laterals, located along 107th Avenue, could potentially be used to deliver water to the treatment facility. RID reports that at the Grand Canal, the turnout gates to the RID 107th Avenue Canal have a capacity of 69 acre-feet per day.

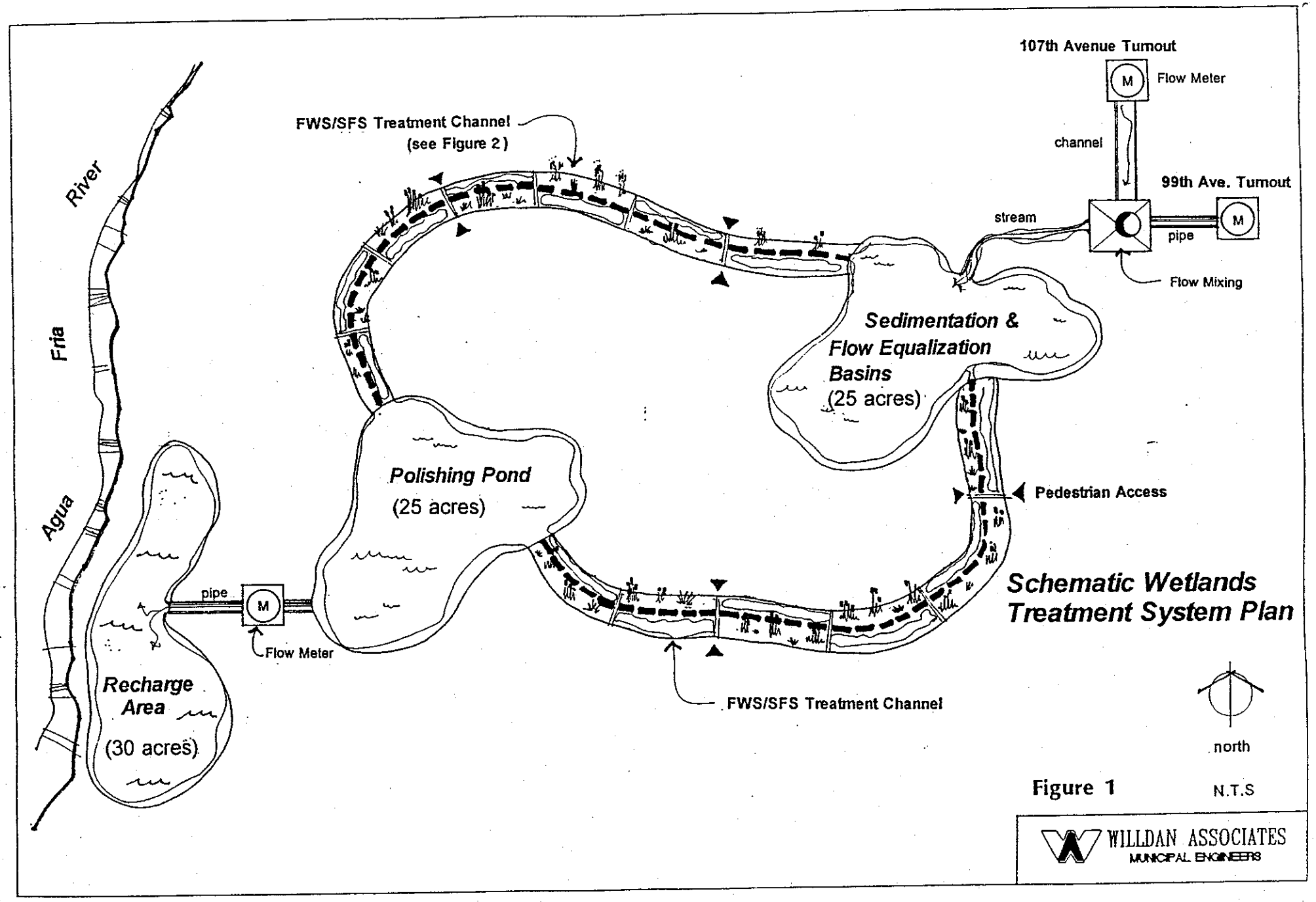
Reach 5, an SRP lateral located along Indian School Road, running from 99th Avenue to 107th Avenue, has a capacity of 74 acre-feet per day. An SRP lateral located about one-half mile south of Thomas Road, Reach 6, running from 99th Avenue to 107th Avenue, has a capacity of 49 acre-feet per day.

SRP reports current canal capacity problems in meeting agricultural water delivery schedules between March and September. The City and SRP are evaluating alternatives including varied diurnal delivery rates and well water exchanges to meet the City's water requirements. It appears that the City's requirement to move thirteen to fourteen acre-feet per day can be accommodated. If further project land develops and a larger wetlands facility is required, those needs can also be met. Agricultural water requirements are anticipated to decrease as future residential and commercial development of the area proceeds.

ANALYSIS OF WATER TREATMENT FACILITIES

DESCRIPTION OF WATER TREATMENT PROCESS

The preliminary design for the treatment process includes two turnouts at laterals from the Grand Canal, flow measurement, interconnecting conveyance piping, nitrate concentration measurement in delivered water, sedimentation, side-stream flow equalization, in-channel denitrification, aerobic polishing, nitrate concentration measurement in treated water, and aquifer recharge. A conceptual illustration of the treatment system components is shown in Figure 1. The anticipated performance of the treatment process includes nitrate concentration reduction of approximately fifty per cent, to produce treated water with a nitrate concentration of less than 10 milligrams per liter.


107th Avenue Turnout
Flow Meter
channel
99th Ave. Turnout
stream
pipe
Flow Mixing
FWS/SFS Treatment Channel
(see Figure 2)
Sedimentation &
Flow Equalization
Basins
(25 acres)
Polishing Pond
(25 acres)
Pedestrian Access
Agua
Fria
River
pipe
Flow Meter
Recharge
Area
(30 acres)
FWS/SFS Treatment Channel
north
Schematic Wetlands
Treatment System Plan
Figure 1
N.T.S
WILLDAN ASSOCIATES
MUNICIPAL ENGINEERS

A propeller flow meter would be installed in the vicinity of each turnout to measure flows delivered to the treatment facility. Nitrate concentration would be monitored by an on-line batch analyzer prior to discharging the water into the sedimentation basins.

Two sedimentation basins would be provided for parallel operation, with one basin capable of operating at average day flows in the event the other basin required cleaning. The preliminary design of the basins assumes 1:1 side slopes, a 4:1 length-to-width ratio, synthetic impermeable liners, gunnite and stone sides, a design mean depth of seven feet, and a design three foot freeboard incorporated into buffer area surrounding the basins. Water would discharge from the basins over weirs. Each basin would require about four acres of land. The design overflow rate for the sedimentation basins would be about 16 gpd/sf. Settleable solids would accumulate in the bottom of the basins. The basins would likely require cleaning to remove accumulated sediments once or twice a year, depending on the quality of the water delivered to the facility.

A single side-stream flow equalization basin would be similar in construction to the sedimentation basins with 1:1 side slopes, a synthetic impermeable liner, gunnite and stone sides, a design mean depth of 8 feet and a design 3 foot freeboard. The freeboard would be incorporated into the buffer area surrounding the basin. The basin would require about 17 acres, including buffer area. The length-to-width ratio of the flow equalization basin would be about 2:1 to promote flow through the basin and minimize stagnation. Water delivered to the treatment system, in excess of its design capacity of 4.5 mgd, would overflow a weir and be diverted to the flow equalization basin. Water would be pumped from the basin and returned to the flow path upstream from the sedimentation basins.

The flow equalization basin design detention time would be 7 days at full design flow, or 35 days at 20 per cent of design flow. The treatment facility could be operated at full design flow for a one week period, based on the anticipated time alternate water supply sources, such as wells pumping groundwater, might be out of service during the canal maintenance period. If alternate groundwater deliveries are not available, the treatment facility could be operated at 20 per cent of full design flow, to maintain plant growth during 30-day Grand Canal drying and maintenance periods.

Two in-channel free water surface/subsurface flow system (FWS/SFS) denitrification streams would be provided for operation in parallel. Each stream would consist of two parallel channels incorporating alternating planted and open water section modules. The alternating planted and open water reaches in each

channel are illustrated in Figure 2. A transverse section of the parallel channels is shown on Figure 3. Partial longitudinal sections of the planted section module are shown on Figure 4. Flow retaining wall structure concepts are illustrated in Figure 5. Nitrate concentration would be monitored from each stream by a continuous on-line batch analyzer, prior to discharging the water into the polishing basin. The nitrate concentration analyzers would be connected to a computer system for recording nitrate concentrations, along with flow rate data.

The polishing basin would require an area of about 25 acres. Preliminary design is based on recommendations provided in Appendix A. The basin would have 3:1 side slopes and be lined with an impermeable liner system. The basin would have a shallow zone with a design depth of 2 feet for emergent vegetation, covering an area of about five acres around the periphery of the basin. The shallow zone would step down to a deeper zone covering an area of about 17 acres with a design depth of 6 feet, to prevent the spread of emergent vegetation over the entire basin. The design freeboard would be 1 foot. The basin would be surrounded by a buffer area, two acres in extent. Dissolved oxygen (DO) concentration would be continuously monitored in the basin, to facilitate oxidation of residual biochemical oxygen demand in the water and to control growth of mosquitoes. Surface aerators would be automatically activated when the DO concentration decreased below one mg/l. Flows leaving the polishing basin could be measured by a propeller flow meter or a weir.

Conceptual design for the recharge basins assumes a total area of about 30 acres. The basins could be constructed with 1:1 side slopes, a design depth of 2 feet, and a design freeboard of 2 feet incorporated into buffer area. The basins would be unlined. The concept assumes two recharge basins, each about fifteen acres in extent. Individual basins could be removed from service on an as-needed basis for maintenance. The City of Avondale is acquiring this recharge site independently from this project. Therefore, the land costs have not been considered in subsequent analyses, although construction costs are included.

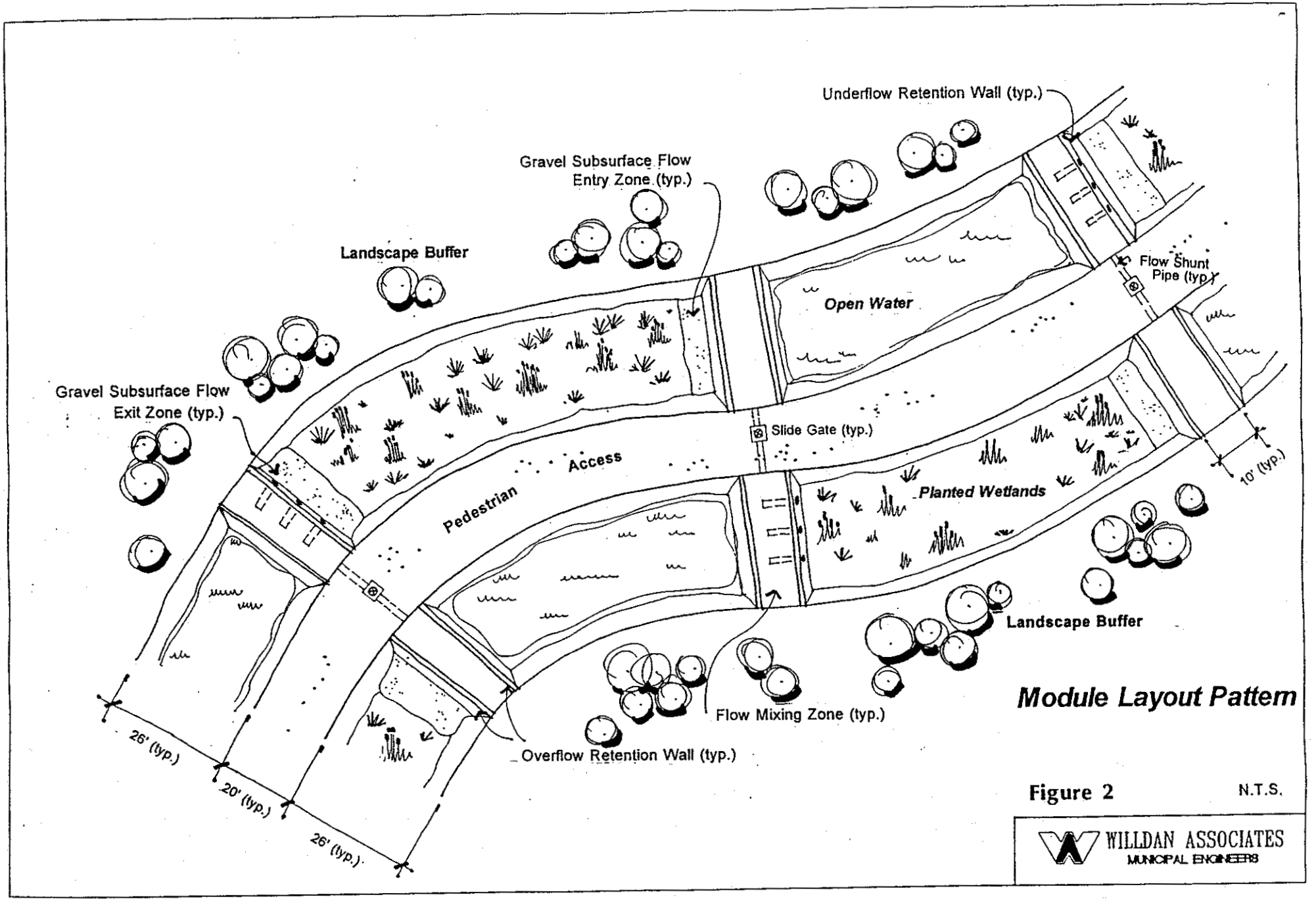

Underflow Retention Wall (typ.)
Gravel Subsurface Flow Entry Zone (typ.)
Landscape Buffer
Flow Shunt Pipe (typ.)
Open Water
Gravel Subsurface Flow Exit Zone (typ.)
Slide Gate (typ.)
Pedestrian Access
Planted Wetlands
10' (typ.)
Landscape Buffer
Flow Mixing Zone (typ.)
Overflow Retention Wall (typ.)
26' (typ.)
20' (typ.)
26' (typ.)
Module Layout Pattern
N.T.S.
WILLDAN ASSOCIATES
MUNICIPAL ENGINEERS

Figure 2

AVONDALE WETLANDS
FWS/SFS TREATMENT MODULE
DETAILS

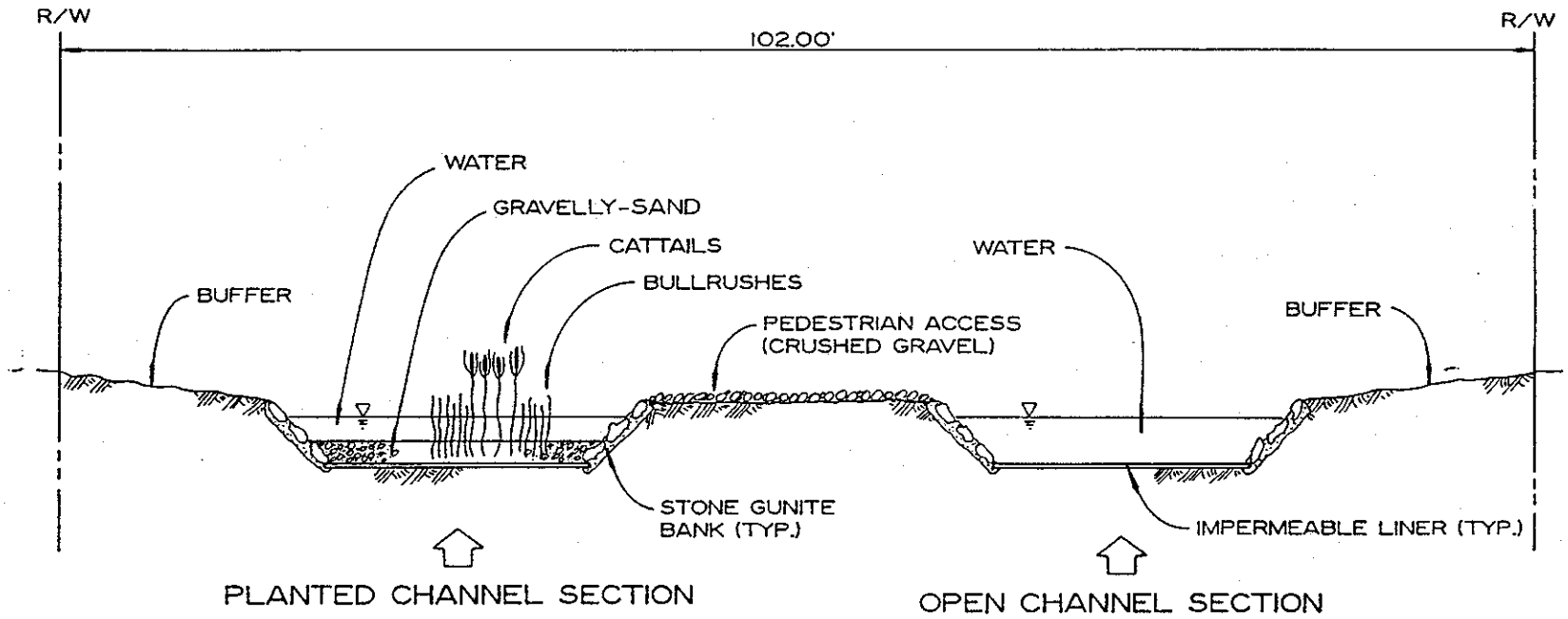
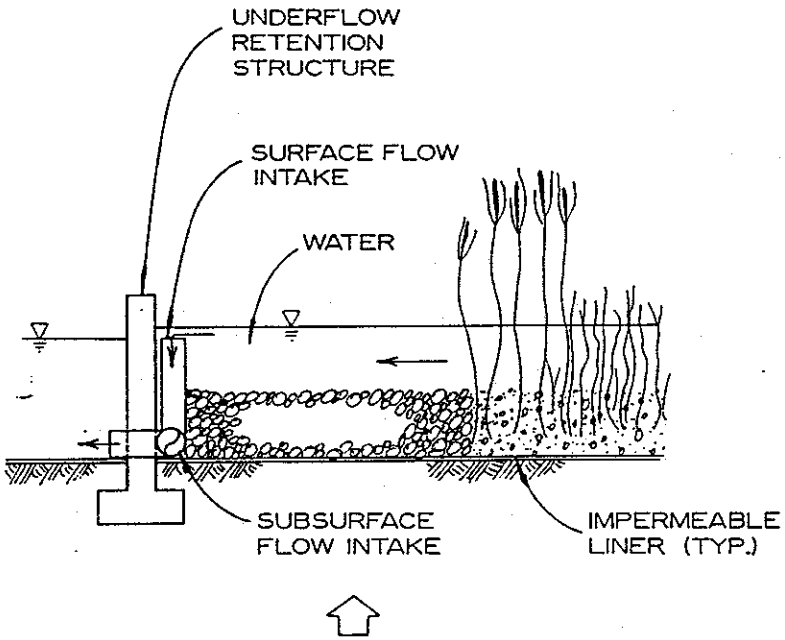


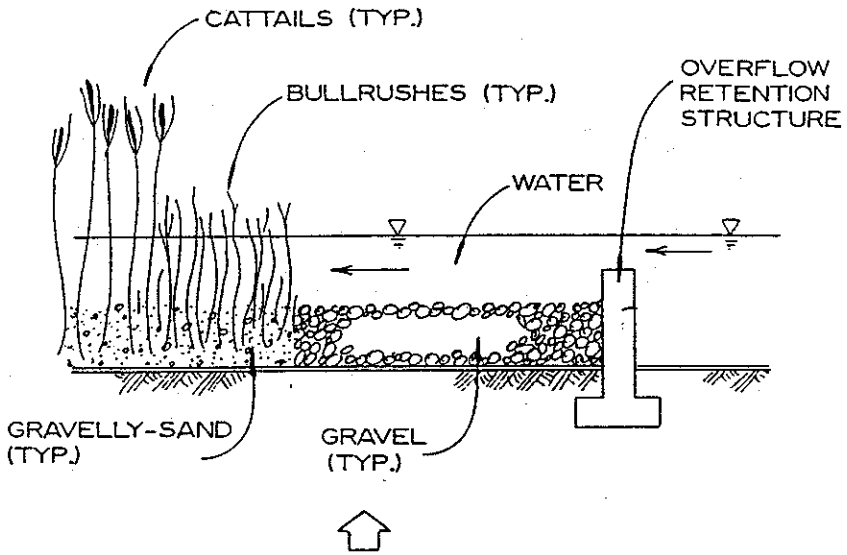
Figure 3

WILLDAN ASSOCIATES
MUNICIPAL ENGINEERS

AVONDALE WETLANDS
FWS/SFS TREATMENT MODULE
DETAILS - PLANTED SECTION



PARTIAL LONGITUDINAL SECTION
(DOWNSTREAM)

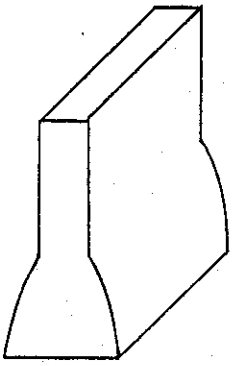


PARTIAL LONGITUDINAL SECTION
(UPSTREAM)

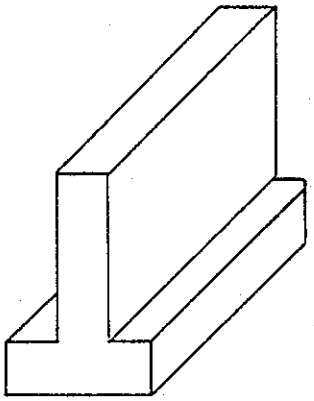
Figure 4

WILLDAN ASSOCIATES
MUNICIPAL ENGINEERS

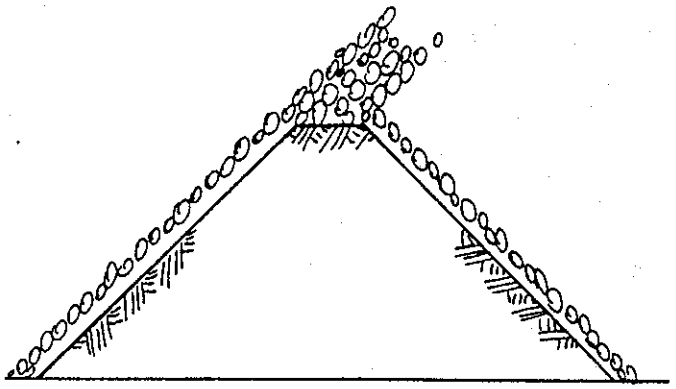
AVONDALE WETLANDS
FWS/SFS TREATMENT MODULE
DETAILS - RETENTION WALL SKETCHES



PRECAST
"JERSEY TURNPIKE"
STYLE



CAST. IN PLACE
"RETAINING WALL"
STYLE



STONE AND GUNITE
"BERM" STYLE

Figure 5

WILLDAN ASSOCIATES
MUNICIPAL ENGINEERS

COSTS OF WATER TREATMENT FACILITY

Exhibit 1 is a schedule which presents the detailed costs of constructing the proposed water treatment facility. The following summary is made:

Construction	$3,306,000
Contractor's Overhead/Profit	496,000
Contingency	951,000
Total Estimated Construction Cost	$4,753,000

As can be observed, the project contingency is twenty five percent of construction costs (including overhead and profit). This relatively large contingency amount was provided since this project is still in the conceptual phase, and actual design has not been undertaken. As design of the project continues, it will be possible to estimate construction costs with greater certainty and to reduce the contingency amount accordingly.

Exhibit 2 is a schedule which includes all other project costs. The following are included in these costs:

- Wetland acreage The facility will require 84 acres of land to construct. It is assumed that land costs for this area are $22,000 per acre. Thus, total land costs are $1.90 million.
- Construction Costs Taken from Exhibit 1.
- Feasibility Costs These costs are based upon an agreement between the City of Avondale and BCI Geonetics for preparing the feasibility study and necessary permits required for this project.
- Engineering and Construction Management These costs, which are fifteen percent of construction costs, are to undertake the engineering design and management of the construction of the project.
- Assessment Engineering These costs are for developing the assessment diagram and the assessment methodology, assuming an improvement district is utilized to finance all or part of this project. Financing methods are discussed in a subsequent section of this report.

AVONDALE WETLANDS
PRELIMINARY COST ESTIMATE

CAP Water Treatment Facility
FWS/SFS Channel Denitrification Alternative

	Quantity	Units	Unit Cost	Cost
Influent Flow Monitor	2	LS	$4,125.00	$8,000
Influent Nitrate Monitor	1	LS	$17,160.00	$17,000
Sedimentation Basins				
Earthwork	116,000	CY	$1.25	$145,000
Impermeable Liner	39,000	SY	$3.50	$137,000
Flow Equalization Basin				
Earthwork	232,000	CY	$1.25	$290,000
Impermeable Liner	70,000	SY	$3.50	$245,000
Surface Aerators	3	EA	$6,600.00	$20,000
Return Flow Pumps	2	EA	$10,000.00	$20,000
FWS/SFS Channels				
Earthwork	67,000	CY	$1.25	$84,000
Gravel	1,200	CY	$25.00	$30,000
Mixed Sand Media	11,000	CY	$15.00	$165,000
Impermeable Liner	81,000	SY	$3.00	$243,000
Emergent Vegetation	8	AC	$3,600.00	$27,000
Module Overflow walls	393	EA	$138.00	$54,000
Module Underflow walls	131	EA	$1,375.00	$180,000
Effluent Nitrate Monitor	2	LS	$17,160.00	$34,000
Piping (48" RGRCP)	8,400	LF	$90.00	$756,000
Landscaping	1	LS	$50,000.00	$50,000
Polishing Pond				
Earthwork	161,000	CY	$1.25	$201,000
Impermeable Liner	121,000	SY	$3.50	$424,000
Emergent Vegetation	5	AC	$3,600.00	$18,000
Surface Aerators	3	EA	$6,600.00	$20,000
D.O. Monitoring	1	LS	$13,200.00	$13,000
Effluent Flow Monitoring	1	LS	$4,125.00	$4,000
Recharge Basin				
Earthwork	97,000	CY	$1.25	$121,000
SUBTOTAL:				$3,306,000
Contractor's O&P:	15%			$496,000
Contractor's Contingency:	0%			$0
Construction Cost:				$3,802,000
Engr. & Constr. Admin.:	15%			$570,000
Project Contingency:	25%			$951,000
PROJECT COST:				$5,323,000

EXHIBIT 1

AVONDALE WATER TREATMENT PROJECT
TOTAL PROJECT COST ANALYSIS

ACRE FEET OF WATER		5000
ACRES OF DEVELOPED LAND		1000
WETLAND ACREAGE		86.2
WETLAND COST		$1,896,000
CONSTRUCTION COST		$4,753,000
FEASIBILITY STUDY		$200,000
ENGINEERING AND C.M @	15.00%	$713,000
ASSESSMENT ENGINEERING		$25,000
CITY ADMINISTRATION @	2.00%	$95,000
SUBTOTAL		$7,682,000
LESS CAWCD PARTICIPATION		($2,000,000)
BOND ISSUANCE @	8.00%	$454,560
CAPITALIZED INTEREST @	8.00%	$490,925
TOTAL PROJECT COSTS FINANCED		$6,627,485

EXHIBIT 2

- City Administration This amount is to reimburse the City of Avondale its costs of administering the improvement district and overseeing design and construction of the project.
- CAWCD Participation The Central Arizona Water Conservation District has tentatively agreed to fund part of the costs of this project.
- Bond Issuance These are the costs incurred by the City or proposed improvement district for the bond counsel, underwriter, financial advisor, and various other costs and fees associated with issuing bonds to finance this project.
- Capitalized Interest This is the cost of interest on the bonds while the project is being constructed.

Thus, total project costs (net of CAWCD participation) are $6.6 million.

ANALYSIS OF OPERATING REQUIREMENTS

SOURCE WATER TREATMENT

Flow meters at the turnouts from the canals will require routine maintenance. The incoming flow nitrate concentration analyzer will require daily checking and annual preventive maintenance.

Sedimentation basins will require periodic maintenance to remove settled solids, and to control erosion of the banks. Settled solids removal can be accomplished by cleaning in situ, or by draining a basin and collecting the sediments.

Maintenance requirements for the flow equalization basin will include bank erosion control, and periodic preventive maintenance for the return flow pumps. If aerators are provided in the flow equalization basin, they will also require annual preventive maintenance.

The in-stream FWS/SFS channel treatment system will require periodic maintenance to control plant growth in the planted sections of the stream channels. The outgoing flow nitrate concentration analyzers will require daily checking and annual preventive maintenance.

Aerators in the polishing basin will require annual preventative maintenance to maintain mechanical operation. Bank erosion control, and periodic harvesting of emergent plants in the basin may also be necessary. Dissolved oxygen concentration monitoring equipment and the effluent flow meter also will require routine maintenance.

Depending on the concentration and nature of suspended solids concentrations in the effluent, gravely sand in the recharge basins may require periodic cleaning. This can be accomplished by temporarily removing a recharge basin from service, allowing the basin floor to dry, discing the surface material as necessary, and bringing the recharge basin back on-line.

FLOW MEASURING AND CONCENTRATION MONITORING

Flow measuring would be by pipe-mounted propeller meters. Flow meters would be located at the turnouts to meter water delivered to the treatment facility. The purpose of the flow meters would be to measure incoming flows to the

treatment system. The meters would be equipped with local flow indication and totalized flow, and would also transmit flow information by means of a 4-20 mA signal to a computer control system for record keeping.

Effluent flow metering would be by a pipe-mounted propeller meter located in the flow stream exiting from the polishing basin. It would be equipped similarly to the influent flow meters and would transmit flow information to the computer control system. By comparing influent and effluent flows, the seasonal effects of evaporation and consumptive use could be identified. The integrity of the impermeable liner system could also be determined by evaluating influent and effluent flow data, after accounting for water losses due to evaporation and consumptive use.

Nitrate-nitrogen concentration would be monitored by an on-line batch nitrate analyzer. The analyzer would sample influent prior to its delivery to the sedimentation basins. This would permit anticipation of shock loadings to the FWS/SFS denitrification system, and adjustments to the system operation as necessary to prevent effluent concentrations from exceeding design maximum effluent nitrate concentration of 10 mg/l.

Effluent nitrate-nitrogen concentration would be monitored from each of the FWS/SFS denitrification stream channels. An on-line batch nitrate analyzer would be used to sample effluent from the channel before discharge to the polishing basin. A 4-20 mA nitrate concentration signal to the computer control system would provide a record of water quality of water recharged.

Annual operating costs, exclusive of the purchase of raw water from CAWCD and SRP, are presented in Exhibit 3. Operating and maintenance costs are estimated to be $24 per acre-foot, or approximately $0.07 per 1,000 gallons of water processed.

AVONDALE WETLANDS
PRELIMINARY OPERATION & MAINTENANCE COSTS

CAP Water Treatment Facility
FWS/SFS Channel Denitrification Alternative

	Quantity	Units	Unit Cost	Cost
Labor				
Turnout	360	hr	$15	$5,000
Flow Metering	200	hr	$15	$3,000
Nitrate Analysis	260	hr	$15	$4,000
Sedimentation Basins	580	hr	$15	$9,000
Flow Equalization Basin	420	hr	$15	$6,000
FWS/SFS Channels	2,080	hr	$15	$31,000
Polishing Basin	420	hr	$15	$6,000
Recharge Basin	850	hr	$15	$13,000
Power				
Flow Metering	47	kWhr	$0.08	$4
Nitrate Analysis	2,000	kWhr	$0.08	$160
Flow Eq Basin Return Pumping	19,000	kWhr	$0.08	$1,500
Flow Eq Basin Aeration	19,000	kWhr	$0.08	$1,500
Polishing Basin Aeration	19,000	kWhr	$0.08	$1,500
Materials				
Nitrate Analyzer Reagents	3	LS	$500	$1,500
Administrative	1,040	hr	$15	$16,000
SUBTOTAL:				$99,000
Contingency:	20%			$20,000
TOTAL ANNUAL O&M COSTS:				$119,000

EXHIBIT 3

ANALYSIS OF PROJECT FINANCING

OVERVIEW OF AVAILABLE FINANCING MECHANISMS

A municipality usually incurs long-term debt to purchase, construct or acquire capital improvements. Several financing mechanisms are available, including:

1. General obligation bonds. General obligation bonds require voter authorization. The bonds are typically issued for a fifteen to twenty year period, and require semi-annual interest and principle payments. Even though a municipality may meet these payments with revenue sources (such as those from a water or sewer system), the bonds are secured by the ability of the City to levy taxes against real property.
2. Revenue bonds. Revenue bonds also require voter authorization. The bonds have the same terms as general obligation bonds, but are secured by a pledge of highway user taxes, water or sewer system revenues. Since they are less secure than general obligation bonds, they usually bear a slightly higher interest rate.
3. Quasi-governmental organization bonds. Quasi-governmental organizations bonds do not require voter authorization. The bonds have the same terms as general obligation and revenue bonds, but are issued under the auspices of a non-profit corporation established by the municipality (such as a Municipal Property Corporation). The non-profit organization holds title to the asset constructed or acquired, and leases it back to the City, which makes semi-annual lease payments in the amount of the bond principal and interest payments. Even though a city may meet these payments using water or sewer system revenues, the bonds are secured by a pledge of sales tax revenues and other non-property tax revenues. They usually bear a slightly higher interest rate than revenue bonds.
4. Improvement district bonds. Some municipalities finance utility system acquisitions or improvements through improvement districts. Improvement districts assess each parcel in a specified area based upon the parcel's relative benefit received from the project. Approval by affected parcels is required, and terms of these bonds are similar to general obligation or revenue bonds. An additional feature of improvement districts is the opportunity afforded to property owners

to pay an assessment in advance, thus avoiding bond issuance and interest costs.

5. Lease-purchase arrangements. Lease-purchase arrangements for fixed assets were frequently used by municipal governments until recent tax code changed made them more complex. However, with a properly structured arrangement, it is still possible for a capital improvement to be financed with this type of vehicle.

6. Developer Contributions. As a requirement of larger projects, developers contribute infrastructure or other municipal assets which are necessary to support their developments.

7. Grants/Intergovernmental Support Although federal grants have been available in lesser amounts in recent years, mutual funding of projects by government agencies is still available.

RECOMMENDED FUNDING METHOD

Consultation has been made with City staff and the City's financial advisors regarding the funding of this project. To protect both the interests of the City as well as the project, it was decided that the following funding sources be used:

- Direct grant/financial participation by the CAWCD. As was previously discussed, the CAWCD has tentatively committed to funding this project in the amount of $2.0 million. This project benefits CAWCD to the extent that it demonstrates the feasibility of other entities receiving and putting their CAP allocations to beneficial use.

- Improvement District. It is recommended that an improvement district be formed which can finance the construction of the project.

- Water Resource Impact Fee. In accordance with A.R.S. 9-463, a municipality may impose a development impact fee on new development which may be used to either pay for the costs of system expansion, or may be used to retire debt incurred for system expansion which directly benefits the development. If the City elects to implement this fee, it is required to observe the following requirements of ARS 9-463.05 (the City Attorney should be involved in this fee implementation process):

- the developed property must directly benefit from the fee.

- the fee must be segregated from other funds; this can be accomplished through segregation in the City's accounting records, or through establishment of a separate bank account.
- the fee should be collected when a building permit for new construction is issued.
- the fee must be based upon the cost of providing the new service.
- the fee cannot discriminate against certain developments; for example, it cannot exempt desirable development and only be assessed against undesirable development.
- the fee cannot duplicate assessments made by an improvement district or community facilities district; this precludes a property owner from paying more than once for a share of system costs.
- advance notice is required for fee implementation or changes; a public hearing process is necessary for this fee.

The City presently does not charge a water resource development fee. It is recommended that implementation of this fee be considered. Since it is difficult for the City to issue debt which is backed by impact fees, it is recommended that the fee be collected and rebated to the improvement district. If this were to occur, then the total costs of the project would not be undertaken solely by the properties within the improvement district.

ANALYSIS OF IMPROVEMENT DISTRICT COSTS

Exhibit 4 presents an analysis of the costs of this project to improvement district properties. These costs are presented on both a per-acre and per-lot basis. On a per acre basis, the cost is approximately $8,000. Since the cost of the land is estimated to be $22,000 per acre, the combined value of land and improvements are $30,000. This provides a coverage ratio of 3.75:1; this appears to be adequate for a project of this nature.

SUMMARY OF FINANCING ANALYSIS

This project appears to be feasible if it is financed utilizing an improvement district. The possible rebate of water resource impact fees to the developer should enhance that organization's confidence in the project. Further, the involvement of CAWCD funding in the project solidifies the financing of the project.

AVONDALE WATER TREATMENT PROJECT
TOTAL PROJECT COST ANALYSIS

ACRE FEET OF WATER		5000
ACRES OF DEVELOPED LAND		1000
WETLAND ACREAGE		86.2
WETLAND COST		$1,896,000
CONSTRUCTION COST		$4,753,000
FEASIBILITY STUDY		$200,000
ENGINEERING AND C.M @	15.00%	$713,000
ASSESSMENT ENGINEERING		$25,000
CITY ADMINISTRATION @	2.00%	$95,000
SUBTOTAL		$7,682,000
LESS CAWCD PARTICIPATION		($2,000,000)
BOND ISSUANCE @	8.00%	$454,560
CAPITALIZED INTEREST @	8.00%	$490,925
TOTAL PROJECT COSTS FINANCED		$6,627,485
PER DEVELOPED ACRE		$8,144
PER DWELLING UNIT		$1,629

EXHIBIT 4

RECHARGE AREA FEASIBILITY

Following the wetlands treatment, the treated water will be transferred to a series of spreading basins in the southwestern portion of the project area, where the water will infiltrate into the aquifer (location shown in Figure 6). The critical elements for successful recharge include a spreading area large enough to accommodate the planned recharge volume, a sufficient infiltration rate at the spreading basins, and desirable recharge effects within the aquifer. We review these elements in the following sections. In a 2-year pilot project, a maximum of 5,000 AFY is allowed by the underground storage and recovery (US&R) permit. The pilot project will clearly establish the overall infiltration rates, and will determine the expected total recharge volume possible in a full scale project, given the total area available for recharge.

Surficial Sediment Characteristics

Several sets of near-surface sediment studies have been conducted near the project area. These studies are summarized in an appendix to the City of Phoenix's 91st Avenue Wastewater Treatment Plant Reclaimed Water Study, Phase II ("Phoenix Study"). All of these soil borings are located outside of the actual Avondale recharge site, but still provide important data on the regional near-surface sedimentary characteristics of the area. This information indicates that most of the sedimentary layers are highly discontinuous, which is typical in an active river-bed setting. The sediment types penetrated in the borings were sands and gravels with local sandy clay or silty clay layers. These fine-grained layers were present in various locations and at various depths and none appear to be laterally continuous. A series of borings for the Maricopa County Highway Department for the new McDowell Road bridge, located at the southwest edge of the project area, penetrated 8- to 13-foot thick clay layers at 60 ft. One- to two-foot zones of cemented sands and gravels were also discovered in boreholes located to the south and east of the project area. These zones also do not appear laterally continuous between the various boring locations. As noted in Appendix 1 of the Phoenix Study, both the clay-rich layers and the cemented layers decrease in thickness and extent closer to the Agua Fria River.

Location of optimum recharge sites will be determined by conducting a grid of 10 to 15 borings spaced throughout the project area. Sedimentologic data gathered from the borehole logs and laboratory analyses of the sediments will provide key information needed to determine the net vertical infiltration rate for the project

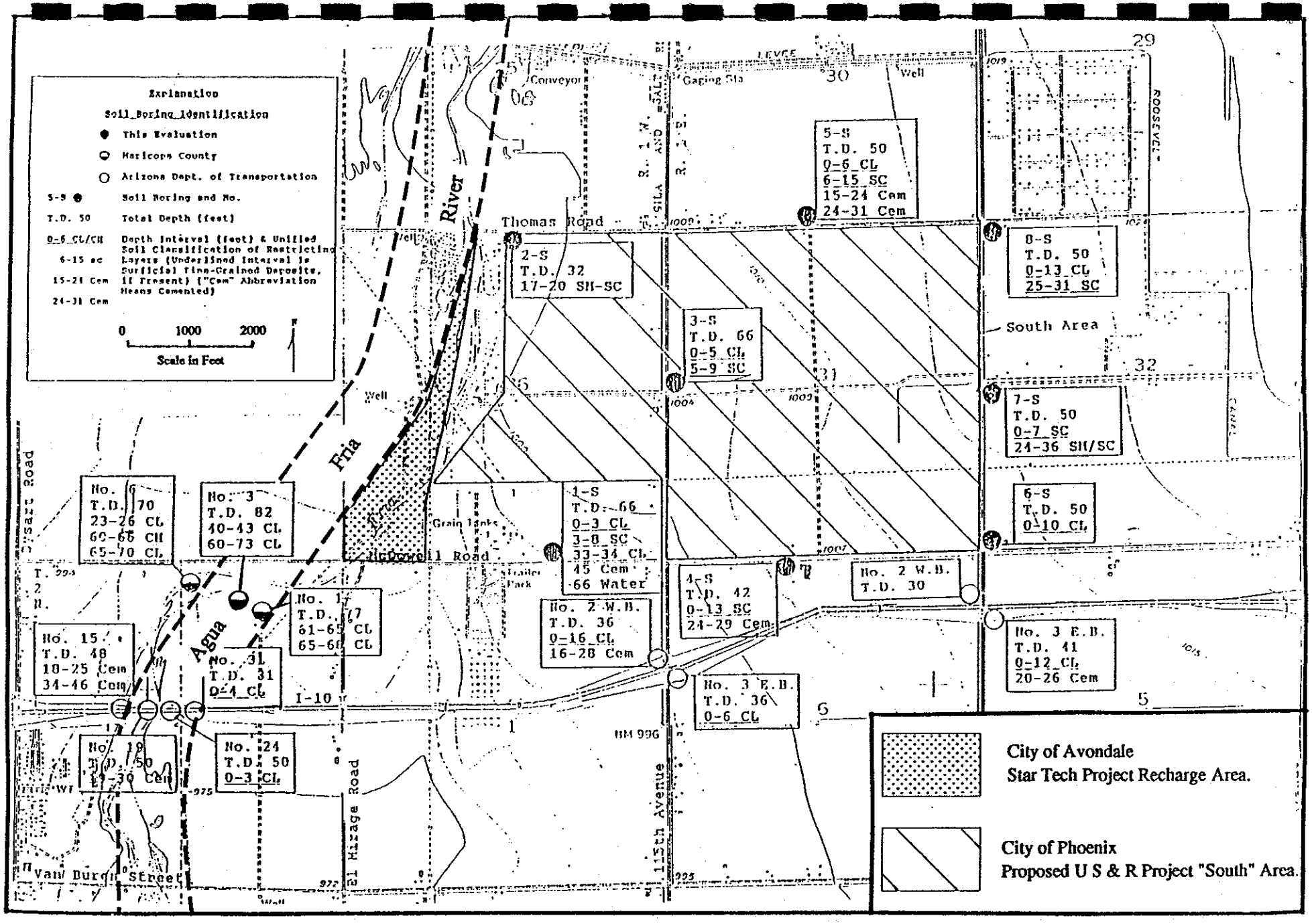


Figure 6. Location map showing City of Avondale's Star Tech project area, and location of nearby soil borings. Also shown is the "South area of City of Phoenix's proposed underground storage and recovery project -- this area has been excluded from their potential recharge project planning. The present channel of the Agua Fria River is shown by dashed lines. Map from Greeley and Hansen (1992).

area. During drilling, careful logging of sediment type, compaction/consolidation, degree of cementation, permeability and depth to water table will be made.

Following the borings, optimum locations for infiltration testing will be selected. Depending on the availability of water at the selected sites, either a small, shallow back hoe-dug pit will be used or a slightly deeper square pit will be constructed. The larger square pit (10 x 10 ft or so), measured over a period of approximately one week, is preferable to provide the most accurate estimate of infiltration rates.

Expected Infiltration Rates

A significant aspect of the sedimentologic study of the site is to conduct a series of infiltration tests to determine representative infiltration rates. Because each spreading basin will cover a large area, the actual infiltration rate will be a composite, or average, of these "point" rates throughout the basin floor. The presence of local, discontinuous clays or cemented layers will lower the overall infiltration rate in a given basin, but higher permeability layers will act to average out the rate. Studies done along various river banks or flood plains in the greater Phoenix area have shown vertical infiltration rates ranging from 0.5 to 2.0 ft/day. Considering the necessity of drying out the basins on a regular basis, which could be up to 50% of time, conservative estimates of actual long-term infiltration rates are between 0.25 and 1.0 ft/day.

Acreage Required for Spreading Ponds

The pilot project will be designed to recharge an estimated 5,000 AFY. The total area of spreading basins will need to be approximately 30 acres, assuming an overall infiltration rate just under 0.5 ft/day (this "overall" rate includes the operating requirement for 50% of the basins to be undergoing a drying-out cycle at any given time). A closer estimate will be possible following the borings analysis and the percolation tests, because the actual infiltration rate will determine the total acreage of spreading basins required for a given amount of annual recharge.

The full-scale project recharging between 20,000 and 40,000 AFY will require between 100 to 200 acres of spreading basins, assuming an overall infiltration rate of 0.5 ft/day. The acreage required for a given amount of recharge capacity is directly related to the recharge rate, and therefore the total area needed for the full

scale project will not be accurately known until results of the pilot scale project are available.

Expected Impacts on Local Groundwater Regime

As part of the permitting process required by Arizona Department of Water Resources (DWR), an analytical model was prepared to determine the amount of groundwater build-up generated by a given quantity of recharge. This model was prepared for both the 2-year, 5000 AFY pilot program and for a full scale, long-term (20-year) program. The model is based on a classical hydrogeologic techniques (the "Hantush" method for regions directly below the spreading basins, and the "Theis" equation for greater distances away), and employs aquifer parameters derived from detailed DWR studies recently conducted nearby. At the request of the DWR, this analysis assumes that no "recovery" will occur (i.e., that all of the recharged water will be left in the ground, and there will be no pumping above the present rate), which represents a "worst" case scenario.

As shown in Figure 7, the recharge mound created by the 5,000 AFY pilot project is approximately 9 ft at 1,000 ft from the center of the recharge area, and diminishes to less than 1 foot high at 18,000 ft away. In the full-scale project model, assuming a maximum of 40,000 AFY is being recharged for 20 years, the mound would build up to approximately 65 ft high at 5,000 ft away, and 10 ft high at 50,000 ft away (Figure 8). In actual operation, the mound will never reach these heights because the recharged water will not be stored in the aquifer over these time periods.

Groundwater Quality Considerations

Critical to the viability of any groundwater recharge project is the compatibility of the water being recharged with the native groundwater. The water quality of the combined SRP and CAP waters present in the Grand Canal is highly variable depending on the relative proportions of the two water types present and the time of year (see Appendix C). The chemistry of the native groundwater is also variable depending on both the location and depth of sampling. In general, however, most chemical parameters in the surface water and groundwater are similar, such as alkalinity, pH, calcium, magnesium, and hardness. Total dissolved solids (TDS) content in the groundwater ranges from 310 ppm at Avondale well #6 to 1,000 ppm at Avondale #8 (see Appendix D). TDS of the combined CAP-SRP water in the Grand Canal ranges from approximately

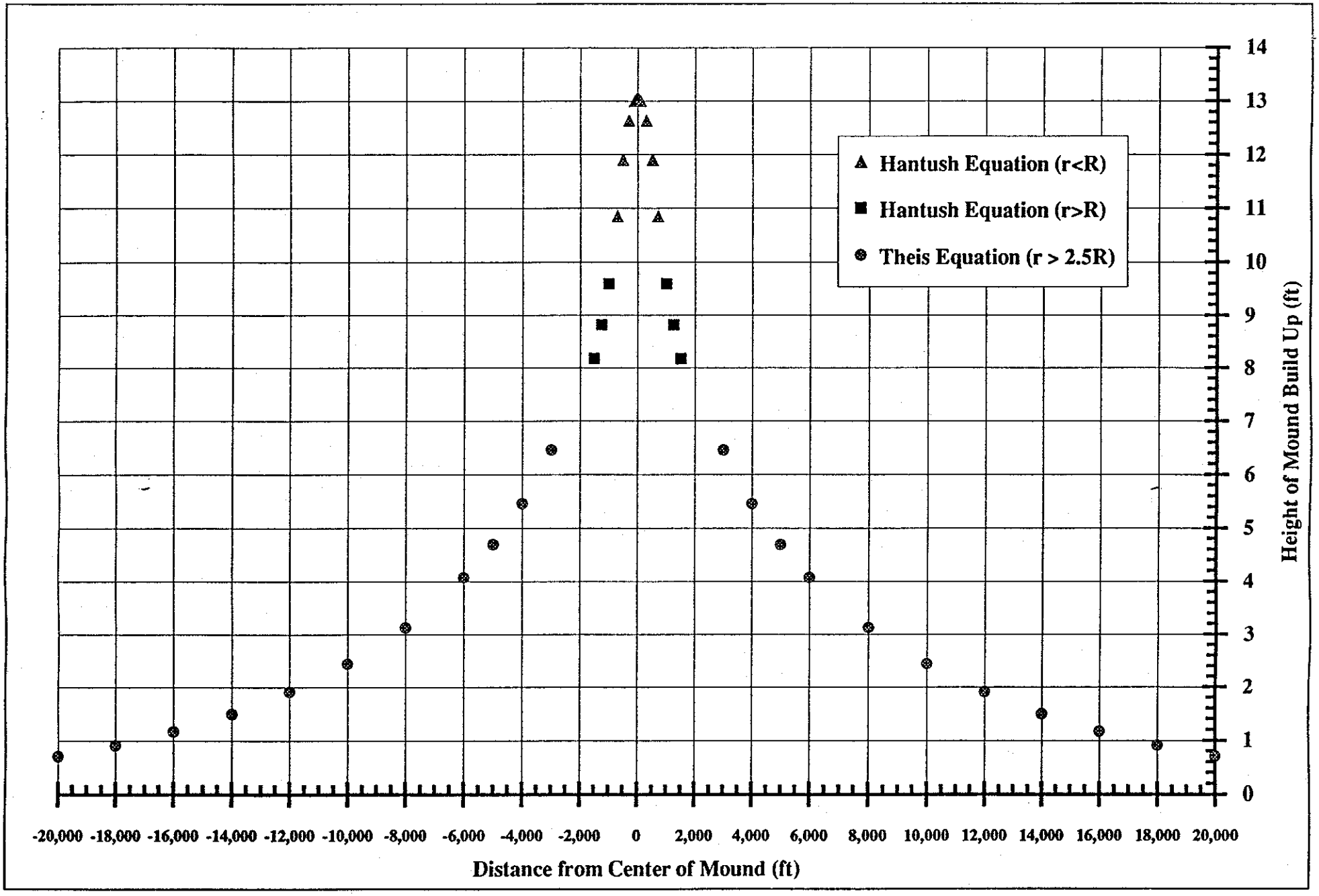


Figure 7. Illustration of height of groundwater recharge mound during 2-year, pilot scale project. No recovery during the entire period is assumed in the calculation. "R" is diameter of recharge basin area; "r" is distance to observation point.

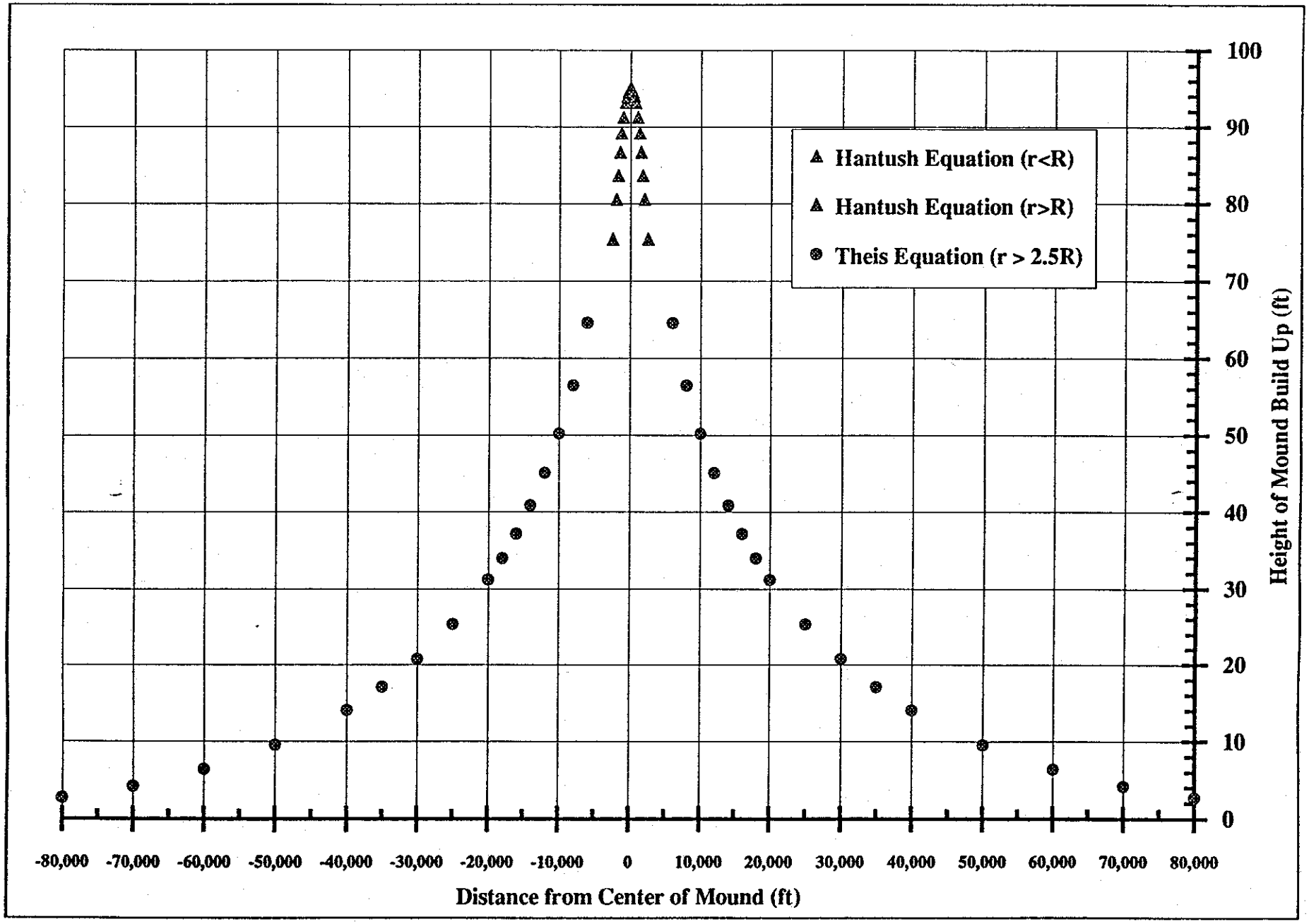


Figure 8. Illustration of height of groundwater recharge mound during 20-year, full scale project. No recovery during the entire period is assumed in the calculation. "R" is diameter of recharge basin area; "r" is distance to observation point.

300 to 850 ppm (Appendix C). Because groundwater flow directions are to the north, however, when the TDS of the CAP-SRP water is high, the groundwater present at Avondale well #6 will likely be partially replaced with the poorer quality water. In general, the wetlands treatment process has only a limited reducing effect on TDS. Any degradation of water quality, however, may be controlled by proper placement of future extraction wells to direct the movement of recharged water away from areas of better water quality.

The nitrate-N concentration of the groundwater at well #6 was just over 4 ppm in June, 1992, whereas the Grand Canal transports water ranging from 0 to 19 ppm (Figure 9). Wetlands treatment processes are very effective in removing nitrate and the system will be operated such that the water entering the recharge basins contains nitrate concentrations that are below MCL limits. Further nitrate removal will likely occur as the recharge water passes through the vadose zone and the saturated aquifer sediments such that the water extracted by any production wells should be significantly lower than the MCL standards for nitrate concentrations.

Permitting Considerations

BCI has had a series of meetings and discussions with both the Arizona Department of Water Resources (DWR) and the Arizona Department of Environmental Quality (DEQ) regarding permitting procedures for pilot and full scale projects. The primary permit required for this project is an "Underground Storage and Recovery Permit" (45-805). BCI has discussed the specific submittals requested in this permit with both Wayne Cooley and Greg Bushner of DWR and with James DuBois of DEQ. Full explanations of the planned pilot and full scale projects were presented to these agency representatives, including potential impacts, local land use issues, and long-term goals of the project.

An area of interest to most parties was the calculated effects of the maximum recharge volume on groundwater flow directions and flow rates at the Phoenix-Goodyear Airport (PGA) to the southwest of the project area. This area is currently in a full scale groundwater remediation program following the determination that significant quantities of organic solvents had infiltrated into the basin. This area, however, is over 4 miles away from the recharge site and it is down gradient (i.e., it has a deeper water table elevation). For the purposes of the DWR Hydrologic study, the groundwater mound model assumes that no extractions will be made over the life of the project, which represents a worst case scenario. The actual operating plan of the full scale project, however, includes extraction of the majority of the recharge water, resulting in a relatively small

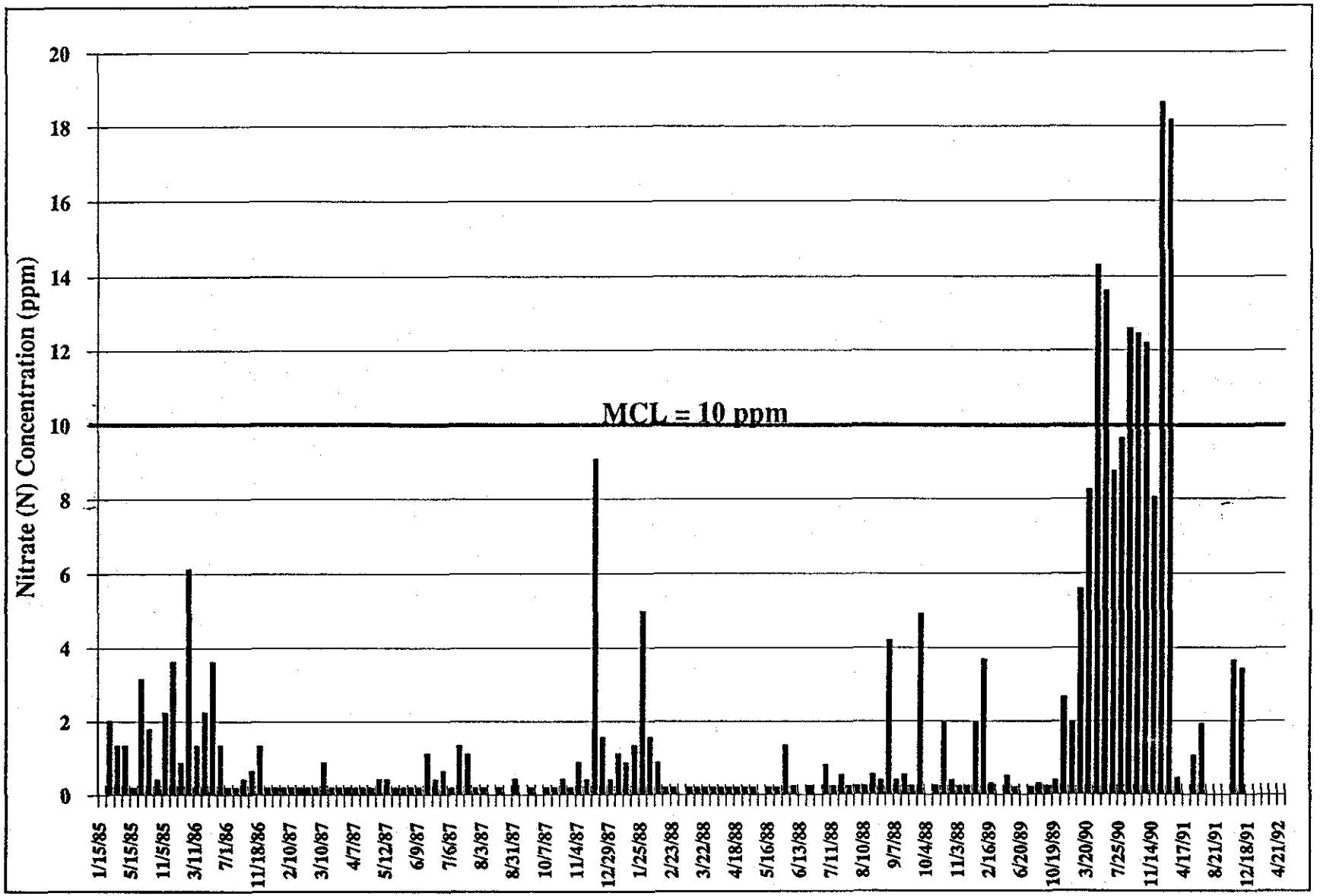


Figure 9. Histogram showing Nitrate Concentrations (as N) as sampled by SRP from Grand Canal at 99th Avenue. Data points without bars indicate analytical zero determined.

BCI Geonetics, Inc.

long-term net storage in the aquifer. The actual water level build-up therefore will mainly be concentrated between the recharge basins and Avondale's production well locations, because the gradient created by the production wells' drawdowns will induce the water to preferentially flow in that direction. Mr. DuBois (DEQ) agreed that there appeared to be no problem about affecting the PGA site, but recommended that future Avondale production well sites be located so the groundwater gradients created by the recharge minimize any chance of affecting the on-going PGA recovery operation.

RECOMMENDATIONS

Based on the information available to us, the pilot project appears to be feasible. The most variable parameter at this time is the relative thickness and extent of clay and cemented layers that were encountered in some boreholes outside of the planned recharge area. We recommend that a limited number of boreholes be drilled as close to the planned recharge site as possible. These boreholes could test for the presence and extent of buried clay and cemented layers, and could be used for some preliminary infiltration tests. More diagnostic infiltration tests should be conducted using small excavated areas over week-long periods.

Permitting of the pilot project appears to be relatively easy. We have already presented the required analyses informally to the regulatory agencies involved, and they could see nothing that would preclude this permitting. The results of the 2-year pilot project would be used as the basis for expansion of the program. There appears to be adequate space available for expanding the program. Permitting for an enlarged program would start during the first year of the pilot program, when there is enough history of operation to justify the expansion. If permitting of an enlarged program exceeded the 2-year time limit of the pilot project, DWR suggested that the permitting of the pilot project could be extended so that there was no "down time".

APPENDIX A

WOODWARD-CLYDE REPORT

CITY OF AVONDALE
CONJUNCTIVE USE
WATER TREATMENT FACILITY PLAN

INTRODUCTION

This report describes the basic physical-chemical mechanisms of wetlands that can be used to purify contaminated water and their application in the design of the Avondale Water Treatment Facility (AWTF) project. The AWTF is part of the City of Avondale's Conjunctive Use Plan to receive Central Arizona Project (CAP) and/or Salt River Project (SRP) water, treat the water to Arizona Department of Environmental Quality aquifer water quality standards, and discharge the treated water to the local aquifer for later use. The water would be delivered via the Grand Canal, a lateral canal that crosses agricultural land along its length. CAP and SRP waters meet most aquifer water quality standards before entering the Grand Canal. However, return flows from agricultural fields introduce occasional spikes in nitrate-nitrogen (N) and other constituents. Data on nitrate-N levels in Grand Canal water since 1990 show levels approaching 20 mg/l in some months (Figure 1; Salt River Project Water Quality Database). Therefore, the design of the Avondale wetlands focuses on the removal of nitrate-N from the influent waters, as nitrate-N is the major inorganic constituent that exceeds aquifer standards. The goal of the system is to treat water with a worst case scenario of 20 mg/l nitrate-N to the aquifer standard of 10 mg/l (50% removal efficiency).

The capacity for water purification, including nitrogen removal, by both natural and artificial wetlands is well documented. Wetlands remove aquatic contaminants through a variety of biological, chemical, and physical processes. In wetlands, nitrate is removed by plants and through microbial action within the wetland sediments. The major mechanism of high-rate nitrate removal in these systems is denitrification, which takes place in the sediments.

Denitrification is an anaerobic respiration performed by certain genera of bacteria, where nitrate or nitrite is used as the terminal electron acceptor for the oxidation of organic compounds and is ultimately reduced to the gaseous end products nitrous oxide (N_2O) and nitrogen gas (N_2) (Mitsch and Gosselink 1986). This process accounts for nitrate removal in wetlands constructed for the purpose of wastewater treatment (Gersberg et al. 1983). However, for optimal high-rate nitrate removal via denitrification, the ratio of dissolved organic carbon (DOC) to nitrate-N must be approximately 2.5:1. Typical DOC levels in CAP and SRP waters are about 2 mg/l, or

well below this optimum ratio (Gersberg, pers. comm.). In order to obtain high-rate removal in the Avondale system, supplemental DOC is warranted.

EVALUATION OF DESIGN CRITERIA

The following analysis is a quantitative estimate of the expected percent nitrate-N removal under several different scenarios that vary depending on influent levels and wetland type:

- Case 1. This alternative assumes a 100-acre free water surface (FWS) constructed wetland with no supplemental DOC addition and an influent mean nitrate-N level of 12-15 mg/l. This nitrate-N level was selected based on the assumption that nitrate-N rarely exceeds 15 mg/l as demonstrated in Figure 1. For all cases, the treatment objective is 10 mg/l nitrate-N.

- Case 2. This scenario assumes a 100-acre FWS constructed wetland with no supplemental DOC and an influent nitrate-N level of 20 mg/l. The nitrate-N level of 20 mg/l is a worst case scenario based on data for 1990-1991 on nitrate-N in Grand Canal waters (Figure 1).

- Case 3. Case 3 assumes a 5-acre subsurface flow (SF) constructed wetland utilizing a supplemental carbon source and including a terminal FWS constructed wetland for polishing. The subsurface wetland provides an anaerobic environment that yields high-rate nitrate removal (greater than 90%) at the front end of the treatment system when coupled with the high carbon:nitrate-N ratio. The terminal FWS wetland will provide polishing to further remove remaining contaminants, such as metals, and/or excess carbon from the exogenous carbon source, if any.

Case 1

For Case 1, which assumes nitrate-N levels of 12-15 mg/l and a 100-acre FWS wetland, the loading rate for nitrate-N would be approximately 230 g $N/m^2/yr$. This annual loading rate for nitrate-N is derived based on an assumed mean delivery rate of 4.5 MGD, a mean instantaneous nitrate-N concentration of 12-15 mg/l, and a treatment area of 100 acres. Loading rates of nitrate-N directly influence nitrate-N removal efficiencies of wetlands; higher loading rates result in reduced removal efficiency (Nichols 1983). Additionally, this hypothetical wetland would not support appreciable rates of denitrification without addition of DOC. Therefore, the primary mechanism for removal in this system would be through plant assimilation wherein nitrate is

incorporated into plant biomass. In a study of a constructed wetland in San Diego, California, Gersberg et al. (1986) reported that the maximum annual harvestable yield of biomass in a constructed wetland was approximately 7 $kg/m^2/yr$. Assuming a conservatively estimated N content of 1% of the dry weight of this biomass, plant uptake of nitrate-N could account for approximately 70 g $N/m^2/yr$. This value represents approximately 30% of the influent nitrate-N loading and would result in an effluent nitrate-N level of 8.4-10.5 mg/l given instantaneous concentrations of 12 mg/l and 15 mg/l, respectively. Therefore, a 100-acre FWS wetland will usually meet the treatment objective of 10 mg/l nitrate-N, if the instantaneous influent nitrate-N level does not rise above 15 mg/l and if plant productivity (harvestable biomass) similar to that reported by Gersberg et al. (1986) can be attained. Lower plant productivity would result in lower nitrate-N assimilation. Further information on soil nutrients, in particular phosphorus, is needed to accurately predict plant productivity at the Avondale site.

Case 2

Case 2 assumes an instantaneous nitrate-N concentration of 20 mg/l and a wetland area of 100 acres. Given these assumptions, the loading rate for nitrate-N would be approximately 300 g $N/m^2/yr$. A removal efficiency of 50% would be required to meet the treatment objective. This can be expressed as either an instantaneous concentration (50% removal of 20 mg/l = 10 mg/l) or as a loading rate (50% removal of 300 g $N/m^2/yr$ = 150 g $N/m^2/yr$).

Two separate approaches were used to estimate the N loading rate and wetland acreage necessary to achieve the goal of 50% removal of N. In both cases, data from the literature on the capacity of wetlands to remove nitrogen from water were used in these calculations. In the first approach, N loadings and percent N removal in several natural wetlands that have received effluents for periods of 1 to 69 years were evaluated (Figure 2). Figure 2 shows high N removal at low loading rates (less than 25 g $N/m^2/yr$), with rapidly declining efficiency as loading rates increase. This figure indicates that removals would be very low at a loading rate of 300 g $N/m^2/yr$. Under this scenario, over 500 acres of FWS wetlands would be required to meet the treatment objective. However, the data shown in Figure 2 are for natural wetlands that are not managed for contaminant removal and also include data for wetlands in colder climates with short growing seasons. To more accurately predict conditions in the Phoenix area, data from the literature were summarized for a number of constructed wetlands that were designed for water purification and were sited in warm climates. These data, presented in Figure 3, demonstrate that the loading rate needed to yield 50% or greater N removal is equal to a value of approximately 150 g $N/m^2/yr$. Thus, approximately 200 acres, or twice the assumed 100-acre wetland, would be required to treat 4.5 MGD of influent.

Case 3

Case 3 assumes that a 5-acre SF wetland can be constructed to efficiently denitrify nitrate-N at a very high rate using supplemental DOC from sources such as acetate, brewery or agricultural waste, or other waste that would create high Biological Oxygen Demand (BOD). This supplemental carbon would be injected into the influent stream feeding into the wetlands. Assuming that such carbon-supplemented wetlands can treat up to 100 cm per day of flow (Gersberg et al. 1983), 5 acres of SF wetlands may treat over 4.5 MGD with high removal efficiencies. If the influent nitrate-N levels are similar to those presented in Case 1 (12-15 mg/l) approximately 100 kg of carbon would be needed daily to supply the carbon demand of denitrification to 10 mg/l. Approximately 450 kg/day of carbon would be needed to completely remove nitrate-N from the influent.

Given the assumptions and conditions presented above, it is recommended that a SF constructed wetland be incorporated into the design. The SF wetland can be used to denitrify efficiently while using relatively little land area. The water delivered to the terminal FWS wetland should meet aquifer water quality standards; however, the FWS would perform the function of polishing or removing remaining contaminants while providing wildlife habitat.

RECOMMENDED DESIGN PARAMETERS

The Avondale Water Treatment Facility wetlands design has been based on the following assumptions:

- The delivery rate of influent waters will be 4.5 MGD. - 13.8 AFD
- The flow equalization basin must be able to hold a 30-day supply of water because of delivery constraints (e.g., the Grand Canal's dry, no-flow condition for one month in the summer).
- The primary settling basin must be large enough to hold several days of water delivery so that it is not a bottleneck in the overall system.
- The terminal FWS wetland may be any size and configuration.

Given these assumptions, two water treatment options have been recommended. These options differ only in the size and depths of the individual components, which are summarized in Table 1 and illustrated in Figures 4 through 7.

In Option 1, the equalization basin would be approximately 70 acres in area and 6 feet deep. The primary settling basin would be approximately 18 acres in area and 6 feet deep. Two parallel subsurface wetlands of 5-acres each would be constructed to allow for potential maintenance requirements. The terminal or polishing FWS wetland would be approximately 35 acres in area with a mean depth of 3 feet.

In Option 2, the size of the flow equalization basin would be reduced to approximately 52 acres and the depth increased to 8 feet. The primary settling basin and subsurface wetlands would be the same as those presented in Option 1. Finally, the polishing wetland would be 22 acres in area with a mean depth of 5 feet.

All components would be lined with either impermeable clay or a manufactured geotextile liner. The flow equalization basin and primary settling pond would not be intentionally covered with sediment; however, sedimentation will occur over time and some maintenance will be required. The two wetland components are described in greater detail below.

SF Wetland

SF wetlands have been used extensively in treatment of municipal sewage. They usually consist of lined excavations containing emergent vegetation growing in a gravel bed 1-3 feet deep. The beds are kept flooded resulting in anaerobic conditions favorable to denitrification. As mentioned above, SF wetlands are highly efficient in removing nitrate-N. Native emergent species would be planted to maximize wildlife benefits and reduce the spread of exotic species. These species would include various bulrush species (*Scirpus acutus*, *S. macrocarpa*, *S. olneyi*, and/or *S. californicus*) and other Arizona native plants. Cattails (*Typha latifolia*, *T. domingensis*) will not be planted but are expected to colonize naturally.

Terminal or Polishing FWS Wetland

This final downstream component would function to further remove remaining contaminants, such as heavy metals and excess BOD from the exogenous carbon source. It is recommended that this component be 4-6 feet deep in the central 3/4 of the wetland to prohibit emergent growth, becoming gradually shallower so that the depth is approximately 2 feet within a "fringe" around the shore that is 20-30 meters wide. This will allow for open water in the center for ducks and other water birds, and will also provide some plants for polishing. The design incorporates a stairstep effect that will allow for viewing over emergent vegetation (Figures 5 and 7). The exact depth at the shore can be varied so that there are relatively shallow expanses for waders such as great blue herons and egrets.

At a previous AWTF project meeting held May 13, 1992, the requirement of artificial aeration of the wetlands to "strip" nitrate was discussed. Aeration of the terminal FWS wetland should not be needed for nitrate removal, which will be denitrified to gaseous NO_2 and N_2 by anaerobic processes; this NO_2 and N_2 will diffuse into the atmosphere prior to entering the terminal wetland. Aeration is generally used to convert ammonium (NH_4)-N to nitrate, which is then denitrified to NO_2 and N_2. Therefore, aeration is not recommended because it would interfere with the anaerobic, denitrification process.

BOD REMOVAL RATES

In FWS wetlands, removal of soluble BOD is due primarily to microbial growth attached to plant roots, stems, leaf litter, and surface soils. Because algae are typically not present if plant cover is complete, the major sources of oxygen for BOD removal are reaeration at the water surface, and plant translocation of oxygen to the roots.

The relationship between organic loading and BOD removal suggests that a linear relationship exists, at least up to a loading rate of about 100 kg/ha per day, which was the highest value in the literature for FWS wetlands. For the constructed wetlands discussed in the literature that were evaluated for the project, loading rates ranged from 18 to 116 kg BOD/ha per day. These wetland systems achieved up to 93% removal. The loading rate for the Avondale FWS wetlands is calculated as 58 kg BOD/ha per day (worst-case scenario) as given in assumptions 3 and 4 below. Therefore, based on information to-date, we could expect removal rates comparable to those discussed in the above-cited literature.

BOD removal by FWS wetlands is further illustrated using an equation developed by the United States Environmental Protection Agency (U.S. EPA). An equation for BOD utilization in constructed FWS wetlands is similar to that for biological treatment in plug-flow reactors. Based on this relationship, an equation has been developed and the constants and coefficients validated by performance data collected in the field on a variety of constructed wetland systems (U.S. EPA, 1988). Combining a first-order plug-flow model with the relationships representing hydraulic residence time results in the following equations:

$$A = \frac{Q\,(\ln C_o - \ln C_e - 0.6539)}{65 K_T d} \qquad \text{Equation (1)}$$

where C_o = influent BOD concentration, mg/l

C_e = effluent BOD concentration, mg/l

K_T = reaction rate constants, $days^{-1}$, K_{20} = 0.0057 $days^{-1}$

d = design water depth in the system

A = design surface area of the wetlands

Q = flow per unit time, m^3/day

We can solve the above equation for the value C_e, the effluent BOD concentration for the 52 acre Avondale FWS wetlands, making the following assumptions:

1. The 52 acre FWS constructed wetlands is polishing the effluent of a 5 acre subsurface flow constructed wetlands. This SF wetland is operating for nitrate removal using the addition of organic carbon to stimulate denitrification.

2. The mean level of nitrate-N in the inflow to the 5 acre SF wetlands is 12 mg/l, and that a value of 3:1 is desired for the carbon:nitrate-N ratio to drive the denitrification process. Therefore, we would need to add approximately 36 mg/l of dissolved carbon to the subsurface flow system.

3. The stoichiometric oxygen demand of the added dissolved carbon is conservatively estimated to be 2 mg/l of oxygen to 1 mg/l of added carbon (Gersberg, pers. comm.). Therefore, the BOD exerted by the addition of the 36 mg/l of dissolved carbon in (2) above, will amount to approximately 72 mg/l, which translates to 58 kg/ha/day.

4. Again, to be most conservative, we will assume a worst case situation wherein none of the added carbon (as represented by a BOD of 72 mg/l in (3) above) is used in denitrification in the subsurface flow system, and all added carbon flows directly into the FWS system. In reality, we expect almost all of the added carbon to be oxidized to CO_2 and H_2O during denitrification of nitrate in the SF system.

5. The following parameters will be used to solve Equation 1 above for the effluent BOD level, C_e.

   a. A = 21 hectares (ha) = 2.1×10^5 m^2

   b. Q = 4.5 mgd = 1.7×10^4 m^3/day

c. C_o = 72 mg/l

d. K_T = 0.0057 days $^{-1}$ (assuming the water temperature to be 20 degrees Celsius).

e. d = 1.5 m

Solving Equation 1 (using the above parameters and assumptions) yields an effluent BOD level of 0.04 mg/l for the 52 acre FWS constructed wetlands, even assuming that none of the added carbon in the subsurface flow wetlands is converted during the denitrification process prior to flow into the FWS wetlands. These calculations indicate that the FWS wetlands may serve as an efficient natural polishing system to remove residual BOD from the system.

CONCLUSIONS

These wetland design options are estimates of the wetlands required to treat the nitrate-N levels of SRP or CAP water delivered via the Grand Canal to acceptable aquifer standards based on our judgement considering the assumptions described herein. In addition, the individual components should provide aesthetic benefits and habitat for wildlife. The larger components, including the flow equalization basin and the primary settling basin, could provide both habitat for wildlife and active recreation (i.e., boating) opportunities for residents. The SF and FWS wetland components would provide the best opportunities for wildlife and passive recreation opportunities, such as bird-watching. Construction costs are primarily associated with excavation and lining of the system. Operation and maintenance would be minimal, despite the cost of the exogenous carbon.

REFERENCES

Gersberg, R.M, B.V. Elkins and C.R. Goldman. 1983. Nitrogen removal in artificial wetlands. Water Research 17: 1009-1014.

Gersberg, R.M., B.V. Elkins and C.R. Goldman. 1986. Role of aquatic plants in wastewater treatment by artificial wetlands. Water Research 20: 363-368.

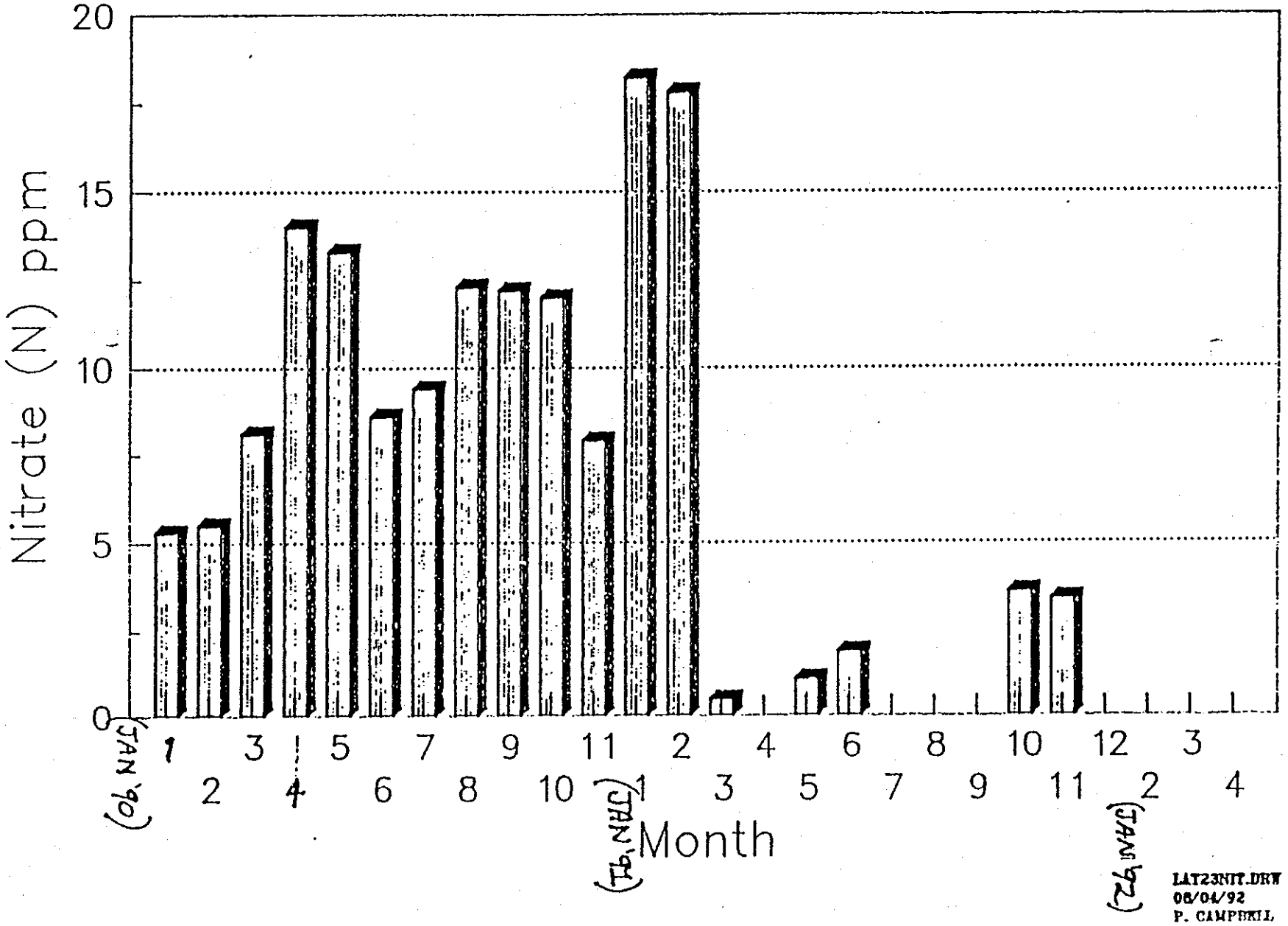
Mitsch, J.M. and J.G. Gosselink. 1986. Wetlands. Van Nostrand Reinhold Company, Inc. New York, New York. 539 pp.

Nichols, D.S. 1983. Capacity of natural wetlands to remove nutrients from wastewater. J. Water Pollut. Control Fed. 55: 495-505.

U.S. EPA. 1988. Design Manual for Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment. EPA/625/1-88/022.

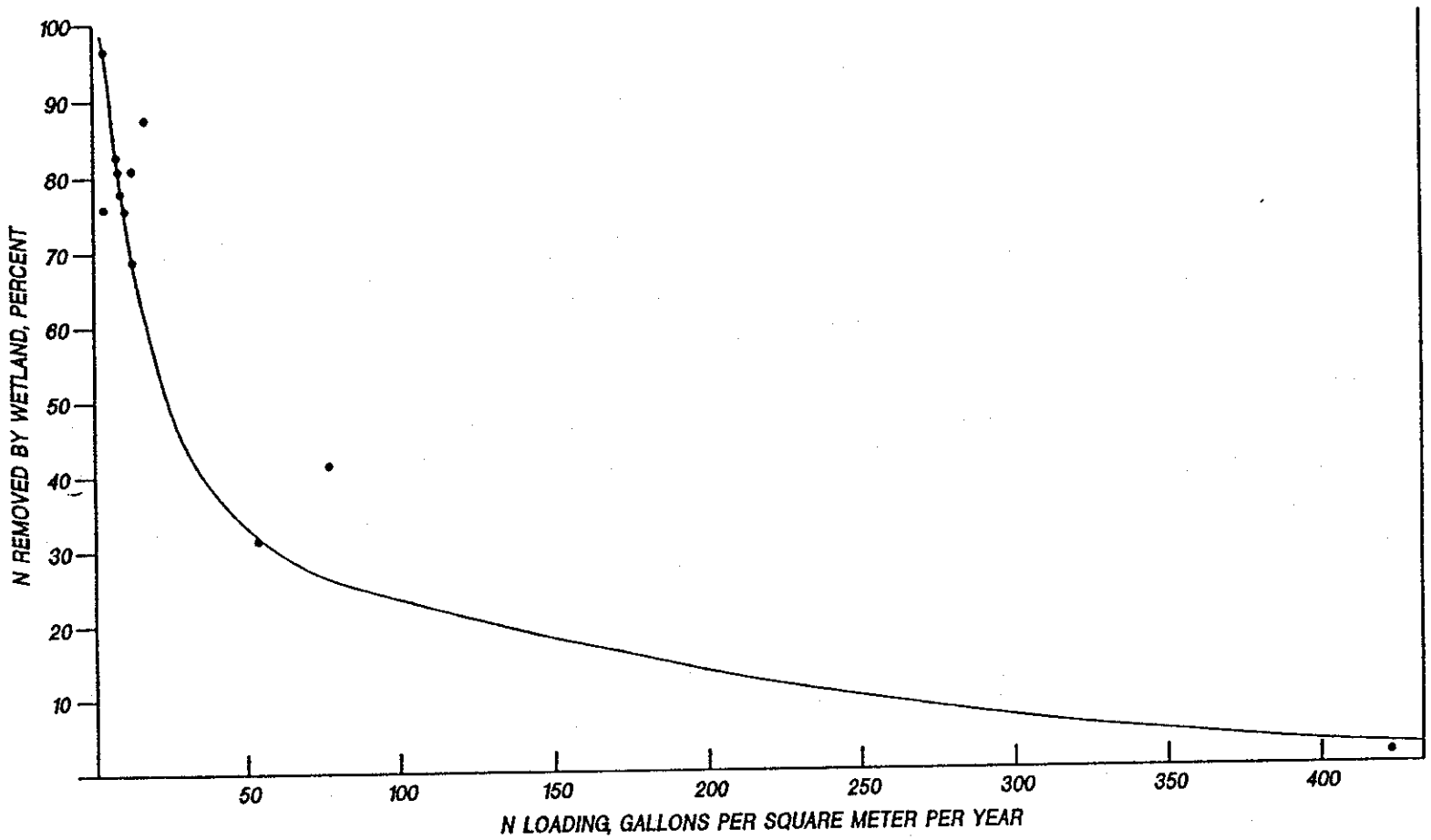
GRAND CANAL @ 99TH AVENUE

Nitrates Since 1990



LAT23NIT.DRW
08/04/92
P. CAMPBELL

FIGURE 1

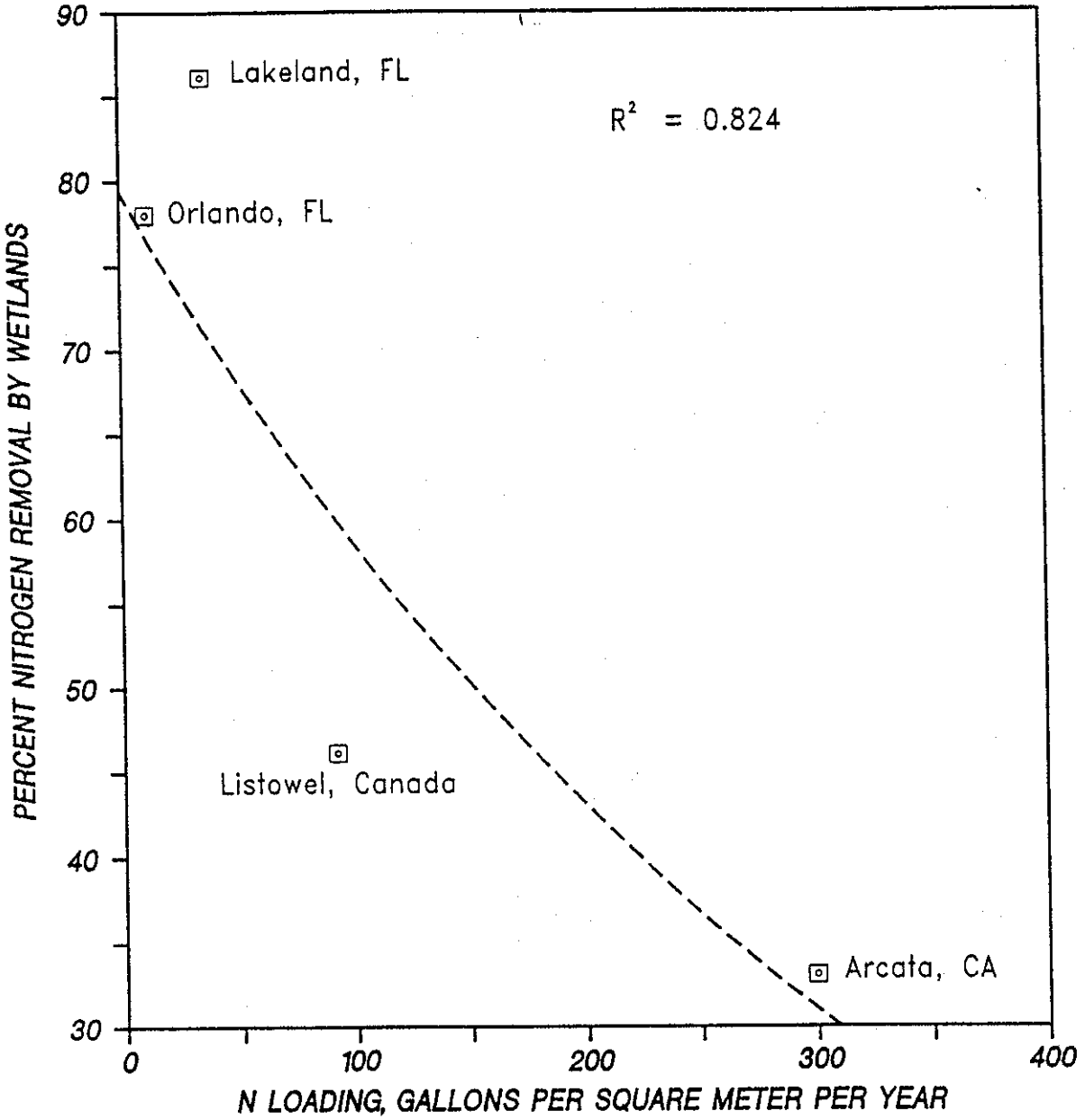


AVONDALE

Nitrogen Removal by Several Natural Wetlands (Modified from Nichols 1983)

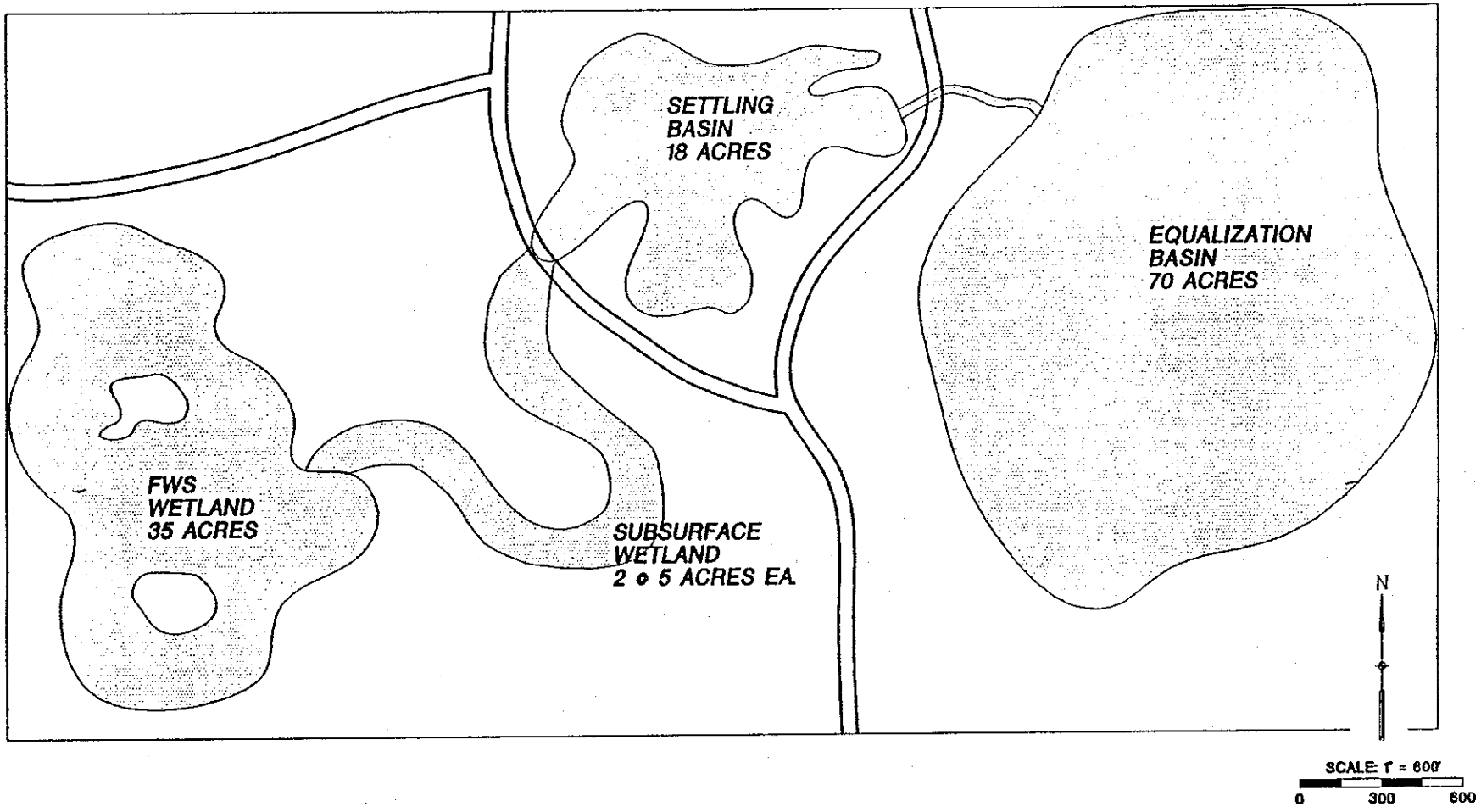
Project No.: 934X071A	May 1993	FIGURE 2

Woodward-Clyde



AVONDALE		
Nitrogen Removal in Constructed Wetlands		
Project No. : 934X071A	May 1993	FIGURE 3

Woodward-Clyde

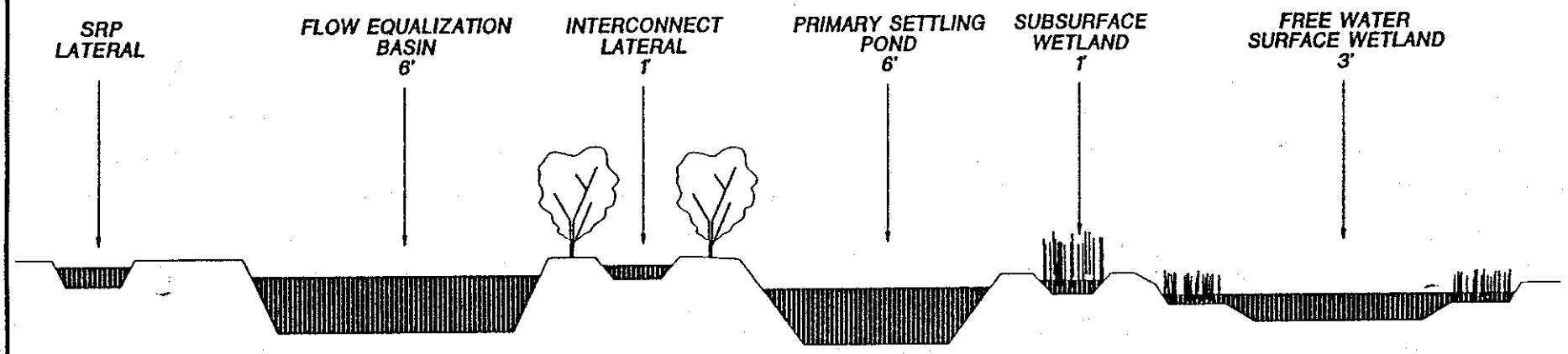


AVONDALE

Water Treatment Facility Plan - Option 'A'

Project No. : 934X071A	May 1993	FIGURE 4

Woodward-Clyde



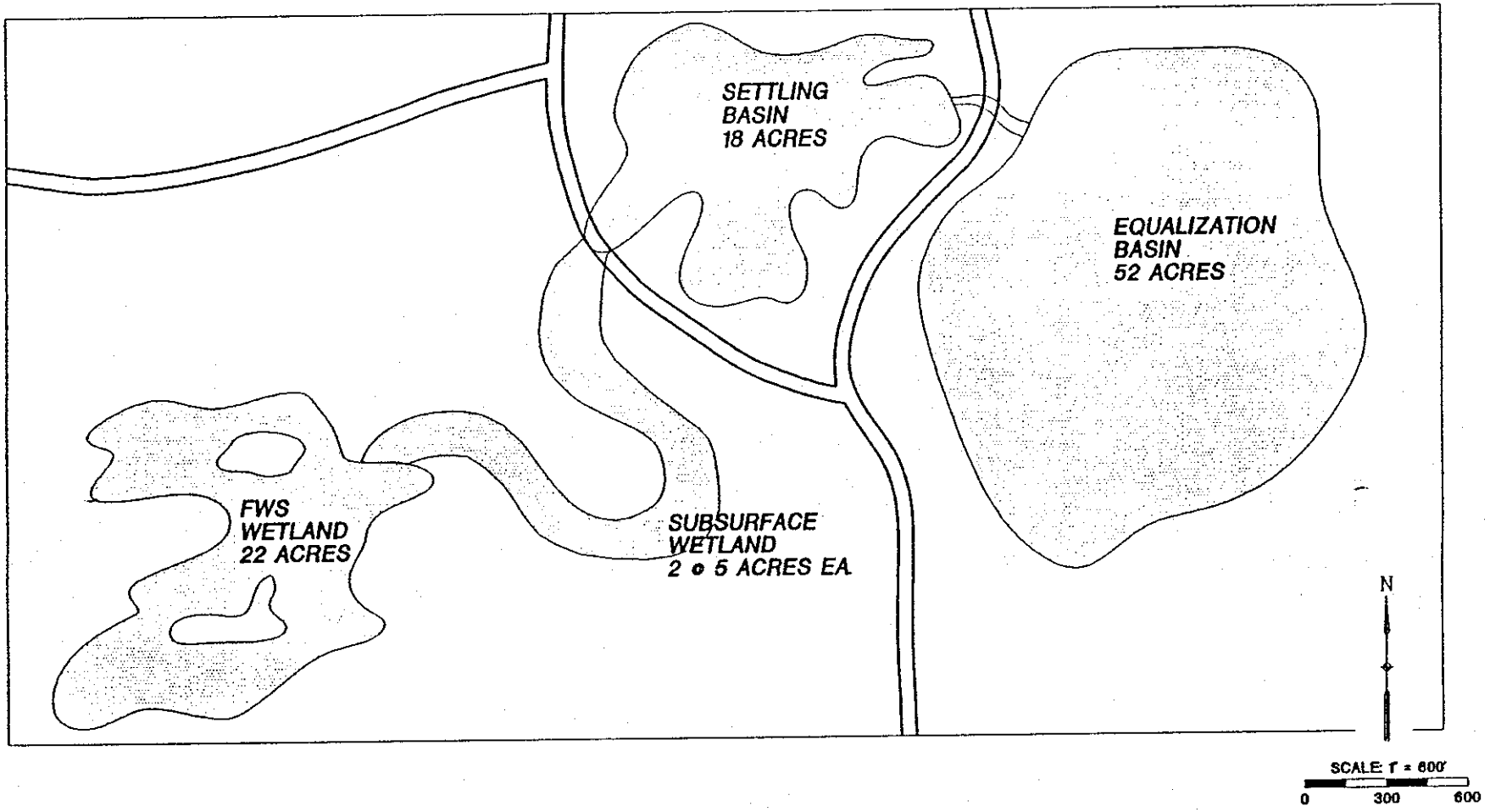
NOT TO SCALE

AVONDALE

Water Treatment Facility Plan - Cross-Sectional View - Option 'A'

Project No.: 934X071A	May 1993	FIGURE 5

Woodward-Clyde

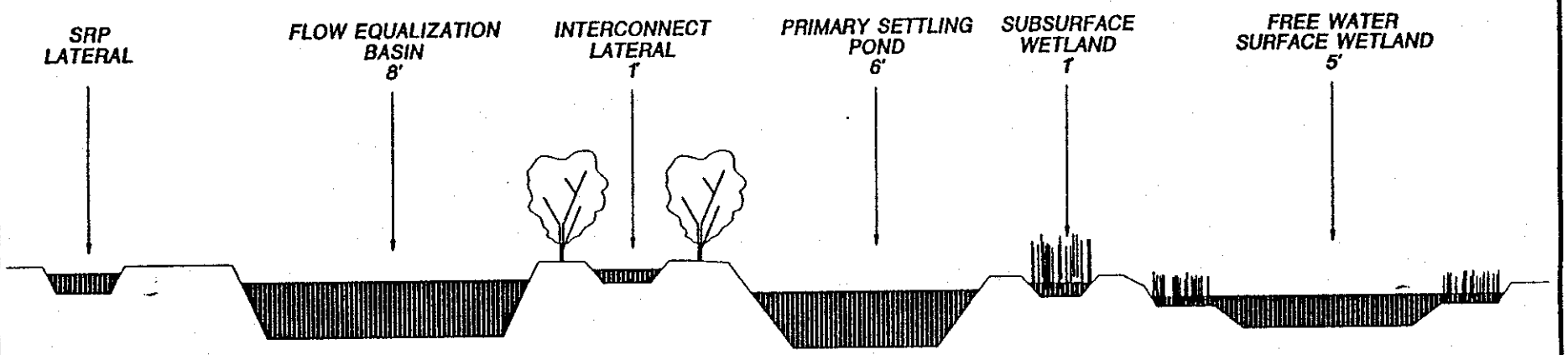


AVONDALE

Water Treatment Facility Plan - Option 'B'

Project No. : 934X071A	May 1993	FIGURE 6

Woodward-Clyde



AVONDALE

Water Treatment Facility Plan - Cross-Sectional View - Option 'B'

Project No.: 934X071A	May 1993	FIGURE 7

Woodward-Clyde

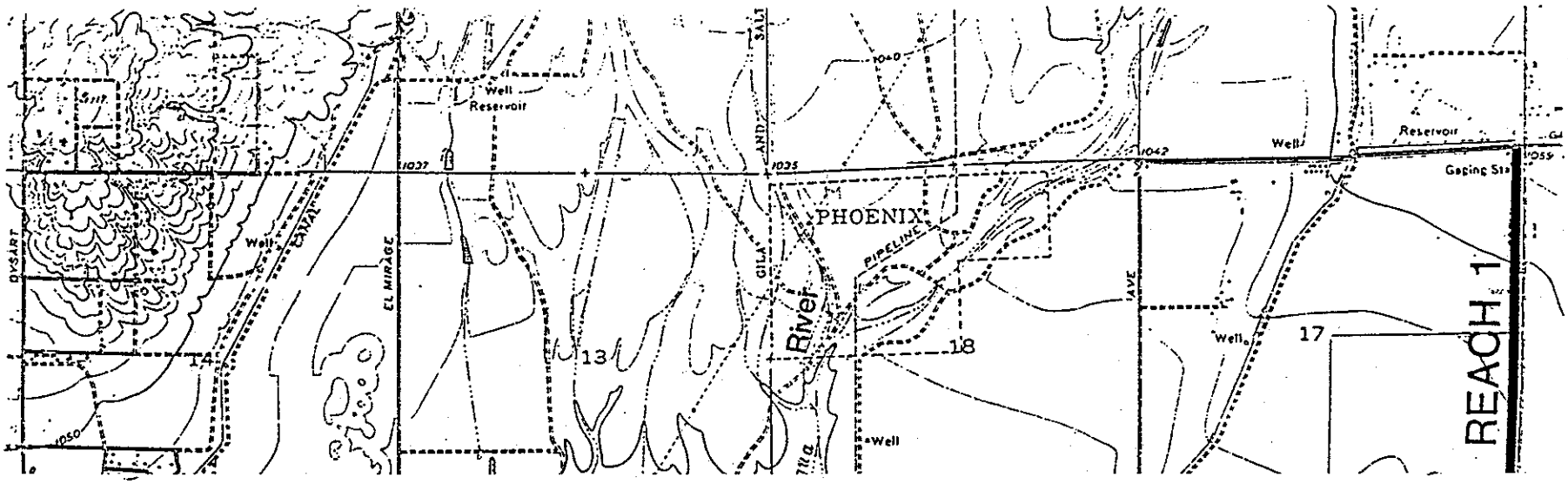
TABLE 1 **Optional Design Parameters for the Avondale Constructed Wetlands**

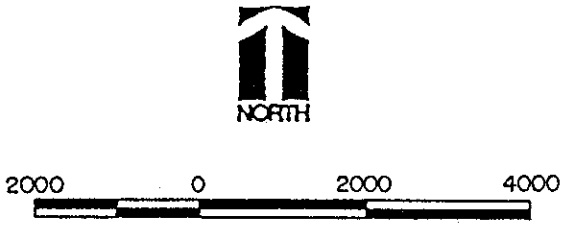
COMPONENT	APPROXIMATE VOLUME (Acre Feet)	APPROXIMATE MEAN DEPTH (Feet)	APPROXIMATE AREA (Acres)
Equalization Basin			
Option A	415	6	70
Option B	415	8	52
Primary Settling Basin	110	6	18
Subsurface Wetlands	NA	NA	10
FWS Wetland			
Option A	110	3	35
Option B	110	5	22
	Total acreage with Option A		134
	Total acreage with Option B		102

APPENDIX B

MAP SHOWING LOCATION OF WATER CONVEYANCE CANALS

WATER CONVEYANCE CANALS





Appendix B

WILLDAN ASSOCIATES
MUNICIPAL ENGINEERS

APPENDIX C

WATER QUALITY DATA FOR GRAND CANAL

MAJOR INORGANICS

SRP
602-236-5545
805 965 0343

SITE CODE=SVLT2-23-0

TE	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
1	15	1985	41.00	14.00	82.00	4.00	159.00
2	15	1985	41.00	17.00	79.00	4.00	171.00
3	15	1985	36.00	15.00	64.00	4.00	164.00
4	15	1985	42.00	15.00	71.00	4.00	171.00
5	15	1985	38.00	15.00	62.00	2.00	153.00
7	15	1985	40.00	13.00	62.00	3.00	149.00
9	15	1985	41.00	14.00	67.00	2.00	144.00
9	15	1985	43.00	14.00	74.00	4.00	140.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	√ FLUORIDE (MGL)	√ NITRATE (MGL) (@ NO3).	TOTAL DISSOLVED SOLIDS (MGL)
0.00	42.00	113.00	0.38	0.00	374
0.00	46.00	97.00	0.57	9.00	377
0.00	39.00	95.00	0.38	6.00	340
0.00	37.00	112.00	0.38	6.00	371
0.00	39.00	89.00	0.19	1.00	321
0.00	29.00	99.00	0.38	14.00	333
0.00	49.00	99.00	0.57	8.00	351
0.00	45.00	116.00	0.19	2.00	367

TOTAL RDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
160.00	30.00	130.00	665	8.0	0.100
172.00	32.00	140.00	680	7.9	0.120
152.00	17.00	135.00	690	7.6	0.110
167.00	27.00	140.00	750	7.6	0.100
157.00	32.00	125.00	620	8.1	0.080
153.00	31.00	122.00	620	7.2	0.350
160.00	42.00	118.00	690	8.0	0.010
165.00	50.00	115.00	620	7.5	0.160

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	18.64	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
11	5	1985	33.00	17.00	30.00	2.00	129.00
2	2	1985	48.00	23.00	70.00	11.00	151.00
1	7	1986	41.00	18.00	65.00	3.00	176.00
2	4	1986	52.00	40.00	51.00	4.00	198.00
3	11	1986	37.00	17.00	51.00	2.00	159.00
4	1	1986	46.00	13.00	77.00	7.00	142.00
5	6	1986	43.00	15.00	91.00	3.00	154.00
6	3	1986	40.00	15.00	96.00	3.00	142.00

BONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL) (as NO_3)	TOTAL DISSOLVED SOLIDS (MGL)
7.00	29.00	48.00	0.57	10.00	239
0.00	66.00	134.00	0.19	16.00	442
10.00	45.00	91.00	0.76	4.00	364
12.00	82.00	86.00	0.57	27.00	451
12.00	39.00	62.00	0.38	6.00	304
5.00	46.00	125.00	0.57	10.00	399
0.00	47.00	140.00	0.38	16.00	431
12.00	66.00	124.00	0.38	6.00	432

TOTAL RDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
152.00	34.00	118.00	450	8.4	0.080
216.00	92.00	124.00	810	7.9	0.150
179.00	19.00	160.00	590	8.3	0.020
295.00	113.00	182.00	520	8.4	0.230
163.00	13.00	150.00	680	8.3	0.130
170.00	46.00	124.00	800	8.3	0.110
171.00	45.00	126.00	780	8.2	0.120
163.00	27.00	136.00	820	8.4	0.200

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.32	.	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
7	1	1986	46.00	16.00	87.00	4.00	165.00
8	5	1986	47.00	17.00	98.00	4.00	183.00
9	2	1986	41.00	17.00	92.00	4.00	153.00
10	7	1986	41.00	23.00	31.00	3.00	183.00
11	18	1986	37.00	26.00	35.00	2.00	196.00
12	23	1986	38.00	25.00	34.00	1.00	201.00
1	6	1987	46.00	16.00	90.00	2.00	177.00
2	3	1987	45.00	13.00	94.00	4.00	162.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	54.00	144.00	0.23	1.00	433
0.00	58.00	136.00	0.19	1.00	451
6.00	46.00	154.00	0.19	2.00	437
6.00	39.00	42.00	0.19	3.00	278
0.00	49.00	48.00	0.38	6.00	299
12.00	51.00	24.00	0.19	1.00	285
0.00	48.00	131.00	0.19	1.00	421
0.00	47.00	142.00	0.19	1.00	426

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
183.00	48.00	135.00	720	8.2	0.050
187.00	37.00	150.00	720	8.2	0.030
175.00	40.00	135.00	760	7.9	0.030
196.00	36.00	160.00	510	8.5	0.160
198.00	37.00	161.00	502	8.4	0.170
197.00	12.00	185.00	495	8.1	0.160
181.00	36.00	145.00	800	8.1	0.100
168.00	35.00	133.00	835	8.2	0.080

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	15.45	.	.	.
0.00	20.32	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

NTH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
2	10	1987	44.00	16.00	85.00	2.00	189.00
2	17	1987	41.00	15.00	87.00	2.00	122.00
2	24	1987	38.00	20.00	54.00	2.00	207.00
3	3	1987	37.00	22.00	43.00	2.00	226.00
3	10	1987	40.00	24.00	33.00	2.00	201.00
3	17	1987	41.00	19.00	62.00	3.00	183.00
3	24	1987	40.00	22.00	44.00	4.00	183.00
3	31	1987	43.00	14.00	98.00	6.00	122.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	55.00	117.00	0.19	1.00	413
18.00	46.00	131.00	0.19	1.00	401
0.00	39.00	71.00	0.19	1.00	327
0.00	30.00	41.00	0.38	1.00	287
24.00	38.00	27.00	0.19	4.00	291
0.00	60.00	82.00	0.00	1.00	358
18.00	47.00	50.00	0.19	1.00	316
24.00	54.00	138.00	0.00	1.00	438

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
176.00	21.00	155.00	760	8.1	0.130
165.00	35.00	130.00	695	8.1	0.110
178.00	8.00	170.00	605	8.2	0.130
181.00	0.00	185.00	575	8.1	0.130
201.00	0.00	205.00	325	8.5	0.140
180.00	30.00	150.00	665	8.1	0.100
194.00	14.00	180.00	590	8.1	0.140
166.00	26.00	140.00	810	8.2	0.090

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
4	7	1987	46.00	13.00	98.00	2.00	177.00
4	14	1987	43.00	13.00	97.00	3.00	140.00
4	21	1987	43.00	16.00	88.00	3.00	146.00
5	5	1987	43.00	16.00	100.00	4.00	146.00
5	12	1987	46.00	16.00	105.00	3.00	165.00
5	19	1987	44.00	16.00	111.00	3.00	153.00
5	26	1987	47.00	16.00	110.00	4.00	165.00
6	2	1987	51.00	15.00	113.00	4.00	159.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	28.00	152.00	0.00	1.00	427
12.00	53.00	142.00	0.00	1.00	433
18.00	56.00	128.00	0.00	1.00	425
6.00	64.00	131.00	0.19	2.00	438
0.00	56.00	160.00	0.00	2.00	469
0.00	61.00	156.00	0.00	1.00	467
0.00	63.00	160.00	0.00	1.00	482
0.00	67.00	174.00	0.00	1.00	503

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
170.00	25.00	145.00	840	7.8	0.100
159.00	24.00	135.00	840	8.3	0.090
176.00	26.00	150.00	775	8.1	0.100
172.00	42.00	130.00	820	8.1	0.100
180.00	45.00	135.00	875	8.2	0.140
177.00	52.00	125.00	825	8.1	0.100
182.00	47.00	135.00	850	7.6	0.130
186.00	56.00	130.00	850	8.0	0.080

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

NTH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
6	9	1987	48.00	18.00	94.00	5.00	201.00
6	16	1987	49.00	23.00	104.00	1.00	183.00
6	26	1987	44.00	18.00	79.00	3.00	183.00
7	1	1987	46.00	19.00	86.00	5.00	177.00
7	6	1987	46.00	18.00	85.00	5.00	183.00
7	13	1987	45.00	21.00	86.00	5.00	171.00
7	20	1987	45.00	18.00	92.00	4.00	178.00
7	27	1987	44.00	17.00	87.00	4.00	190.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	62.00	138.00	0.00	1.00	465
0.00	106.00	145.00	0.00	5.00	523
0.00	53.00	109.00	0.00	2.00	398
0.00	58.00	128.00	0.00	3.00	432
0.00	54.00	126.00	0.00	1.00	425
0.00	66.00	131.00	0.00	6.00	444
0.00	53.00	131.00	0.00	5.00	436
0.00	48.00	114.00	0.00	1.00	408

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
195.00	30.00	165.00	820	7.9	0.090
217.00	67.00	150.00	880	8.1	0.050
185.00	35.00	150.00	730	7.7	0.070
193.00	48.00	145.00	760	8.3	0.090
190.00	40.00	150.00	730	8.3	0.060
197.00	57.00	140.00	780	8.2	0.170
189.00	43.00	146.00	745	8.3	0.140
181.00	25.00	156.00	700	8.2	0.100

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

SITE CODE=SVLT2-23-0
(continued)

MONTH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
8	3	1987	44.00	15.00	98.00	3.00	131.00
8	10	1987	46.00	16.00	112.00	4.00	159.00
8	17	1987	49.00	13.00	123.00	4.00	157.00
8	25	1987	41.00	16.00	97.00	4.00	147.00
8	31	1987	44.00	15.00	101.00	3.00	162.00
9	10	1987	44.00	13.00	115.00	4.00	165.00
9	16	1987	44.00	14.00	118.00	5.00	153.00
9	30	1987	43.00	13.00	118.00	5.00	153.00

CARBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
12.00	53.00	147.00	0.00	1.00	437
0.00	46.00	190.00	0.00	0.00	492
0.00	58.00	181.00	0.00	1.00	506
0.00	55.00	133.00	0.38	0.00	418
0.00	53.00	145.00	0.00	2.00	443
0.00	58.00	169.00	0.19	0.00	484
0.00	57.00	177.00	0.19	1.00	491
0.00	52.00	170.00	0.19	0.00	476

TOTAL HARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
171.00	43.00	128.00	750	8.4	0.080
181.00	51.00	130.00	865	8.3	0.070
174.00	45.00	129.00	950	8.2	0.110
167.00	47.00	121.00	780	8.3	0.110
171.00	38.00	133.00	810	8.2	0.090
165.00	30.00	135.00	820	8.1	0.140
167.00	42.00	125.00	890	8.3	0.120
162.00	37.00	125.00	880	8.1	0.110

PHOSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

SITE CODE=SVLT2-23-0
(continued)

NTH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
10	7	1987	37.00	20.00	28.00	2.00	201.00
10	13	1987	38.00	20.00	34.00	3.00	201.00
10	19	1987	34.00	21.00	31.00	3.00	153.00
10	26	1987	33.00	23.00	32.00	3.00	177.00
11	4	1987	34.00	18.00	38.00	13.00	183.00
11	10	1987	33.00	21.00	43.00	15.00	195.00
12	16	1987	74.00	43.00	90.00	7.00	177.00
12	22	1987	41.00	23.00	54.00	56.00	275.00

ARBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	35.00	24.00	0.19	1.00	246
0.00	32.00	33.00	0.00	1.00	260
18.00	40.00	32.00	0.19	2.00	256
18.00	39.00	29.00	0.00	1.00	265
0.00	42.00	52.00	0.19	4.00	291
6.00	48.00	52.00	0.19	2.00	316
0.00	103.00	195.00	0.38	40.00	639
0.00	59.00	78.00	0.95	7.00	453

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
175.00	10.00	165.00	430	8.3	1.280
176.00	11.00	165.00	490	8.3	0.200
170.00	15.00	155.00	490	8.5	0.120
177.00	2.00	175.00	480	8.4	0.130
159.00	9.00	150.00	520	7.9	0.120
171.00	1.00	170.00	540	8.3	0.220
363.00	218.00	145.00	1200	7.8	0.210
198.00	0.00	225.00	740	7.9	0.150

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
1.58	.	.	.	.
0.95	.	.	.	.
0.00	0.00	.	.	.
1.90	.	.	.	.

GRAND CANAL AT 5TH AVE
MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
12	29	1987	38.00	24.00	40.00	3.00	195.00
1	5	1988	40.00	28.00	44.00	4.00	195.00
1	11	1988	39.00	29.00	45.00	4.00	189.00
1	19	1988	23.00	9.00	22.00	14.00	113.00
1	25	1988	53.00	29.00	51.00	5.00	140.00
2	2	1988	35.00	28.00	35.00	3.00	217.00
2	8	1988	39.00	26.00	37.00	4.00	195.00
2	15	1988	39.00	25.00	32.00	3.00	226.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
6.00	48.00	41.00	0.00	2.00	298
6.00	55.00	57.00	0.57	5.00	335
12.00	50.00	60.00	0.38	4.00	336
0.00	24.00	35.00	0.95	6.00	189
0.00	70.00	128.00	0.19	22.00	427
9.00	43.00	29.00	0.38	7.00	296
18.00	45.00	39.00	0.38	4.00	308
6.00	41.00	25.00	0.19	1.00	283

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
192.00	22.00	170.00	540	8.0	0.150
214.00	44.00	170.00	600	8.5	0.160
215.00	40.00	175.00	580	8.5	0.100
94.00	1.00	93.00	370	8.1	0.070
252.00	137.00	115.00	750	8.1	0.080
201.00	9.00	193.00	550	7.9	0.130
205.00	15.00	190.00	570	8.3	0.150
200.00	5.00	195.00	490	8.4	0.210

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

SITE CODE=SVLT2-23-0
(continued)

NTH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
2	23	1988	35.00	23.00	30.00	2.00	220.00
3	1	1988	42.00	14.00	113.00	4.00	159.00
3	7	1988	42.00	14.00	114.00	2.00	159.00
3	14	1988	41.00	14.00	111.00	3.00	171.00
3	22	1988	39.00	17.00	89.00	4.00	177.00
3	29	1988	40.00	16.00	97.00	4.00	171.00
4	5	1988	39.00	18.00	89.00	7.00	165.00
4	11	1988	38.00	16.00	96.00	5.00	183.00

ARBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
6.00	42.00	21.00	0.38	1.00	268
6.00	67.00	161.00	0.19	0.00	485
6.00	53.00	167.00	0.19	1.00	477
0.00	55.00	158.00	0.38	1.00	467
12.00	44.00	119.00	0.19	1.00	412
12.00	46.00	138.00	0.38	1.00	438
12.00	45.00	128.00	0.38	1.00	420
0.00	47.00	149.00	0.19	1.00	442

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
181.00	0.00	190.00	490	8.4	0.100
164.00	24.00	140.00	870	8.3	0.100
163.00	23.00	140.00	870	8.3	0.070
160.00	20.00	140.00	880	8.3	0.090
169.00	4.00	165.00	800	8.7	0.120
164.00	4.00	160.00	760	8.3	0.090
171.00	16.00	155.00	775	8.5	0.180
161.00	11.00	150.00	840	8.3	0.170

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

NTH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
4	18	1988	36.00	18.00	60.00	2.00	201.00
4	25	1988	38.00	16.00	89.00	5.00	189.00
5	3	1988	35.00	19.00	27.00	3.00	201.00
5	9	1988	40.00	16.00	83.00	3.00	177.00
5	16	1988	41.00	17.00	75.00	3.00	180.00
5	24	1988	41.00	16.00	74.00	4.00	171.00
5	31	1988	43.00	14.00	104.00	3.00	159.00
6	7	1988	39.68	13.38	127.80	-3.13	158.65

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
18.00	39.00	69.00	0.19	1.00	342
0.00	51.00	126.00	0.19	1.00	419
12.00	35.00	22.00	0.19	1.00	253
6.00	43.00	118.00	0.19	0.00	396
9.00	55.00	113.00	0.19	1.00	403
12.00	49.00	117.00	0.19	1.00	398
12.00	58.00	170.00	0.19	6.00	488
12.00	47.07	145.39	0.19	1.24	465

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
164.00	0.00	195.00	630	8.5	0.080
162.00	7.00	155.00	800	8.4	0.310
168.00	0.00	185.00	490	8.6	0.130
165.00	10.00	155.00	800	8.5	0.110
174.00	12.00	163.00	690	8.2	0.120
168.00	8.00	160.00	730	8.5	0.120
166.00	16.00	150.00	865	8.4	0.090
154.16	4.02	150.14	830	8.4	0.070

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
0.00	0.00	.	.	.
-0.95	.	.	.	.

SITE CODE=SVLT2-23-0
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
6	13	1988	39.68	14.35	121.80	4.69	152.55
6	20	1988	39.68	13.98	121.50	3.52	170.86
6	28	1988	42.08	16.05	122.10	4.69	158.65
7	6	1988	43.29	15.56	158.40	3.52	152.55
7	11	1988	40.08	14.71	121.20	5.08	146.45
7	18	1988	39.48	14.71	112.20	3.52	158.65
7	25	1988	38.68	16.90	135.90	3.52	158.65
8	2	1988	40.88	12.89	137.70	4.69	152.55

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
12.00	49.95	139.71	0.19	-1.24	457
6.00	52.83	156.02	0.19	1.24	479
12.00	53.79	155.31	0.19	-1.24	484
6.00	69.64	200.35	0.19	3.72	575
12.00	50.91	142.55	0.19	1.24	460
6.00	50.91	134.04	0.19	2.48	441
6.00	50.91	173.75	0.19	1.24	505
6.00	47.07	172.34	0.19	1.24	498

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
158.17	13.03	145.14	790	8.5	0.120
156.67	6.52	150.14	810	8.4	0.110
171.18	21.04	150.14	770	8.4	0.150
172.18	37.05	135.13	960	8.4	0.110
160.67	20.54	140.13	760	8.4	0.140
159.17	19.03	140.13	850	8.4	0.100
166.18	26.05	140.13	850	8.4	0.060
155.16	20.03	135.13	820	8.4	0.110

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.

MAJOR INORGANICS

---------- SITE CODE=SVLT2-23-0 ----------
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
8	10	1988	42.28	14.71	138.60	3.52	152.55
8	15	1988	41.68	14.71	121.50	3.13	158.65
8	24	1988	42.08	13.98	139.50	-3.13	170.86
8	29	1988	31.46	8.63	104.10	3.13	176.96
9	7	1988	45.29	13.50	180.30	5.47	183.06
9	13	1988	41.08	13.38	174.60	-3.13	170.86
9	19	1988	42.08	14.35	188.10	5.08	164.75
9	28	1988	43.29	15.81	182.40	5.08	170.86

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
6.00	50.91	158.86	0.19	1.24	491
6.00	49.95	143.26	0.19	2.48	461
0.00	48.99	143.97	0.19	1.86	474
0.00	43.23	110.64	0.19	18.60	407
0.00	31.22	205.67	0.19	1.86	573
0.00	28.82	212.76	0.19	2.48	557
0.00	26.42	207.44	0.19	1.24	566
0.00	74.45	202.12	0.19	21.70	629

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
166.17	31.04	135.13	850	8.3	0.090
164.67	24.54	140.13	770	8.5	0.090
162.67	22.53	140.14	820	8.3	0.070
114.12	0.00	145.14	630	7.6	0.080
168.67	18.53	150.15	1000	8.2	0.090
157.66	17.53	140.14	1030	8.2	0.080
164.17	29.04	135.13	960	8.4	0.110
173.18	33.05	140.14	1020	8.0	0.130

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.

SITE CODE=SVLT2-23-0
(continued)

TE	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
10	4	1988	36.27	13.38	149.40	3.52	164.75
10	10	1988	48.30	29.91	206.10	4.30	183.06
10	18	1988	37.88	13.25	75.30	4.69	183.06
10	25	1988	30.66	18.00	51.60	-3.13	170.86
11	3	1988	29.86	18.97	48.90	3.13	195.26
11	8	1988	34.07	19.46	69.00	3.13	213.57
11	17	1988	38.08	22.62	51.00	3.91	225.77
1	17	1989	61.30	38.90	74.70	5.10	177.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	62.44	171.98	0.19	-1.24	518
0.00	54.75	176.59	0.19	1.24	611
0.00	50.91	80.14	0.19	8.68	361
6.00	46.11	42.91	0.19	1.86	281
12.00	41.31	33.33	0.38	1.24	285
24.00	41.31	60.64	0.19	1.24	358
0.00	38.90	55.67	0.38	8.68	330
0.00	180.00	96.70	0.33	16.30	560

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
145.65	10.52	135.13	870	8.5	0.130
243.78	93.63	150.15	870	8.5	0.140
149.16	0.00	150.15	615	8.3	0.100
150.67	0.53	150.14	480	8.5	0.130
152.68	0.00	180.17	550	8.5	0.170
165.19	0.00	215.20	550	8.6	0.130
188.22	3.04	185.18	570	8.2	0.130
313.00	168.00	145.00	380	7.9	0.200

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-0.95	.	.	.	.
-1.00	.	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

NTH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
2	16	1989	37.20	24.40	32.30	3.20	201.00
3	23	1989	47.20	15.20	101.00	5.58	195.00
4	21	1989	48.00	15.70	131.00	5.40	165.00
5	25	1989	48.40	13.40	136.00	4.20	171.00
6	20	1989	48.00	17.90	122.00	4.40	189.00
7	19	1989	47.50	17.00	123.00	8.20	195.00
8	15	1989	44.60	17.40	119.00	3.90	195.00
9	27	1989	45.20	15.70	129.00	3.80	171.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
24.00	45.30	21.60	0.34	1.50	288
0.00	46.00	157.00	0.27	-1.00	468
0.00	46.40	205.00	0.29	2.40	535
0.00	70.00	195.00	0.33	1.00	552
0.00	47.90	192.00	0.28	-1.00	525
0.00	38.00	160.00	0.27	1.10	491
0.00	53.90	200.00	0.26	1.50	536
0.10	41.10	157.00	0.30	1.20	477

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
193.00	28.00	165.00	520	8.6	0.150
180.00	20.00	160.00	1140	8.1	0.110
180.00	45.00	135.00	980	7.8	0.110
180.00	40.00	140.00	1010	8.1	-0.080
190.00	35.00	155.00	1040	8.4	0.120
189.00	29.00	160.00	1020	7.7	0.090
183.00	23.00	160.00	1010	8.2	0.100
110.00	0.00	140.00	985	8.4	0.110

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.

MAJOR INORGANICS

SITE CODE=SVLT2-23-0
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
10	19	1989	34.70	31.00	47.40	3.50	275.00
11	15	1989	60.90	44.40	99.60	4.60	268.00
12	13	1989	52.70	40.40	68.90	4.30	279.00
2	20	1990	55.60	40.20	94.70	4.90	238.00
2	20	1990	56.40	39.90	94.80	4.20	256.00
3	20	1990	66.80	44.80	102.00	3.10	281.00
5	1	1990	88.10	55.20	131.00	5.30	220.00
5	24	1990	82.70	49.00	129.00	4.90	201.00

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	72.60	33.90	0.36	1.80	360
0.00	124.00	141.00	0.61	11.80	618
15.00	88.40	67.90	0.42	8.80	484
0.00	90.70	127.00	0.46	X24.00	554
0.00	89.00	126.00	0.46	24.70	561
0.00	97.70	185.00	0.52	36.40	674
0.00	99.90	263.00	0.50	63.00	814
0.00	120.00	299.00	0.44	60.00	843

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
214.00	0.00	225.00	615	8.4	0.190
334.00	114.00	220.00	1035	8.3	0.420
298.00	73.00	225.00	845	8.5	0.250
304.00	109.00	195.00	1000	8.1	0.520
304.00	94.00	210.00	975	8.2	0.210
351.00	121.00	230.00	1220	8.2	0.590
446.00	266.00	180.00	1320	8.3	0.470
408.00	243.00	165.00	1470	8.2	0.420

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.
-1.00	.	.	.	.

SITE CODE=SVLT2-23-0
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
6	21	1990	69.40	37.70	162.00	4.40	183.00
7	25	1990	60.50	31.50	152.00	5.30	329.00
8	22	1990	73.70	43.60	124.00	4.10	342.00
9	20	1990	77.30	45.80	109.00	5.50	299.00
10	23	1990	92.00	48.40	120.00	4.30	215.94
11	14	1990	68.20	41.30	79.20	3.10	263.52
1	23	1991	102.00	58.40	109.00	6.80	267.18
2	20	1991	76.20	45.40	81.10	5.80	200.08

RBONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)
0.00	92.10	285.00	0.48	38.60	779
0.00	77.00	224.00	0.42	42.50	755
0.00	104.00	256.00	0.31	55.50	829
0.00	95.50	242.00	0.39	54.90	777
10.80	130.00	257.00	0.45	53.80	822
3.60	92.10	111.00	0.31	35.60	564
0.00	95.30	239.00	0.29	82.10	824
0.00	87.20	214.00	0.43	80.10	688

TOTAL ARDNESS (MGL)	NON CARBONATE HARDNESS (MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)
328.00	178.00	150.00	1260	7.8	0.250
280.00	10.00	270.00	1320	8.0	0.270
363.00	83.00	280.00	1300	8.1	0.310
381.00	136.00	245.00	1400	8.1	0.380
428.00	251.00	177.00	1370	8.1	0.480
339.00	123.00	216.00	1070	8.1	0.290
494.00	275.00	219.00	1390	7.9	0.370
377.00	213.00	164.00	1140	8.3	0.310

OSPHATE (MGL)	SILICA (MGL)	BORON DISSOLVED (MGL)	BROMIDE (MGL)	CALCIUM DISSOLVED (MGL)
-1.00	.	.	.	.
-0.08	.	.	.	.
-0.08	.	.	.	.
-0.08	.	.	.	.
-0.08	.	.	.	.
-0.08	.	.	.	.
-0.08	.	.	.	.
-0.08	.	.	.	.

GRAND CANAL AT LATERAL 23 (99TH AVE)
MAJOR INORGANICS

---------- SITE CODE=SVLT2-23-0 ----------
(continued)

TH	DAY	YEAR	CALCIUM (MGL)	MAGNESIUM (MGL)	SODIUM (MGL)	POTASSIUM (MGL)	BICARBONATE (MGL)
3	12	1991	43.80	16.00	116.00	3.80	80.50
4	17	1991	47.00	17.50	128.00	16.30	143.00
5	15	1991	48.70	17.90	142.00	4.30	84.20
6	12	1991	51.30	19.20	182.00	23.00	45.80
7	24	1991	48.70	16.50	161.00	4.20	39.70
8	21	1991	46.30	16.80	147.00	6.10	40.30
9	18	1991	47.20	14.90	155.00	6.00	76.90
10	15	1991	58.80	25.70	153.00	5.50	75.60
1	13	1991	43.90	21.50	36.70	4.00	111.00
2	18	1991	40.70	18.10	85.00	7.30	102.00
2	18	1992	36.10	18.60	26.10	-2.00	101.00
3	24	1992	39.90	13.70	104.00	4.50	86.60
4	21	1992	43.80	15.00	103.00	-2.00	115.00

BONATE (MGL)	SULFATE (MGL)	CHLORIDE (MGL)	FLUORIDE (MGL)	NITRATE (MGL)	TOTAL DISSOLVED SOLIDS (MGL)	TOTAL HARDNESS (MGL)
0.00	42.40	181.00	0.28	2.13	445	175.00
0.00	56.70	204.00	0.23	-1.80	540	189.00
0.00	54.00	248.00	0.25	4.77	561	195.00
0.00	64.00	299.00	0.27	8.62	# 670	207.00
0.00	51.50	265.00	0.22	-1.80	566	189.00
0.00	50.70	220.00	0.21	-1.80	507	185.00
0.00	50.50	237.00	0.22	-1.80	548	174.00
0.00	73.10	248.00	0.29	16.20	617	252.00
0.00	49.40	50.90	0.20	15.20	276	198.00
0.00	46.10	127.00	0.20	-1.80	374	175.00
0.00	32.20	19.80	0.22	-1.80	L 182	167.00
0.00	42.00	165.00	0.27	-1.80	412	156.00
0.00	30.40	174.00	0.27	-1.80	423	171.00

NON RBONATE DNESS MGL)	ALKALINITY (MGL)	CONDUCTIVITY, LAB (MICROMHOS)	PH, LAB	BORON (MGL)	PHOSPHATE (MGL)	SILICA (MGL)
43.00	132.00	900	8.0	0.13	0.11	.
102.00	87.20	960	8.3	0.13	-0.08	.
57.00	138.00	1140	7.9	-0.06	-0.08	.
132.00	75.00	1380	7.9	0.15	-0.08	.
124.00	65.00	1210	8.4	0.19	-0.08	.
119.00	66.00	1030	8.1	0.13	-0.08	.
48.00	126.00	1090	8.2	0.21	-0.08	.
128.00	124.00	1130	8.7	0.22	0.14	.
.00	182.00	540	8.1	0.14	-0.08	.
8.00	167.00	805	8.0	0.14	0.14	.
1.00	166.00	445	8.3	0.11	-0.08	13.00
14.00	142.00	840	8.2	0.16	-0.08	19.50
0.00	189.00	830	8.2	0.05	-0.08	27.40

APPENDIX D

WATER QUALITY RESULTS FROM AVONDALE WELLS

Drinking Water Quality

INORGANIC CHEMICAL ANALYSIS REPORTING FORM

Before completing, please read instructions on reverse side.

#9101689
SPECIMEN NO.

02/21/91
DATE RECEIVED

NOTE: WATER SYSTEM MUST COMPLETE ALL BLANKS INSIDE THIS BOX

PWS ID. NO. (1-7): 0 4 0 7 0 8 8

LAB NAME & ADDRESS

WESTECH LABORATORIES, INC.
3737 EAST BROADWAY ROAD
P.O. BOX 20946
PHOENIX ARIZONA 85036

LAB ID.NO (42-46): 0 0 0 1 0

SAMPLE DATE (31-36): Month 0 2, Day 2 0, Year 9 1

SAMPLE
Type (37): D
Time (Hours) (38-41): 1 3 3 5

WATER SYSTEM NAME: CITY OF AVONDALE

SAMPLING POINT - WELL NO. OR EXACT LOCATION: WELL #6

MAILING NAME & ADDRESS

CITY OF AVONDALE
ATTN R. SULLINS
525 N. CENTRAL AVE.
AVONDALE, AZ 85323

SAMPLE APPEARANCE
- [X] Clear
- [ ] Turbid
- [ ] Other (comment)

WATER SUPPLY
- [X] Well
- [ ] Surface

SAMPLER'S COMMENTS OR INSTRUCTIONS

Sample Type Codes
C - Check Sample
D - Regular Distribution Sample
P - Plant Tap Sample
R - Raw Water Sample
S - Special Sample

CONTAMINANT CODE (10-13)	ANALYSIS METHOD (14-16)	CONTAMINANT NAME	(MCL)	ANALYSIS RESULTS (mg/l) (17-20)	EXCEEDS
1005	101	Arsenic	(0.05)	0.033	
1010	101	Barium	(1.0)	<0.05	
1015	101	Cadmium	(0.010)	<0.0005	
1020	101	Chromium	(0.05)	0.015	
1025	107	Fluoride	(1.4-2.0)	1.6	
1030	101	Lead	(0.05)	0.013	
1035	103	Mercury	(.002)	<0.001	
1040	109	Nitrates (N)	(10.)	3.2	
1045	101	Selenium	(0.01)	<0.005	
1050	101	Silver	(0.05)	<0.002	
1927	149	Alkalinity		140.	
1016	101	Calcium		16.	
1017	149	Chloride		52.	
1022	101	Copper		<0.05	
1915	141	Hardness		65.	
1028	101	Iron		<0.05	
1031	101	Magnesium		6.2	
1032	101	Manganese		<0.05	
1925	135	pH		8.4	
1052	101	Sodium		94.	
1055	137	Sulfate		36.	
1930	139	TDS		330.	
1095	101	Zinc		<0.05	
		Langelier Index		0.27	

Pursuant to R9-8-223 Check Samples are REQUIRED for ANY and ALL contaminant(s) checked in the Exceeds Column.

LOCATION CODE (28-30)

ANALYSIS DATE (22-27): Month 0 3, Day 1 5, Year 9 1

COMMENTS

ANALYST

CLIENT COPY

DRINKING WATER QUALITY

INORGANIC CHEMICAL ANALYSIS REPORTING FORM

92-103836 (SPEC MEN NO)

Before completing, please read instructions on reverse side

06/02/92 (DATE REC'D)

NOTE: WATER SYSTEM MUST COMPLETE ALL BLANKS INSIDE THIS BOX

PWS ID NO. 0 4 0 7 0 8 8

LAB NAME AND ADDRESS (LAB NO) AZ 0 0 0 6

Steven B. Hankins, Director
ARIZONA TESTING LABORATORIES
810 East Hammond Lane
Phoenix, Arizona 85034 (602) 254-6181

SAMPLE DATE Mo. 0 6 Day 0 2 Yr. 9 2

SAMPLE Type: D (37) Time (Hrs.): 1 2 3 5 (36-41)

WATER SYSTEM NAME: City of Avondale

SAMPLING POINT—WELL NO. OR EXACT LOCATION: Well 6, Indian School & El Mirage

MAILING NAME AND ADDRESS
City of Avondale
Attn: Esmeralda Avila
525 North Central
Avondale, Arizona 85323

SAMPLE APPEARANCE
- [ ] Clear
- [ ] Turbid
- [ ] Other (comment)

WATER SUPPLY SOURCE
- [X] Well
- [ ] Surface

SAMPLE TYPE CODES
C - Check Sample
D - Regular Distribution Sample
P - Plant Tap Sample
R - Raw Water Sample
S - Special Sample

SAMPLER'S COMMENTS OR INSTRUCTIONS

CONTAMINANT CODE	ANALYSIS METHOD	CONTAMINANT NAME	(MCL)	ANALYSIS RESULTS (mg/l)	EXCEEDS
1005	101	Arsenic	(0.05)	0.027	
1010	101	Barium	(1.)	< 0.50	
1015	101	Cadmium	(0.010)	< 0.0050	
1020	101	Chromium	(0.05)	0.010	
1025	107	Fluoride	(1.4-2.0)	1.3	
1030	101	Lead	(0.05)	< 0.0020	
1035	103	Mercury	(.002)	< 0.0010	
1040	109	Nitrates (N)	(10.)	4.1	
1045	101	Selenium	(0.01)	< 0.0050	
1050	101	Silver	(0.05)	< 0.020	
1927	149	Alkalinity		120.	
1016	101	Calcium		14.	
1017	149	Chloride		68.	
1022	101	Copper		< 0.050	
1915	141	Hardness		60.	
1028	101	Iron		0.15	
1031	101	Magnesium		6.0	
1032	101	Manganese		< 0.050	
1925	135	pH		8.0	
1052	101	Sodium		110.	
1055	137	Sulfate		40.	
1930	139	TDS		330.	
1095	101	Zinc		< 0.050	

Pursuant to R9-8-223 check samples are REQUIRED for ANY and ALL contaminant(s) checked in the exceeds column.

LOCATION CODE (28-35): 92-103836

< = less than the practical quantitation limit (PQL) given

COMMENTS 2 cc: ADEQ, 1 cc: MCHD

ANALYST: Umesh Rao, Ph.D.

ANALYSIS DATE (22-27): Mo. 0 7 Day 2 9 Yr. 9 2

Drinking Water Quality

INORGANIC CHEMICAL ANALYSIS REPORTING FORM

Before completing, please read instructions on reverse side.

#9101690
SPECIMEN NO.

02/21/91
DATE RECEIVED

NOTE: WATER SYSTEM MUST COMPLETE ALL BLANKS INSIDE THIS BOX

PWS ID. NO.
0 4 0 7 0 8 8
1-7

LAB NAME & ADDRESS

LAB ID.NO. 0 0 0 1 0 (42-46)

WESTECH LABORATORIES, INC.
3737 EAST BROADWAY ROAD
P.O. BOX 20946
PHOENIX ARIZONA 85036

SAMPLE DATE		
Month	Day	Year
0 2	2 0	9 1

31-36

SAMPLE	
Type	Time (Hours)
D	1 4 0 8
37	38-41

WATER SYSTEM NAME
CITY OF AVONDALE

SAMPLING POINT - WELL NO. OR EXACT LOCATION
WELL #7

MAILING NAME & ADDRESS

CITY OF AVONDALE
ATTN R. SULLINS
525 N. CENTRAL AVE.
AVONDALE, AZ 85323

SAMPLE APPEARANCE	
X	Clear
	Turbid
	Other (comment)

WATER SUPPLY	
X	Well
	Surface

SAMPLER'S COMMENTS OR INSTRUCTIONS

Sample Type Codes
C - Check Sample
D - Regular Distribution Sample
P - Plant Tap Sample
R - Raw Water Sample
S - Special Sample

CONTAMINANT CODE	ANALYSIS METHOD	CONTAMINANT NAME	(MCL)	ANALYSIS RESULTS (mg/l)	EXCEEDS
1005	101	Arsenic	(0.05)	0.032	
1010	101	Barium	(1.0)	<0.05	
1015	101	Cadmium	(0.010)	<0.0005	
1020	101	Chromium	(0.05)	0.016	
1025	107	Fluoride	(1.4-2.0)	1.6	
1030	101	Lead	(0.05)	0.018	
1035	103	Mercury	(.002)	<0.001	
1040	109	Nitrates (N)	(10.)	3.4	
1045	101	Selenium	(0.01)	<0.005	
1050	101	Silver	(0.05)	<0.002	
1927	149	Alkalinity		140.	
1016	101	Calcium		15.	
1017	149	Chloride		54.	
1022	101	Copper		<0.05	
1915	141	Hardness		63.	
1028	101	Iron		<0.05	
1031	101	Magnesium		6.1	
1032	101	Manganese		<0.05	
1925	135	pH		8.4	
1052	101	Sodium		94.	
1055	137	Sulfate		35.	
1930	139	TDS		320.	
1095	101	Zinc		<0.05	
		Langelier Index		0.19	
10-13	14-16			17-20	

Pursuant to R9-8-223 Check Samples are REQUIRED for ANY and ALL contaminant(s) checked in the Exceeds Column

LOCATION CODE
28-30

ANALYSIS DATE		
Month	Day	Year
0 3	1 5	9 1

22-27

COMMENTS

ANALYST

CLIENT COPY

DRINKING WATER QUALITY

INORGANIC CHEMICAL ANALYSIS REPORTING FORM

92-103837
SPECIMEN NO

Before completing, please read instructions on reverse side.

06/02/92
DATE REC'D

NOTE: WATER SYSTEM MUST COMPLETE ALL BLANKS INSIDE THIS BOX

PWS ID NO.: 0 4 0 7 0 8 8

LAB NAME AND ADDRESS: AZ 0 0 0 6

Steven B. Hankins, Director
ARIZONA TESTING LABORATORIES
810 East Hammond Lane
Phoenix, Arizona 85034 (602) 254-6181

SAMPLE DATE (Mo. Day Yr): 0 6 0 2 9 2

SAMPLE — Type: D; Time (Hrs.): 1 2 2 0

WATER SYSTEM NAME: City of Avondale

SAMPLING POINT—WELL NO. OR EXACT LOCATION: Well 7, El Mirage Rd.

MAILING NAME AND ADDRESS:
City of Avondale
Attn: Esmeralda Avila
525 North Central
Avondale, Arizona 85323

SAMPLE APPEARANCE: Clear / Turbid / Other (comment)

WATER SUPPLY SOURCE: X Well / Surface

SAMPLE TYPE CODES
C - Check Sample
D - Regular Distribution Sample
P - Plant Tap Sample
R - Raw Water Sample
S - Special Sample

SAMPLER'S COMMENTS OR INSTRUCTIONS

CONTAMINANT CODE	ANALYSIS METHOD	CONTAMINANT NAME	(MCL)	ANALYSIS RESULTS (mg/l)	EXCEEDS
1005	101	Arsenic	(0.05)	0.021	
1010	101	Barium	(1.)	< 0.50	
1015	101	Cadmium	(0.010)	< 0.0050	
1020	101	Chromium	(0.05)	< 0.010	
1025	107	Fluoride	(1.4-2.0)	1.2	
1030	101	Lead	(0.05)	< 0.0020	
1035	103	Mercury	(.002)	< 0.0010	
1040	109	Nitrates (N)	(10.)	3.0	
1045	101	Selenium	(0.01)	< 0.0050	
1050	101	Silver	(0.05)	< 0.020	
9027	149	Alkalinity		160.	
1016	101	Calcium		22.	
1017	149	Chloride		38.	
0022	101	Copper		< 0.050	
9015	141	Hardness		100.	
1028	101	Iron		< 0.10	
0031	101	Magnesium		11.	
0032	101	Manganese		< 0.050	
9025	135	pH		7.8	
0052	101	Sodium		90.	
0055	137	Sulfate		44.	
9030	139	TDS		310.	
0095	101	Zinc		< 0.050	

Pursuant to R9-8-223 check samples are REQUIRED for ANY and ALL contaminant(s) checked in the exceeds column.

LOCATION CODE: 92-103837

< = less than the practical quantitation limit (PQL) given

COMMENTS 2 cc: ADEQ, 1 cc: MCHD

ANALYSIS DATE: 07 29 92

ANALYST: Umesh Rao, Ph.D.

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY
CORROSIVITY ANALYSIS REPORTING FORM

SPECIMEN NUMBER 92-104274 DATE REC'D 06/23/92

PWS ID NUMBER: Ø 4 0 7 0 8 8

LAB PERFORMING ANALYSIS NAME AND ADDRESS

Arizona Testing Laboratories
810 East Hammond Lane
Phoenix, Arizona 85034

LAB ID NUMBER: AZ 0 0 0 6

SAMPLE DATE: MO 0 6 DAY 2 3 YEAR 9 2

SAMPLE TYPE: D

SAMPLE TIME: 0 9 5 5

(PLEASE COMPLETE BOTTOM OF PAGE)

WATER SYSTEM NAME	SAMPLING POINT – WELL OR LEGAL NAME
City of Avondale	Well 7

SYSTEM MAILING NAME & ADDRESS
City of Avondale
Attn: Esmeralda Avila
525 North Central Ave.
Avondale, Arizona 85323

SAMPLE APPEARANCE	
	CLEAR
	TURBID
	OTHER (COMMENT)

SUPPLY SOURCE	
X	WELL
	SURFACE

CONTAMINANT CODE	ANALYSIS METHOD	CONTAMINANT NAME	ANALYSIS RESULTS (mg/l)
1919	141	HARDNESS/CALCIUM	35
1925	135	pH	8.4
1927	149	ALKALINITY	150
1930	139	TDS	310
1996	130	TEMPERATURE °C	26.6
1997	138	*LANGELIER INDEX	+0.3

LOCATION CODE

< = Less than the detection limit given.

Construction Materials (indicate quantities, percentages or locations of each)

Lead:

Copper/Copper Alloys:

Ferrous Piping:

Asbestos Cement Piping:

PVC Piping:

*By Calculation: It can have a postive or negative value. A negative value indicates corrosive water.

ANALYSIS DATE: MO 0 8 DAY 0 7 YEAR 9 2

Analyst [signature] Umesh, Rao, Ph.D.

LAB'S COMMENTS OR INSTRUCTIONS 2 cc: ADEQ, 1 cc: MCHD

SAMPLER'S COMMENTS OR INSTRUCTIONS

Drinking Water Quality

INORGANIC CHEMICAL ANALYSIS REPORTING FORM

Before completing, please read instructions on reverse side.

#9101691
SPECIMEN NO.

02/21/91
DATE RECEIVED

NOTE: WATER SYSTEM MUST COMPLETE ALL BLANKS INSIDE THIS BOX

PWS ID. NO.
0 4 0 7 0 8 8
1-7

LAB NAME & ADDRESS

WESTECH LABORATORIES, INC.
3737 EAST BROADWAY ROAD
P.O. BOX 20946
PHOENIX ARIZONA 85036

LAB ID.NO 0 0 0 1 0 (42-46)

SAMPLE DATE		
Month	Day	Year
0 2	2 0	9 1

31-36

SAMPLE	
Type	Time (Hours)
D	1 4 4 1
37	38-41

WATER SYSTEM NAME
CITY OF AVONDALE

SAMPLING POINT - WELL NO. OR EXACT LOCATION
WELL #8

MAILING NAME & ADDRESS

CITY OF AVONDALE
ATTN R. SULLINS
525 N. CENTRAL AVE.
AVONDALE, AZ 85323

SAMPLE APPEARANCE	
X	Clear
	Turbid
	Other (comment)

WATER SUPPLY	
X	Well
	Surface

SAMPLER'S COMMENTS OR INSTRUCTIONS

Sample Type Codes
C - Check Sample
D - Regular Distribution Sample
P - Plant Tap Sample
R - Raw Water Sample
S - Special Sample

CONTAMINANT CODE	ANALYSIS METHOD	CONTAMINANT NAME	(MCL)	ANALYSIS RESULTS (mg/l)	EXCEEDS
1005	101	Arsenic	(0.05)	0.018	
1010	101	Barium	(1.0)	0.10	
1015	101	Cadmium	(0.010)	<0.0005	
1020	101	Chromium	(0.05)	0.018	
1025	107	Fluoride	(1.4-2.0)	1.1	
1030	101	Lead	(0.05)	0.025	
1035	103	Mercury	(.002)	<0.001	
1040	109	Nitrates (N)	(10.)	9.8	
1045	101	Selenium	(0.01)	<0.005	
1050	101	Silver	(0.05)	<0.002	
1927	149	Alkalinity		140.	
1016	101	Calcium		58.	
1017	149	Chloride		200.	
1022	101	Copper		<0.05	
1915	141	Hardness		270.	
1028	101	Iron		<0.05	
1031	101	Magnesium		31.	
1032	101	Manganese		<0.05	
1925	135	pH		8.1	
1052	101	Sodium		110.	
1055	137	Sulfate		60.	
1930	139	TDS		620.	
1095	101	Zinc		<0.05	
		Langelier Index		0.46	
10-13	14-16			17-20	

Pursuant to R9-8-223 Check Samples are REQUIRED for ANY and ALL contaminant(s) checked in the Exceeds Column.

LOCATION CODE
28-30

ANALYSIS DATE		
Month	Day	Year
0 3	1 5	9 1

22-27

COMMENTS

ANALYST

CLIENT COPY

DRINKING WATER QUALITY

INORGANIC CHEMICAL ANALYSIS REPORTING FORM

92-103838
SPECIMEN NO

Before completing, please read instructions on reverse side.

06/02/92
DATE RECD

NOTE: WATER SYSTEM MUST COMPLETE ALL BLANKS INSIDE THIS BOX

PWS ID NO. 0 4 0 7 0 8 8

LAB NAME AND ADDRESS AZ 0 0 0 6

Steven B. Hankins, Director
ARIZONA TESTING LABORATORIES
810 East Hammond Lane
Phoenix, Arizona 85034 (602) 254-6181

SAMPLE DATE Mo. 0 6 Day 0 2 Yr. 9 2

SAMPLE Type: D Time (Hrs.) 1 3 0 0

WATER SYSTEM NAME City of Avondale

SAMPLING POINT—WELL NO. OR EXACT LOCATION Well 8, 99th Ave. & McDowell

MAILING NAME AND ADDRESS
City of Avondale
Attn: Esmeralda Avila
525 North Central
Avondale, Arizona 85323

SAMPLE APPEARANCE
- [ ] Clear
- [ ] Turbid
- [ ] Other (comment)

WATER SUPPLY SOURCE
- [x] Well
- [ ] Surface

SAMPLE TYPE CODES
C - Check Sample
D - Regular Distribution Sample
P - Plant Tap Sample
R - Raw Water Sample
S - Special Sample

SAMPLER'S COMMENTS OR INSTRUCTIONS

CONTAMINANT CODE	ANALYSIS METHOD	CONTAMINANT NAME	(MCL)	ANALYSIS RESULTS (mg/l)	EXCEEDS
1005	101	Arsenic	(0.05)	< 0.010	
1010	101	Barium	(1.)	< 0.50	
1015	101	Cadmium	(0.010)	< 0.0050	
1020	101	Chromium	(0.05)	0.016	
1025	107	Fluoride	(1.4-2.0)	0.41	
1030	101	Lead	(0.05)	< 0.0020	
1035	103	Mercury	(.002)	< 0.0010	
1040	109	Nitrates (N)	(10.)	13.	X
1045	101	Selenium	(0.01)	< 0.0050	
1050	101	Silver	(0.05)	< 0.020	
1927	149	Alkalinity		120.	
1016	101	Calcium		84.	
1017	149	Chloride		298.	
1022	101	Copper		< 0.050	
1915	141	Hardness		407.	
1028	101	Iron		< 0.10	
1031	101	Magnesium		48.	
1032	101	Manganese		< 0.050	
1925	135	pH		7.5	
1052	101	Sodium		130.	
1055	137	Sulfate		77.	
1930	139	TDS		870.	
1095	101	Zinc		< 0.050	

Pursuant to R9-8-223 check samples are REQUIRED for ANY and ALL contaminant(s) checked in the exceeds column.

LOCATION CODE 03 83 8

92-103838

< = less than the practical quantitation limit (PQL) given

COMMENTS 2 cc: ADEQ, 1 cc: MCHD

ANALYSIS DATE Mo. 0 7 Day 2 9 Yr. 9 2

ANALYST
Umesh Rao, Ph.D.

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY
CORROSIVITY ANALYSIS REPORTING FORM

SPECIMEN NUMBER 92-104275 DATE REC'D 06/23/92

PWS ID NUMBER: Ø 4 0 7 0 8 8

LAB PERFORMING ANALYSIS NAME AND ADDRESS

Arizona Testing Laboratories
810 East Hammond Lane
Phoenix, Arizona 85034

LAB ID NUMBER: AZ 0 0 0 6

SAMPLE DATE: MO 0 6 DAY 2 3 YEAR 9 2

SAMPLE TYPE: D TIME: 1 0 2 0

(PLEASE COMPLETE BOTTOM OF PAGE)

WATER SYSTEM NAME	SAMPLING POINT – WELL OR LEGAL NAME
City of Avondale	Well 8

SYSTEM MAILING NAME & ADDRESS
City of Avondale
Attn: Esmeralda Avila
525 North Central Ave.
Avondale, Arizona 85323

SAMPLE APPEARANCE	
	CLEAR
	TURBID
	OTHER (COMMENT)

SUPPLY SOURCE	
X	WELL
	SURFACE

CONTAMINANT CODE	ANALYSIS METHOD	CONTAMINANT NAME	ANALYSIS RESULTS (mg/l)
1919	141	HARDNESS/CALCIUM	260.
1925	135	pH	8.0
1927	149	ALKALINITY	130.
1930	139	TDS	1000.
1996	130	TEMPERATURE °C	26.1
1997	138	*LANGELIER INDEX	+0.7

LOCATION CODE

< = Less than the detection limit given.

Construction Materials (indicate quantities, percentages or locations of each)

Lead:

Copper/Copper Alloys:

Ferrous Piping:

Asbestos Cement Piping:

PVC Piping:

*By Calculation: It can have a postive or negative value. A negative value indicates corrosive water.

ANALYSIS DATE: MO 0 8 DAY 0 7 YEAR 9 2

Analyst [signature] Umesh Rao, Ph.D.

LAB'S COMMENTS OR INSTRUCTIONS 2 cc: ADEQ, 1 cc: MCHD

SAMPLER'S COMMENTS OR INSTRUCTIONS