SURPRISE
ARIZONA

FINAL Report

Integrated Water Master Plan
Water Infrastructure

JULY 2009

Electronic copy of final document; sealed original document is with Timothy Francis, Cert. #22684.

4957-002

MALCOLM PIRNIE

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July 31, 2009

James E. Swanson, Manager
Public Works Department
City of Surprise
12425 W. Bell Road, Suite C305
Surprise, AZ 85374

Re: *Integrated Water Master Plan:* Water Infrastructure
Final Report

Dear Mr. Swanson:

Malcolm Pirnie, Inc. is pleased to submit the Final Report for the Water Infrastructure component of the *Integrated Water Master Plan* project. The Water Infrastructure component builds on the recommended water resources management and assured water supply strategies by recommending drinking water, reclaimed water, and wastewater infrastructure projects to support future City growth.

We sincerely appreciate the assistance and guidance provided by the City's Technical and Steering Committees during preparation of the *Integrated Water Master Plan*, and we look forward to continuing our working relationship in the future.

Very truly yours,

MALCOLM PIRNIE, INC.

Timothy Francis, P.E.
Senior Associate
Project Manager
Board Certified Environmental Engineer

Enclosures

4957-002

City of Surprise, Arizona

Public Works Department • 12425 West Bell Road • Surprise, AZ 85374-9002

Integrated Water Master Plan

Water Infrastructure

July 2009

Report Prepared By:

Malcolm Pirnie, Inc.

4646 East Van Buren Street
Suite 400
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List of Abbreviations

A.R.S.	Arizona Revised Statutes
AAC	Arizona Administrative Code
AACE	Association for the Advancement of Cost Engineering
AAWC	Arizona American Water Company
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADWR	Arizona Department of Water Resources
AF	acre-feet
AL	alert levels
AMA	active management area
AOC	Approval of Construction
APP	Aquifer Protection Permit
ASU	Arizona State University
ATC	Approval to Construct
AWQS	Aquifer Water Quality Standards
BADCT	best available demonstrated control technology
BOD_5	biological oxygen demand
CAAA	Clean Air Act Amendments
CAGRD	Central Arizona Groundwater Replenishment District
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
$CBOD_5$	carbonaceous biological oxygen demand
CCL	Contaminant Candidate List
City	City of Surprise
cMOM	capacity, management, operations, and maintenance
CO	carbon monoxide
CPP	continuing planning process
D/DBPR	disinfectants/disinfection by-products rule
DBP	disinfection by-products
DI	ductile iron
ENR CCI	Engineering News Record Consumer Cost Index
FBRR	Filter Backwash Recycling Rule
FCDMC	Flood Control District of Maricopa County
ft/day	feet per day
ft/s	feet per second
GIS	geographical information systems
gpm	gallons per minute
GWR	Groundwater Rule
GWUDISW	groundwater under the direct influence of surface water

HAP	hazardous air pollutants
IDSE	Initial Distribution System Evaluation
IESWTR	Interim Enhanced Surface Water Treatment Rule
IOC	inorganic chemicals
ISO	Insurance Services Office
LCR	Lead and Copper Rule
LS	lift station
LT1ESWTR	Long Term 1 Enhanced Surface Water Treatment Rule
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MAG	Maricopa Association of Governments
MBR	membrane bio-reactor
MCAQD	Maricopa County Air Quality Department
MCESD	Maricopa County Environmental Services Department
MCL	maximum contaminant level
MG	million gallons
µg/L	micrograms per liter
mg/L	milligrams per liter
mgd	million gallons per day
MLE	Modified Ludzack Ettinger
MPA	municipal planning area
NFF	needed fire flow
NOx	nitrous oxides
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
PLC	programmable logic control
POC	point of compliance
POTW	publicly owned treatment works
PRV	pressure reducing valve
psi	pounds per square inch
PVC	polyvinyl chloride
PWS	public water system
RW	recovery wells
SBR	sequencing batch reactor
SCADA	supervisory control and data acquisition
SDWA	Safe Drinking Water Act
SOC	synthetic organic chemicals
SPA	special planning area
SSO	sanitary sewer overflow
SWQS	Surface Water Quality Standards
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
TOC	total organic carbon

TSS	total suspended solids
UCMR	Unregulated Contaminant Monitoring Regulation
UCMR3	Unregulated Contaminant Monitoring Regulation 3
UIC	underground injection
USDW	underground sources of drinking water
USEPA	United States Environmental Protection Agency
USF	underground storage facility
VOC	volatile organic chemicals
WQMP	Water Quality Management Plan
WRF	water reclamation facility
WS	water storage
WSF	water supply facility
WTP	water treatment plant
WW	wastewater

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Executive Summary

Introduction

The City of Surprise (City) Public Works Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

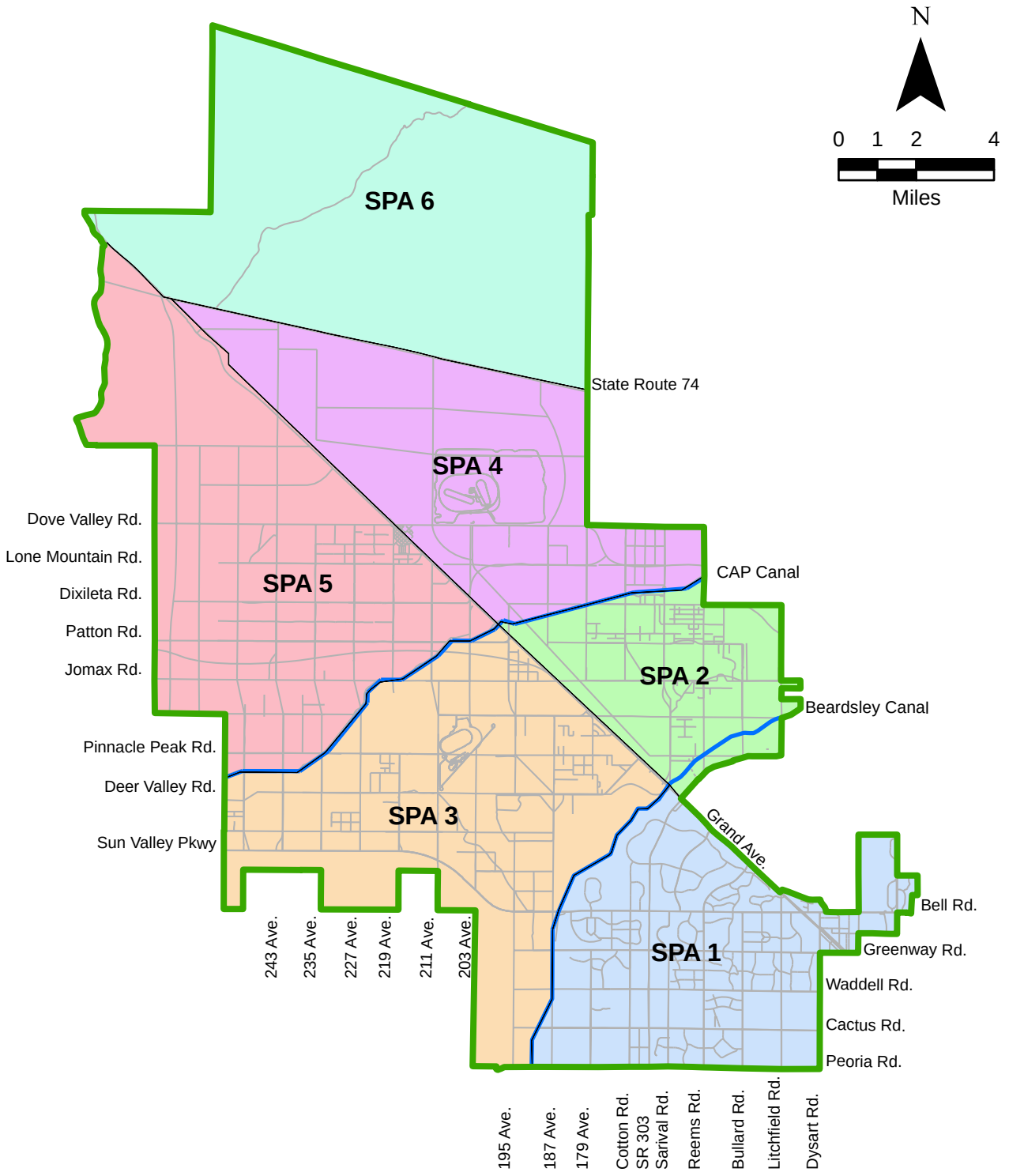
The City is expecting to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007) within the planning area shown on Figure ES-1. The planning area is divided into six special planning areas (SPAs) to maintain consistency with the City's previous water resources and infrastructure planning efforts and for convenience of wastewater and reclaimed water planning; i.e., the SPAs are logical drainage areas for existing and potential water reclamation facilities.

Because of recent growth activity, the City commissioned the *Integrated Water Master Plan* project, which has Water Resources and Water Infrastructure components. This executive summary addresses the Water Infrastructure component, which identifies the most feasible drinking water, wastewater, reclaimed water, and recharge infrastructure strategies. It also develops comprehensive plans for implementing the water infrastructure improvements and expansions in a legal, cost-effective, and sustainable manner.

The *Integrated Water Master Plan* project was completed under the guidance of two City committees: the Technical Committee composed of management staff from the City Public Works, Information Technology, and Planning Departments; and the Steering Committee composed of the Deputy City Managers and the Assistant City Manager overseeing public works, planning, and development agreement activities. The Technical Committee provided information and data to the consultant team, reviewed the consultant team's technical work, and provided water, wastewater, and reclaimed water technical advice and guidance. The Steering Committee provided policy direction and oversight. The two committees gave valuable input and guidance on technical memoranda developed during the project and participated in all project workshops where results of the technical work were presented.

Water Resource Component Considerations

The Water Resources component of the *Integrated Water Master Plan* developed key guidance for completing the Water Infrastructure component:



Legend

- Municipal Planning Area
- Special Planning Areas
- Canals
- Streets

SURPRISE ARIZONA

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Study Area

July 2009 | **Figure ES-1**

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- The recommended reclaimed water management strategy is to install a dual distribution system to serve only the largest reuse customers (e.g., landscape irrigation of homeowner's association (HOA) common areas, schools, and parks), to use surface basin recharge where possible to balance reclaimed water demand and supply, and to recharge excess reclaimed water that is not directly reused.
- A Water Resource Demand Module (Demand Module) was created that dynamically simulates existing and future water resource needs derived from GIS-based data and land use-based demand factors. The Demand Module provides water demand (potable and non-potable) and wastewater flow projections in a format compatible with the City drinking water, wastewater, and reclaimed water infrastructure hydraulic models. Using the Demand Module, the City determined that to balance build-out water demands with available water supplies, it must plan for a build-out target population between 500,000 (Rural Residential density of 0.5 du/acre) and 700,000 (Rural Residential density of 1.0 du/acre). To achieve this balance, the City must control growth and enforce landscape guidelines. Table ES-1 presents the projected drinking water demands, wastewater flows, reclaimed water availability, and reclaimed water demands through City build-out.
- To ensure development of uniform water infrastructure and provision of a uniform level of water service for all residents within the City's planning area, the City considered service to all areas within its planning area, including the new SPA 6 and all private water company service areas, except that of Arizona American Water Company (AAWC) and the City of El Mirage. As development progresses to the north, the City will continue to evaluate the feasibility of acquiring private water companies located in its service area.

Table ES-1.
Drinking Water, Wastewater, and Reclaimed Water Projections[1]

SPA/ Drainage Basin	Drinking Water Demand		Wastewater Flow		Reclaimed Water Available[2]		Reclaimed Water Demand	
	2020 (mgd)	Build-out (mgd)	2020 (mgd)	Build-out (mgd)	2020 (mgd)	Build-out (mgd)	2020 (mgd)	Build-out (mgd)
1	7.3	8.8	17.4	22.8	15.6	20.5	2.5	2.7
2	4.8	13.7	3.1	10.1	2.8	9.1	0.9	2.8
3	9.5	28.0	5.6	19.4	5.1	17.4	0.9	4.0
4	3.5	19.1	1.7	13.8	1.5	12.4	0.5	5.9
5	6.4	23.6	3.9	15.7	3.5	14.1	1.2	5.7
6	0.5	16.3	0.07	5.4	0.06	4.9	0.2	7.2
Totals	**32.0**	**109.5**	**31.8**	**87.2**	**28.6**	**78.4**	**6.1**	**28.4**

NOTES:
(1) Based on mid-population scenario described in the Water Resources component of the *Integrated Water Master Plan*.
(2) Reclaimed water not used for irrigation will be recharged.

System Performance and Design Criteria

The City's existing design guidelines for drinking water, wastewater, and reclaimed water infrastructure were reviewed with respect to historical water demand and wastewater flow characteristics and design criteria and guidelines used by other cities in the Phoenix Metropolitan area and recognized water industry organizations. System performance and design criteria for infrastructure evaluations and master plan development were developed based on discussions with the City's Technical and Steering Committees. The City will use these criteria as a starting basis when new design guidelines are developed as part of its ongoing *Water Technology Assessment* project.

Drinking Water Infrastructure

Existing Drinking Water System Evaluation

The City's drinking water system was modeled under steady-state conditions using a Bentley WaterCAD® V8 XM Edition hydraulic model. The calibrated WaterCAD® model was used to evaluate the existing system to identify any deficiencies during current average day, maximum day, maximum day plus fire flow, and peak hour demand conditions. No significant system deficiencies were noted during average day, maximum day, and peak hour demand conditions. The modeling did reveal a few deficiencies in residential areas where a needed fire flow (NFF) of 2,000 gpm could not be provided while maintaining a residual pressure of 20 psi. All commercial areas were, however, found to have a NFF of 3,000 gpm at a residual pressure of 20 psi or greater. Upgrades and improvements, such as modifying the set point pressures for certain water supply facility (WSF) pumps, new parallel pipes, and/or pipe replacements were considered and included in the evaluation of infrastructure alternatives and master plan development.

Selected Drinking Water Infrastructure Alternative

Four drinking water infrastructure alternatives were evaluated that considered the source of water (all groundwater or a groundwater and surface water blend), spacing of WSFs (smaller service areas vs. larger, interconnected service areas), and Central Arizona Project (CAP) water recharge locations (local City-owned or regional). The selected drinking water infrastructure alternative consisted of an all well supply with fewer WSFs and a larger interconnected system, which provided the following benefits:

- It had the lowest capital, O&M, and total present worth costs because fewer production wells, WSFs (reservoirs, booster stations, and arsenic treatment facilities), and City recharge facilities were required.
- The Central Arizona Water Conservation District (CAWCD) has already built affordable capacity for recharging CAP allocations.
- It did not preclude the construction of a CAP Water Treatment Plant (WTP). That is, the decision of whether to build a CAP WTP can be deferred to future updates of the *Integrated Water Master Plan*.

Recommended Drinking Water Infrastructure Master Plan

The recommended near-term (2009 to 2020) and long-term (2021 to build-out) drinking water infrastructure improvements are shown on Figures ES-2 and ES-3, respectively. Because the span of time between near-term and long-term was largely unknown, the frequency of infrastructure upgrades cannot be definitively determined; thus, long-term infrastructure was presented as equivalent capacities for each short-term infrastructure that needed improvements for the long-term. Table ES-2 presents a listing of the recommended improvements and identifies the estimated capital costs to plan, design, and construct the improvements.

The following additional recommendations are made to facilitate future planning and implementation of the recommended drinking water master plan:

- Continue to periodically update the *Integrated Water Master Plan* every three to five years. Growth within the City's MPA is dynamic, and as actual development occurs, the projected water demands and drinking water infrastructure needs will change.
- Continue to refine the dwelling unit information in the City's GIS. There were some discrepancies found with the dwelling unit counts, which affected estimates of water demand factors.
- Work with AAWC to develop a refined water customer billing database for at least the last five years. Approximately 10 percent of the water meters could not be geographically located. The goal of these actions should be to refine the water demand factors in the Demand Module.
- Increase the set point pressure for the variable frequency drive pumps at the Mountain Vista Ranch WSF to achieve needed fire flows throughout its service area. All other existing system deficiencies identified in Section 5 are addressed in the recommended system improvements.
- In future discussions with CAWCD, request that as much as possible, the City's CAP allocations should be recharged at the Hieroglyphic Mountains facility.
- Reexamine current developer agreement structures to identify the means to accommodate fewer, larger WSFs.
- Carefully site and design future WSFs based on the most current information on development patterns and existing infrastructure.
- Conduct hydrogeologic investigations in the near-term to identify the most suitable areas for well development and start locating well sites for the recommended WSFs. Future production well sites are not located in the information above.
- Continue reevaluating the option of constructing a CAP WTP in all future updates of the *Integrated Water Master Plan* as additional information becomes available on actual groundwater quality (i.e., the need for groundwater treatment).

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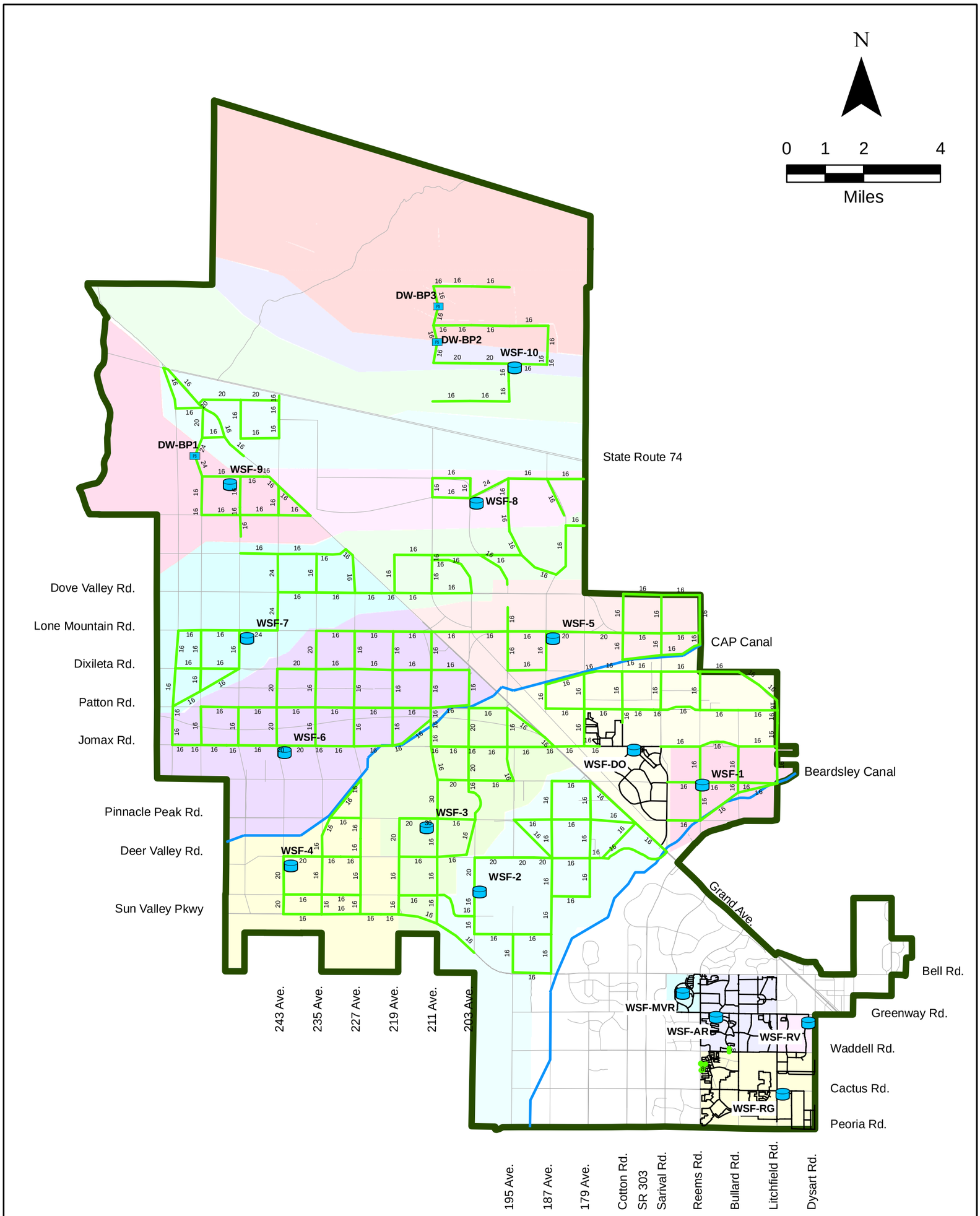

NOTE: Refer to Figure 3-1 for the water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilities
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Drinking Water Infrastructure Improvements

July 2009 | **Figure ES-2**

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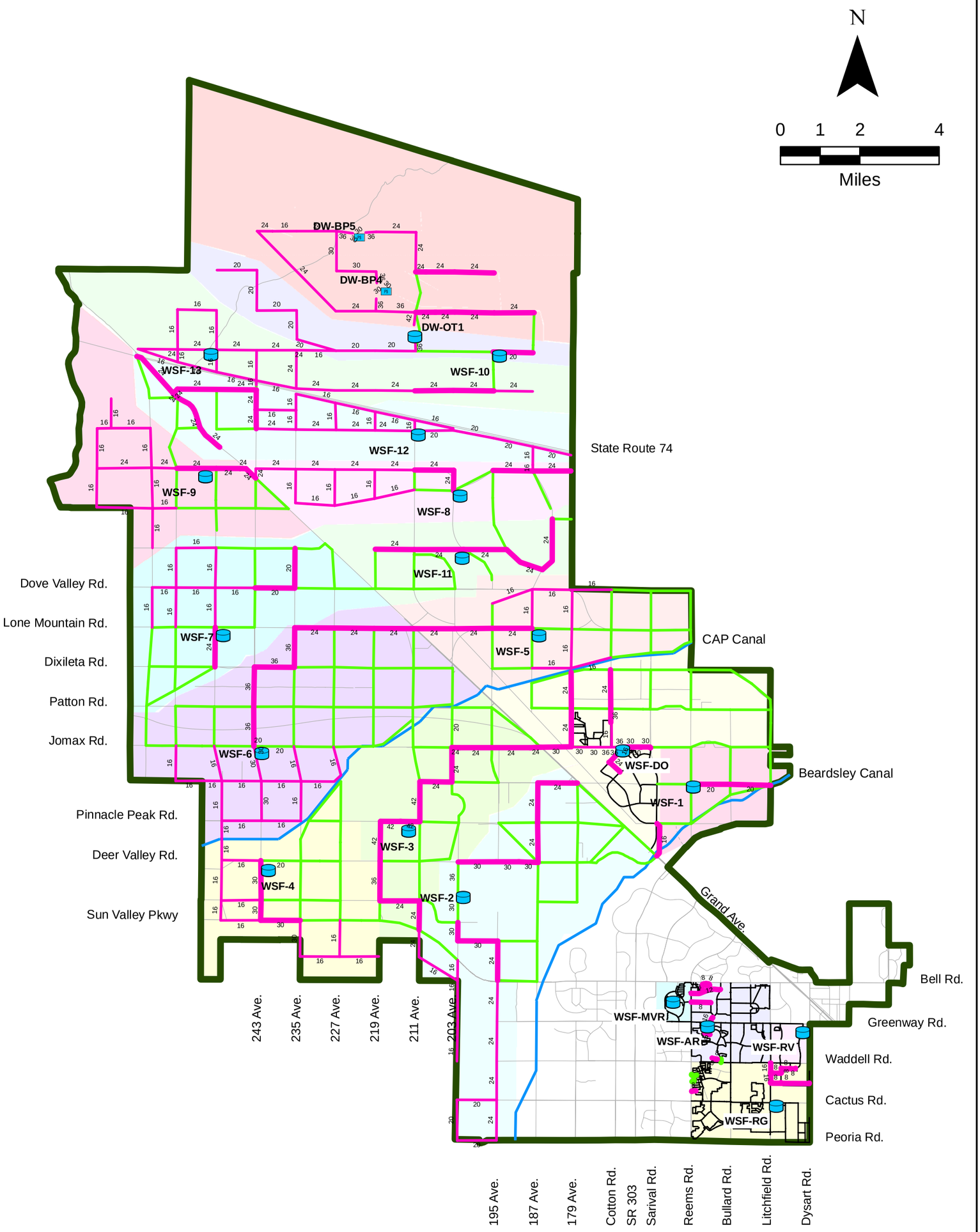

NOTE: Refer to Figure 3-1 for the water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilities
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)
- 2021 - Build-out (New)
- 2021 - Build-out (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Drinking Water Infrastructure Improvements

July 2009

Figure ES-3

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Table ES-2.
Recommended Drinking Water Infrastructure Improvements Schedule

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
Water Supply Facilities (Pressure Zone)						
Ashton Ranch, WSF-AR (PZ-1c)			**$ -**			**$ 800,000**
Land	-		$ -	-		$ -
Production Wells	-		$ -	-		$ -
Storage Reservoirs	-		$ -	-		$ -
Booster Pump Stations	-		$ -	6,900 gpm	140 TDH	$ 800,000
Arsenic Treatment	-		$ -	-		$ -
Transmission Mains	-		$ -	-		$ -
Roseview, WSF-RV (PZ-1a)			**$ 4,210,000**			**$ -**
Land	0.3 acres		$ 10,000	-		$ -
Production Wells	1 wells		$ 2,200,000	-		$ -
Storage Reservoirs	-		$ -	-		$ -
Booster Pump Stations	-		$ -	-		$ -
Arsenic Treatment	1,050 gpm		$ 2,000,000	-		$ -
Transmission Mains	-		$ -	-		$ -
Desert Oasis, WSF-DO (PZ-2a, 3a)			**$ 9,500,000**			**$ 22,900,000**
Land	1.5 acres		$ 100,000	-		$ -
Production Wells	2 wells		$ 4,400,000	4 wells		$ 8,700,000
Storage Reservoirs	-		$ -	2 MG		$ 2,400,000
Booster Pump Stations	-		$ -	9,000 gpm	220 TDH	$ 800,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	4,200 gpm		$ 7,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
20 in	-		$ -	5,280 LF		$ 2,100,000
Rancho Mercado, WSF-1 (PZ-2c)			**$ 17,300,000**			**$ 19,900,000**
Land	5.5 acres		$ 200,000	-		$ -
Production Wells	3 wells		$ 6,500,000	3 wells		$ 6,500,000
Storage Reservoirs	1 MG		$ 2,100,000	2 MG		$ 3,500,000
Booster Pump Stations	4,827 gpm	144 TDH	$ 2,500,000	10,700 gpm	168 TDH	$ 1,900,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	3,150 gpm		$ 5,900,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
20 in	2,640 LF		$ 1,000,000	2,640 LF		$ 1,000,000
WSF-2 (PZ-2b)			**$ 23,200,000**			**$ 43,300,000**
Land	6.8 acres		$ 300,000	-		$ -
Production Wells	4 wells		$ 8,700,000	7 wells		$ 15,300,000
Storage Reservoirs	2 MG		$ 3,000,000	5 MG		$ 5,000,000
Booster Pump Stations	6,332 gpm	110 TDH	$ 2,100,000	22,000 gpm	163 TDH	$ 3,700,000
Arsenic Treatment	3,150 gpm		$ 5,900,000	7,350 gpm		$ 13,700,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	10,560 LF		$ 2,100,000
20 in	5,280 LF		$ 2,100,000	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
30 in	-		$ -	2,640 LF		$ 1,400,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-3 (PZ-3b)			**$ 36,600,000**			**$ 39,400,000**
Land	7.0 acres		$ 300,000	-		$ -
Production Wells	6 wells		$ 13,100,000	6 wells		$ 13,100,000
Storage Reservoirs	3 MG		$ 4,400,000	4 MG		$ 4,400,000
Booster Pump Stations	9,138 gpm	130 TDH	$ 2,500,000	25,000 gpm	195 TDH	$ 3,700,000
Arsenic Treatment	5,250 gpm		$ 9,800,000	6,300 gpm		$ 11,700,000
Transmission Mains						
12 in	10,560 LF		$ 2,100,000	10,560 LF		$ 2,100,000
24 in	10,560 LF		$ 4,400,000	10,560 LF		$ 4,400,000
WSF-4 (PZ-3c)			**$ 17,300,000**			**$ 31,600,000**
Land	6.0 acres		$ 300,000	-		$ -
Production Wells	3 wells		$ 6,500,000	5 wells		$ 10,900,000
Storage Reservoirs	1 MG		$ 2,000,000	4 MG		$ 4,800,000
Booster Pump Stations	7,590 gpm	157 TDH	$ 2,500,000	15,000 gpm	200 TDH	$ 2,400,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	7,920 LF		$ 1,600,000
20 in	2,640 LF		$ 1,000,000	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
WSF-5 (PZ-4a)			**$ 11,500,000**			**$ 31,400,000**
Land	5.8 acres		$ 200,000	-		$ -
Production Wells	2 wells		$ 4,400,000	5 wells		$ 10,900,000
Storage Reservoirs	1 MG		$ 1,700,000	3 MG		$ 4,200,000
Booster Pump Stations	4,126 gpm	135 TDH	$ 2,100,000	12,800 gpm	156 TDH	$ 2,800,000
Arsenic Treatment	1,050 gpm		$ 2,000,000	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	7,920 LF		$ 1,600,000
20 in	-		$ -	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
WSF-6 (PZ-4b)			**$ 35,900,000**			**$ 56,600,000**
Land	7.8 acres		$ 300,000	-		$ -
Production Wells	6 wells		$ 13,100,000	9 wells		$ 19,600,000
Storage Reservoirs	4 MG		$ 4,800,000	6 MG		$ 5,600,000
Booster Pump Stations	10,100 gpm	138 TDH	$ 2,800,000	30,000 gpm	168 TDH	$ 3,700,000
Arsenic Treatment	5,250 gpm		$ 9,800,000	9,450 gpm		$ 17,600,000
Transmission Mains						
12 in	7,920 LF		$ 1,600,000	26,400 LF		$ 5,300,000
20 in	2,640 LF		$ 1,000,000	5,280 LF		$ 2,100,000
24 in	2,640 LF		$ 1,100,000	-		$ -
30 in	2,640 LF		$ 1,400,000	5,280 LF		$ 2,700,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-7 (PZ-5b)			**$ 17,400,000**			**$ 31,300,000**
Land	6.0 acres		$ 300,000	-		$ -
Production Wells	3 wells		$ 6,500,000	5 wells		$ 10,900,000
Storage Reservoirs	2 MG		$ 2,700,000	3 MG		$ 4,000,000
Booster Pump Stations	5,802 gpm	137 TDH	$ 1,900,000	14,700 gpm	189 TDH	$ 2,900,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	7,920 LF		$ 1,600,000
20 in	2,640 LF		$ 1,000,000	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
WSF-8 (PZ-6a)			**$ 15,900,000**			**$ 5,700,000**
Land	5.0 acres		$ 200,000	-		$ -
Production Wells	3 wells		$ 6,500,000	1 wells		$ 2,200,000
Storage Reservoirs	1 MG		$ 2,100,000	1 MG		$ 900,000
Booster Pump Stations	4,863 gpm	122 TDH	$ 1,600,000	5,000 gpm	180 TDH	$ 100,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	1,050 gpm		$ 2,000,000
Transmission Mains						
12 in	7,920 LF		$ 1,600,000	2,640 LF		$ 500,000
WSF-9 (PZ-6b)			**$ 11,000,000**			**$ 12,400,000**
Land	5.0 acres		$ 200,000	-		$ -
Production Wells	2 wells		$ 4,400,000	2 wells		$ 4,400,000
Storage Reservoirs	1 MG		$ 1,400,000	1 MG		$ 2,000,000
Booster Pump Stations	3,608 gpm	165 TDH	$ 1,900,000	5,500 gpm	145 TDH	$ 1,000,000
Arsenic Treatment	1,050 gpm		$ 2,000,000	2,100 gpm		$ 3,900,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
WSF-10 (PZ-9)			**$ 10,500,000**			**$ 13,200,000**
Land	5.0 acres		$ 200,000	-		$ -
Production Wells	2 wells		$ 4,400,000	2 wells		$ 4,400,000
Storage Reservoirs	1 MG		$ 1,100,000	2 MG		$ 2,400,000
Booster Pump Stations	3,231 gpm	184 TDH	$ 1,700,000	5,950 gpm	185 TDH	$ 1,400,000
Arsenic Treatment	1,050 gpm		$ 2,000,000	2,100 gpm		$ 3,900,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
WSF-11 (PZ-5a)			**$ 200,000**			**$ 39,600,000**
Land	5.8 acres		$ 200,000	-		$ -
Production Wells	-		$ -	7 wells		$ 15,300,000
Storage Reservoirs	-		$ -	4 MG		$ 4,400,000
Booster Pump Stations	-		$ -	12,900 gpm	154 TDH	$ 3,000,000
Arsenic Treatment	-		$ -	6,300 gpm		$ 11,700,000
Transmission Mains						
12 in	-		$ -	10,560 LF		$ 2,100,000
20 in	-		$ -	7,920 LF		$ 3,100,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-12 (PZ-7)			**$ 200,000**			**$ 34,800,000**
Land	5.5 acres		$ 200,000	-		$ -
Production Wells	-		$ -	6 wells		$ 13,100,000
Storage Reservoirs	-		$ -	4 MG		$ 4,800,000
Booster Pump Stations	-		$ -	10,600 gpm	206 TDH	$ 2,900,000
Arsenic Treatment	-		$ -	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	-		$ -	10,560 LF		$ 2,100,000
20 in	-		$ -	5,280 LF		$ 2,100,000
WSF-13 (PZ-8)			**$ 200,000**			**$ 28,200,000**
Land	5.3 acres		$ 200,000	-		$ -
Production Wells	-		$ -	5 wells		$ 10,900,000
Storage Reservoirs	-		$ -	3 MG		$ 3,800,000
Booster Pump Stations	-		$ -	8,001 gpm	171 TDH	$ 2,600,000
Arsenic Treatment	-		$ -	4,200 gpm		$ 7,800,000
Transmission Mains						
12 in	-		$ -	10,560 LF		$ 2,100,000
20 in	-		$ -	2,640 LF		$ 1,000,000
Off-Site Storage Tanks						
Land	4.0 acres		$ 200,000	-		$ -
DW-OT1	-		$ -	16 MG		$ 13,500,000
Distribution Booster Pump Stations			**$ 5,100,000**			**$ 8,300,000**
Land	1.5 acres		$ 100,000	-		$ -
DW-BP1	3,452 gpm	144 TDH	$ 1,800,000	-		$ -
DW-BP2	3,113 gpm	191 TDH	$ 1,600,000	17,600 gpm	263 TDH	$ 3,400,000
DW-BP3	3,030 gpm	163 TDH	$ 1,600,000	-		$ -
DW-BP4	-		$ -	10,500 gpm	152 TDH	$ 2,900,000
DW-BP5	-		$ -	6,000 gpm	166 TDH	$ 2,000,000
Distribution System Pipelines			**$ 373,100,000**			**$ 414,000,000**
8 in	1,800 LF		$ 200,000	20,204 LF		$ 2,700,000
12 in	-		$ -	356 LF		$ 100,000
16 in	1,171,800 LF		$ 316,000,000	405,587 LF		$ 109,400,000
20 in	119,100 LF		$ 46,600,000	99,465 LF		$ 39,000,000
24 in	21,700 LF		$ 9,000,000	423,329 LF		$ 176,300,000
30 in	2,600 LF		$ 1,300,000	78,369 LF		$ 40,400,000
36 in	-		$ -	55,535 LF		$ 33,600,000
42 in	-		$ -	18,033 LF		$ 12,500,000
GRAND TOTAL			**$ 588,900,000**			**$ 847,100,000**

NOTES:
WSF – water supply facility; DW – drinking water; PZ – pressure zone; OT – off-site tank; BP – booster pump
(1) January 2009 costs (ENR CCI = 8,549). Unit capital costs include engineering/design, materials of construction, installation, and contractor overhead and profit.

Wastewater Infrastructure

Existing Collection System Evaluation

The City's existing collection system was modeled under steady-state, peak flow conditions using a SewerCAD®, V8 XM Edition hydraulic model. Of the total 282,000 feet of modeled gravity sewer system, only 2,600 feet (less than one percent of the system) was found to have surcharging under peak flow conditions. In total, six deficient areas were identified under existing conditions, two of which are likely due to errors in the GIS data. Upgrades and improvements, such as pipe replacements, parallel pipes, regrading of invert elevations, and modifying diversions were considered and included in the evaluation of infrastructure alternatives and master plan development.

Selected Wastewater Infrastructure Alternative

Because of the close interrelation between wastewater, reclaimed water, and recharge, these infrastructure alternatives were evaluated simultaneously. Three infrastructure alternatives were evaluated that varied in the number of WRFs that would be constructed. The selected wastewater, reclaimed water, and recharge infrastructure alternative includes construction of six water reclamation facilities (WRFs) because it provided the following benefits:

- It was more accommodating to development as there would be more flexibility in phasing the WRFs and infrastructure as development occurs within each WRF service area.
- It reduced the need for larger conveyance and distribution piping and also reduced pumping requirements for the reclaimed water.
- It followed the recommendation of the previous master plan that the City has been following and implementing since 2004.

Recommended Wastewater Infrastructure Master Plan

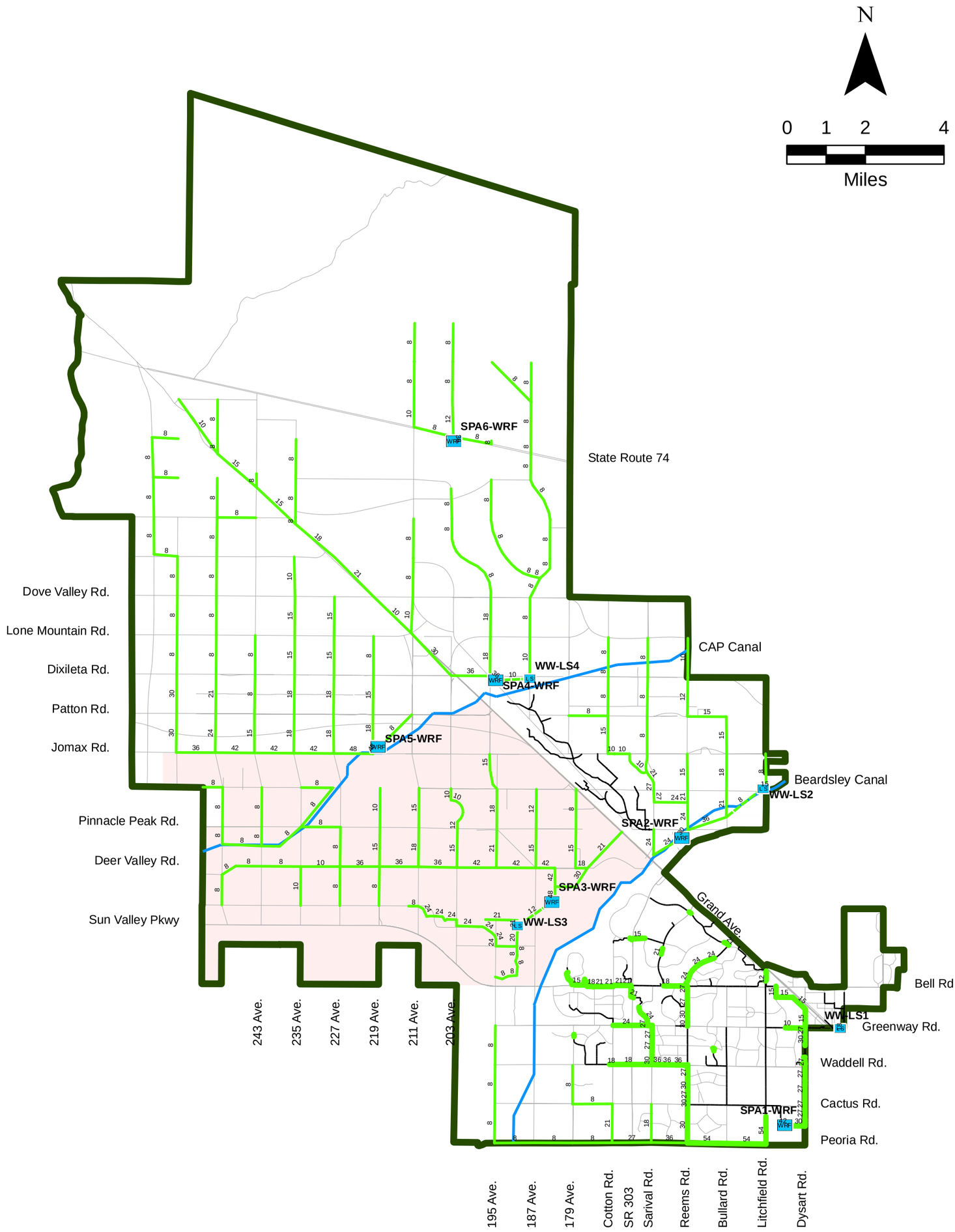
The recommended near-term (2009 to 2020) and long-term (2021 to build-out) wastewater infrastructure improvements are shown on Figures ES-4 and ES-5, respectively. Table ES-3 presents a listing of the recommended improvements and identifies the estimated capital costs to plan, design, and construct the improvements.

The following additional recommendations were made to facilitate future planning and implementation of the recommended wastewater master plan:

- Continue to periodically update the *Integrated Water Master Plan* every three to five years. Growth within the City MPA is dynamic, and as actual development occurs, the projected wastewater flows and wastewater infrastructure needs will change.
- Carefully site and design future WRFs based on the most current information on development patterns and existing infrastructure. Interim solutions (i.e., pumping

between drainage basins, phasing of facilities, etc.) should be considered if they meet the needs of the City, the community, and developers.

- Continue to refine the dwelling unit information in the City's GIS, there were some discrepancies found with the dwelling unit counts, which affected estimates of wastewater flow factors.
- Continue to document WRF influent flow data and collection system flow data from future flow monitoring studies with the objective of refining the wastewater flow factors in the Demand Module.
- Plug the diversion to Cactus Road in the 27-inch trunk sewer in Reems Road to mitigate surcharging of trunk sewers downstream of the Cactus Road trunk sewer.
- Verify collection system invert elevations and actual construction details at all locations identified as existing deficiencies in Section 5, particularly at the following locations: 1) intersection of Bell Road and Sunrise Boulevard, and 2) pipe connections to the existing pump station on Greenway Road. All other existing system deficiencies identified are addressed in the recommended system improvements.



NOTE: Refer to Figure 3-2 for the sewer service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Drainage Basins
- Canals
- Streets
- Water Reclamation Facilities
- Lift Stations

Force Mains

- Existing
- 2009 - 2020 (New)

Gravity Sewers

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Wastewater Infrastructure Improvements

July 2009 | **Figure ES-4**

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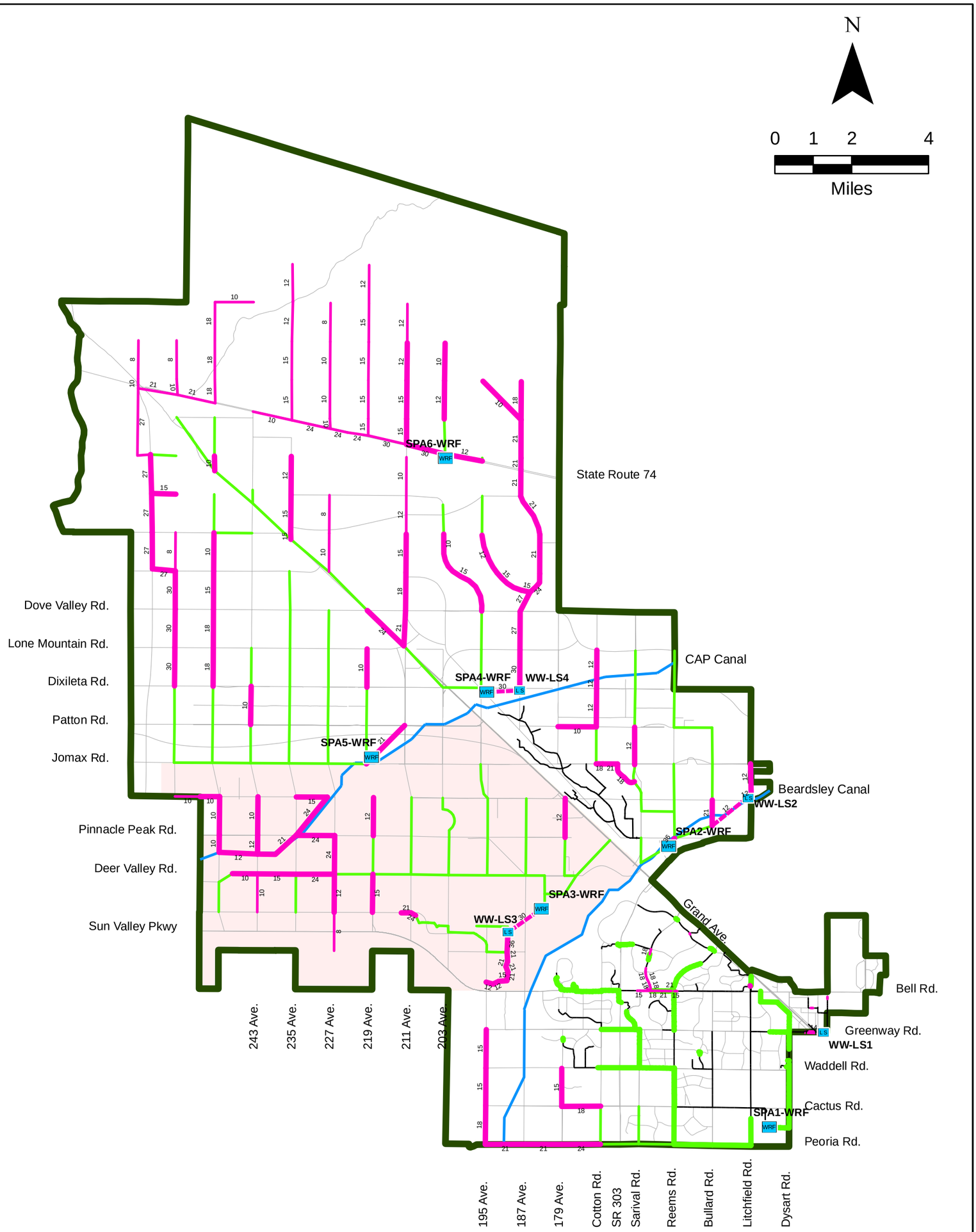

NOTE: Refer to Figure 3-2 for the sewer service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Drainage Basins
- Canals
- Streets
- Water Reclamation Facilities
- Lift Stations

Force Mains

- Existing
- 2021 - Build-out (Improved)

Gravity Sewers

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)
- 2021 - Build-out (New)
- 2021 - Build-out (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Wastewater Infrastructure Improvements

July 2009 | **Figure ES-5**

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Table ES-3.
Recommended Wastewater Infrastructure Improvements Schedule

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
Water Reclamation Facilities[2]						
SPA-2			**$ 42,800,000**			**$ 87,900,000**
SPA2-WRF	3.1 mgd		$ 38,900,000	7.0 mgd		$ 87,900,000
Land	93 acres		$ 3,900,000	-		$ -
SPA-3			**$ 74,400,000**			**$ 173,200,000**
SPA3-WRF	5.6 mgd		$ 70,300,000	13.8 mgd		$ 173,200,000
Land	96 acres		$ 4,100,000	-		$ -
SPA-4			**$ 25,300,000**			**$ 151,900,000**
SPA4-WRF	1.7 mgd		$ 21,300,000	12.1 mgd		$ 151,900,000
Land	94 acres		$ 4,000,000	-		$ -
SPA-5			**$ 52,900,000**			**$ 148,100,000**
SPA5-WRF	3.9 mgd		$ 48,900,000	11.8 mgd		$ 148,100,000
Land	95 acres		$ 4,000,000	-		$ -
SPA-6			**$ 5,100,000**			**$ 66,500,000**
SPA6-WRF	0.1 mgd		$ 1,300,000	5.3 mgd		$ 66,500,000
Land	91 acres		$ 3,800,000	-		$ -
Lift Stations			**$ 5,640,000**			**$ 23,700,000**
Land	1 acres		$ 40,000	-		$ -
WW-LS2	505 gpm	45 TDH	$ 1,700,000	1,833 gpm	80 TDH	$ 6,300,000
WW-LS3	1,504 gpm	50 TDH	$ 2,400,000	9,861 gpm	20 TDH	$ 8,000,000
WW-LS4	444 gpm	40 TDH	$ 1,500,000	11,599 gpm	32 TDH	$ 9,400,000
Force Mains			**$ 3,100,000**			**$ 6,300,000**
8 in	6,267 LF		$ 1,000,000	-		$ -
10 in	4,572 LF		$ 900,000	-		$ -
12 in	5,615 LF		$ 1,200,000	6,267 LF		$ 1,400,000
20 in	-		$ -	-		$ -
30 in	-		$ -	10,187 LF		$ 4,900,000
8 in	6,267 LF		$ 1,000,000	-		$ -
Gravity Sewers			**$ 192,500,000**			**$ 124,100,000**
8 in	388,046 LF		$ 44,500,000	31,746 LF		$ 3,600,000
10 in	67,134 LF		$ 9,000,000	105,614 LF		$ 14,200,000
12 in	18,925 LF		$ 3,000,000	99,573 LF		$ 15,800,000
15 in	114,611 LF		$ 21,400,000	105,769 LF		$ 19,700,000
18 in	73,695 LF		$ 16,400,000	55,047 LF		$ 12,300,000
21 in	52,690 LF		$ 13,900,000	74,925 LF		$ 19,800,000
24 in	45,992 LF		$ 13,200,000	49,578 LF		$ 14,200,000
27 in	32,725 LF		$ 10,300,000	38,213 LF		$ 12,000,000
30 in	45,547 LF		$ 15,600,000	32,304 LF		$ 11,000,000
36 in	44,903 LF		$ 17,800,000	3,668 LF		$ 1,500,000
42 in	32,231 LF		$ 14,600,000	-		$ -
48 in	8,926 LF		$ 4,500,000	-		$ -
54 in	14,270 LF		$ 8,300,000	-		$ -
GRAND TOTAL			**$ 401,740,000**			**$ 781,700,000**

NOTES:
WRF – water reclamation facility; WW – wastewater; LS – lift station
(1) January 2009 costs (ENR CCI = 8,549). Unit capital costs include engineering/design, materials of construction, installation, and contractor overhead and profit.
(2) WRF land requirements assume odor and noise control are not provided.

Reclaimed Water and Recharge Infrastructure

Selected Reclaimed Water and Recharge Infrastructure Alternative

Because of the close interrelation between wastewater, reclaimed water, and recharge, these infrastructure alternatives were evaluated simultaneously. Four infrastructure alternatives were evaluated that varied in the number of WRFs that would be constructed. The selected wastewater, reclaimed water, and recharge infrastructure alternative included construction of six WRFs because it provided the following benefits:

- It was more accommodating to development as there would be more flexibility in phasing the WRFs and infrastructure as development occurs within each WRF service area.
- It reduced the need for larger conveyance and distribution piping and also reduced pumping requirements for the reclaimed water.
- It followed the recommendation of the previous master plan that the City has been following and implementing since 2004.

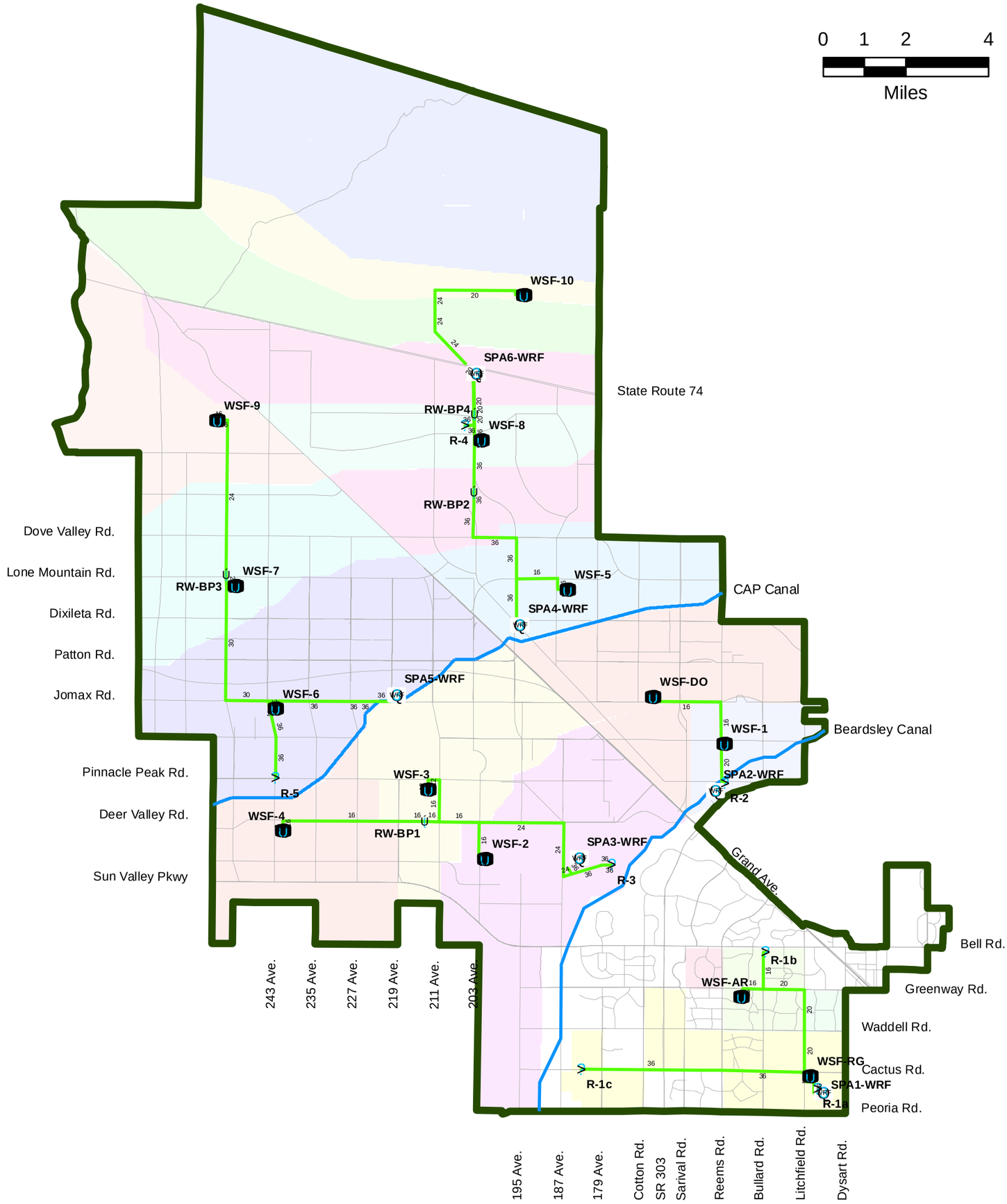
Recommended Reclaimed Water and Recharge Infrastructure Master Plan

The reclaimed water system consisted of two modeled systems: transmission mains from the WRFs to the WSFs and distribution system pipelines from the WSFs to reuse customers:

- The recommended near-term and long-term reclaimed water transmission main improvements are shown on Figures ES-6 and ES-7, respectively.
- The recommended near-term and long-term reclaimed water distribution system improvements are shown on Figures ES-8 and ES-9, respectively.

Table ES-4 presents a listing of the recommended improvements and identifies the estimated capital costs to plan, design, and construct the improvements.

The ability of the master-planned reclaimed water system to accommodate all potential water reuses identified by the Demand Module (maximum reuse, including all residential and commercial outside uses) was evaluated. The system to serve only the large irrigation uses was designed to supply a peak hour demand of 142 mgd (28 mgd annual average). However, the maximum reuse demand condition would require supplying a peak hour demand of 335 mgd (67 mgd annual average), a nearly threefold increase in demand. Nearly every pipe, pump, and storage reservoir in the master-planned reuse system would have to be significantly improved to accommodate the increase in demand. As such, there were no specific areas in the master-planned reuse system that could be feasibly upgraded without drastically modifying the entire system. Consequently, no adjustments to fortify the master-planned reclaimed water system to accommodate all potential water reuses are recommended at this time.



NOTE: Refer to Figure 3-1 for the reclaimed water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Reclamation Facilities
- Water Supply Facilitiies
- Surface Spreading Basins
- Transmission Main Booster Stations

Transmission Mains

- 2009 - 2020 (New)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Reclaimed Water Transmission Main Improvements

July 2009 | **Figure ES-6**

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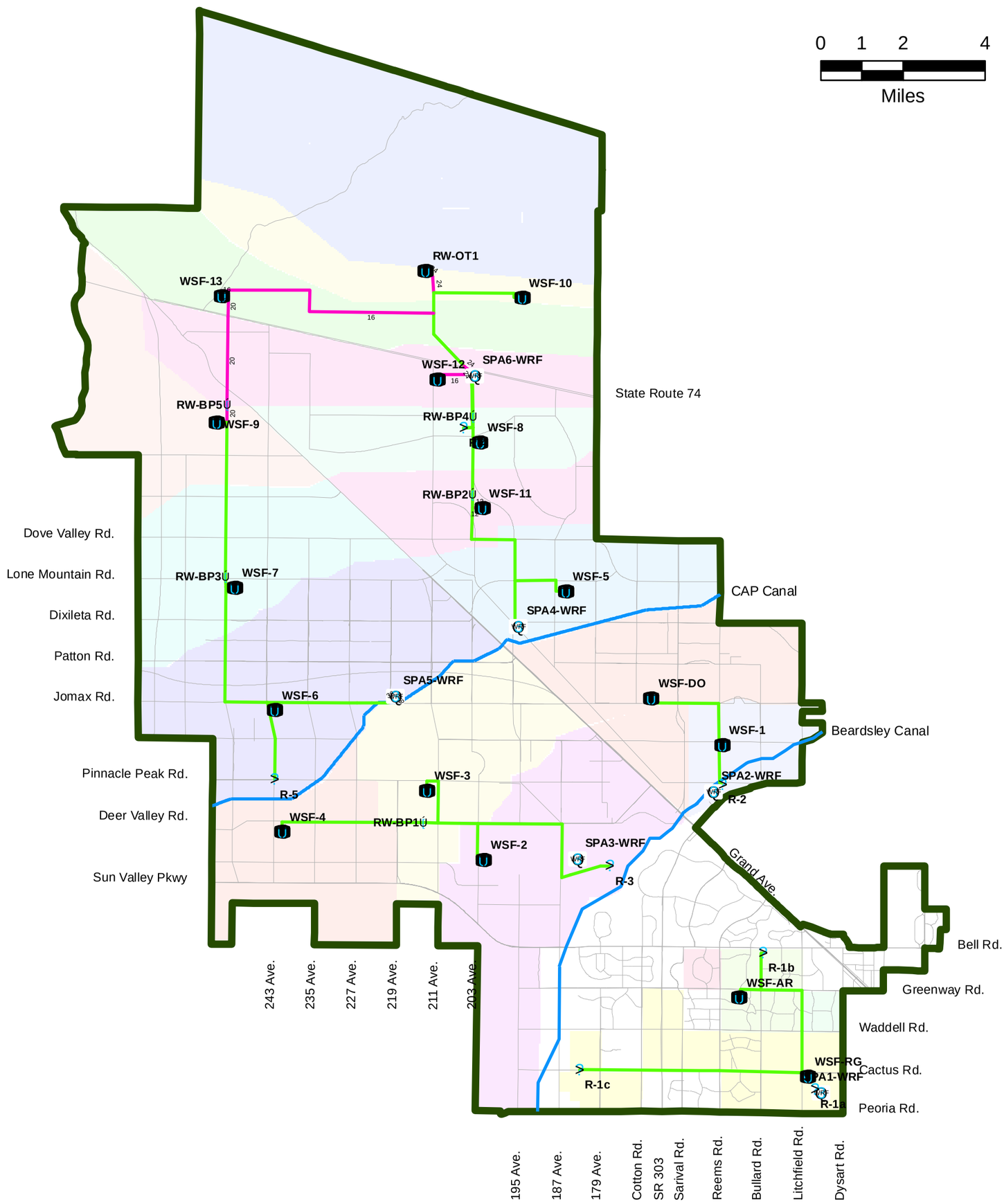

NOTE: Refer to Figure 3-1 for the reclaimed water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Reclamation Facilities
- Water Supply Facilitiies
- Surface Spreading Basins
- Transmission Main Booster Stations

Transmission Mains

- 2009 - 2020 (New)
- 2021 - Build-out (New)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Reclaimed Water Transmission Main Improvements

July 2009 | **Figure ES-7**

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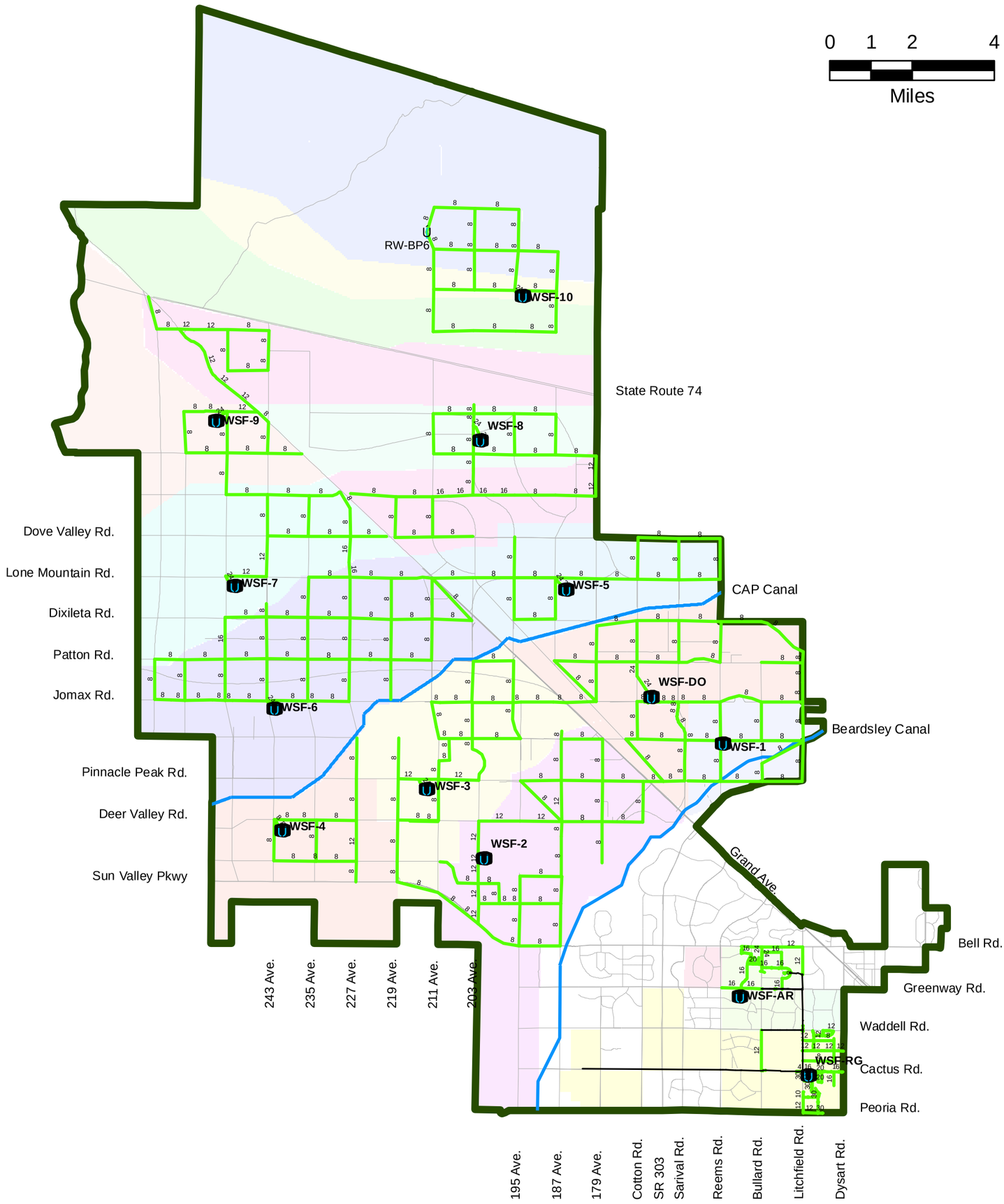

NOTE: Refer to Figure 3-1 for the reclaimed water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilitiies
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Reclaimed Water Distribution System Improvements

July 2009 | **Figure ES-8**

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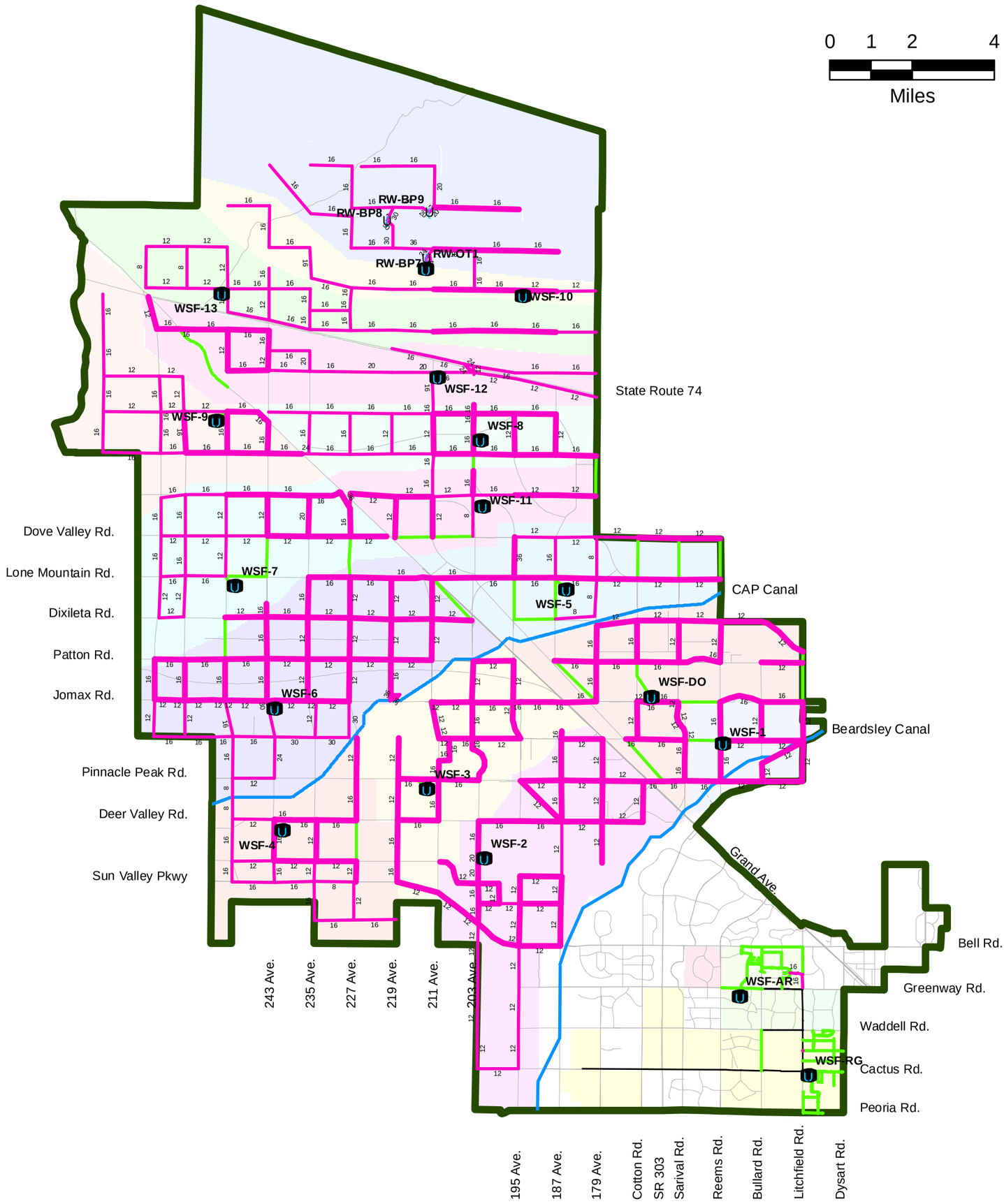

NOTE: Refer to Figure 3-1 for the reclaimed water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilitiies
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)
- 2021 - Build-out (New)
- 2021 - Build-out (Improved)

SURPRISE

MALCOLM PIRNIE

INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Reclaimed Water Distribution System Improvements

July 2009 | **Figure ES-9**

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Table ES-4.
Recommended Reclaimed Water and Recharge Infrastructure Improvements Schedule

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
Water Supply Facilities (Pressure Zone)						
Ashton Ranch, WSF-AR (PZ-1c)			**$ 3,700,000**			**$ -**
Storage Reservoir	1.4 MG		$ 2,100,000	-		$ -
Booster Pumps	4,930 gpm	161 TDH	$ 1,600,000	4,930 gpm	161 TDH	$ -
Rancho Gabriella, WSF-RG (PZ-2d)			**$ 3,100,000**			**$ 660,000**
Storage Reservoir	1.0 MG		$ 1,400,000	.35 MG		$ 530,000
Booster Pumps	3,330 gpm	208 TDH	$ 1,700,000	3,572 gpm	194 TDH	$ 130,000
Desert Oasis, WSF-DO (PZ-2a, 3a)			**$ 2,100,000**			**$ 4,600,000**
Storage Reservoir	.7 MG		$ 1,000,000	1.4 MG		$ 2,100,000
Booster Pumps	836 gpm	71 TDH	$ 400,000	1,584 gpm	75 TDH	$ 400,000
	1,409 gpm	197 TDH	$ 700,000	5,506 gpm	180 TDH	$ 2,100,000
Rancho Mercado, WSF-1 (PZ-2c)			**$ 900,000**			**$ 1,700,000**
Storage Reservoir	.3 MG		$ 400,000	.5 MG		$ 800,000
Booster Pumps	892 gpm	111 TDH	$ 500,000	2,713 gpm	110 TDH	$ 900,000
WSF-2 (PZ-2b)			**$ 1,300,000**			**$ 3,400,000**
Storage Reservoir	.4 MG		$ 600,000	1.1 MG		$ 1,600,000
Booster Pumps	1,279 gpm	108 TDH	$ 700,000	6,736 gpm	176 TDH	$ 1,800,000
WSF-3 (PZ-3b)			**$ 900,000**			**$ 700,000**
Storage Reservoir	.3 MG		$ 400,000	.2 MG		$ 300,000
Booster Pumps	876 gpm	158 TDH	$ 500,000	1,667 gpm	119 TDH	$ 400,000
WSF-4 (3c)			**$ 900,000**			**$ 4,500,000**
Storage Reservoir	.3 MG		$ 400,000	1.4 MG		$ 2,100,000
Booster Pumps	919 gpm	107 TDH	$ 500,000	5,611 gpm	177 TDH	$ 2,400,000
WSF-5 (PZ-4a)			**$ 700,000**			**$ 4,000,000**
Storage Reservoir	.2 MG		$ 300,000	1.2 MG		$ 1,800,000
Booster Pumps	759 gpm	180 TDH	$ 400,000	5,009 gpm	119 TDH	$ 2,200,000
WSF-6 (PZ-4b)			**$ 1,800,000**			**$ 5,500,000**
Storage Reservoir	.5 MG		$ 800,000	2.1 MG		$ 3,100,000
Booster Pumps	1,837 gpm	216 TDH	$ 1,000,000	9,023 gpm	153 TDH	$ 2,400,000
WSF-7 (PZ-5b)			**$ 1,000,000**			**$ 3,600,000**
Storage Reservoir	.3 MG		$ 500,000	1.1 MG		$ 1,600,000
Booster Pumps	1,028 gpm	193 TDH	$ 500,000	4,832 gpm	205 TDH	$ 2,000,000
WSF-8 (PZ-6a)			**$ 900,000**			**$ 4,600,000**
Storage Reservoir	.3 MG		$ 400,000	1.4 MG		$ 2,100,000
Booster Pumps	954 gpm	125 TDH	$ 500,000	5,726 gpm	139 TDH	$ 2,500,000
WSF-9 (PZ-6b)			**$ 1,100,000**			**$ 4,600,000**
Storage Reservoir	.3 MG		$ 500,000	1.4 MG		$ 2,100,000
Booster Pumps	1,151 gpm	239 TDH	$ 600,000	5,991 gpm	166 TDH	$ 2,500,000
WSF-10 (PZ-9)			**$ 640,000**			**$ 2,600,000**
Storage Reservoir	.20 MG		$ 290,000	.8 MG		$ 1,200,000
Booster Pumps	675 gpm	205 TDH	$ 350,000	3,432 gpm	202 TDH	$ 1,400,000
WSF-11 (PZ-5a)			**$ -**			**$ 3,200,000**
Storage Reservoir	-		$ -	1.0 MG		$ 1,500,000
Booster Pumps	-		$ -	3,353 gpm	118 TDH	$ 1,700,000
WSF-12 (PZ-7)			**$ -**			**$ 4,700,000**
Storage Reservoir	-		$ -	1.8 MG		$ 2,700,000
Booster Pumps	-		$ -	6,163 gpm	161 TDH	$ 2,000,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-13 (PZ-8)			**$ -**			**$ 5,900,000**
Storage Reservoir	-		$ -	2.2 MG		$ 3,400,000
Booster Pumps	-		$ -	7,742 gpm	166 TDH	$ 2,500,000
Off-Site Storage Tanks						
RW-OT1	.20 MG		$ 300,000	4.0 MG		$ 5,300,000
Reclaimed Water System PRVs			**$ 12,900,000**			**$ 7,600,000**
8 in	7	1.1 mgd	$ 4,200,000	1	1.1 mgd	$ 600,000
16 in	5	4.5 mgd	$ 8,700,000	4	4.5 mgd	$ 7,000,000
High Service Pumps			**$ 5,700,000**			**$ 14,700,000**
SPA1-WRF	-	-	$ -	17,107 gpm	228 TDH	$ 2,500,000
SPA2-WRF	2,314 gpm	261 TDH	$ 1,200,000	7,560 gpm	205 TDH	$ 1,700,000
SPA3-WRF	4,213 gpm	282 TDH	$ 2,200,000	14,524 gpm	286 TDH	$ 2,800,000
SPA4-WRF	1,279 gpm	222 TDH	$ 700,000	10,332 gpm	293 TDH	$ 2,500,000
SPA5-WRF	2,942 gpm	289 TDH	$ 1,500,000	11,786 gpm	300 TDH	$ 2,900,000
SPA6-WRF	270 gpm	220 TDH	$ 100,000	4,615 gpm	286 TDH	$ 2,300,000
Distribution and Transmission Boosters Pumps			**$ 1,100,000**			**$ 17,600,000**
RW-BP1	368 gpm	216 TDH	$ 200,000	2,245 gpm	88 TDH	$ 1,000,000
RW-BP2	972 gpm	122 TDH	$ 500,000	10,332 gpm	134 TDH	$ 2,600,000
RW-BP3	464 gpm	213 TDH	$ 200,000	6,186 gpm	320 TDH	$ 1,900,000
RW-BP4	218 gpm	272 TDH	$ 100,000	4,615 gpm	17 TDH	$ 2,400,000
RW-BP5	-	-	$ -	3,790 gpm	314 TDH	$ 2,000,000
RW-BP6	171 gpm	347 TDH	$ 100,000	-	-	$ -
RW-BP7	-	-	$ -	13,812 gpm	261 TDH	$ 3,200,000
RW-BP8	-	-	$ -	8,573 gpm	139 TDH	$ 2,800,000
RW-BP9	-	-	$ -	5,152 gpm	97 TDH	$ 1,700,000
Reclaimed Water Transmission Mains			**$ 80,000,000**			**$ 81,600,000**
8 in	81,357 LF		$ 11,000,000	-		$ -
12 in	56,917 LF		$ 11,500,000	-		$ -
16 in	13,824 LF		$ 3,700,000	84,357 LF		$ 22,700,000
20 in	46,477 LF		$ 18,200,000	16,834 LF		$ 6,600,000
24 in	26,476 LF		$ 11,000,000	20,308 LF		$ 8,500,000
30 in	LF		$ -	20,221 LF		$ 10,400,000
36 in	40,722 LF		$ 24,600,000	55,234 LF		$ 33,400,000
Reclaimed Water Distribution Mains			**$ 204,500,000**			**$ 417,400,000**
8 in	1,130,492 LF		$ 152,400,000			$ -
10 in	514 LF		$ 100,000	LF		$ -
12 in	127,649 LF		$ 25,800,000	699,846 LF		$ 141,500,000
14 in			$ -	LF		$ -
16 in	53,759 LF		$ 14,500,000	884,835 LF		$ 238,600,000
18 in			$ -	LF		$ -
20 in	6,039 LF		$ 2,400,000	27,371 LF		$ 10,700,000
24 in	12,350 LF		$ 5,100,000	14,244 LF		$ 5,900,000
30 in	8,159 LF		$ 4,200,000	22,969 LF		$ 11,800,000
36 in	LF		$ -	14,780 LF		$ 8,900,000
Recharge						
R-1c			**$ 15,200,000**			**$ 6,400,000**
Land	146 acres		$ 6,200,000	-		$ -
Spreading Basin	8.0 mgd		$ 9,000,000	5.9 mgd		$ 6,400,000
R-2			**$ 9,200,000**			**$ 8,100,000**
Land	116 acres		$ 4,900,000	-		$ -
Spreading Basin	3.3 mgd		$ 4,300,000	7.6 mgd		$ 8,100,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
R-3			**$ 16,200,000**			**$ 15,300,000**
Land	215 acres		$ 9,100,000	-		$ -
Spreading Basin	6.1 mgd		$ 7,100,000	14.8 mgd		$ 15,300,000
R-4			**$ 9,300,000**			**$ 13,600,000**
Land	155 acres		$ 6,600,000	-		$ -
Spreading Basin	1.8 mgd		$ 2,700,000	13.0 mgd		$ 13,600,000
R-5			**$ 15,100,000**			**$ 18,900,000**
Land	232 acres		$ 9,800,000	-		$ -
Spreading Basin	4.3 mgd		$ 5,300,000	18.5 mgd		$ 18,900,000
Recharge Recovery						
Recovery Wells (R-4)	-		$ -	3 wells		$ 6,500,000
GRAND TOTAL			**$ 388,500,000**			**$ 667,300,000**

NOTES:
WSF – water supply facility; WRF – water reclamation facility; R – recharge; RW – reclaimed water; PZ – pressure zone; OT – off-site tank; BP – booster pump
(1) January 2009 costs (ENR CCI = 8,549). Unit capital costs include engineering/design, materials of construction, installation, and contractor overhead and profit.

The following additional recommendations were made to facilitate future planning and implementation of the recommended reclaimed water and recharge master plan:

- Continue to periodically update the *Integrated Water Master Plan* every three to five years. Growth within the City MPA is dynamic and as actual development occurs, the projected reclaimed water demands, reclaimed water availability, and reclaimed water infrastructure needs will change.
- Carefully design future reclaimed water supply facilities based on the most current information on development patterns and existing infrastructure. Interim solutions (i.e., interconnects, phasing of facilities, etc.) should be considered if they meet the needs of the City, the community, and developers.
- Start documenting reclaimed water demands with the objective of refining the reuse demand factors in the Demand Module.
- Start documenting WRF influent and effluent flows with the objective of refining the reclaimed water production factor in the Demand Module.
- Conduct hydrogeologic assessments, groundwater recharge, and water quality studies throughout the City's planning area. The primary purpose of the studies would be to remove the uncertainties related to 1) recharge capabilities and locations, 2) potential for future treatment of groundwater supplies, and 3) identification of suitable future production well sites.

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1. Introduction

1.1. Background

The City of Surprise (City) Public Works Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

The City is projected to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007). To prepare for this growth and additional growth as the City approaches build-out, the City prepared a *Water Resources Master Plan* and an *Infrastructure Master Plan* in June 2004. The Water Resources Master Plan was developed to ensure that the City's water supplies were adequate to meet the current and projected demands. The Infrastructure Master Plan addressed water, wastewater, reclaimed water, and groundwater recharge infrastructure. The master plans considered a municipal planning area (MPA) of 228 square miles that was broken up into five special planning areas (SPAs): SPA 1 through SPA 5. The master plans, however, did not consider the sixth, 71 square-mile expansion area in the north, SPA 6, that has since been added to the City's MPA.

The existing water resources and infrastructure master plans are in need of updating; they are now four years old, and considerable changes have been experienced in growth and development patterns, as well as the addition of SPA 6 to the City's MPA. In December 2007, the City retained Malcolm Pirnie, Inc., in association with Replenishment Services, LLC and ASU Decision Theater, to update the master plans into an *Integrated Water Master Plan*.

1.2. Project Purpose and Scope

The purpose of the *Integrated Water Master Plan* project is to provide a long-term guidance document for the orderly improvement and growth of the City's water supply portfolio and drinking water, wastewater, reclaimed water, and groundwater recharge infrastructure. Table 1-1 provides a summary of the scope of work technical tasks for the *Integrated Water Master Plan* project.

The *Integrated Water Master Plan project* is divided into two components: Water Resources and Water Infrastructure. The purpose of the Water Resources component (Tasks 2.1 through 2.14) is to identify the projected water demands as the City continues to grow and to develop a water supply strategy that will meet the demands in a cost-effective and sustainable manner. To prepare for the Water Infrastructure component, the

Water Resources component also includes updates to projections of wastewater flows, reclaimed water availability, and reclaimed water demands in an integrated fashion. Finally, the Water Resources component includes a review and evaluation of water reuse options and reuse program alternatives, a critical element of the City's water resource portfolio.

The purpose of the Water Infrastructure component (Tasks 3.1 through 6.5) is to support the findings and general approaches outlined in the Water Resources component by developing comprehensive plans and infrastructure improvements that allow the City to implement water infrastructure improvements and expansions in a legal, cost-effective, and sustainable manner.

Table 1-1.
Integrated Water Master Plan Technical Scope of Work Tasks

Water Resources	**Water Infrastructure: Drinking Water**
2.1 Review of Regulations and Guidelines	4.1 Review of Regulations and Guidelines
2.2 Review of Background Information	4.2 Review of Background Information
2.3 Supplies	4.3 Fire Flow Testing
2.4 CAGRD Replenishment Obligations	4.4 Flow Model
2.5 Demand and Flow Factors	4.5 Evaluation of the Existing System
2.6 Demand Module	4.6 Improvements to the Existing System
2.7 Additional Water Supplies	4.7 Drinking Water Master Plan Report
2.8 Reclaimed Water Management	**Water Infrastructure: Wastewater**
2.9 Dual Water System Evaluation	5.1 Review of Regulations and Guidelines
2.10 Water Resource Model	5.2 Review of Background Information
2.11 Water Resource Scenarios	5.3 Wastewater Collection System Monitoring
2.12 Water Resource Management	5.4 Flow Model
2.13 Assured Water Supply Management	5.5 Evaluation of the Existing System
2.14 Water Resources Master Plan Report	5.6 Improvements to the Existing System
	5.7 Wastewater Master Plan Report
Water Infrastructure: Recharge	**Water Infrastructure: Reclaimed Water**
3.1 Regulations and Background Information	6.1 Review of Background Information
3.2 Recharge Methods and Evaluation	6.2 Flow Model
3.3 Recharge Improvements	6.3 Evaluation of the Existing System
3.4 Build-out of the Recharge System	6.4 Improvements to the Existing System
3.5 Recharge Master Plan Report	6.5 Reclaimed Water Master Plan Report

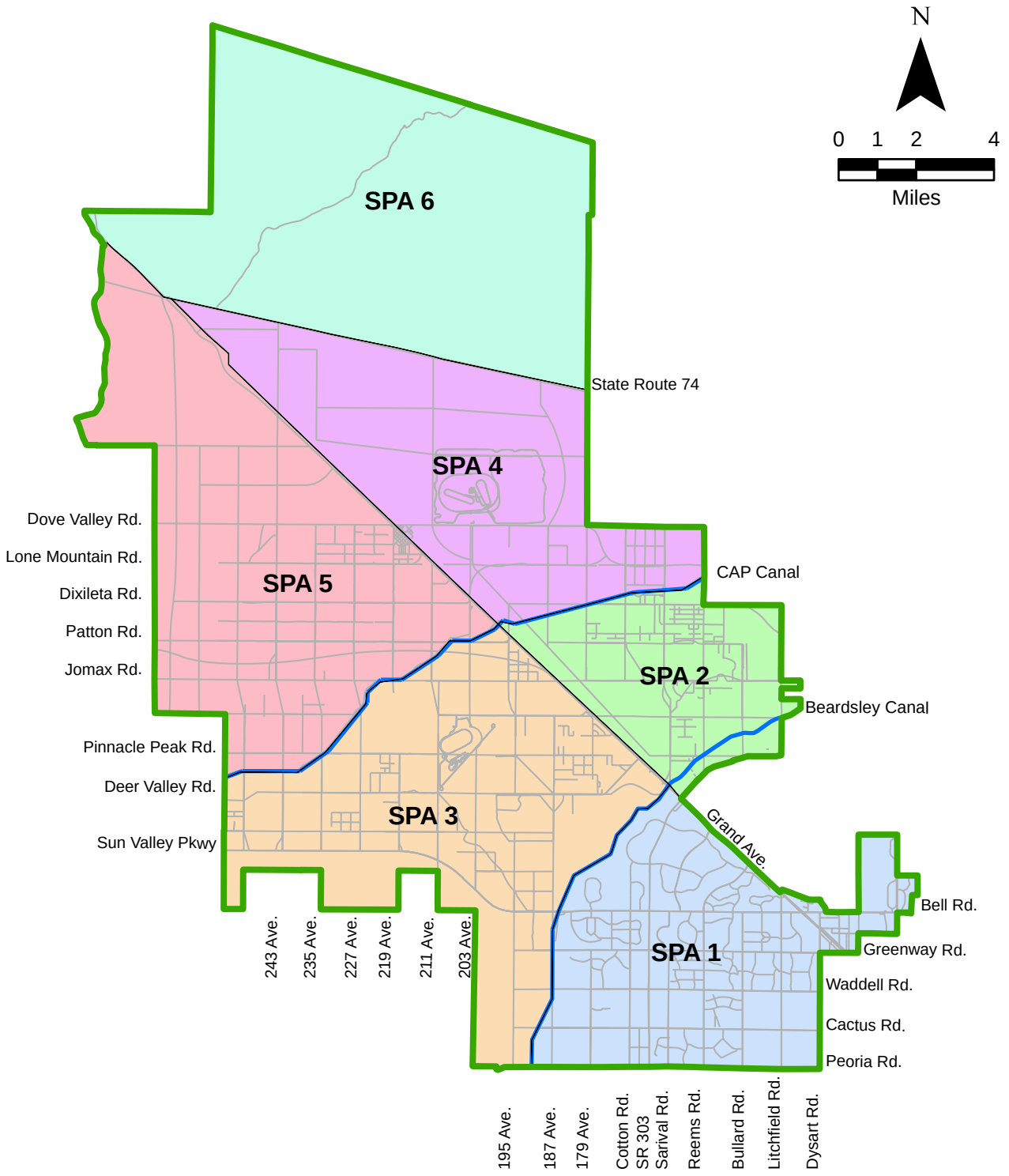
1.3. City Technical and Policy Guidance

The *Integrated Water Master Plan* project was completed under the guidance of two City committees: the Technical Committee composed of management staff from the City Public Works, Information Technology, and Planning Departments; and the Steering

Committee composed of the Deputy City Manager and the Assistant City Managers overseeing public works, planning, and development agreement activities. The Technical Committee provided information and data to the consultant team, reviewed the consultant team's technical work, and provided water, wastewater, and reclaimed water technical advice and guidance. The Steering Committee provided policy direction and oversight. The two committees gave valuable input and guidance on technical memoranda developed during the project and participated in all project workshops where results of the technical work were presented.

1.4. Study Area

The study area for this project, illustrated on Figure 1-1, includes all of the City's MPA. The MPA has been divided into six SPAs to maintain consistency with the City's previous master plan efforts and for convenience of wastewater and reclaimed water planning; i.e., the SPAs comprise logical drainage areas for existing, planned, and potential water reclamation facilities.



Legend

- Municipal Planning Area
- Special Planning Areas
- Canals
- Streets

SURPRISE ARIZONA

MALCOLM PIRNIE

INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Study Area

July 2009 | **Figure 1-1**

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2. Regulatory Framework

This section provides a brief overview of the applicable regulations, ordinances, and guidelines related to developing and maintaining drinking water, wastewater, and groundwater recharge infrastructure. The regulatory framework for water reclamation and reuse are provided in the Water Resources Component of the *Integrated Water Master Plan*. For the complete description of a particular regulation, ordinance, or guideline, contact local, state, or federal authorities to obtain a copy of the document in question.

Beyond the requirements of the federal, state, and county regulations summarized in this section, the City of Surprise has its own set of water guidelines and standards that it uses in establishing development agreements. Refer to the following documents for the most current guidelines and policies:

- General Plan
- Integrated Water Master Plan: Water Resources and Water Infrastructure
- Water Guidelines and Standards
- Engineering Development Standards

In the event that there is a conflict between any of these documents and individual development agreements, the development agreements will prevail.

2.1. Drinking Water

Surprise is currently a groundwater system serving approximately 54,000 people. In the future, it may include both groundwater and surface water sources to supply up to 700,000 people. These changes may significantly affect its regulatory obligations.

In Arizona, drinking water quality is regulated by Arizona Department of Environmental Quality (ADEQ) under primacy granted by the United States Environmental Protection Agency (USEPA). The applicable regulations are promulgated under the federal Safe Drinking Water Act (SDWA) and the Arizona Administrative Code (AAC), Title 18 "Environmental Quality," Chapter 4 "Department of Environmental Quality Safe Drinking Water." In Maricopa County, ADEQ delegates much of the regulatory enforcement to the Maricopa County Environmental Services Division (MCESD).

2.1.1. Safe Drinking Water Act

Passed by Congress in 1974, the intent of the SDWA is to protect public health by regulating the nation's public drinking water supply. The SDWA authorizes the USEPA to set health-based national standards for drinking water quality to protect against both naturally-occurring and synthetic contaminants that may be found in drinking water. In addition to the health-related primary drinking water regulations, the SDWA also authorizes USEPA to develop secondary regulations for contaminants that may adversely affect the aesthetic quality of drinking water. Secondary standards are non-enforceable guidelines.

With the exception of the secondary standards which have not been adopted, Arizona's AAC Title 18 regulations follow the SDWA requirements. ADEQ is currently in the process of changing Title 18 to incorporate the SDWA regulations by reference, rather than providing a state-specific interpretation of the regulations.

Some of the key federal standards and regulations governing surface and groundwater systems are listed in Table 2-1. For current regulations, the published date is listed; for future regulations, proposed dates are shown. Table 2-1 also indicates whether a specific regulation currently applies to the City system and whether it will apply in the future. The four surface water treatment rules, for example, would only apply to the City in the future if surface water treatment becomes part of the City's water supply.

A brief summary of the regulatory requirements of the existing rules summarized in Table 2-1 is provided below.

- **Maximum Contamination Levels (MCLs).** There are currently over 90 contaminants within inorganic chemicals (IOCs), volatile organic chemicals (VOCs), synthetic organic chemicals (SOCs), radionuclides, and disinfection by-products (DBPs) that require monitoring by a Public Water System (PWS).
- **Stage 1 Disinfectants/Disinfection By-Products Rule (D/DBPR).** The Stage 1 D/DBPR is aimed at improving public health protection by reducing exposure to DBPs. This rule establishes limits for disinfection residuals and DBP formation and may require conventional treatment plants to employ enhanced coagulation to achieve total organic carbon (TOC) removal to help reduce DBP formation in the system.
- **Stage 2 Disinfectants/Disinfection By-Products Rule.** The Stage 2 D/DBPR aims to further reduce public exposure to DBPs by establishing new MCL goals for certain DBPs and basing DBP compliance on locational monitoring at individual distribution system sites instead of system-wide monitoring. Monitoring locations, particularly for high-DBP areas of the system, are identified by an Initial Distribution System Evaluation (IDSE) program.
- **Surface Water Treatment Rule (SWTR).** For surface water treatment systems, the SWTR establishes requirements for *Giardia* and virus removal, turbidity standards, and disinfectant residual in the distribution system. The rule also applies to

Table 2-1.
Drinking Water Regulation Applicability

Regulation	Final Rule Date	Applicability		
		Current Groundwater System	Future Groundwater System	Future Groundwater and Surface Water Systems
MCLs for IOCs, VOAs, SOCs, Radionuclides, and DBPs	1976 - current	X	X	X
Stage 1 D/DBP Rule	1998	X	X	X
Stage 2 D/DBP Rule	2006	X	X	X
Surface Water Treatment Rule	1989			X
Interim Enhanced Surface Water Treatment Rule and Long-Term 1 Enhanced Surface Water Treatment Rule	1998 and 2002			X
Long Term 2 Enhanced Surface Water Treatment Rule	2006			X
Filter Backwash Recycling Rule	2001			X
Total Coliform Rule	1989	X	X	X
Lead and Copper Rule	1991	X	X	X
Arsenic Rule	2001	X	X	X
Groundwater Rule	2007	X	X	
Unregulated Contaminant Monitoring Regulation	1999 - current	X	X	X
TCR Revisions and Distribution System Rule	2011-2012	X	X	X
Radon Rule	2009	X	X	X

groundwater systems that are deemed Groundwater Under the Direct Influence of Surface Water (GWUDISW).

- **Interim Enhanced Surface Water Treatment Rule (IESWTR) and the Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR).** The IESWTR focuses on further protections against microbial contaminants for systems serving greater than 10,000 people, and the LT1ESWTR applies these same requirements to systems serving less than 10,000 people. These rules establish requirements for *Cryptosporidium* removal, turbidity monitoring and standards, and DBP profiling and benchmarking for water treatment systems that exceed certain DBP concentrations. The rules also prohibit construction of new uncovered finished water storage facilities.
- **Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).** The purpose of the LT2ESWTR is to reduce illness linked with *Cryptosporidium* and other microorganisms in drinking water. The rule supplements existing regulations by targeting additional *Cryptosporidium* treatment requirements to higher risk

systems. The rule establishes requirements for initial monitoring to determine treatment requirements, treatment based on monitoring, covering of uncovered finished water reservoirs or treatment for virus, and benchmarking current level of microbial treatment before making significant changes in disinfection practices.

- **Filter Backwash Recycling Rule (FBRR).** The FBRR adds new requirements for conventional and direct filtration plants to ensure that recycle streams are properly treated.
- **Lead and Copper Rule (LCR).** The LCR establishes action levels for lead and copper. Exceeding the action level is not a violation but may trigger additional sampling, corrosion control treatment, and public notification and/or education.
- **Arsenic Rule.** The Arsenic Rule applies to groundwater sources as well as to surface water sources and reduces the arsenic MCL from 0.050 to 0.010 milligrams per liter (mg/L).
- **Unregulated Contaminant Monitoring Regulation (UCMR).** USEPA uses the UCMR to collect data for contaminants suspected to be present in drinking water but that do not have health-based standards set under the SDWA. Every five years USEPA reviews the list of contaminants, largely based on the Contaminant Candidate List (CCL). The UCMR incorporates a tiered monitoring approach and establishes classified lists of contaminants to be monitored by specified groups of utilities.
- **Groundwater Rule (GWR).** The GWR became effective in January 2007, with compliance beginning December 1, 2009. The GWR provides increased protection against microbial pathogens in public water systems that use groundwater. The GWR establishes requirements for periodic sanitary surveys of groundwater systems, triggered source water monitoring when a water system identifies a positive sample during TCR monitoring, corrective actions, and compliance monitoring to ensure treatment technologies reliably achieve virus removal.
- **Total Coliform Rule Revision and Distribution System Rule.** The original Total Coliform Rule (TCR) set the total coliform standard based on the presence or absence of the total coliform bacteria rather than the bacterial density. USEPA is currently revising the TCR. The revision focuses on assessing the effectiveness of the current TCR in reducing public health risk and the possible use of more economic-effective alternatives or additional monitoring strategies that would maintain or improve public health protection. The proposed changes to the TCR will likely not change the number of total coliform samples taken by water utilities. The major change is likely to be that total coliform positive samples will require assessment of the problem but will no longer be an MCL violation requiring public notice.
- **Revised Unregulated Contaminant Monitoring Regulation 3 (UCMR3).** In February 2008, the USEPA released the draft CCL 3 that will be considered for possible monitoring and regulation.
- **Radon Rule.** When finalized, the Radon Rule will establish an MCL for radon and will require monitoring at each entry point to the system.

2.1.2. System Design and Operational Requirements

State rules and regulations of the ADEQ are outlined in the 1978 Arizona Department of Health Services (ADHS) Engineering Bulletin Number (No.) 8 "Disinfection of Water Systems" and Bulletin No. 10 "Guidelines for the Construction of Water Systems." These Bulletins set forth rules and guidelines for public water system design, construction, and operation in the State of Arizona.

- Bulletin No. 8 requires proper and adequate disinfection of unsafe water supplies and facilities prior to usage by the general public. In addition, the bulletin provides disinfection methods and procedures that may apply to water mains, storage reservoirs/tanks, and wells after their construction or repair, in order to destroy any bacterial pollution introduced to these facilities during such work.
- Bulletin No. 10 provides guidance and minimum design criteria for modification and construction of water systems. It is intended to provide guidance to water system planning, design, plan development, specification writing, review, and construction. The bulletin provides guidance and planning criteria for general service, fire protection, hydro-pneumatic tanks, storage facilities, and distribution systems.

2.1.3. Fire Protection Standards

The need for fire protection ultimately affects the water infrastructure with respect to size of pipelines, amount of storage, capacity of booster pumps, and amount of water production capacity needed. Fire protection facilities are periodically examined and rated by the Insurance Services Office (ISO) Commercial Risk Service. The ISO uses three components to rate a city's municipal fire protection program to develop its ratings: fire alarms (10 percent of score), fire department (50 percent), and water supply (40 percent).

The ISO determines the needed fire flow (NFF) for individual buildings based on their construction, effective area, occupancy, exposure, and communication or passageways. The NFF for a building shall never exceed 12,000 gallons per minute (gpm) or be less than 500 gpm. For one- and two-family dwelling units that do not exceed two stories in height, the maximum NFF is 1,500 gpm. For other inhabited buildings, the maximum NFF is 3,500 gpm.

The adequacy of the water supply infrastructure is determined by physically verifying the system's ability to serve the NFF in an area for a specific amount of time with a minimum residual system pressure of 20 pound per square inch (psi). For an NFF of 2,500 gpm or less, the system must be able to maintain the supply for two hours, and a three hour supply is needed for an NFF up to 3,500 gpm. If a building has an NFF greater than 3,500 gpm, it is given a public protection classification separate from the City's water system.

2.2. Wastewater

Wastewater management planning and the construction and operation of wastewater collection, treatment, and reuse systems are subject to numerous federal, state, and local laws, regulations, and rules. The purpose of these documents is to protect public health, natural resources, and receiving waters. The regulatory, legal, and institutional requirements that affect the City's wastewater infrastructure planning are summarized below. Regulations related to reclaimed water and reuse are presented in the Water Resources component of the *Integrated Water Master Plan*.

2.2.1. Federal Regulations

The federal regulations pertaining to wastewater systems include the National Pollutant Discharge Elimination System (NPDES) program, biosolids disposal regulations, and the proposed Sanitary Sewer Overflow (SSO) Rule.

The NPDES permit program establishes requirements for discharges to watercourses and is enforced through monitoring and reporting. The USEPA relies on both Federal Clean Water Act mandates and State Surface Water Quality Standards (SWQS) in developing plant-specific discharge standards for NPDES permits. In 2002, Arizona received approval from the USEPA to operate the NPDES Permit program at the state level. Arizona will now administer permits authorized or issued under the NPDES program, including expired permits that USEPA has continued in effect.

Biosolids are a primarily organic by-product of the wastewater treatment process that can be beneficially recycled. *The Standards for the Use or Disposal of Sewage Sludge* (40 CFR, Part 503) established requirements for the final use or disposal of biosolids when applied to land as a soil conditioner or fertilizer, placed in a surface disposal site, or incinerated. The rule also indicates that if biosolids are placed in a municipal landfill, the biosolids must meet the provisions of 40 CFR, Part 258, *Criteria for Municipal Solid Waste Landfills.* ADEQ became the state's biosolids enforcement authority, with oversight from USEPA, after the approval of Arizona's Biosolids/Sewage Sludge Management program by USEPA Region 9 in 2004.

The proposed SSO Rule was published by USEPA in the Federal Register in 2001. The proposed rule clarifies and expands permit requirements under the Clean Water Act for 19,000 municipal sanitary sewer collection systems in order to reduce SSOs. USEPA withdrew the proposed rule from the Federal Register during the same month to provide the U.S. President's Administration and USEPA time to review the rule. Capacity, management, operations, and maintenance (cMOM) is an integral component of the pending SSO Rule that will govern the impact, response, documentation, public communication, and prevention of avoidable sewer overflows. Once the regulation is enacted, cMOM compliance will become a standard condition of NPDES permits as the permits are reissued.

The cMOM requirements are mostly procedural in nature. Though it may be several years before the City is legally required to comply with the pending SSO Rule and cMOM components, many forward-looking utilities are already beginning to assess their existing level of compliance in order to be better prepared upon passage of the regulation. In January 2005, the State of Arizona issued a voluntary version of the cMOM requirement with the release of R18-9-C305. The "voluntary" General Permit administered by the ADEQ went into effect November 14, 2005. With the release of these "voluntary" requirements, the State has set the precedence to incorporate the USEPA cMOM requirements.

2.2.2. State Regulations

State regulations and guidelines that pertain to wastewater systems include the Environmental Quality Act, State SWQS, and the Unified Water Quality Permit.

- The Arizona Environmental Quality Act of 1986 was established to develop rules, regulations, and guidelines regarding water quality, air quality, solid waste management, hazardous waste disposal, underground storage tanks, and light pollution. Relative to water quality, ADEQ establishes surface water, aquifer, drinking water, and wastewater collection and treatment standards.
- The SWQS identify protected use designations and establish water quality criteria for water bodies throughout Arizona. The SWQS are subjected to triennial reviews, as required by the Federal Clean Water Act. Because USEPA must incorporate State SWQS into NPDES permits, proposed revisions to the standards have a potential direct impact on treatment plant processes and operations. The most recent revisions to the SWQS resulting from the triennial review process became effective on March 31, 2003; however, there is a subsequent revision pending promulgation expected in early 2009.
- The Unified Water Quality Permit was promulgated in 2001 by ADEQ and includes a unified permitting approach for wastewater treatment, collection, reuse, and recharge systems. The Aquifer Protection Permit (APP) program rules were expanded to include all categories of discharge, and the previously existing sewerage rules were repealed and placed in the APP Rules. The new APP Rules eliminated the Approval to Construct (ATC) and Approval of Construction (AOC) processes, modified definitions of Best Available Demonstrated Control Technology (BADCT) for wastewater treatment plants, and incorporated guidelines and requirements of Engineering Bulletin No. 11 "Minimum Requirements for Design, Submission of Plans and Specifications of Sewage Works" and Engineering Bulletin No. 12 "Minimum Requirements for Design and Installation of Septic Tank Systems and Alternative On-site Disposal Systems". The Federal NPDES program was not unified with the new program.

2.2.3. Regional Factors

Regional programs that pertain to wastewater systems include the local programs derived from the federal Clean Water Act Section 208 and the Clean Air Amendments.

Under section 208 of the Clean Water Act, regional planning agencies are required to develop comprehensive Water Quality Management Plans (WQMPs). The WQMPs identify existing and proposed wastewater treatment facilities to meet the anticipated municipal and industrial waste treatment needs of an area over a 20-year period and provide general planning guidance for non-point source, sludge, storm water, and other activities. The WQMPs assure the State's water quality standards will be consistently maintained and provide control over the discharge or placement of dredged or fill material. The area-wide plans are incorporated into the State WQMPs through the State Continuing Planning Process (CPP). To assure the proposed facility or usage will be consistent with the existing Certified Regional WQMP, Consistency Reviews are required for NPDES permits (new and renewals), new wastewater treatment facilities discharging over 3,000 gallons per day, and modifications to existing facilities.

Of the eleven titles that compose the federal Clean Air Act Amendments (CAAA) of 1990, Titles I, III, and V are especially important to wastewater treatment plants. The federal regulations refer to wastewater treatment plants that are subject to these rules as Publicly Owned Treatment Works (POTWs). USEPA and Arizona have delegated their authority to Maricopa County to operate its own Air Quality Program. Under this delegation, the Maricopa County Air Quality Department (MCAQD) regulates businesses (including POTWs) relative to air quality, including issuing air quality permits. The air pollutants that are typically of primary concern for POTWs are VOCs, nitrous oxides (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter, hydrogen sulfide (H_2S), and hazardous air pollutants (HAPs). The primary sources of NOx, CO, and SO_2 emissions are combustion units, such as incinerators, boilers, engines, and digester gas flares. While VOCs are also combustion by-products, VOCs, HAPs, and H_2S are primarily generated from wastewater treatment operations. Hydrogen sulfide is most commonly present in wastewater collection systems and treatment plants as a result of the wastewater's dissolved sulfide being stripped into the air. The VOCs and HAPs are also often found in collection systems and wastewater treatment plants as a result of industrial and commercial discharges and household products disposal.

2.3. Recharge

This section provides a summary of state and federal rules and guidelines that pertain to recharging reclaimed water. The primary recharge rules and guidelines include the Arizona Department of Water Resources (ADWR) rules for Aquifer Storage and Recovery Wells, ADEQ Aquifer Protection Permit rules, and the USEPA rules for Underground Injection Control. Other permits and approvals such as floodplain use

permits or right-of-way permits, issued by Flood Control District of Maricopa County (FCDMC), may be required if a proposed recharge facility is located on a floodplain or on county property.

2.3.1. Aquifer Storage and Recovery Wells

Arizona Revised Statutes (A.R.S. § 45) provide jurisdiction for ADWR to permit and monitor operation and reporting of underground storage facilities (USF), water storage (WS) facilities, and recovery wells (RW). USF permits are issued to allow the owner to operate a facility that discharges reclaimed water to the vadose zone and aquifer. To attain a USF permit in Maricopa County, the owner must, among others, demonstrate that the facility design is hydrologically feasible, does not cause unreasonable harm to land or other water users in the area of impact, and is continually monitored to ensure that the storage does not cause migration of poor quality water.

WS permits are issued to allow the owner to store reclaimed water at a permitted USF. Applications for WS permits are typically submitted concurrently with the USF permits.

RW permits are issued to allow the owner to recover long-term storage credits or to recover stored water annually. Specifically, the owner may recover stored water anywhere within their service area provided the reclaimed water is stored in the same Active Management Area (AMA) where the water is to be recovered. ADWR also allows a city to apply with a single permit to have existing production wells, within its service area, listed as recovery wells on the RW permit. For each new service area well that will be used as a recovery well, the owner is still required to conduct a well impact analysis in order to ensure that the recovering of the stored water in the proposed areas does not damage other land and water users. Existing, permitted, service area wells do not require a well impact analysis.

2.3.2. Aquifer Protection Permit Rules

Arizona Revised Statutes also provide jurisdiction to ADEQ to issue APPs for facilities that recharge reclaimed water to the aquifer using recharge basins and injection wells. The intent of the APP regulations is to protect the aquifer water quality from recharge facilities that dispose of reclaimed water into the vadose zone and aquifers. APPs require the owner to monitor the quality of the reclaimed water as well as conduct compliance monitoring of groundwater at a designated point of compliance (POC) down gradient from the facility. The quality of the reclaimed water is typically regulated under a separate APP for the WRF. These two facilities can also be combined under one APP under the State's Unified Permit Rule if they are proximal to each other.

Under APP, recharge facilities must be designed, constructed and operated in such a way that there will be no migration of pollutants in excess of Aquifer Water Quality Standards (AWQS) to the aquifer or vadose zone; the groundwater quality must meet the AWQS or

permit specific Alert Levels (AL) at the designated POC; and the treatment processes must utilize the BADCTs to meet the water quality parameters for reclaimed water as summarized in Table 2-2.

Table 2-2.
Applicable BADCT Water Quality Requirements

Water Quality Parameter	BADCT Effluent Requirements (A.A.C.R18-9-B204)
BOD_5 (mg/L)	< 30 (30-day average) and 45 (seven-day average)
$CBOD_5$ (mg/L)	< 25 (30-day average) and 40 (seven-day average)
TSS (mg/L)	< 30 (30-day average) and 45 (seven-day average)
pH	6.0 – 9.0
Removal Efficiency	85% for BOD_5, $CBOD_5$, and TSS
Total N (mg/L)	< 10 (5 month rolling geometric mean)
Pathogens (Fecal coliforms/E. Coli)	No Fecal Coliform or *E. coli* in four (4) of the seven (7) daily samples collected during the week. Single sample maximum of Fecal Coliform 23 cfu/100ml or *E. Coli* 15 cfu/100ml.
R18-11-406(B-G) constituents	Numeric water quality standards must be met
A.R.S. 49-243(I) regulated chemicals	Removal to greatest extent possible without regard to cost
Trihalomethanes µg/L	Minimize THM compounds generated as disinfection by-products using chlorination, dechlorination.

2.3.3. Underground Injection Control

USEPA has jurisdiction to issue Underground Injection Control (UIC) permits. The permits are based on classification of the UIC wells. The UIC wells utilized for municipal wastewater disposal typically fall under Class I and Class V wells.

Class I wells are permitted by USEPA in consultation with ADEQ and are wells that are designed and constructed to inject hazardous and non-hazardous wastes into deep, isolated rock formations below the lowermost underground sources of drinking water (in Arizona this could occur below the regional aquifers). They are most commonly used by petroleum refineries, metal production, chemical production, pharmaceutical production, commercial disposal, and food production industries, as well as municipal wastewater treatment facilities. The wells are large diameter (up to 36 inches) casing that rely on gravity to place fluids underground and to reach depths between 1,700 feet to 10,000 feet in depth. Permits require demonstrations that the injection zone is separated from

USDWs by several types and thickness of confining layers. There are no wells of this type currently permitted in Arizona.

Class V wells are shallow vadose zone injection wells. Permitting of Class V wells is relatively easy when compared to Class V wells and are permitted by USEPA via notification (i.e., no permit application). ADEQ retains jurisdiction over the water quality parameters in the reclaimed water. ADEQ routinely permits vadose zone injection wells using APPs, and there are many such wells currently permitted in Arizona.

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3. Existing Infrastructure

The City's water infrastructure includes all elements of the drinking water, wastewater, reclaimed water, and recharge systems. The existing and planned infrastructure is summarized in this section. Existing infrastructure includes pipelines and facilities that have been constructed and were operational as of May 2008. Planned infrastructure included developer- and City-planned facilities and pipelines that can be considered "in-progress" (either under design or in construction) but have not yet been completed.

3.1. Service Areas

Within the City's MPA, there are 11 water service providers and two wastewater service providers. As such, the City's water and wastewater service areas differ from each other. The service areas include both areas with existing customers as well as areas that will be served in the future as the City grows. The City's reclaimed water service area is the same as the water service area, with the exception of one development in the southern portion of the service area.

3.1.1. Drinking Water and Reclaimed Water

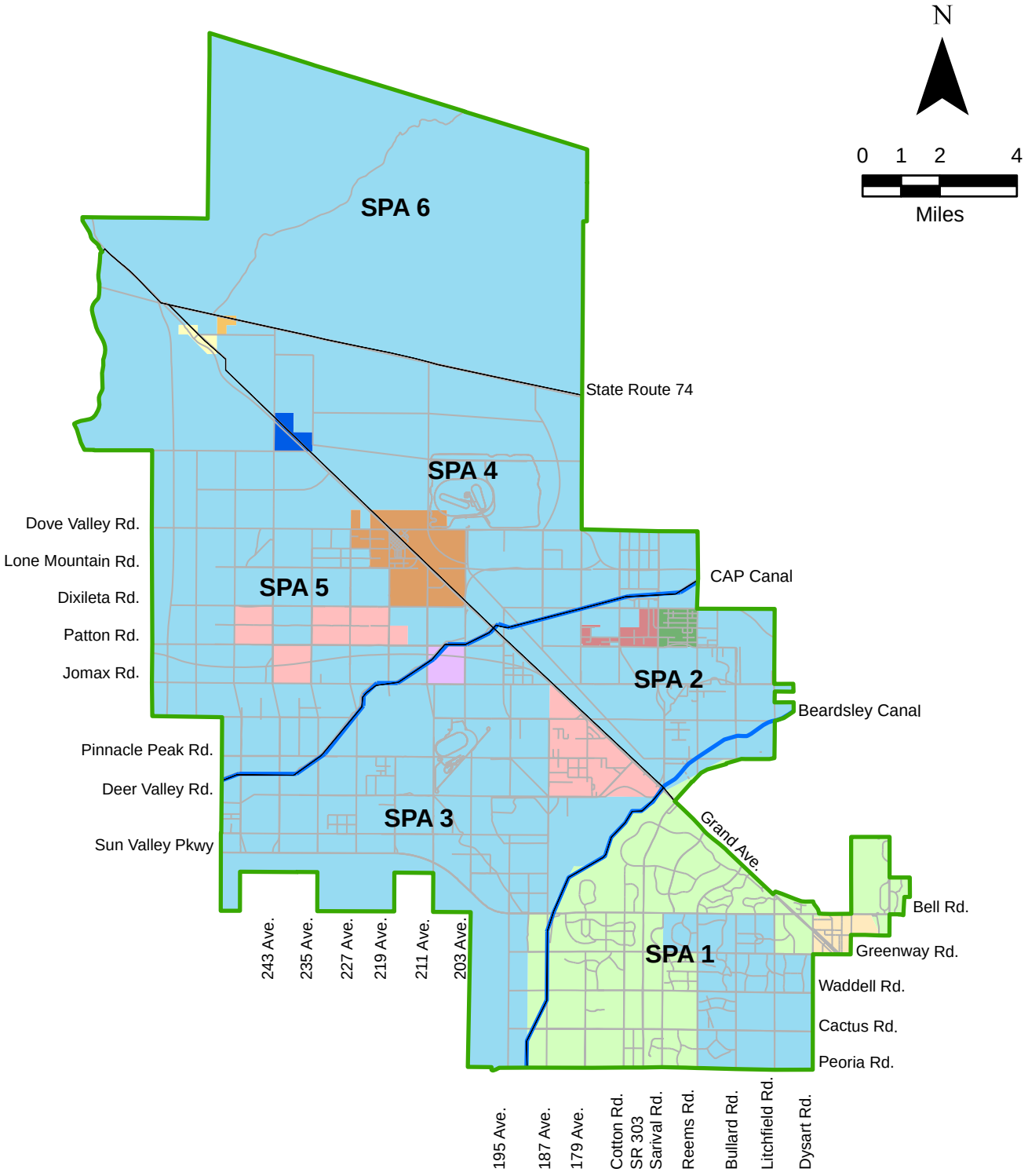
The current drinking water service area for the City of Surprise, shown on Figure 3-1, consists of the remaining portion of the City's MPA not served by one of the 10 private water companies or the City of El Mirage. With much of the MPA currently undeveloped, the City is currently only serving drinking water to existing developments in SPA 1 and SPA 2 and reclaimed water to two local farms: G Farms south of Peoria Avenue (outside the City's planning area) and Kenly Farms to the north. The reclaimed water service area (Figure 3-1) includes the City's water service area and an additional development (Prasada) located in Arizona American Water Company's (AAWC's) potable water service area.

3.1.2. Wastewater

Throughout the City's MPA, there are only two sewer service providers (Figure 3-2). While the City serves most of the planning area, AAWC serves the Coyote Lakes development and several small areas along Bell Road at the southeastern portion of the MPA.

3.2. Existing Drinking Water Infrastructure

The elements in the City's drinking water infrastructure include production wells; water supply facilities (WSFs), which include water treatment facilities, storage facilities, and pump stations; and transmission and distribution pipelines (Figure 3-3). The drinking



Legend

- Municipal Planning Area
- Special Planning Areas
- Canals
- Streets
- City of Surprise
- AZ American Water Company
- City of El Mirage
- Beardsley Water Company
- Brook/Circle City Water
- Chaparral Water Company
- Morristown Water Company
- Puesta del Sol Water Company
- Saguaro Acres
- Saguaro View
- West End Water Company

SURPRISE ARIZONA

MALCOLM PIRNIE

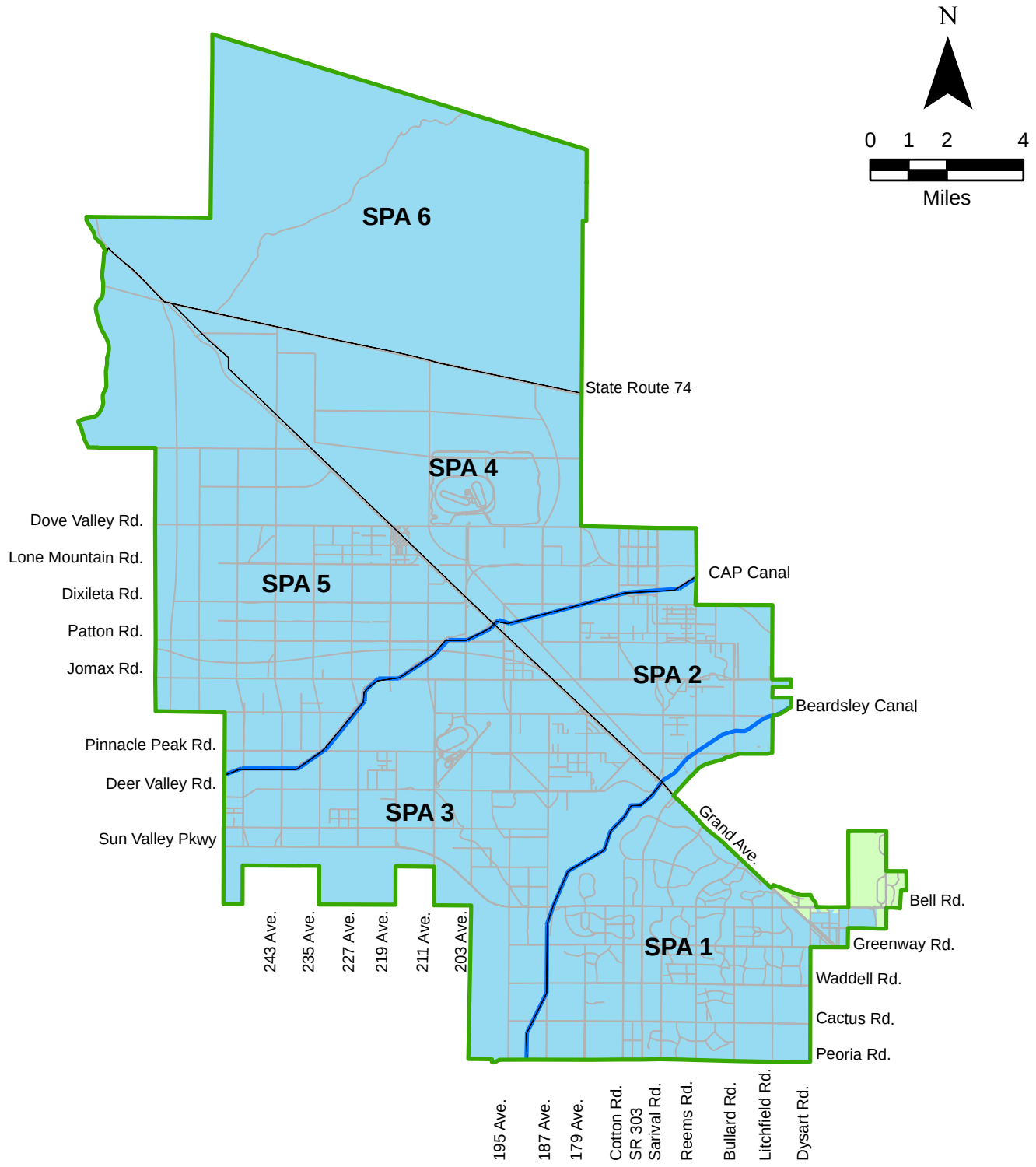
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Drinking Water and Reclaimed Water Service Providers

July 2009

Figure 3-1

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 3-1 Drinking Water and Reclaimed Water Service Providers.mxd



Legend

- Municipal Planning Area
- Special Planning Areas
- Canals
- Streets

Sewer Service Providers

- City of Surprise
- AZ American Water Company

SURPRISE ARIZONA

MALCOLM PIRNIE

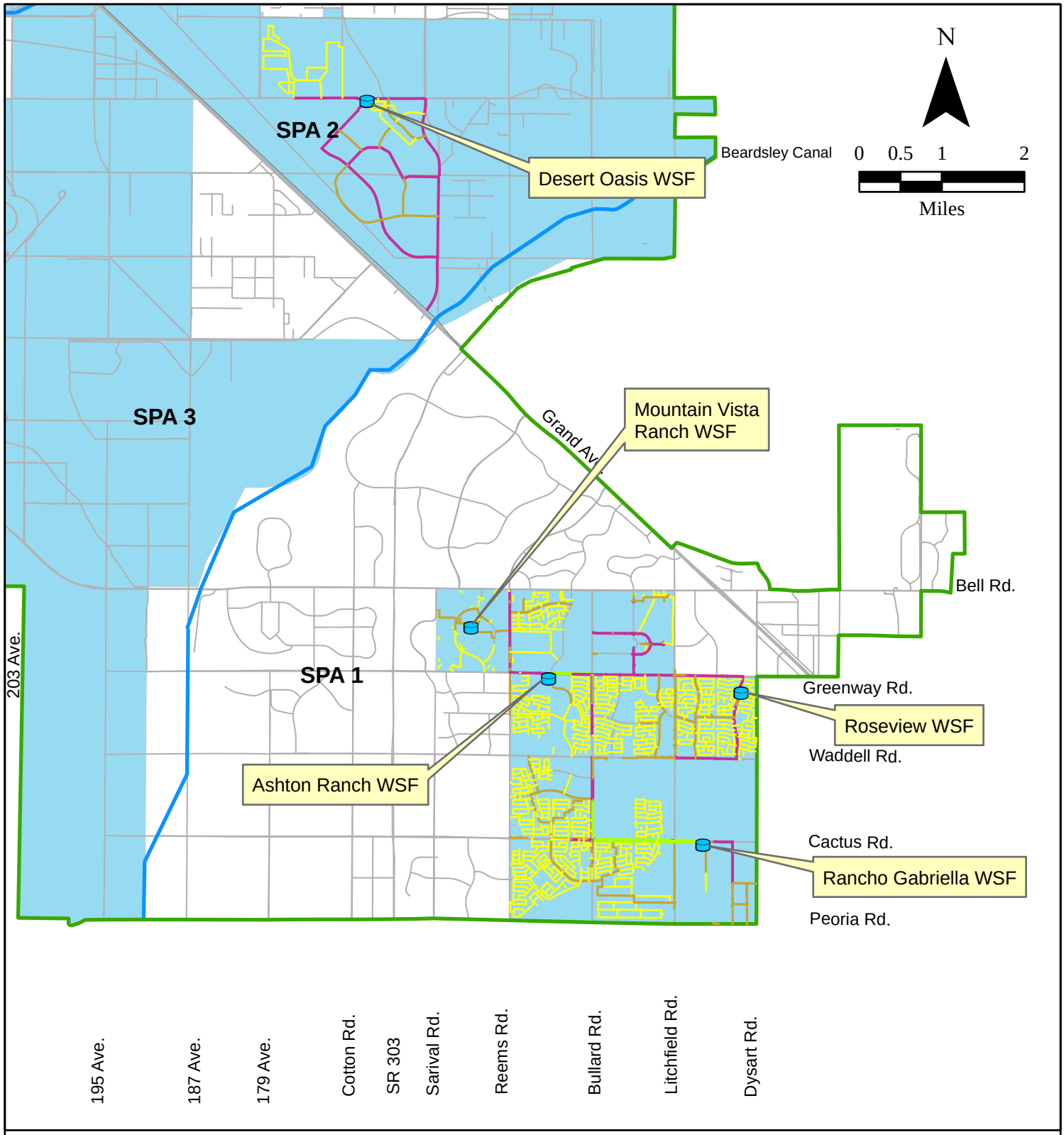
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Sewer Service Providers

July 2009

Figure 3-2

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 3-2 Sewer Service Providers.mxd



Legend

- Municipal Planning Area
- City of Surprise Water Service Area
- Canals
- Streets
- Water Supply Facilities

Drinking Water Pipelines

- 8 inch - 10 inch
- 12 inch
- 16 inch
- 20 inch - 30 inch

SURPRISE ARIZONA

INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Existing Drinking Water Infrastructure

July 2009 | **Figure 3-3**

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 3-3 Existing Drinking Water Infrastructure.mxd

water facilities are currently operated and maintained by AAWC under contract with the City. The AAWC contract terminates June 30, 2009, at which time, the City plans to take over operations and maintenance of the drinking water system within its water service area.

3.2.1. Production Wells

The existing groundwater production wells for the City service area were identified using the City's GIS files and discussions with City staff. Eleven groundwater production wells are currently used to meet water demands in the City's service area. Two wells (City of Surprise and Marley Park 1) are also owned by the City but not used to meet potable water demands. Twelve additional wells are currently under construction or in the planning stages to meet the future demand. The existing and planned groundwater production wells are summarized in Table 3-1.

The production wells are set to operate based on the water levels at the storage facilities at each WSF. The City's existing wells have a firm capacity of approximately 19 million gallons per day (mgd). The City currently defines firm well capacity as 80 percent of the total well capacity. The expected design capacity of each new well is 1,000 to 1,500 gpm.

Water quality data for some of the City's existing wells were available in new source approval reports and are presented in Table 3-2. Because data were only from one sampling event for each well, the values may not be representative of long term trends in the wells; however, the data provide a good indication of potential water quality problems. For example, arsenic in all samples exceeded the City's goal of 7 micrograms per liter (µg/L) and the federal MCL of 10 µg/L. Fluoride in one well (Litchfield Manor) was equal to the secondary MCL but was below the MCL of 4 mg/L. All other parameters were below their respective MCLs.

3.2.2. Water Supply Facilities

The City currently operates five WSFs. WSFs are centralized treatment, storage, and distribution points for water from one to five production wells in a given area. The location and capacity of each WSF is shown in Table 3-3. Information on the system components and infrastructure at each WSF is provided in the sections below.

Table 3-1.
Groundwater Production Wells

Site Name	Status	Well Capacity	
		(gpm)	(mgd)
SPA1			
Mountain Vista Ranch WSF			
Mountain Vista Ranch 1	Existing	1,260	1.81
Mountain Vista Ranch 2	Planned	TBD[1]	TBD
Ashton Ranch WSF			
Ashton Ranch 1	Existing	1,180	1.70
Orchards	Existing	1,780	2.56
City of Surprise Well	Existing	1,700	2.45
Royal Ranch	Existing	1,470	2.12
Sierra Verde	Existing	1,270	1.83
Future	Planned	TBD	TBD
Future	Planned	TBD	TBD
Roseview WSF			
Roseview	Existing	1,900	2.74
Litchfield Manor	Existing	800	1.15
Rancho Gabriela WSF			
Rancho Gabriela 1	Existing	1,250	1.80
Rancho Gabriela 2	Existing	1,270	1.83
Marley Park 1	Existing	1,150	1.66
Marley Park 2	Planned	TBD	TBD
Marley Park 3	Planned	TBD	TBD
Marley Park 4	Planned	TBD	TBD
Surprise Pointe	Planned	TBD	TBD
Nitta / Cyburt Hall	Planned	TBD	TBD
Future	Planned	TBD	TBD
Future	Planned	TBD	TBD
SPA 2			
Desert Oasis WSF			
Desert Oasis 1	Existing	1,400	2.02
Desert Oasis 2	Existing	1,280	1.84
Desert Oasis (Lancer)	Planned	TBD	TBD

Notes:
(1) TBD – To Be Determined.

Table 3-2.
Water Quality Data

Site Name	Arsenic	Fluoride	Nitrate	Sulfate	pH	Alkalinity	Calcium Hardness	TDS
	(µg/L)	(mg/L)	(mg/L)	(mg/L)	(SU)	(mg/L)	(mg/L)	(mg/L)
SPA1								
Mountain Vista Ranch WSF								
Mountain Vista Ranch 1	-	-	-	-	-	-	-	-
Ashton Ranch WSF								
Ashton Ranch 1	-	-	-	-	-	-	-	-
Orchards	**14**	0.8	1	-	-	-	-	290
City of Surprise Well	-	-	-	-	-	-	-	
Royal Ranch	8	0.5	7.1	84	8.1	120	59	390
Sierra Verde	**12**	1.2	1.6	77	8.1	120	51	360
Roseview WSF								
Roseview	**12**	1.7	1.1	31	8.1	148	49	250
Litchfield Manor	**48**	2.0	1.1	33	8.1	140	10	250
Rancho Gabriela WSF								
Rancho Gabriela 1	-	-	-	-	-	-	-	-
Rancho Gabriela 2	**12**	1.7	3.1	80	7.9	94	35	400
Marley Park 1	**11**	1.1	4.4	81	7.5	100	53	400
SPA 2								
Desert Oasis WSF	-	-	-	-	-	-	-	-
Desert Oasis W1	-	-	-	-	-	-	-	-
Desert Oasis W2	**27**	0.9	0.6	20	8.3	110	27	260

NOTE: Values in bold, red font are equal to or exceed the MCL for each contaminant

Table 3-3.
Existing Water Supply Facilities

Water Supply Facility	Address	SPA	Maximum Capacity (mgd)	Service Area (Sq. miles)
Mountain Vista Ranch	15921 W Tasha Dr.	1	8.6	1
Ashton Ranch	15151 W Greenway Rd.	1	7.5	4
Roseview	13280 W Country Gables Dr.	1	6.5	1
Rancho Gabriela	12116 W 136th Ave.	1	10.8	6
Desert Oasis	16849 W Jomax Rd.	2	10.8	1

Each WSF operates individually as a regional facility supplying water to specific regions in the system. The WSFs function as follows:

- Water from production wells is routed to a regional WSF.

- Contaminants, if present above 70 percent of the MCL, are removed prior to entering the above ground storage facilities.
- Water is chlorinated prior to distribution.
- Booster pumps at each WSF then pump water at desired pressure to the region of distribution system it is serving.

For system redundancy purposes, several interconnects are provided within the system:

- Mountain Vista Ranch WSF connects to Ashton Ranch WSF.
- Ashton Ranch WSF connects to Rancho Gabriela WSF.
- Roseview WSF connects to Rancho Gabriela WSF.

The interconnects are rarely used, but they provide alternate source and system redundancy during emergencies. The City also receives water from AAWC using interconnects at Mountain Vista Ranch and Ashton Ranch WSF.

The WSFs are equipped with a programmable logic control (PLC) system and a chart recorder to record operational data; currently these systems are not connected to the central supervisory control and data acquisition (SCADA) system. In addition, each WSF has backup power supply.

3.2.2.1. Water Treatment

To date, the City's water treatment facilities include arsenic removal and disinfection processes. Depending on source water quality and regulatory drivers, additional treatment may be needed in the future.

The Ashton Ranch facility has an active arsenic treatment plant. At this facility, direct filtration with ferric chloride is used to remove elevated levels of arsenic in the groundwater. The City is currently in the process of designing an arsenic adsorption system using granular ferric oxide at Roseview WSF and direct filtration systems with ferric chloride at Rancho Gabriela WSF and Desert Oasis WSF. No other facilities require treatment at this time; however, arsenic, fluoride, and nitrate remain contaminants of concern for the future. The City's upcoming *Water Technology Assessment* project will consider site-specific constraints and identify potential treatment processes for these contaminants.

For disinfection, Rancho Gabriela WSF has an on-site hypochlorite generation facility, and tablet chlorination is used at Desert Oasis and Roseview WSFs. The City is currently replacing tablet chlorinators at Ashton Ranch and Mountain Vista Ranch WSFs with on-site hypochlorite generation facilities. Disinfection practices for future sites will be evaluated in the *Water Technology Assessment Project.*

3.2.2.2. Storage Facilities

Each WSF is equipped with storage tanks that store water following treatment at the WSF. The storage facilities are above ground cylindrical steel tanks ranging from 0.2 million gallons (MG) to 5 MG in capacity. The water levels in these storage facilities dictate the operation of production wells supplying water to the particular WSF. The capacity and number of existing and planned storage facilities at each WSF is listed in Table 3-4.

Table 3-4.
Existing Storage Facilities

Water Supply Facility	Storage Facility	Capacity (MG)	Status
Mountain Vista Ranch	Tank #1	1.2	Operational
	Tank # 2	0.2	Planned (2008)
Ashton Ranch	Tank #1	1	Operational
	Tank # 2	5	Planned (2008)
Roseview	Tank #1	1.2	Operational
Rancho Gabriela	Tank #1	3.5	Operational
	Tank # 2	2	Not in Operation
Desert Oasis	Tank #1	1.75	Operational

3.2.2.3. Pump Stations

The booster pumps at each WSF pump water from the storage facilities to the distribution system region being served. The booster pumps are set to operate at a desired pressure in the distribution system just downstream of booster station. Booster stations at each WSF are equipped with additional pumps for emergency system demand such as fire flow. The design capacity and number of pumps at each WSF booster station are summarized in Table 3-5.

3.2.3. Pressure Zones and System Piping

The City's pipe network for water includes transmission piping and distribution piping. Transmission piping conveys water pumped from wells to each WSF, and distribution piping conveys water from the WSF to customers throughout the City's service area. Water transmission pipes range from 12 inches to 24 inches in diameter. Water distribution pipes range in size from 6 inches to 48 inches in diameter. Most of the pipes in the system are made of ductile iron (DI) or polyvinyl chloride (PVC) materials; however, there are some pipes made of asbestos concrete, cast iron, or steel materials.

Except for Desert Oasis WSF, which has a low pressure zone and a high pressure zone, each WSF provides water to a single pressure zone.

Table 3-5.
Existing Pumps Station Details

Pump Station	Number of Pumps	Motor Type	Design Head (ft)	Design Flow (gpm)	Pressure Set point (psi)
Mountain Vista Ranch	4	Variable Speed	175	1,500	72
Ashton Ranch	4	Constant Speed	163	600	-
	2	Constant Speed	140	1,500	-
Roseview	3	Variable Speed	171	1,500	76
	1	Constant Speed	171	400	-
Rancho Gabriela	5	Variable Speed	185	1,500	93
	2	Constant Speed	185	500	-
Desert Oasis	3	Variable Speed	220	1,500	99
	2	Variable Speed	220	1,500	53

3.3. Existing Wastewater Infrastructure

The elements in the City's wastewater infrastructure include water reclamation facilities (WRFs), lift stations, and collection system pipes (Figure 3-4).

3.3.1. Water Reclamation Facilities

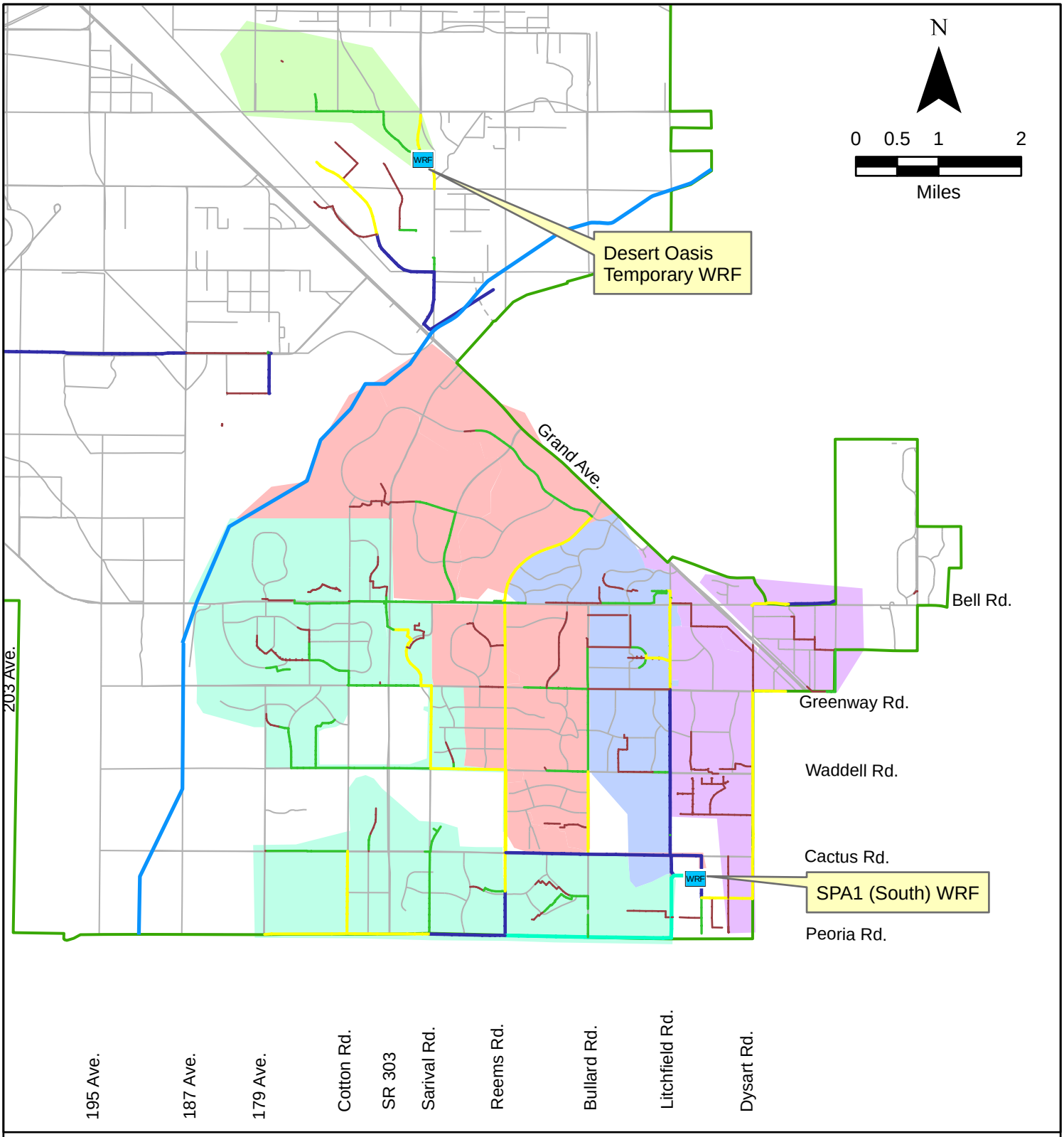
There are currently two existing WRFs in the City: the South WRF, which serves SPA 1, and Desert Oasis WRF, a temporary facility that serves developments in SPA 2. A permanent WRF in SPA 2 is currently under construction.

3.3.1.1. South Water Reclamation Facility

The South WRF, also known as the SPA 1 WRF, is located north of Peoria Road, between Dysart Road and Litchfield Road. The South WRF was constructed in phases and consists of 5 working plants (Plants 1 to 5) and 2 proposed plants (Plants 6 and 7). South WRF Plants 6 and 7 are master-planned on the site, but are not constructed yet. The plant capacities for Plants 1 through 5 at the South WRF are shown in Table 3-6. The ultimate capacity of the facility is planned to be between 24 and 28 mgd.

Table 3-6.
South WRF Existing Plant Capacities

Plant	Capacity (mgd)
1	0.8
2	2.7
3	4.8
4	4.0
5	4.0
Total	16.3



Legend

- Municipal Planning Area

Drainage Areas

- 1A
- 1B
- 1C
- 1D
- 2A
- Canals
- Streets
- WRF Water Reclamation Facilities

Collection System Pipelines

- 12 inch
- 15 inch - 18 inch
- 21 inch - 27 inch
- 30 inch - 36 inch
- 42 inch- 48 inch

SURPRISE ARIZONA

INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Existing Wastewater Collection System Infrastructure

July 2009 | **Figure 3-4**

M:\4957002\GIS\Projects_MXDs\R-1_Final\Figure 3-4 Existing Wasterwater Collection System Infrastructure.mxd

Plants 1 and 2 get their influents from the Dysart Road trunk line, and Plants 3 to 7 get, or will get, influents from the Litchfield Road trunk line. The WRF employs a series of physical, biological, and chemical processes for advanced treatment of wastewater to yield State of Arizona Class A+ effluent and bio-solids for beneficial reuse and disposal at a local landfill. The liquid stream treatment process train at the South WRF is as follows:

- Headworks – grit removal and screening of large solids
- Oxidation ditch – aeration and microbial activity (activated sludge) treatment
- Clarification – settling of large activated sludge particles
- Filtration (disk filters) – removal of small particles
- Chlorination (on-site sodium hypochlorite generation) – disinfection of microorganisms
- Storage - lined basins for direct, non-potable reuse and/or spreading basin recharge

The solids removed from the wastewater are mixed with polymers and sent to belt thickeners. Water is removed from the solids in the belt thickeners and the water goes back to the headworks. The solids are stored for approximately 1 week before being disposed at a landfill. The belt thickeners will be replaced by thickening centrifuges in the future.

3.3.1.2. SPA 2 Water Reclamation Facility

The temporary Desert Oasis WRF currently serves SPA 2. The facility is located on the southeast corner of 163rd Avenue and Desert Oasis Boulevard. The Desert Oasis WRF is a 0.35 mgd facility, serving an approximate one-square mile development. This facility uses a Modified Ludzack Ettinger (MLE) treatment technology that produces Class A^+ reclaimed water. The effluent from the sequencing batch reactor (SBR) passes through disk filters and a chlorine contact chamber before going to an unlined water storage basin located just west of the facility. When the basin nears capacity, the reclaimed water is used to irrigate desert landscaping around the facility. There is no treatment for solids in this facility; these solids are cleaned out and taken to a local landfill for disposal.

The City has designed a permanent SPA 2 WRF, and Phase 1 of the new WRF is currently under construction. The facility will have an initial capacity of 1.2 mgd and will use a SBR treatment technology that will also produce Class A^+ reclaimed water. Following start-up of the permanent facility, the temporary facility will be abandoned. Phase 2 will add an additional 2.5 mgd of capacity, and construction is scheduled to start in 1 to 3 years.

3.3.1.3. Other Water Reclamation Facilities

The SPA 3 WRF 1.8 mgd Developer Phase construction is complete, and the design of the SPA 3 WRF Regional Phase is 90 percent complete. The City's previous Infrastructure Master Plan identified WRFs for SPAs 4 and 5, but the designs for these facilities have not started. There are currently no plans for a WRF in SPA 6.

3.3.2. Lift Stations and Force Mains

Lift stations and force mains are used to pump wastewater from lower to higher elevations in the system when it is not feasible to rely on gravity flow for conveyance. Currently, the City's wastewater system has one lift station, which is located on Greenway Road just west of El Mirage Road. Wastewater entering the lift station wet well is pumped through a 14-inch force main to the next downstream manhole once it exceeds a predetermined level in the wet well. The station pumps wastewater from the Surprise Original Town Site into the Dysart Collector line.

The lift station has three pumps. Each pump has a design capacity of 1,297 gpm at 43 feet of total dynamic head. These pumps lift from a wet well which is 9 feet in diameter and 12 feet deep.

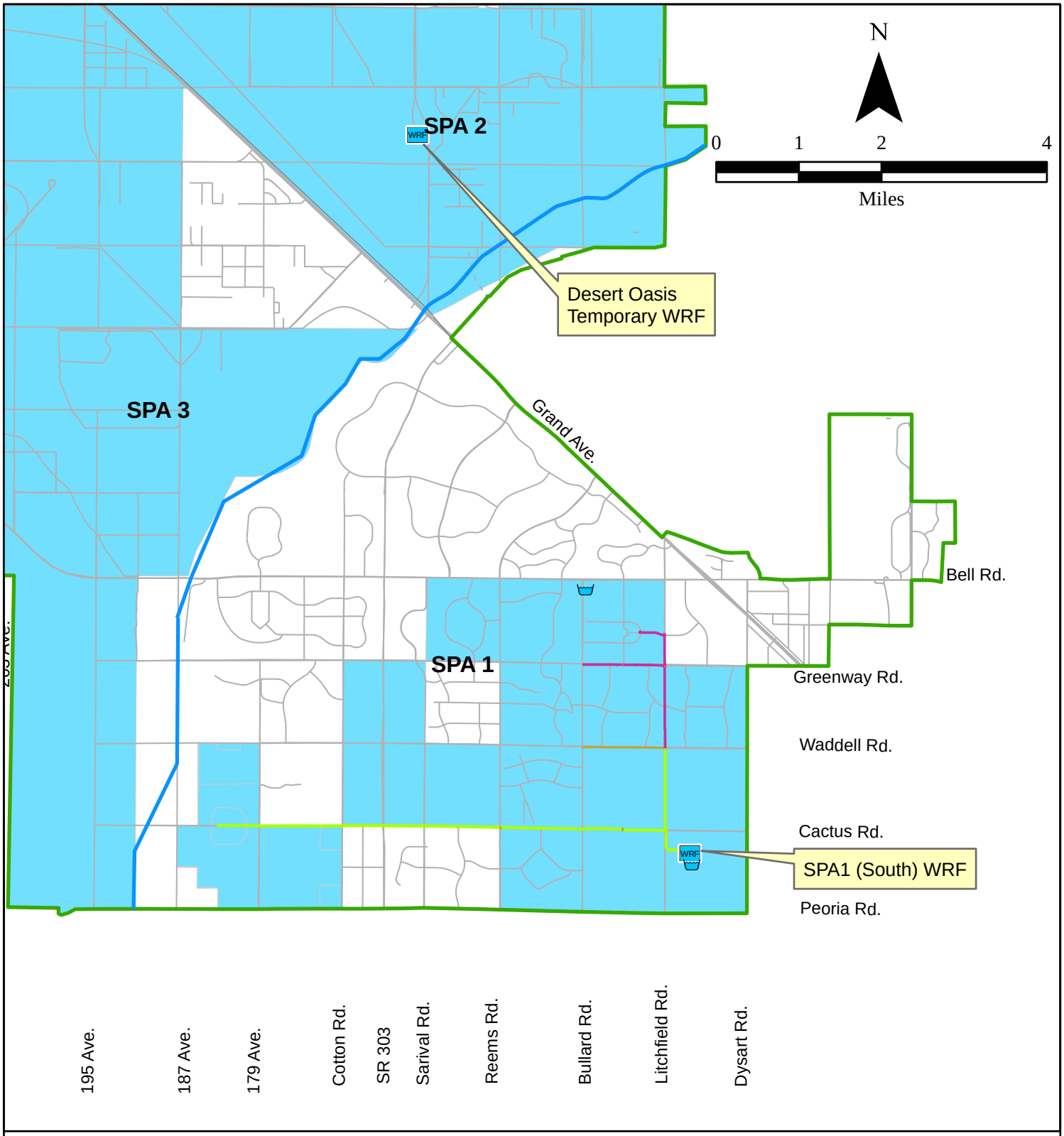
3.3.3. Collection System

The City's collection system currently serves only SPA 1 and SPA 2 (Figure 3-4). There are five drainage areas for the existing collection system; four in SPA 1 and one in SPA 2.

- Wastewater from drainage area 1A is carried to Plants 1 and 2 at the South WRF through a 24-inch trunk like along Dysart Road.
- Wastewater from drainage areas 1B, 1C, and 1D flows into Plants 3, 4, and 5 at the South WRF. Wastewater from drainage area 1B flows into the facility via a 48-inch trunk line along Litchfield Road, and wastewater from drainage area 1D flows into the facility via a 30-inch trunk line along Litchfield Road. Both of these trunk lines intersect on Litchfield Road before entering the facility. Drainage area 1C wastewater flows into the facility via a 30 inch trunk line along Cactus Road.
- Drainage area 2A is the primary basin for all wastewater generated in SPA 2 and currently flows into the temporary Desert Oasis WRF.

3.4. Existing Reclaimed Water and Recharge Infrastructure

This section summarizes the City's existing and currently planned reclaimed water and recharge systems (Figure 3-5). All WRFs produce Class A+ reclaimed water, which is suitable for direct reuse.



Legend

- Municipal Planning Area
- Reclaimed Water Service Area
- Canals
- Streets
- Water Reclamation Facilities
- Recharge Facilities

Reclaimed Water Pipelines

- 12 inch
- 16 inch
- 20 inch - 30 inch

SURPRISE ARIZONA

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Existing Reclaimed Water and Recharge Infrastructure

July 2009 | **Figure 3-5**

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 3-5 Existing Reclaimed Water and Recharge Infrastructure System.mxd

3.4.1. Reclaimed Water Storage and Distribution

The reclaimed water produced at the South WRF is currently sent to two local farms: G Farms south of Peoria Avenue (outside the City's planning area) and Kenly Farms to the north. The City is in the process of installing reclaimed water meters at a nearby retail and commercial park and will supply reclaimed water to this location once the meters are installed. The City also plans to deliver reclaimed water to a development (Prasada) in the AAWC potable water service area.

The reclaimed water produced at Desert Oasis WRF in SPA 2 is being used for desert irrigation in the vicinity of the WRF. The City is planning to build additional reclaimed water storage in the northwest portion of the Desert Oasis development. A pipeline will connect this storage to the Asante and Desert Oasis developments.

3.4.1.1. Storage Facilities

The storage reservoirs in the reclaimed system are used to store the water treated from the WRFs. The South WRF has two open reservoirs (4 MG total) that hold water after treatment from South WRF. Before entering the open reservoirs, the treated water is disinfected in chlorine contact chambers. The City may line the two remaining surface recharge basins located at the South WRF site (23 acres total) to provide additional reclaimed water storage capacity.

The Desert Oasis WRF in SPA 2 also stores the treated and disinfected water in an open reservoir before it is pumped out for desert irrigation.

3.4.1.2. Pump Stations

The reclaimed water pumps are painted a distinct purple color. There are total of nine pumps at the South WRF, seven high service pumps and two plant pumps to supply flow within the treatment facility. Out of the seven high service pumps, five pumps supply flow to the low pressure system, while the remaining two pumps to the high pressure system (Table 3-7). The low pressure pumps are controlled by demand, whereas the pumps serving the high pressure system are controlled by the pressure in the distribution system downstream. The low pressure system currently conveys water to G Farms. The high pressure system currently conveys water to Kenly Farms and reclaimed water uses north of the SPA 1 WRF.

The Desert Oasis WRF has two constant speed pumps, which pump water needed for desert irrigation near the facility. The pumps are controlled by the valves in the sprinkler system that is used for desert irrigation.

Table 3-7.
Existing Reclaimed Water Pumps

Reclaimed Water Pump Station	Number of Pumps	Motor Type	Purpose	Design Head (ft)	Design Flow (gpm)	Pressure Zone
South WRF	5	Variable Speed	Booster	65	5,900	Low
	2	Variable Speed	Booster	220	3,500	High

3.4.1.3. Pressure Zones and Reclaimed Distribution System Piping

The South WRF and temporary Desert Oasis WRF serve portions of SPA1 and SPA2 individually, so there are no pressure zones. However, within SPA 1, the South WRF serves a lower pressure zone south of the facility and a higher pressure zone north of the facility.

The existing reclaimed water pipes, which are painted a distinct purple color, extend only a few miles from the WRFs. The pipes range from 4 inches to 30 inches in diameter. The pipes are made of DI and PVC materials. The existing reclaimed water pipes in the City's reclaimed water network are shown on Figure 3-5.

3.4.2. Recharge Facilities

The reclaimed water that is not delivered for direct reuse is recharged using a combination of surface spreading basins and vadose zone injection wells. The locations of currently permitted recharge facilities and proposed recharge facilities for other SPAs are shown on Figure 3-5 and are described in the sections that follow.

3.4.2.1. Recharge in SPA 1

SPA 1 contains the City's only currently permitted recharge facility, the South Recharge Facility. The South Recharge Facility receives reclaimed water from the SPA 1 water reclamation facility and has been recharging reclaimed water under USF permit 71-562521.0002 since May 1998. The South Recharge Facility occupies an area of approximately 160 acres which has not been fully developed. The current USF permit allows the City to recharge up to 8,066 acre-feet per year (AF/year) of reclaimed water or the equivalent of 7.2 mgd. According to the City's annual recharge report for 2006, 1011.5 AF of reclaimed water was recharged at the South Recharge Facility.

Reclaimed water is currently recharged in two spreading basins No. 3 and No.4, which are 11 and 12 acres, respectively. The City reported that the infiltration rate during 2006 in basins No. 3 and No. 4 ranged from 0.21 to 0.45 feet per day (ft/day). In 2009, the City installed five vadose zone injection wells at the South Recharge Facility, each with a

recharge rate of 300 to 350 gallons per minute (gpm). The City plans to add an additional five injection wells between 2012 and 2014. Fifteen wells are also planned between years 2015 to 2020.

3.4.2.2. Recharge in SPA 2

Currently SPA 2 has a 1.2 mgd WRF under construction. Reclaimed water that is not delivered for direct reuse will be recharged using spreading basins and vadose zone injection wells. Infiltration testing at the proposed recharge location, near the SPA 2 WRF, indicates that the average saturated hydraulic conductivity is approximately 1.21 ft/day (SGC, 2006).

3.4.2.3. Recharge in SPA 3

A WRF planned for SPA 3 will use surface spreading basins to recharge reclaimed water that is not delivered for direct reuse. Infiltration testing for the proposed recharge facility site indicates infiltration rates ranging from approximately 4 to 10 ft/day (Fluid Solutions, 2006). Fluid Solutions (2006) recommended that four recharge basins, totaling 5.5 acres, should be constructed to recharge up to 1.8 mgd of reclaimed water.

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4. Historical Demands, Flows, and Peaking Factors

Understanding historical water usage trends helps cities develop more accurate predictions for the future. This section presents historical drinking water, wastewater, and reclaimed water production and/or consumption data and discusses how these data were used to determine annual average demands/flows and peaking factors.

4.1. Historical Drinking Water Demands

Annual water production data from the City's five WSFs for 2004 to 2007 are summarized in Table 4-1. Increases in demands from 2004 to 2007 are largely attributed to growth, and the fluctuations from year to year can be attributed to the relative immaturity of the City water system.

Table 4-1.
Historical Drinking Water Production

WSFs/Wells/Interconnects	Total Production (MG)			
	2004	2005	2006	2007
Mountain Vista Ranch WSF	**295**	**289**	**282**	**283**
Mountain Vista Ranch 1	1	62	177	180
Mountain Vista Ranch Interconnect[1]	294	226	105	103
Ashton Ranch WSF	**444**	**609**	**857**	**960**
Ashton Ranch Interconnect[1]	79	135	62	21
Ashton Ranch 1	365	144	295	342
Orchards	0	331	353	343
Royal Ranch	0	0	0	43
Sierra Verde	0	0	147	212
Roseview WSF	**11**	**309**	**354**	**419**
Roseview	11	285	265	417
Litchfield Manor	0	24	89	2
Rancho Gabriela WSF	**246**	**401**	**614**	**684**
Rancho Gabriela 1	246	401	394	370
Rancho Gabriela 2	0	0	221	315
Desert Oasis WSF	**0**	**7**	**67**	**116**
Desert Oasis 1	0	4	32	96
Desert Oasis 2	0	3	35	20
Entire System (MG)	**996**	**1,615**	**2,175**	**2,463**
Annual Average Production (mgd)	**2.7**	**4.4**	**6.0**	**6.8**

Note: (1) Interconnect to the Arizona American Water Company System

Maximum day to average day demand peaking factors for individual WSFs and the entire potable distribution system in 2006 and 2007 are shown in Table 4-2. The observed maximum day peaking factors ranged from 1.1 to 3.3 for individual WSFs, while the system-wide ratio ranged from 1.6 to 1.7. In 2007, the maximum day peaking factor for Desert Oasis WSF was considerably higher than all other WSFs. This could be attributed to an increased demand associated with construction activities in SPA 2.

Table 4-2.
Historical Drinking Water Maximum Day Peaking Factors

Water Supply Facility		2006	2007
Mountain Vista Ranch WSF	Average Day Production (mgd)	0.8	0.8
	Maximum Day Production (mgd)	0.9	1.0
	Maximum Day Peaking Factor	**1.1**	**1.2**
Ashton Ranch WSF	Average Day Production (mgd)	2.4	2.6
	Maximum Day Production (mgd)	3.3	4.2
	Maximum Day Peaking Factor	**1.4**	**1.6**
Roseview WSF	Average Day Production (mgd)	1.0	1.2
	Maximum Day Production (mgd)	2.1	2.1
	Maximum Day Peaking Factor	**2.1**	**1.8**
Rancho Gabriela WSF	Average Day Production (mgd)	1.7	1.9
	Maximum Day Production (mgd)	3.1	3.1
	Maximum Day Peaking Factor	**1.8**	**1.6**
Desert Oasis WSF	Average Day Production (mgd)	0.2	0.3
	Maximum Day Production (mgd)	0.4	1.0
	Maximum Day Peaking Factor	**2.0**	**3.3**
System-Wide	Average Day Production (mgd)	6.0	6.8
	Maximum Day Production (mgd)	9.8	11.4
	Maximum Day Peaking Factor	**1.6**	**1.7**

Chart recorders were obtained for some of the WSFs and used to calculate the peak hour to maximum day demand factor (Table 4-3). The peak hour factors ranged from 1.4 to 1.8. Peaking factors calculated at the Ashton Ranch WSF are only representative of the peaks noted at the WSF and do not factor in variable flows from the AAWC interconnect.

Table 4-3.
Historical Peak Hour to Maximum Day Peaking Factors

Water Supply Facility	2006	2007
Ashton Ranch WSF [1]	1.8	1.7
Roseview WSF	1.5	1.4
Rancho Gabriela WSF	1.6	1.8

NOTE:
(1) Does not account for any variable flows from the AAWC interconnect.

4.2. Historical Wastewater Flows

Daily wastewater flow data for 2006 and 2007 from the South (SPA 1) WRF SCADA system were used to assess historical wastewater flows (Table 4-4). According to the data, wastewater flows fluctuated seasonally. During the warmer, summer months (May to August), there was a reduction in the average flows, whereas the winter months (October to April) showed an increase above the average flow. This variation could be attributed to partial-year residents who typically relocate to cooler regions of country during the summer months. The historical wastewater flow data were also used to calculate a maximum month to annual average peaking factor, also shown in Table 4-4. For the highest flow months, September 2006 and October 2007, the maximum month peaking factors were 1.17 and 1.22, respectively.

The SPA 2 Developer Phase WRF is currently a temporary facility with low flows. Because historical flow and peaking factor data from this facility may not accurately represent a permanent facility, data from the SPA 2 temporary WRF were not analyzed.

Table 4-4.
South WRF Historical Average Wastewater Flows and Peaking Factors

	2006		2007	
	Flow (mgd)	Maximum Month/ Annual Average Peaking Factor	Flow (mgd)	Maximum Month/ Annual Average Peaking Factor
January	7.13	0.98	7.86	1.02
February	7.35	1.01	7.86	1.02
March	7.62	1.05	8.15	1.06
April	7.57	1.04	7.76	1.01
May	6.58	0.90	7.25	0.95
June	6.29	0.86	6.98	0.91
July	6.56	0.90	6.72	0.88
August	7.77	1.07	7.14	0.93
September	8.5	1.17	7.28	0.95
October	7.46	1.02	9.38	1.22
November	7.45	1.02	7.75	1.01
December	7.24	0.99	7.87	1.03
Annual Average	**7.29**	**-**	**7.67**	**-**

Source: City of Surprise SCADA data January 2006-December 2007

Dry weather peaking in a collection system can be represented by a peaking factor that is multiplied by the average dry weather flow in the system. A dry weather peaking factor is calculated using the peak hour flow during dry (no precipitation) weather conditions and annual average day flow. During precipitation events that produce significant run-

off, infiltration through manhole covers and other leaks within the collection system piping can increase the total flow through the collection system. A wet weather peaking factor is calculated in a similar manner to the dry weather peaking factor, except that it is based on wastewater flows during a precipitation event. Historical dry and wet weather peaking factors could not be calculated because the City's SCADA system only maintains hourly data for a period of 90 days.

4.3. Historical Reclaimed Water Production

The historical daily effluent flow data for 2005 through 2007 from the South WRF were used to determine reclaimed water production (Table 4-5). Reclaimed water production increased steadily from 2005 to 2007 and is anticipated to continue to increase as the City grows toward build-out. The reclaimed water produced was approximately 90 percent of the wastewater influent flow as determined in the Water Resources component of the *Integrated Water Master Plan*.

Table 4-5.
South WRF Historical Reclaimed Water Production

Year	Production (mgd)
2005	5.20
2006	5.85
2007	6.99

At the time this analysis was performed, there were no meters within the reclaimed water distribution system. Much of the water was either recharged or pumped to local farms in the area. Maximum day and peak hour demand factors could not be determined for existing reclaimed water uses.

5. Existing System Evaluation

This section presents recommended system performance and design criteria for the City's water (drinking water, wastewater, reclaimed water, and recharge) infrastructure, and the evaluations that were performed on the existing water infrastructure using computer hydraulic models. The drinking water and wastewater systems were evaluated to identify existing system deficiencies. No evaluation was performed on the reclaimed water system (or recharge system) because the system currently consists of only a few pipes with no metered customers.

5.1. Existing Drinking Water System

5.1.1. Existing Drinking Water Demands

Section 4 provides an analysis of historical drinking water demands and production data using 2004 to 2007 monthly operating reports for the City's service area. Based on the analysis, the existing drinking water system was evaluated using an existing (2007) annual average demand of 6.8 mgd.

5.1.2. System Performance and Design Criteria

Prior to the existing system evaluation, a review was performed of the City's existing drinking water system design guidelines. The existing guidelines were compared to values calculated from historical data, and design criteria and guidelines used by other cities in the Phoenix Metropolitan area and recognized water industry organizations. A summary of the review is provided in Appendix A. Based on the review and discussions with the City's Technical and Steering Committees, the recommended drinking water system performance and design criteria are presented in Table 5-1. Key design criteria are described in more detail below:

- **Peaking Factors –** An analysis of historical water demands (Section 4) indicated that maximum day demand ranged from 1.1 to 3.3 times the average day demand within the water service area, with averages of 1.6 and 1.7, respectively for 2006 and 2007. The City's current design guideline maximum day peaking factor of 2.0 falls within the observed range; thus, the design guideline maximum day demand peaking factor was recommended to be retained. Hourly flow data for three WSFs indicated that peak hour to average day demands from 2.5 to 3.2. The City's current design guideline peak hour peaking factor of 3.0 falls within the observed range; thus, the design guideline peak hour demand peaking factor was also recommended to be retained.

Table 5-1.
Drinking Water System Performance and Design Criteria

			Current Standard	Recommended Standard
Peaking Factors		**Maximum Day to Annual Average Peaking Factor**	2	2
		Peak Hour to Annual Average Peaking Factor	3	3
Wells/Production Facility		**Production Capacity**	1.25 X Maximum Day Demand	Maximum Day Demand
		Firm Capacity	-	Must meet maximum day demand with largest well out of service.
Arsenic Treatment		**Treatment Capacity**	Average Day Demand	Maximum Day Demand
Storage Facility		**Equalizing Storage**	1.2 X Average Day Demand	20 % of Maximum Day Demand
		Fire Storage		Fire Flow x Duration
		Emergency Storage		10 % of Maximum Day Demand
Pipe	**Transmission**	**Velocity**	-	<5 ft/s
		Head Loss	<10 ft/ 1,000 ft	< 2 ft / 1,000 ft
		Design Criteria	Maximum Day + Fire Flow	Maximum Day
	Distribution	**Velocity**	< 5 ft/s	< 5 ft/s
		Head Loss	<10 ft/ 1000 ft	<10 ft/ 1,000 ft
		Design Criteria	Maximum Day + Fire Flow	Larger of Maximum Day + Fire Flow or Peak Hour Demand
		Fire Flow Velocity	-	< 10 ft/sec
Fire Flow		**Single Family Residential**	2,000 gpm for 2 hours	2,000 gpm for 2 hours
		Multi Family Residential	2,000 gpm for 2 hours	2,000 gpm for 2 hours
		Commercial	3,000 gpm for 3 hours	3,000 gpm for 3 hours
		Industrial	3,000 gpm for 3 hours	3,000 gpm for 3 hours
System Pressure		**Maximum Pressure**	80 psi	100 psi
		Max Day/Peak Hour Conditions	40 to 80 psi	40 psi to 100 psi
		Fire Flow Conditions	20 psi Minimum	20 psi Minimum
Booster Station		**With Storage**	-	Larger of Maximum Day + Fire Flow or Peak Hour Demand
		Without Storage	-	
		Firm Capacity	-	Largest Pump out of Service

- **Production Wells –** The City's current design guidelines indicate that wells should be sized to meet 1.25 times the maximum day demand. Because the drinking water system is planned to have many production wells, it is recommended that wells need to supply only the maximum day demand. To allow for system maintenance, however, it is recommended that maximum day demand be met with the largest well out of service within each WSF.
- **Arsenic Treatment –** The City currently designs arsenic treatment facilities to treat the average day demand. In order to prevent arsenic treatment from limiting the production capacity of the WSFs, it was recommended that arsenic treatment facilities be sized to treat the maximum day demand. Arsenic treatment facilities are typically designed for split-stream treatment such that the final blended arsenic concentration is at or below the target concentration.
- **Storage –** The City's current design guidelines indicate that storage should be provided for 1.2 times the average day demand. Drinking water system storage should provide a reserve supply for operational equalization to meet hourly demand fluctuations, meet the fire flow demands, and also provide emergency storage in case of unexpected system failures. To satisfy these requirements, the recommended storage to be provided was the sum of the following volumes:
  - Equalization volume = 20 percent of maximum day demand
  - Fire flow volume = Fire flow required × duration of the fire flow
  - Emergency volume = 10 percent of maximum day demand

  This typically will result in less storage than the City's current guidelines, but with wells and arsenic treatment facilities sized for maximum day demands and booster stations sized for peak hour, the recommended storage is considered sufficient.
- **Transmission Mains –** Transmission mains convey pumped groundwater from production wells to the WSFs and thus do not need to be designed the same as distribution mains. It is recommended that transmission mains be designed to convey maximum day demands and that head loss and velocities in these mains be limited to less than 2 feet per 1,000 feet and 5 feet per second, respectively.
- **Distribution Mains –** The City's existing design guidelines for distribution mains are typical and are in accordance with recognized water industry organization guidelines. Thus, it is recommended that the existing guidelines be retained, including designing the mains to convey the larger of the maximum day plus fire flow or peak hour demand, and limiting the head loss and velocities in the mains to be less than 10 feet per 1,000 feet and 5 feet per second, respectively. The velocity should be less than 10 feet per second during fire flow conditions.
- **Fire Flow Conditions –** Using the City's fire code as a basis, the recommended fire flow criteria was to provide fire flow capacity in residential areas at 2,000 gpm for two hours and 3,000 gpm for three hours in non-residential (commercial and industrial) areas.

- **System Pressure -** The City's current design guidelines state that a maximum pressure of 80 psi is permitted. However, with the recent change to the City's plumbing code requiring pressure reducing valves on all new homes, the maximum water system pressures can be increased. Thus, the recommended maximum allowable system pressure was increased to 100 psi. During maximum day demand conditions, the recommended system pressure should be maintained between 40 psi and 100 psi. The minimum residual pressure during fire flow conditions should be 20 psi.
- **Booster Stations –** There were no existing City guidelines on the sizing of booster stations. In order to provide sufficient capacity to accommodate large flows in the system, it was recommended that booster stations be sized for the larger of peak hour demand or maximum day plus fire flow. All booster stations should also include a redundant pump to allow for maintenance.

5.1.3. Drinking Water System Model

The City's drinking water distribution system was modeled under steady-state conditions using Bentley WaterCAD® V8 XM Edition hydraulic model. Appendix B provides a description of the model, model development, and model calibration. Drinking water demands were developed with the Water Resource Demand Module (Demand Module) developed in the Water Resources component of the *Integrated Water Master Plan*.

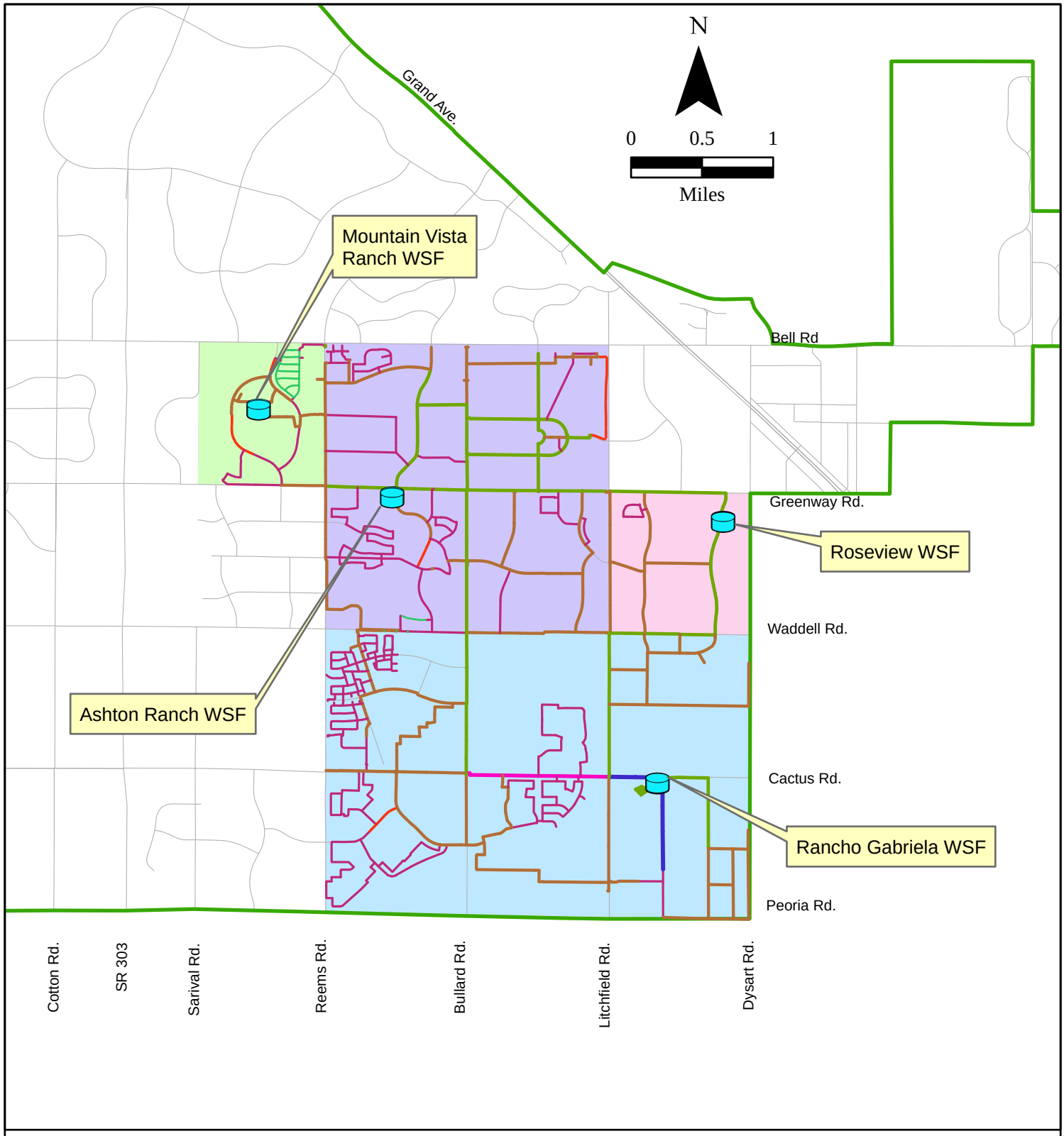
5.1.4. Modeled Drinking Water System

The primary sources of information for the existing drinking water system were the most current geographical information system (GIS) shapefiles provided by the City and the hydraulic model that was created as part of the City's 2004 *Water Infrastructure Master Plan*. The entire existing drinking water system, shown previously on Figure 3-3, has a total pipe length of just over 1,000,000 feet.

The water system was "skeletonized" using standard hydraulic modeling procedures to remove pipes that did not significantly change of affect system hydraulics. Maps of the modeled drinking water system are shown on Figures 5-1 and 5-2 for SPA 1 and SPA 2, respectively. The lengths of modeled pipes compared to the total lengths of all pipes in the ground are shown in Table 5-2. The pipes in the drinking water system model accounted for 49 percent of the total pipe length and 70 percent of the total water volume in the distribution system, which is typical for master planning efforts.

5.1.5. Existing Drinking Water System Deficiencies

The calibrated WaterCAD model was used to evaluate the existing system to identify any deficiencies during current average day, maximum day, maximum day plus fire flow, and peak hour demand conditions:



Legend

- Municipal Planning Area
- WSF Service Areas
- Streets
- Water Supply Facilities

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16
- 20
- 24

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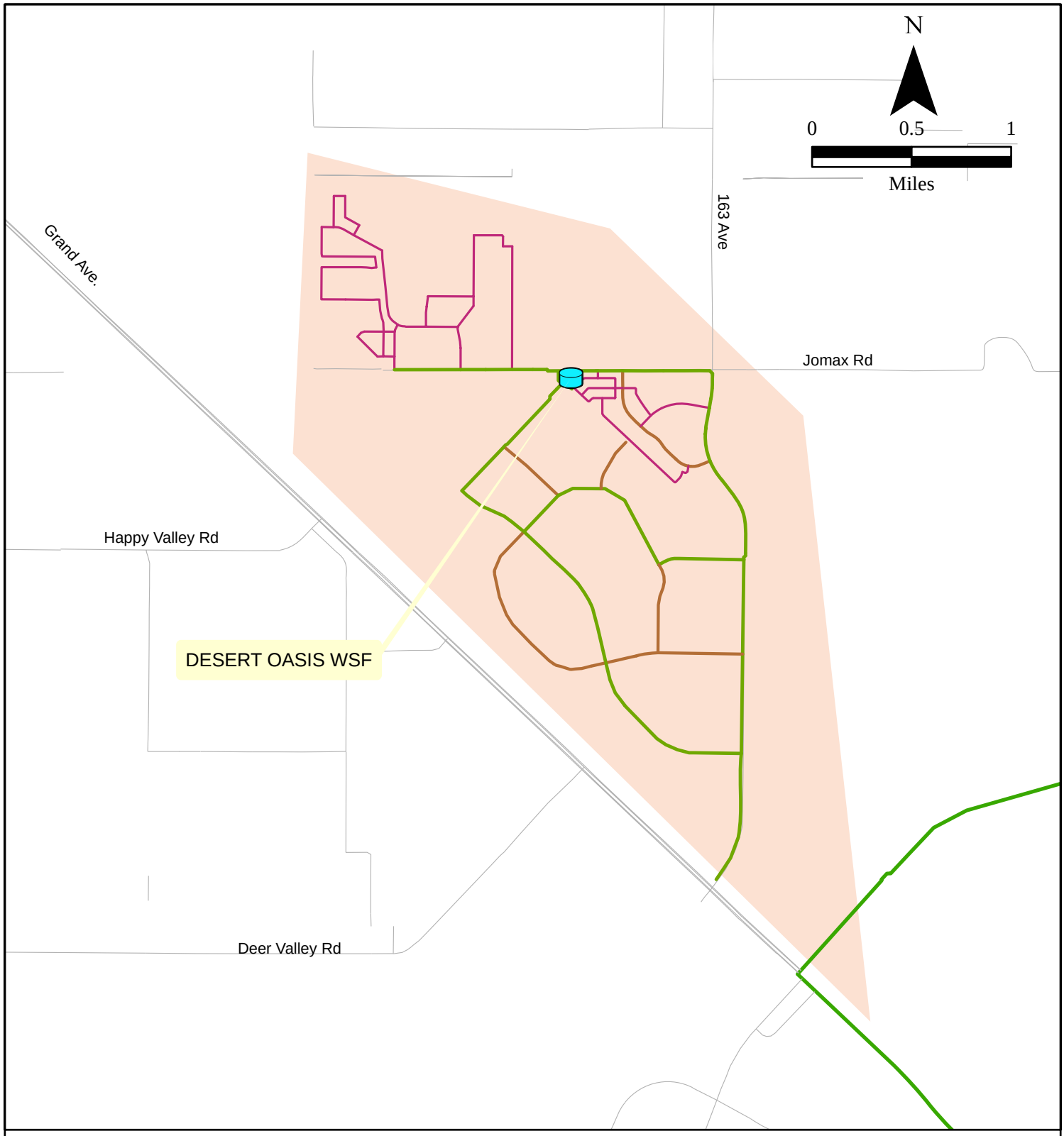
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

SPA 1 Modeled Drinking Water System

July 2009

Figure 5-1

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 5-1 SPA 1 Modeled Drinking Water Distribution System.mxd



Legend

- Municipal Planning Area
- **WSF Service Area**
- Desert Oasis
- Streets
- Water Supply Facility

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16

SURPRISE ARIZONA

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

SPA 2 Modeled Drinking Water System

July 2009

Figure 5-2

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 5-2 SPA 2 Modeled Drinking Water Distribution System.mxd

Table 5-2.
Modeled Drinking Water Pipes

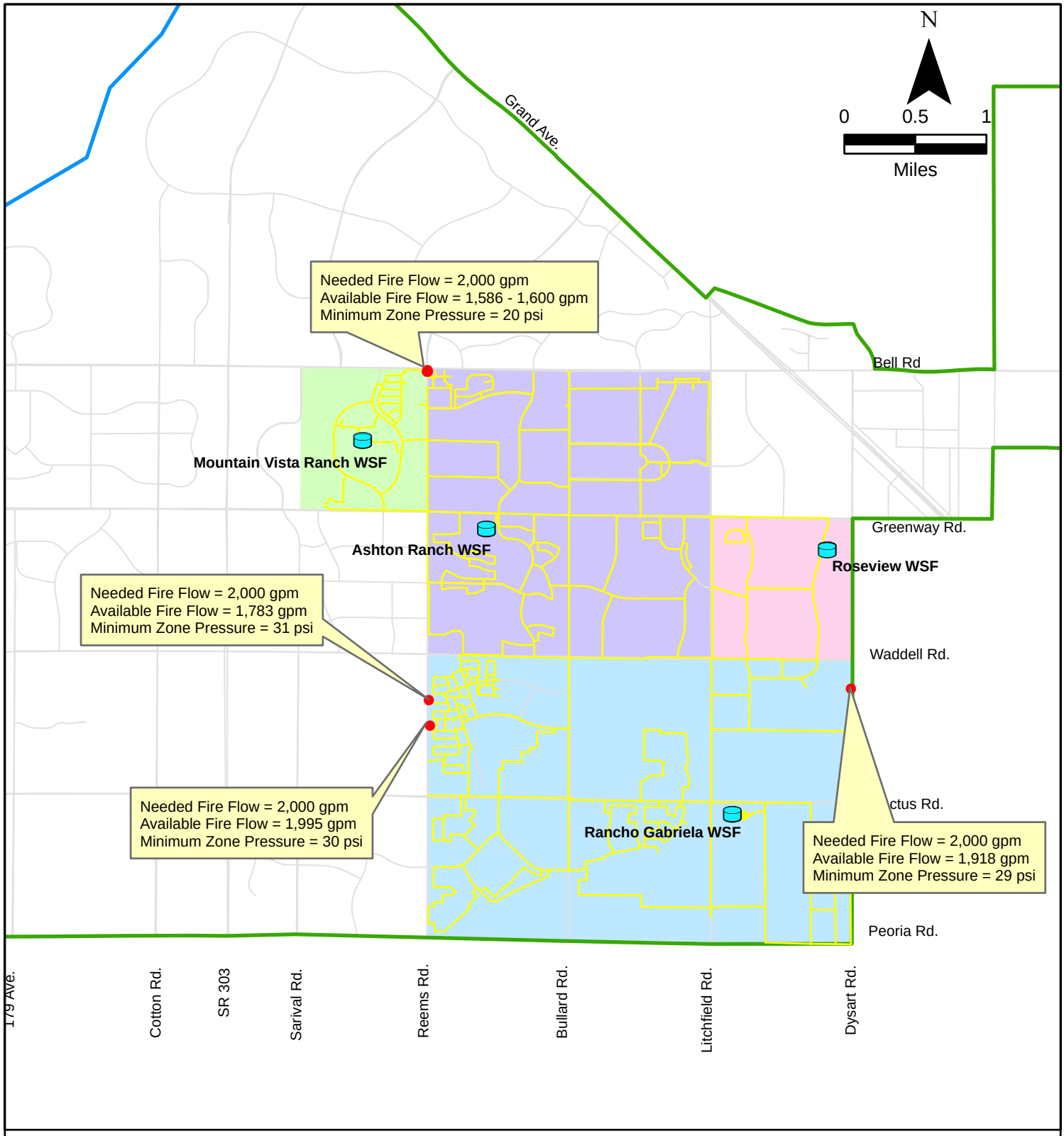
Pipe Diameter (in)	Length (feet)			Volume (gallons)		
	Total	In Model	% in Model	Total	In Model	% in Model
1	133	0	0	5	0	0
2	748	0	0	122	0	0
3	1,648	0	0	605	0	0
4	7,557	0	0	4,933	0	0
6	93,019	23,291	25	136,617	34,207	25
8	621,290	177,187	29	1,622,195	462,637	29
10	9,117	9,117	100	48,298	48,300	100
12	166,538[1]	166,568	100	978,374	978,550	100
16	115,555	115,555	100	1,206,862	1,206,857	100
20	5,515	5,515	100	89,998	89,998	100
24	5,618	5,618	100	132,018	132,018	100
Total	**1,029,459**	**502,851**	**49**	**4,220,028**	**2,952,568**	**70**

Note:
(1) Some pipes with incorrect diameters in the City's GIS were corrected in the model based on information provided by the City.

- **Average Day Demand –** No system deficiencies were noted during average day demand conditions. Velocity, head loss, and system pressure were all within appropriate system performance criteria ranges.
- **Maximum Day Demand** - Under maximum day demand conditions, the head loss, pressure, and velocity in all distribution piping met the system performance criteria. Pipe velocities greater than five feet per second, but less than six feet per second were noted in some of the booster station piping at Ashton Ranch WSF; however, these areas were not considered to be deficient because they often relate to short segments of pipe with fittings and bends in close proximity to the booster pump discharges.
- **Maximum Day Plus Fire Flow Demand –** The steady-state fire flow modeling analysis revealed a number of deficiencies in residential areas where a NFF of 2,000 gpm could not be produced while maintaining a residual pressure of 20 psi (Figure 5-3). All commercial areas were found to have an available fire flow of 3,000 gpm at a residual pressure of 20 psi or greater.
- **Peak Hour Demand –** The evaluation of the existing system did not reveal any additional deficiencies under peak hour demand conditions.

Based on the modeling evaluations above, three areas were identified as deficient for current demand conditions:

- The nodes to the northeast of the Mountain Vista Ranch WSF did not meet the fire flow requirements.



Legend

- Municipal Planning Area
- WSF Service Areas
- Canals
- Streets
- Water Supply Facilities
- Fire Flow < 2,000 gpm
- Distribution System Pipelines

SURPRISE ARIZONA

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Existing Drinking Water System Deficiencies

July 2009

Figure 5-3

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 5-3 Existing Drinking Water System Deficiencies.mxd

- The nodes at the end of Surrey Road and in the intersection of North Reems Road and Sweetwater Road also did not meet the fire flow requirements.
- The node on Dysart Road (lying south of Cactus Road) had insufficient fire flow.

Note that the three deficient areas would likely require additional improvements as demands increase in the future. As such, upgrades and improvements such as modifying the set point pressures for certain WSF pumps, new parallel pipes, and/or pipe replacements were considered and included in the evaluation of infrastructure alternatives and recommended system improvements in Sections 6 and 7, respectively.

5.2. Existing Wastewater System

5.2.1. Existing Wastewater Flows

Section 4 provides an analysis of historical wastewater flows in SPAs 1 and 2 using 2005 to 2007 SCADA reports. Average influent wastewater flows in 2007 were 7.7 mgd. During the wastewater flow monitoring conducted in June 2008 (used to calibrate the City's wastewater model), wastewater flows were approximately 5.9 mgd. Given the seasonal flows patterns described in Section 4, this would correspond to an estimated 2008 annual average flow of 6.6 mgd, which is approximately 1.1 mgd less than the 2007 average flow. The difference is likely due to the number of home vacancies that have occurred since the start of the current national economic crisis. Based on this analysis, the existing wastewater system was evaluated for an existing (2008) annual average flow of 6.6 mgd.

5.2.2. System Performance and Design Criteria

Prior to performing the existing system evaluation, a review was performed of the City's wastewater collection system design guidelines. The guidelines were compared to values calculated from historical flow data and design criteria used by other cities in the Phoenix Metropolitan area. A summary of the review is provided in Appendix A. Based on the review and discussions with the City's Technical and Steering Committees, the recommended wastewater system performance and design criteria are presented in Table 5-3. Key design criteria are described in more detail below:

- **Maximum Month Peaking Factor –** Wastewater flow data from the South WRF for 2005 through 2007 were reviewed to evaluate the monthly variation in wastewater flows (Section 4). The monthly flow data indicated a trend of elevated flows in the fall/winter and lower flows in the summer. The greatest monthly peaking factor was observed in October 2007, where the flow was 20 percent greater than the 2007 average. Thus, a maximum month to annual average flow factor of 1.2 was recommended.

Table 5-3.
Wastewater System Performance and Design Criteria

Element	Design Criteria	Current Standard	Recommended Standard
Peaking Factors	**Maximum Month (based on average annual flow)**	None	1.2
	Overall (based on average annual flow)	< 12-inch Pipe = 4.0	< 12-inch Pipe = 4.0
		≥ 12-inch Pipe = 2.5	≥ 12-inch Pipe = 3.0
Gravity Sewers	**Design Criteria**	None	Peak flow
	Manning's Coefficient	0.013	0.013
	Minimum Velocity	2 ft/s Flowing Full	2 ft/s Flowing Full
	Maximum Velocity	9 ft/s	9 ft/s
	Minimum Pipe Size	8-inch	8-inch
	Depth Ratio	None	<0.8
Force Mains	**Minimum Velocity**	None	3 ft/s
	Maximum Velocity	None	8 ft/s
Pump Stations	**Design Criteria**	None	Firm Capacity Exceeds Peak Flow
	Firm Capacity	None	Largest Pump out of Service

- **Overall Peaking Factor -** The current City design guidelines recommend an overall peaking factor of 2.5 times the average day flow to determine peak design flows for 12-inch or larger trunk sewers and 4.0 times the average day flow for pipes less than 12 inches. The actual peaking factor will vary based on drainage area characteristics. Smaller areas draining to smaller pipes will typically experience greater peak flows and greater variation in flow than larger drainage areas. The results of collection system flow monitoring were used for calibrating the City's wastewater system hydraulic model (Appendix C) and to assess flow peaking in the system. The instantaneous peaking factors observed at the flow meters ranged from 1.1 to 3.0, all of which occurred during dry weather conditions. Therefore, using a factor of 2.5 applied to the average annual flows may not adequately account for wet weather flows. Thus, the recommended overall peaking factor for pipes 12 inches and greater in diameter was 3.0, which should account for wet weather peaking. The current design guideline peaking factor of 4.0 for pipes smaller than 12 inches in diameter was retained.
- **Gravity Sewers –** The City's current design guidelines for sizing gravity sewers are consistent with other communities in the area. It was recommended that the current City design guidelines for gravity sewers be retained.
- **Gravity Sewer Surcharge -** The depth ratio is the ratio of the maximum flow depth to the diameter of the pipe and is often used to establish an allowable degree of surcharge in the collection system. The depth ratio for surrounding communities

ranged from slightly less than full (depth ratios from 0.8 to 0.9) to half full (depth ratio of 0.50; typically applied in pipes with diameters less than 12-inches). Based on this information, a depth ratio of 0.80 (flowing 80 percent full) was recommended as the maximum degree of allowable surcharge in a gravity sewer.

- **Force mains –** The City did not currently have design guidelines for sewer force mains. Thus, it was recommended that force mains be sized to maintain velocities between 3 feet per second (ft/s) and 8 ft/s. The lower bound of the velocity range is the minimum velocity needed to prevent solid deposition, while the upper bound of the velocity range limits the frictional pressure losses. This range was also typical of the velocity range used by surrounding communities (2 to 10 ft/s). The Hazen-Williams pipe roughness coefficient used for sizing force mains was assumed to be 100. This corresponds to typical wastewater force main piping systems that have been in place for over 15 years.

Pump Stations - The pump stations should handle the maximum flows in the collection system. For the system analysis, the pump station's firm capacity (operating with the largest unit out of service) was designed to convey the peak flow.

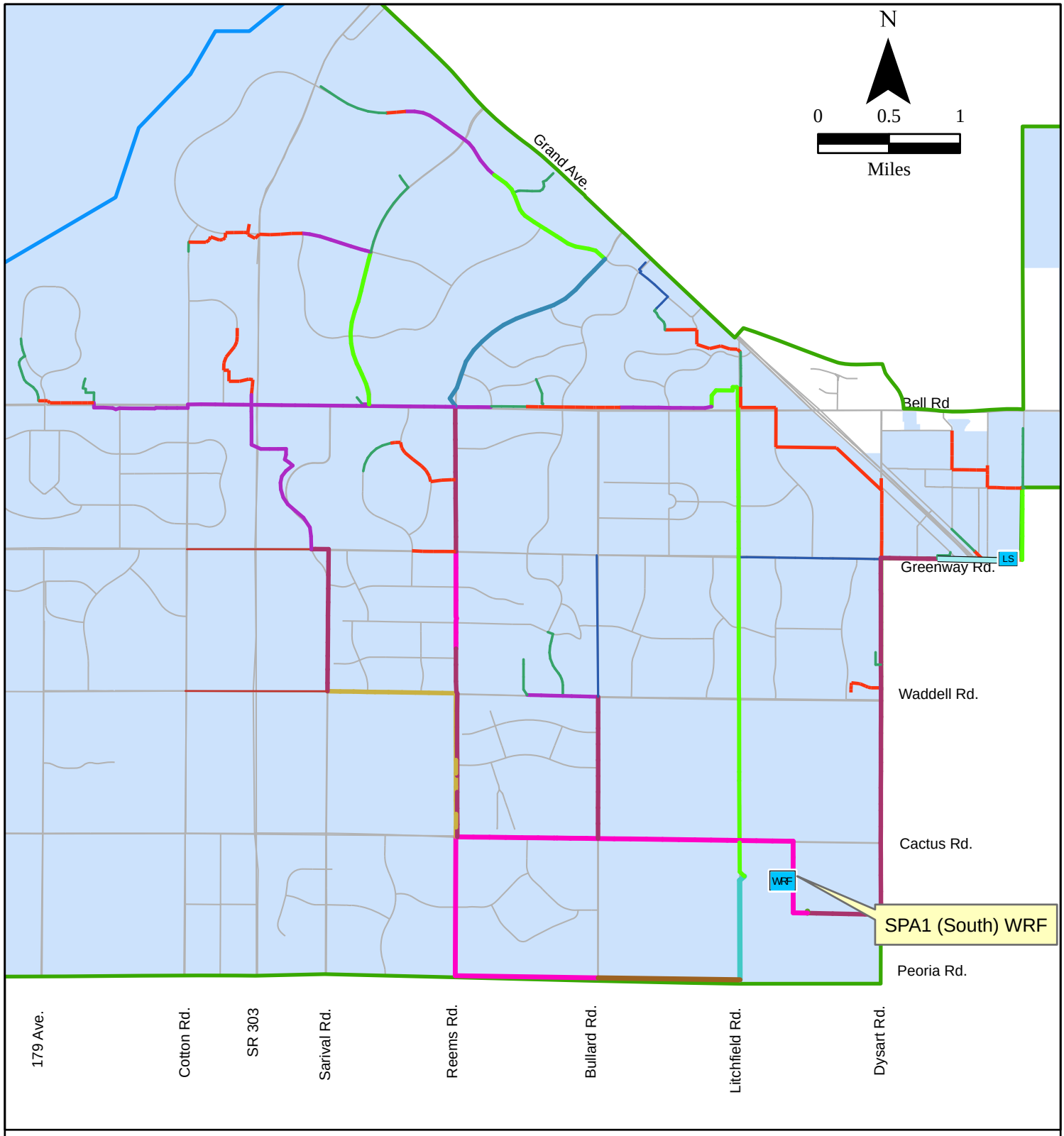
5.2.3. Wastewater System Model

The City's existing collection system was modeled under steady-state conditions using SewerCAD®, V8 XM Edition. Appendix C provides a description of the model, model development, and model calibration. Wastewater flows were developed with the Water Resource Demand Module (Demand Module) developed in the Water Resources component of the *Integrated Water Master Plan*.

5.2.4. Modeled Wastewater System

The primary sources of information for the modeling effort were the most current GIS shapefiles provided by the City and the wastewater system hydraulic model that was created as part of the City's 2004 *Water Infrastructure Master Plan*.

Because a majority of existing developments were located within the SPA 1 boundaries, the existing system model update was limited to SPA 1. No existing system wastewater model was available for SPA 2. The entire existing wastewater system was previously shown on Figure 3-4. Because not all pipelines were necessary to adequately model a collection system, a skeletonized network of pipes was represented in the existing model provided by the City. A comparison of the modeled system (Figure 5-4) versus the entire collection system (as measured from the City's GIS database) is shown in Table 5-4. The percentages of the existing wastewater infrastructure shown in the table were typical for master planning efforts.



Legend

- Municipal Planning Area
- City of Surprise Wastewater Service Area
- Canals
- Streets
- WRF Water Reclaimation Facility
- LS Lift Stations
- Force Mains

Gravity Sewers

- 6 inch
- 8 inch
- 10 inch
- 12 inch
- 15 inch
- 18 inch
- 21 inch
- 24 inch
- 27 inch
- 30 inch
- 42 inch
- 48 inch
- 54 inch

SURPRISE ARIZONA

INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Modeled Wastewater System

July 2009

Figure 5-4

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 5-4 Modeled Wastewater Collection System.mxd

Table 5-4.
Modeled Wastewater System

System Attribute	Modeled	System Total	Percent of System Modeled
Manholes	553	11,250	4.9%
Gravity Sewers (feet)	202,000	2,903,299	7.0%
Force Mains (feet)	2,619	60,385	4.3%
Pump Stations	2	7	28.6%

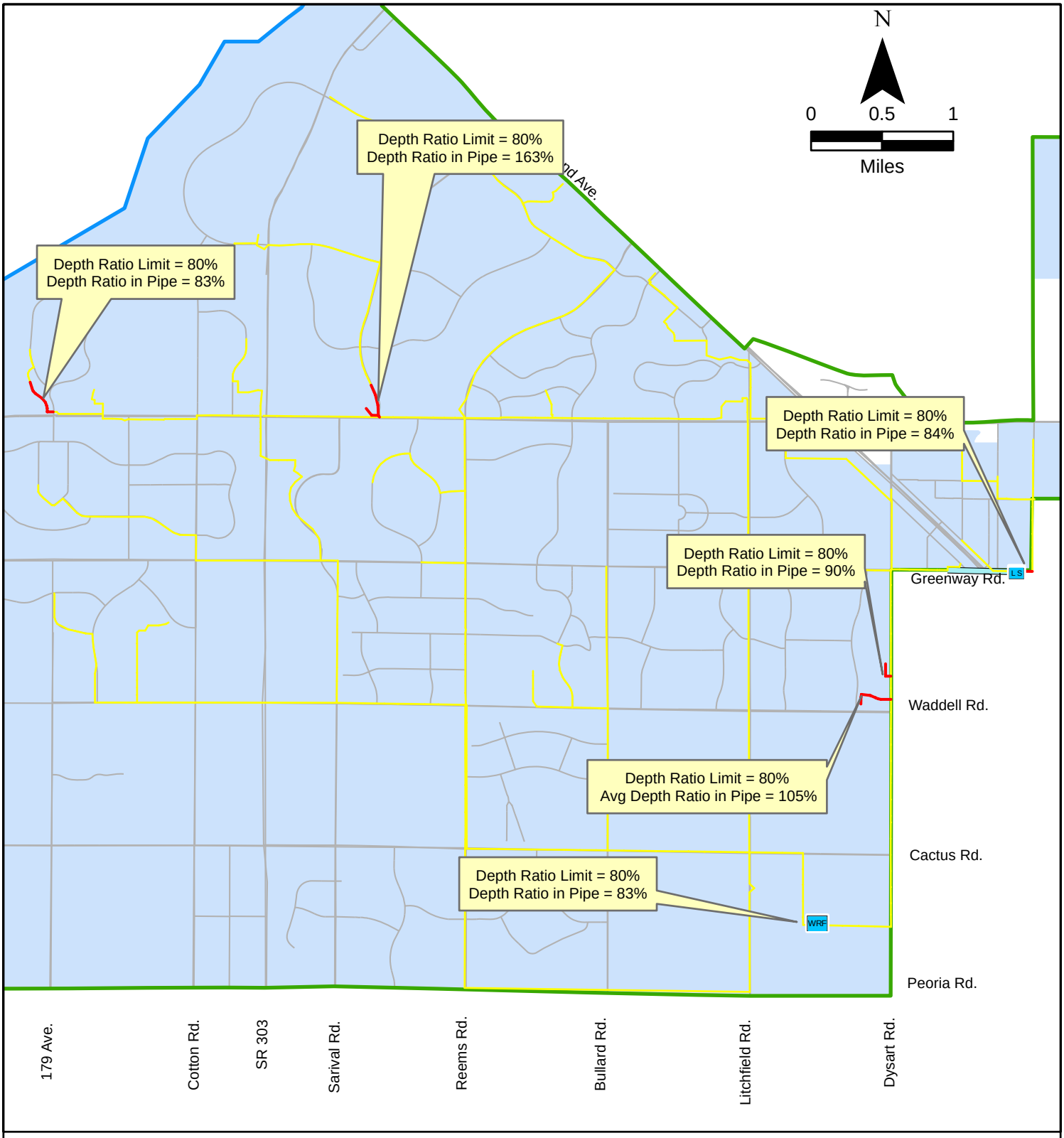
5.2.5. Existing Wastewater System Deficiencies

The existing wastewater system was analyzed under peak flow conditions. The system was originally designed to convey peak flows with the sewers flowing at 80 percent full. Figure 5-5 shows the results from this analysis by grouping the ratio of the depth of flow to the diameter of the gravity sewer into two categories:

- Surcharging Conditions - Flowing more than 80 percent full (pipes shown in red)
- Sufficient Gravity Sewer Capacity - Flowing less than 80 percent full (pipes shown in yellow)

Of the total 282,000 feet of modeled gravity sewer system, only 2,600 feet of the sewer system was found to have surcharging under the peak flow conditions. This represented slightly less than one percent of the system. In total, six deficient areas were identified for the existing conditions, described below:

- The existing 10-inch gravity sewer along White Tanks Vista between Dawn Drive and Deneen Way was surcharging. The cause of the surcharging is attributed to the existing 10-inch gravity sewer having insufficient capacity to convey peak flows.
- The gravity pipe located along Bell Road at the intersection with Sunrise Boulevard was surcharging in 700 feet of the collection system. The cause of the surcharging in this area is attributed to apparent mismatches with the gravity sewer inverts. The downstream invert elevation of the sewer along Sunrise Boulevard at the connection to the Bell Road trunk sewer had an invert elevation 2.6 feet lower than the Bell Road trunk sewer.
- There was a total of 286 feet of gravity sewer along Greenway Road near the existing pump station that was surcharging, 25 feet of this was the influent sewer for the pump station wet well. This influent pipe was modeled as connecting to the invert of the wet well. This configuration caused the downstream end of the sewer to be surcharged (the pump operating elevations are greater than the wet well invert elevations). The remaining 261 feet of surcharged sewer located along Greenway Road was found to have insufficient capacity to convey the peak flows.



Legend

- Municipal Planning Area
- City of Surprise Wastewater Service Area
- Canals
- Streets
- Water Reclamation Facilities
- Pump Stations
- Force Mains

Gravity Sewers

- Sufficient (< 80 percent full)
- Surcharged (> 80 percent full)

SURPRISE ARIZONA

MALCOLM PIRNIE

INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Existing Wastewater System Deficiencies

July 2009

Figure 5-5

M:\4957002\GIS\Project_MXDs\R-1_Final\Figure 5-5 Existing Wastewater Collection System Deficiencies.mxd

- The 199-foot, 10-inch gravity sewer located along West Hearn Road at the intersection with Dysart Road was found to be surcharged. The cause of the surcharging was attributed not to a capacity issue, but rather to this smaller diameter sewer connecting to the larger diameter Dysart trunk sewer with the inverts matching. The 24-inch sewer's depth of flow submerged the downstream end of the 10-inch gravity sewer.
- Surcharging was found in 529 feet of gravity sewer adjacent to the South WRF. The existing system has a connection at Cactus Road between the parallel Reems Road trunk sewers. Based on the flow monitoring data, 20 percent of the flow along the 27-inch Reems Road trunk sewer (the western Reems Road trunk sewer) is diverted to the Cactus Road trunk sewer. The Cactus Road trunk sewer eventually contributes to the surcharged gravity sewer. If flow was prevented from diverting, the gravity sewer adjacent to the WRF may be able to convey the peak flow without surcharging.

Note that all of the above areas will likely require additional improvements for future demand conditions. There are several potential methods of alleviating surcharging conditions:

- Replacing the existing pipe with a larger diameter pipe to increase the capacity
- Installing a parallel pipe to increase the capacity
- Changing the invert elevations of the pipe (i.e., regrading) such that downstream piping does not cause backups in the collection system

These upgrades and improvements for the six areas noted above were considered and included in the evaluation of infrastructure alternatives and recommended system improvements in Sections 6 and 7, respectively.

5.3. Reclaimed Water System Performance and Design Criteria

The City did not have an existing reclaimed water system model. As such, no existing system evaluation was performed. Similarly, because the City is not supplying reclaimed water to customers at this time, historical reclaimed water demand data could not be used to develop peaking factors. A review was performed, however, of the City's reclaimed water system design guidelines as described below. A steady-state reclaimed water system hydraulic model was also developed using Bentley WaterCAD® V8 XM Edition hydraulic model. Appendix D provides a description of the model, model development, and model calibration.

The reclaimed water system operates similarly to the drinking water system, so the design criteria applicable to a drinking water system were also valid for a reclaimed water system. However, the reclaimed water system may have different pressure requirements and peaking factors than a typical drinking water system. As such, design criteria for other communities with reclaimed systems, textbook values, and widely-used industry standards were compared with the City's existing design guidelines for the reclaimed

water system. A summary of the review is provided in Appendix A. As expected, there were some variations in the criteria used among different cities, and some of the relevant information was not available from all sources for comparison. Based on the review and discussions with the City's Technical and Steering Committees, the recommended reclaimed water system performance and design criteria are presented in Table 5-5. Key design criteria are described in more detail below:

Table 5-5.
Reclaimed Water System Design and Performance and Design Criteria

Design Parameters			Current Standard	Recommended Standard
Peaking Factors		Maximum Day	2 x Average Day Demand	2 x Average Day Demand
		Peak Hour	3 x Maximum Day Demand	2.5 x Maximum Day Demand
Storage Facility			Average Day Demand	Average Day Demand
Pipe Sizing	Distribution	Velocity	< 5 ft/s	< 5 ft/s
		Head Loss	<10 ft/ 1000 ft	<10 ft/ 1,000 ft
		Design Flow	Peak Hour of Maximum Day	Peak Hour of Maximum Day
	Transmission	Velocity	-	< 5 ft/s
		Head Loss	-	<10 ft/ 1,000 ft
		Design Flow	-	Maximum Day Demand
	Recharge Mains	Velocity	-	< 5 ft/s
		Head Loss	-	<10 ft/ 1,000 ft
		Design Flow	Maximum Reclaimed Water Available	Maximum Reclaimed Water Available
System Pressure		Maximum Pressure	100 psi	100 psi
		Minimum Pressure (Peak Hour)	-	25 psi
Booster Station Design Criteria		at WSF	Peak Hour	Peak Hour
		at Distribution System		
		at WRF	-	Maximum Reclaimed Water Available
		at Transmission Mains Boosting to WSF only	-	Maximum Day Demand
		Firm Capacity	-	Largest Pump Out of service

- **Peaking Factors –** Historical reclaimed water flow data were not available to calculate the City's current peaking factor in the system. The City's current criterion was 2.0 times the average day demand for maximum day conditions and 3.0 times the

maximum day demand for peak hour conditions. Peaking factors for reclaimed water systems vary based on type and time of application and available storage. The City's reclaimed water system was analyzed assuming no onsite storage at customer locations, so the peaking factor used for sizing the facilities corresponded to the peak hour factor. Typical peaking factors (peak hour to maximum day) for agricultural irrigation and landscape irrigation varies from 2 to 3 and 4 to 6, respectively. The City of Goodyear uses a weighted composite maximum day peak hour factor of 2.43 assuming different operation hours for different types of reclaimed water demand. Based on the review, a peak hour factor of 2.5 times the maximum day demand was recommended (resulting in a peak hour factor of 5 times average day demand).

- **Storage –** The distribution system storage tanks provides water for daily operational needs. The City's current criteria require an average day demand of storage to equalize storage needed between reclaimed water production and peak hour pumping in the distribution system. Emergency storage requirements in reclaimed water systems are not as critical as in drinking water systems. Thus, the existing City guideline for reclaimed water storage was retained. Seasonal storage requirements were addressed by the recharge facilities.
- **Transmission, Distribution, and Recharge Mains -** To avoid wasting energy due to high head loss and water hammer resulting from excessive velocity in the mains, the head loss in the mains should be less than 10 feet per 1,000 feet and velocity should be less than 5 feet per second, which are consistent with the City's current design guidelines for distribution mains. These criteria were also recommended for transmission and recharge mains. The design flows will be different for the various mains. The recharge mains that convey water from the WRF to recharge locations should be designed to convey maximum reclaimed water produced at the WRF. The transmission mains that convey water from the WRF to the WSFs should be designed for maximum day demand. The distribution mains supplying reclaimed water from the WSFs to the distribution system should be designed for the peak hour flow during the maximum day.
- **System Pressure –** The current City design guidelines for the reclaimed water system includes only a maximum system pressure of 100 psi, which was recommended to be retained. During peak hour demand conditions, the minimum system pressure should be 25 psi. Typically a reclaimed water distribution system is operated at slightly lower pressure than drinking water distribution system to prevent cross-contamination between two systems. For ease of operations, the City's reclaimed and drinking water distribution system were modeled to operate at the same maximum high pressure. However, it is recommended that customers be provided with appropriate cross-connection safeguards, such as reduced pressure backflow prevention assemblies on their drinking water supply connections.

  Booster Stations –Assuming there will be no onsite storage at the customer locations, the peak pumping rate should correspond to the peak hour demand. The pumps at the WRFs and the boosters along the reclaimed transmission mains that boost to recharge locations should be designed to pump maximum reclaimed water available when there is no reclaimed water demand, and the boosters along the

reclaimed transmission mains that boost to WSFs should be designed to convey maximum day reclaimed water demand to the WSFs. All booster stations should meet the peak pumping rate when operating at their firm capacity, i.e., with the largest pump out of service.

5.4. Recharge Performance and Design Criteria

The recommended reclaimed water management strategy developed in the Water Resources component of the *Integrated Water Master Plan* indicated that surface basin recharge should be used where possible to balance reclaimed water demand and supply, and to recharge excess reclaimed water that was not directly used. The City did not currently have design guidelines for surface spreading basin recharge facilities. Key spreading basin recharge design criteria depend primarily on local hydrogeologic and climatic conditions. When permitting a facility, designers will likely be required to show that the basins have been sufficiently sized for the amount of water that will be recharged, including sufficient depth for flow equalization during wet weather events and freeboard. Because the design criteria are so site-specific, recommended system performance and design criteria were not developed for surface recharge facilities; rather criteria were assumed based on available regional hydrogeologic information.

Recharge performance and design criteria were developed based on review of the literature and criteria used by nearby existing and proposed recharge facilities. A summary of the review is presented in Appendix A. Based on the review and discussions with the City's Technical and Steering Committees, the recharge performance and design criteria assumed for the purposes of master planning are presented in Table 5-6. These assumptions should not be used in lieu of site-specific, detailed hydrogeologic assessments and site surveys.

- **Design Flow** - As described in the Water Resources component of the *Integrated Water Master Plan*, reclaimed water may contribute up to 80 percent of the City's future water supply portfolio. The potential reclaimed water demand will generally range from 10 to 30 percent of reclaimed water available within the SPAs, and the remaining reclaimed water will need to be recharged. Further, there may be times of the year (rainy season) where reuse demands will be minimal. Thus, reclaimed water recharge facilities should be sized to receive all reclaimed water produced by each WRF; i.e., the surface recharge basins should be sized to accommodate the maximum month flows from the WRFs.
- **Treatment Requirements** - Spreading basins can be designed to improve water quality (e.g., maximize nitrogen, suspended solids, or biological oxygen demand removals) and/or to maximize infiltration rates. Because the City will achieve the necessary constituent removals at the WRF, City spreading basins designed for WRF effluent should be designed to maximize recharge.

Table 5-6.
Assumed Spreading Basin Recharge Design Criteria

Parameter	Assumed Standard
Loading Rate (ft/year)	122
Loading Rate: Infiltration Rate (%)	33
Infiltration Rate (ft/day)	1
Wet/Dry Ratio	0.5
Application Period (days)	4
Drying Period (days)	8
Number of Basins	3
Basin Depth (ft)	5
Sidewall Slope (Rise:Run)	1:3
Ramp Gradient (%)	10
Distance Between Basins (ft)	12

- **Infiltration and Loading Rates** – Infiltration rates and loading rates (accounts for the wet/dry ratio) will depend on the local hydrogeologic conditions. The Hieroglyphics Recharge Facility experiences infiltration rates around 2 ft/day while El Mirage experiences infiltration rates of up to 4 ft/day. Infiltration tests conducted in the City of Surprise have shown infiltration rates between 0.21 and 10 ft/day. Because this criterion is largely responsible for sizing the recharge basins, site-specific infiltration tests should be performed prior to design. An infiltration rate of 1ft/day was assumed for this master planning effort.
- **Wet/Dry Ratio -** The wet/dry ratio refers to the intermittent wetting and drying cycles of spreading basins. The drying cycle helps to inhibit biological growth, promotes drying and cracking of fine grained material that builds up on the basin floor, and allows for periodic basin maintenance to remove accumulated wind-blown and suspended solids to optimize/ maintain basin performance. For warmer climates, such as Phoenix, the typical wet/dry ratio is 0.75, or 9 days of wetting followed by 12 days of drying when maximizing recharge volumes (Crites et al., 2000). This allows sufficient time for the basins to dry and basin maintenance to be performed, if needed. The Hieroglyphics Recharge Facility only dries its basins when the infiltration rate decreases. While this may keep the size of the recharge facility to a minimum, it may lead to irreversible fouling of the subsurface soil. El Mirage used a wet/dry ratio of 1.0. A wet/dry ratio of 0.5 was assumed for master planning (1.0 with the third basin out of service). This ratio will vary throughout the year as customers utilize portions of the reclaimed water.
- **Number of Basins** – The number of basins is generally governed by the wet/dry ratio. Larger basins are typically easier to operate but can result in localized fouling if the water is not properly distributed into the basins while filling. Smaller basins are typically more cumbersome to operate but will result in a smaller footprint when an

out-of-service basin is included. Taking into account the wet/dry ratio of 0.5, three basins were assumed for master planning.

- **Basin Depth** - Arizona Department of Health Services Engineering Bulletin No. 11 requires a minimum freeboard of 3 feet. Adding an additional 1.5 to 2.0 feet for equalization, storage, and wet weather events, the minimum depth of the basins assumed was 5 feet.
- **Slopes, Gradients, and Distances** - Sidewall slopes ranged from 1:2 to 1:3. Typically, steeper slopes with coarse rip-rap are used near airports to discourage birds from inhabiting the area. Steeper slopes, however, may lead to more erosion if storm water drainage is not properly addressed. Ramps allowing for tractor access should be designed for each basin, with gradients ranging from 10 to 20 percent. The distance between basins (for tractor and truck maintenance roads) is typically between 10 and 12 feet, but at a minimum must be 8 feet (Engineering Bulletin No. 11). A sidewall slope of 1:3 and ramp gradient of 10 percent was assumed.

Note again that these assumptions were used for the purposes of this master planning efforts and should not be used in lieu of site-specific, detailed hydrogeologic assessments and site surveys. Selecting locations with favorable infiltration rates and subsurface conditions (i.e. lack of significant clay layers, depth to groundwater greater than 200 feet, and high aquifer transmissivities) will minimize the surface area needed for recharge, decreasing overall costs.

6. Evaluation of Infrastructure Alternatives

This section briefly describes the alternatives that were evaluated for drinking water, wastewater, and reclaimed water infrastructure and presents the alternatives chosen for master plan development. The drinking water infrastructure alternatives were evaluated separately. However, because of the close interrelation between wastewater, reclaimed water, and recharge infrastructure, the three systems were evaluated simultaneously to identify the most cost effective total solution for the City. Appendices E (drinking water) and F (wastewater, reclaimed water and recharge) contain the details of the evaluations, including system performance and design criteria, description of alternatives (including schematics), description of infrastructure components, basis for costs, and itemized costs.

The infrastructure evaluations were conducted at a time when the system performance and design criteria and unit cost factors were still in development. As such, the evaluations presented in Appendices E and F were based on preliminary design criteria and cost factors that reflected initial guidance and planning assumptions provided by the City and cost information available at the time. The key differences between the preliminary design criteria (presented in Appendices E and F) and the finalized criteria presented in Section 5 were related to production well capacity, arsenic treatment sizing, and reclaimed water storage requirements. Unit costs for collection system and water distribution system piping were also updated, particularly for the larger diameter piping (i.e., the unit cost presented in Appendices E and F may differ from the cost factors utilized in Section 7). Although these differences may affect the overall cost of each infrastructure alternative, they were not believed to alter the relative rankings of the alternatives.

The objective of the alternative evaluations performed in this section was to develop long-term plans for the City's water infrastructure. Interim solutions and modifications to the strategies may be considered on a case-by-case basis as the system actually develops.

6.1. Basis for Alternatives Development and Evaluation

All infrastructure alternatives were developed using a common set of guidelines and assumptions relating to water demands and wastewater flow projections, the reclaimed water management strategy, and system layouts and configurations.

6.1.1. Water Resource Demand Projections

The Water Resources component of the *Integrated Water Master Plan* recommended that the City plan to balance water demands with existing available supplies (groundwater,

CAP surface water, and reclaimed water) at build-out. In order to achieve this demand/supply balance, the recommended strategy was to target a build-out population between 500,000 and 700,000 by managing future growth. The infrastructure evaluations were conducted using this "mid-population" scenario, and the water resources demand projections (drinking water demands, wastewater flows, reclaimed water availability, and reclaimed water demand) were developed using the Demand Module developed in the Water Resources component of the *Integrated Water Master Plan*.

6.1.2. Reclaimed Water Management Strategy

The Water Resources component of the *Integrated Water Master Plan* also recommended that the City install a dual distribution system to serve only the largest irrigation reuse customers (landscape irrigation of homeowner association common areas, schools, parks, etc.), to use surface basin recharge where possible to balance reclaimed water demand and supply, and to recharge excess reclaimed water that was not directly used.

To remain consistent with current City design guidelines, reclaimed water storage and pumping facilities were also placed at drinking water WSF locations such that, during times when reclaimed water demand exceeded available supply (e.g., in early years of development) or if the supply of reclaimed water was interrupted for any reason, untreated groundwater could be introduced into the reclaimed water storage tanks and used for landscape irrigation.

6.1.3. System Layouts and Configurations

When configuring future infrastructure systems, the following general guidelines and assumptions were used:

- Piping networks followed the road alignments in the City's transportation element of the General Plan. No pipes were located in areas that were known to be undevelopable (e.g., the northern mountainous region in SPA 6 and large washes).
- Crossings of canals and major roads (e.g., Grand Avenue) were minimized.
- Drinking water distribution pipes in arterial streets had a minimum diameter of 16 inches.
- As discussed in the Water Resources component of the *Integrated Water Master Plan,* the City will plan to serve all private water company service areas, except for the service areas of the City of El Mirage and the Arizona American Water Company.
- Areas having known or planned developments already in progress were used as the boundaries for WSF facility service areas.
- WSFs were centrally located within a service area to minimize pumping requirements.
- Specific sites for individual wells were not identified. Costs for well transmission piping to the WSFs facilities were based on an average of one-half mile per well.

- Future drinking water and reclaimed water pressure zones were delineated every 120 feet of elevation change in the planning area (12 pressure zones total) to accommodate the significant elevation changes in the north.
- The piping networks for the future system were skeletonized models of the drinking water distribution, wastewater collection, and reclaimed water distribution systems to an approximate one square-mile grid. Smaller piping (e.g., on-site or "neighborhood" piping) was not included in the evaluations.
- Gravity sewers were assumed to be 15 feet deep to allow future developments to connect directly into the trunk sewer. The gravity network followed the natural slope of the land to convey the wastewater to the WRFs to minimize the need for pumping.
- The locations of the SPA 2 through 5 WRFs remained unchanged from previous plans.
- The WRF in SPA 6 was located at a low elevation to take maximum advantage of gravity flow.
- All infrastructure alternatives included improvements to correct any system deficiencies identified in Section 5.
- Spreading basin recharge facilities were located in areas where the depth to groundwater was high and away from potential interferences such as the landfill, the airport, and other regional recharge projects.
- The WSF locations in the lowest cost drinking water infrastructure alternative were used in the reclaimed water evaluations.

6.2. Drinking Water Infrastructure Evaluations

6.2.1. Infrastructure Alternatives

The drinking water infrastructure alternatives were developed with the assistance of the City's Technical and Steering Committees. The alternatives generally considered the source of the drinking water (all groundwater or a groundwater and surface water blend), spacing of WSFs (smaller service areas vs. larger, interconnected service areas), and CAP water recharge locations (local City-owned or regional). The following specific alternatives were identified for evaluation:

- **All Well Supply and CAP Recharge at Regional Facilities** - Under this alternative, the City will continue with its current philosophy for water supply, treatment, and distribution. All potable water will be supplied with wells, and the City's CAP allocation will be recharged at the Hieroglyphic Mountains Recharge Facility. Each WSF will serve a 4 to 6 square mile area, creating 31 new WSFs in addition to the WSFs already operating in SPA 1 and SPA 2.
- **All Well Supply and CAP Recharge at City-Owned Facilities** – Under this alternative, the City will continue with its current philosophy for water supply, treatment, and distribution. All potable water will be supplied with wells, and the City's CAP allocation will be recharged at a local City-owned facility in SPA 5.

- **All Well Supply with Fewer WSFs and Larger Interconnected Systems** – Under this alternative, all potable water will be supplied with wells, and the City's CAP allocation will be recharged at the Hieroglyphic Mountains Recharge Facility. The service area and size of each WSF will increase, and the water system will be more interconnected. In general, each WSF will be a combination of two or three WSFs identified in the previous alternatives resulting in 12 new WSFs. The WSFs currently operating in SPAs 1 and 2 will remain.
- **CAP WTP with Wells for Additional Production and Backup Supply -** In this alternative, a CAP water treatment plant (WTP) will be constructed to treat the surface water for direct potable use. The capacity of the WTP will be approximately 13 mgd, which includes the City's existing CAP allocation and potential additional CAP allocation from Circle City Water Company. Additional production capacity will be supplied with wells, the service area and size of each WSF will increase, and the water system will be more interconnected, similar to the previous alternative. The CAP WTP will be located near the intersection of the CAP Canal and Grand Avenue in SPA 5. Additional wells will be provided in this alternative to back up the CAP WTP in the event of a CAP Canal outage.

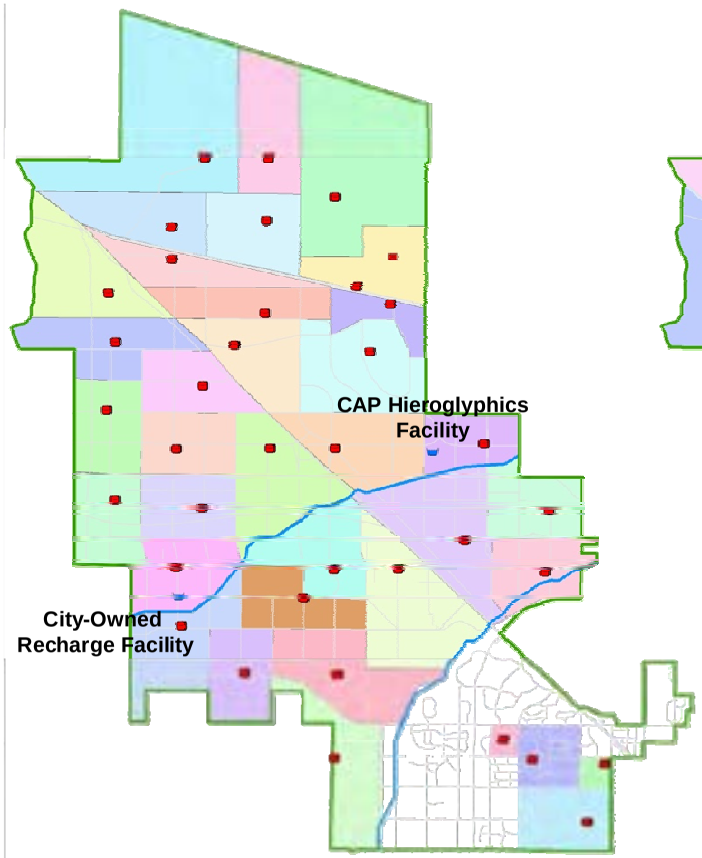
A comparison of the key differences between drinking water infrastructure alternatives (specifically related to WSF and WTP service areas) is shown on Figure 6-1.

6.2.2. Economic Evaluation

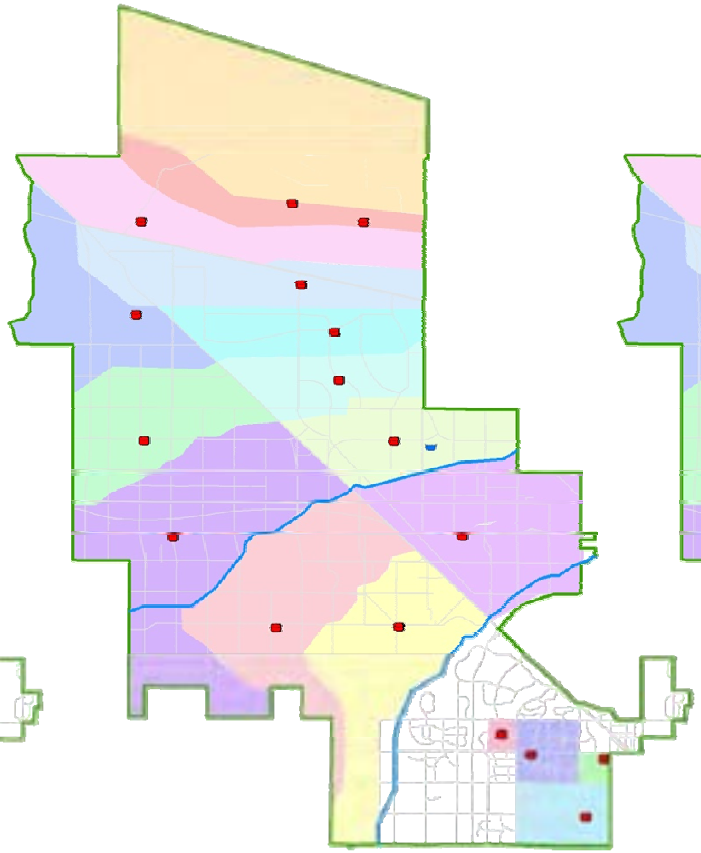
A summary of the capital, operations and maintenance (O&M), and 20-year present worth costs determined for each of the four drinking water infrastructure alternatives is presented in Table 6-1 and is shown graphically on Figure 6-2. The present worth cost is the sum of total capital costs plus the total annual O&M costs over a 20-year period at 7 percent interest.

Table 6-1.
Summary of Costs for Drinking Water Infrastructure Alternatives

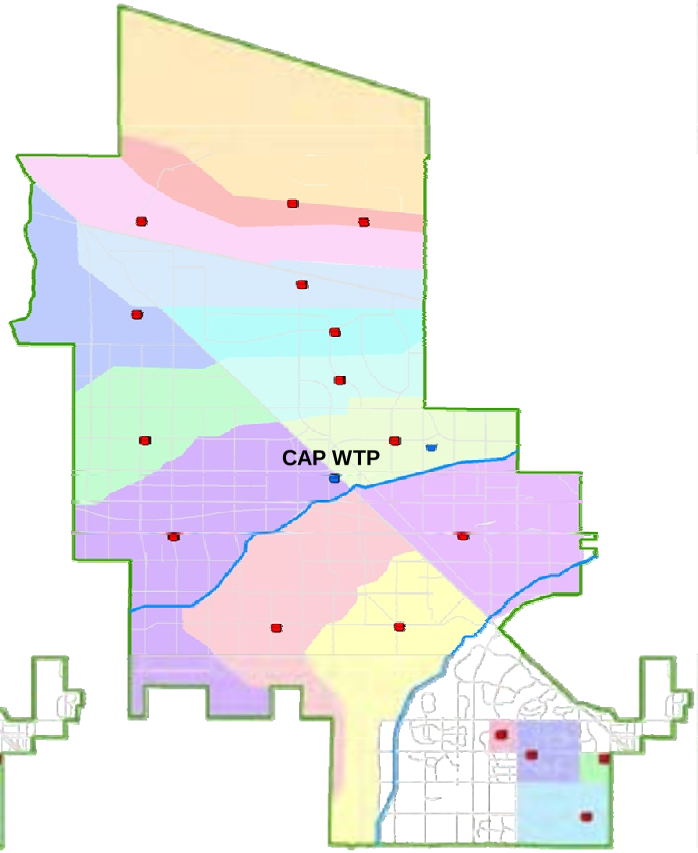
Alternative	Total Capital Cost ($M)	Total Annual O&M Cost ($M)	20-Year Present Worth ($M)	Cost Rank
All Well Supply and CAP Recharge at Regional Facilities	$1,449	$32	$1,784	3
All Well Supply and CAP Recharge at City-Owned Facilities	$1,467	$32	$1,803	4
All Well Supply with Fewer WSFs and Larger Interconnected Systems	$1,230	$30	$1,545	1
CAP WTP with Wells for Additional Production and Backup Supply	$1,253	$30	$1,574	2



All Wells Supply with CAP Recharge at Regional and City-Owned Facilities



All Wells Supply with Fewer WSFs and Larger Interconnected Systems



CAP WTP with Wells for Additional Production and Backup Supply

NOTE: Shading represents WSF service area boundaries.

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Drinking Water Infrastructure Alternatives

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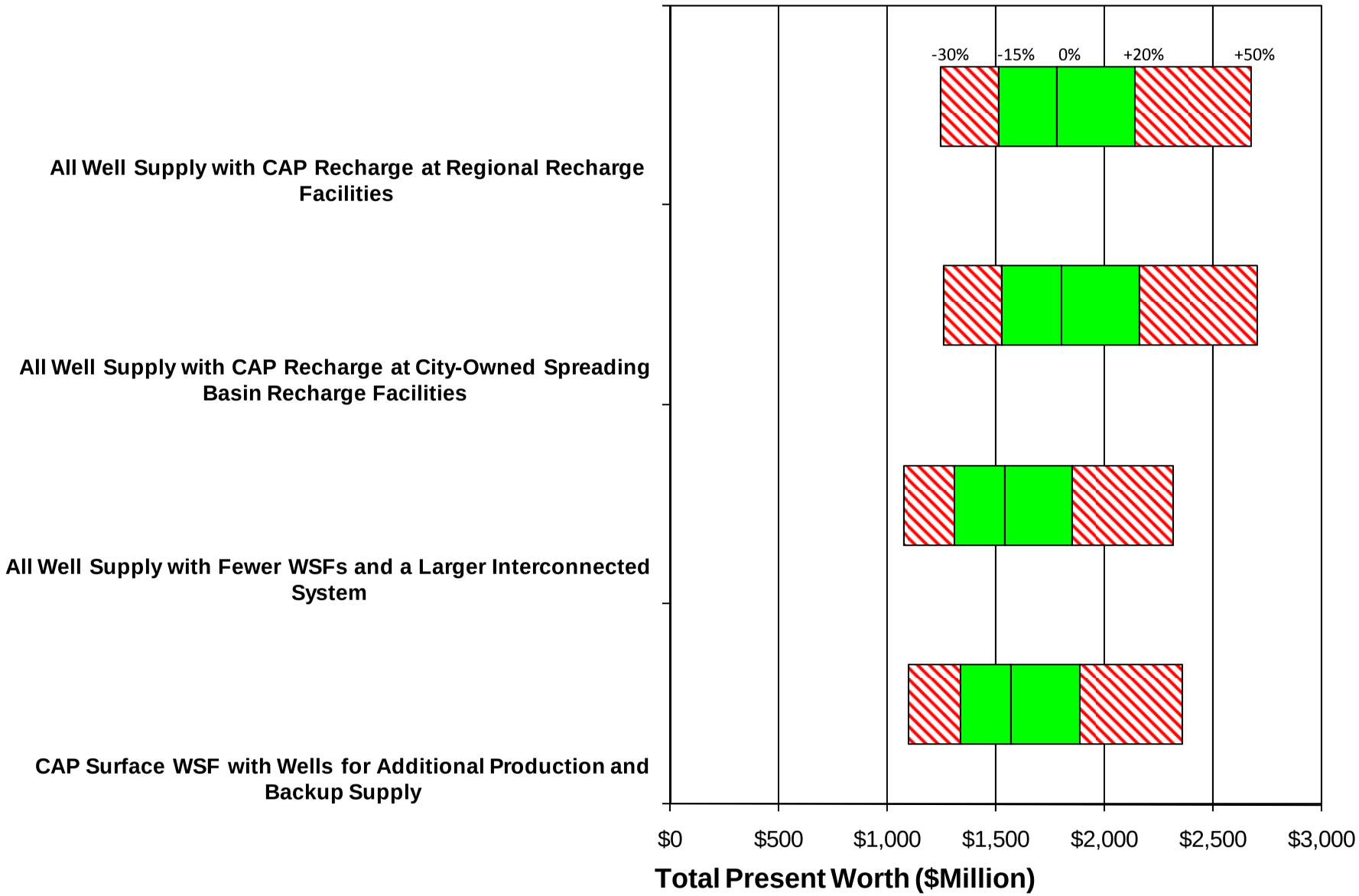
Figure 6-1



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Drinking Water Infrastructure Alternatives – Total Present Worth

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Figure 6-2

6.2.3. Selected Alternative

In analyzing the above cost evaluations, note that there were three decisions that were made:

- **Where should CAP surface water allocations be recharged?** This can be evaluated by comparing the first two alternatives. The total 20-year present worth costs for the first two alternatives were essentially the same at this level of planning. That is, the capital and O&M costs for recharge were relatively insignificant when compared to the costs of all other infrastructure. However, recharge at City-owned recharge facilities would require that additional infrastructure be funded, constructed, and operated, whereas recharge at regional facilities would only take execution of an agreement with the CAWCD, something which the City has recently done. The regional recharge facilities were built for exactly that purpose, to recharge CAP water. Based on the City's recent agreement with CAWCD, the CAWCD has the flexibility to recharge the City's CAP water at any of three facilities: Tonapah, Hieroglyphic Mountains, and Agua Fria Recharge Facilities. A disadvantage of this alternative was that the City's CAP allocations may not be recharged within the City's planning area all the time. However, if the CAWCD has to recharge the City's water somewhere else, that may mean the Hieroglyphic Mountains facility was already at capacity (i.e., recharging the maximum amount of CAP water within the City's planning area).
- **Should the City continue with its current philosophy of a WSF serving every four to six square miles as an isolated water system, or should the water system be more interconnected with fewer and larger WSFs?** This can be evaluated by comparing the third alternative against the first two alternatives. The total 20-year present worth cost for the third alternative was approximately 15 percent less than the costs for the first two alternatives. The analysis showed that if the future water system were more interconnected, there would be a need for fewer wells, less storage, and less pumping because system redundancy requirements would be shared over larger service areas, resulting in lower costs. A disadvantage of the third alternative may be that implementation of the larger WSFs may not follow the current City/developer agreement philosophy. Another disadvantage may be that construction of the larger WSFs may be less accommodating to actual development. For example, some remote developments may be required to construct longer pipelines to reach the larger WSFs in the early years of development.
- **Should the City build a CAP WTP or continue with recharge and recovery?** This can be evaluated by comparing the last alternative against all other alternatives. The total 20-year cost for the last alternative was essentially the same as the lowest cost of the other three alternatives at this level of planning. That is, the savings resulting from fewer WSFs and less arsenic treatment were offset by the capital and operating costs of a 13 mgd CAP WTP. Some of this offset was also due to additional wells that must be provided to back up the WTP during canal shutdowns. Note that this finding depended highly on assumptions made that all future groundwater will need treatment for arsenic and other groundwater contaminants.

The costs for the other alternatives would be lower if groundwater quality in newer parts of the City's planning area is better than anticipated. In particular, the cost advantage of the third alternative (all well supply with fewer WSFs and a larger interconnected system) compared to the last alternative would become greater.

Based on the cost comparison of alternatives, an all well supply with fewer WSFs and a larger interconnected system was the recommended drinking water infrastructure alternative. This alternative provided the following benefits:

- It had the lowest capital, O&M, and total present worth costs because fewer production wells, WSFs (reservoirs, booster stations, and arsenic treatment facilities) and City recharge facilities were required.
- The CAWCD has already built affordable capacity for recharging CAP allocations.
- This alternative did not preclude the construction of a CAP WTP. That is, the decision of whether to build a CAP WTP can be deferred to future updates of the *Integrated Water Master Plan*.

6.3. Wastewater, Reclaimed Water, and Recharge Infrastructure Evaluations

As noted previously, because of the close interrelation between wastewater, reclaimed water, and recharge, these infrastructure components were evaluated simultaneously. The location and number of WRFs will affect reclaimed water distribution piping and pumping, so reclaimed water infrastructure was included in the alternative descriptions and evaluation. Reclaimed water that was not reused must be recharged, so the infrastructure requirements for reclaimed water recharge were also included in the descriptions.

6.3.1. Infrastructure Alternatives

The wastewater, reclaimed water, and recharge infrastructure alternatives were developed with the assistance of the City's Steering and Technical Committees. The alternatives included in this evaluation were all based on the number of regional WRFs that would be constructed. The following specific alternatives were identified for evaluation:

- **Construct and Operate 6 WRFs -** Under this alternative, the City will continue with the recommendations provided in the 2004 *Water Infrastructure Master Plan* and design and construct a WRF in each SPA. Reclaimed water will be pumped from the WRF to storage and booster facilities that are co-located with WSFs. All surplus reclaimed water will be recharged. With the exception of the southernmost area of SPA 3 that conveys wastewater to the SPA 1 collection system (common to all alternatives), the wastewater collection systems in each SPA will remain separate.
- **Construct and Operate 4 WRFs -** Under this alternative, the City will design and construct four WRFs: one each in SPAs 1, 2, 3, and 5. The SPA 1, 2, and 3 WRFs will receive flows from their respective SPA. The SPA 5 WRF will receive

wastewater flows from SPAs 4, 5, and 6. Reclaimed water storage, distribution, and recharge will be similar to the first alternative; however, reclaimed transmission mains and booster pumping will change slightly.

- **Construct and Operate 3 WRFs -** Under this alternative, the City will design and construct 3 WRFs: one each in SPAs 1, 2, and 3. Collection system flows from SPA 5 will be routed to the WRF in SPA 3. Flows from SPAs 4 and 6 will flow into the WRF in SPA 2. Reclaimed water storage, distribution, and recharge will be similar to the first two alternatives, but reclaimed water transmission and booster pumping will change.

A comparison of the key differences between these infrastructure alternatives (specifically related to drainage basins and reclaimed water transmission mains) is shown on Figure 6-3.

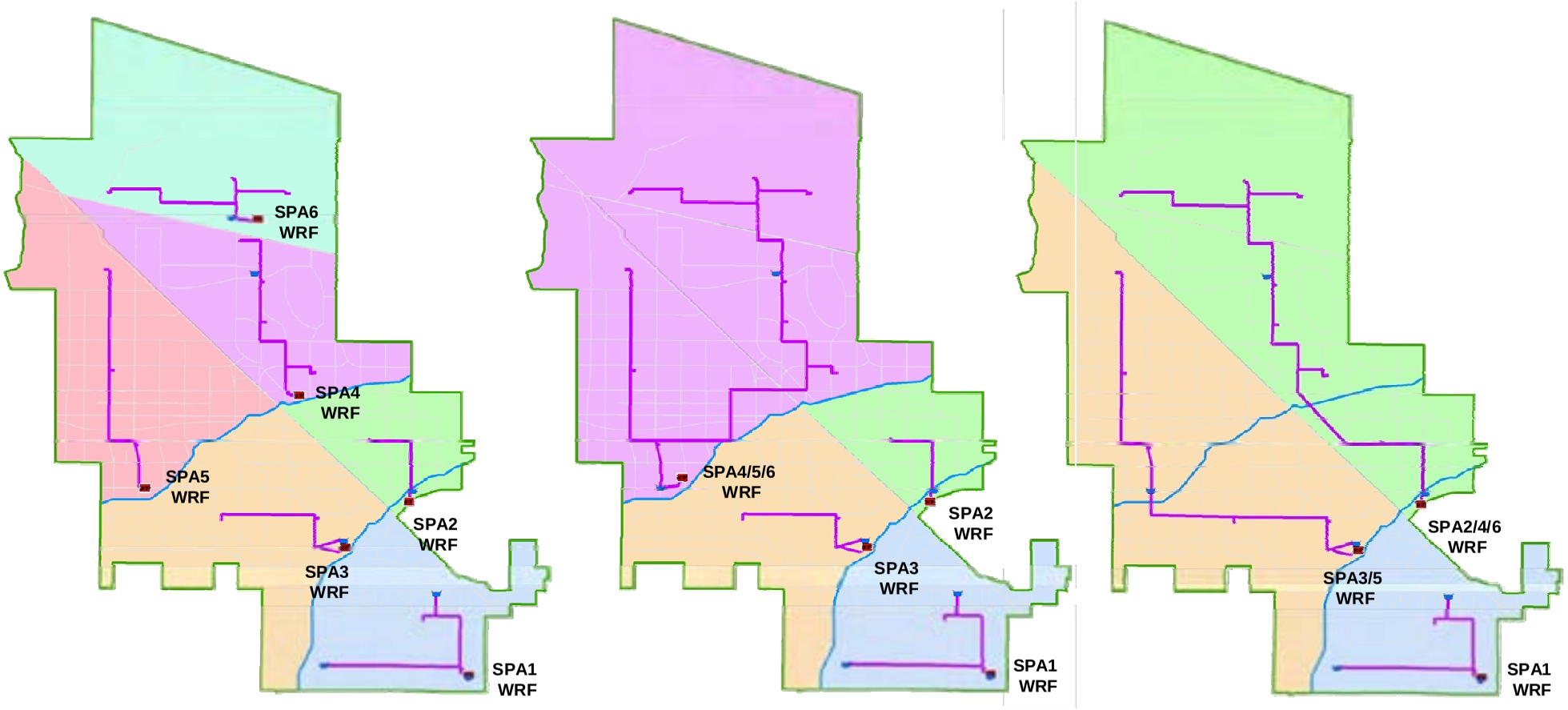
6.3.2. Economic Evaluation

The cost of each alternative includes the total costs for wastewater collection and treatment, reclaimed water storage and distribution, and recharge. A summary of the capital, O&M, and 20-year present worth costs determined for each of the three alternatives is presented in Table 6-2 and is shown graphically on Figure 6-4.

Table 6-2.
Summary of Costs for Wastewater, Reclaimed Water, and Recharge Infrastructure Alternatives

Alternative	Total Capital Cost ($M)	O&M Cost ($M)	20-Year Present Worth ($M)	Cost Rank
Construct and Operate 6 WRFs	$1,894	$24	$2,149	3
Construct and Operate 4 WRFs	$1,902	$21	$2,129	2
Construct and Operate 3 WRFs	$1,901	$21	$2,123	1

The total 20-year present worth costs for the three alternatives were essentially the same at this level of planning with less than 1.5 percent difference between the highest and lowest total present worth costs. The cost savings from building fewer WRFs was offset by the larger collection system piping needed to convey wastewater from the northern areas to the WRFs and by the additional pumping of reclaimed water back to the northern areas. The 6 WRFs alternative had the lowest capital costs, but the highest annual O&M (due primarily to operating 6 WRFs). The 3 WRFs alternative had higher capital costs but the lowest annual O&M costs (due to lower WRF O&M and lift station pumping costs). The 3 WRFs alternative did have a slight 20-year present worth cost advantage over the other alternatives.



6 WRFs 4 WRFs 3 WRFs

NOTE: Shading represents WRF service area boundaries. Reclaimed water transmission mains are shown in purple.

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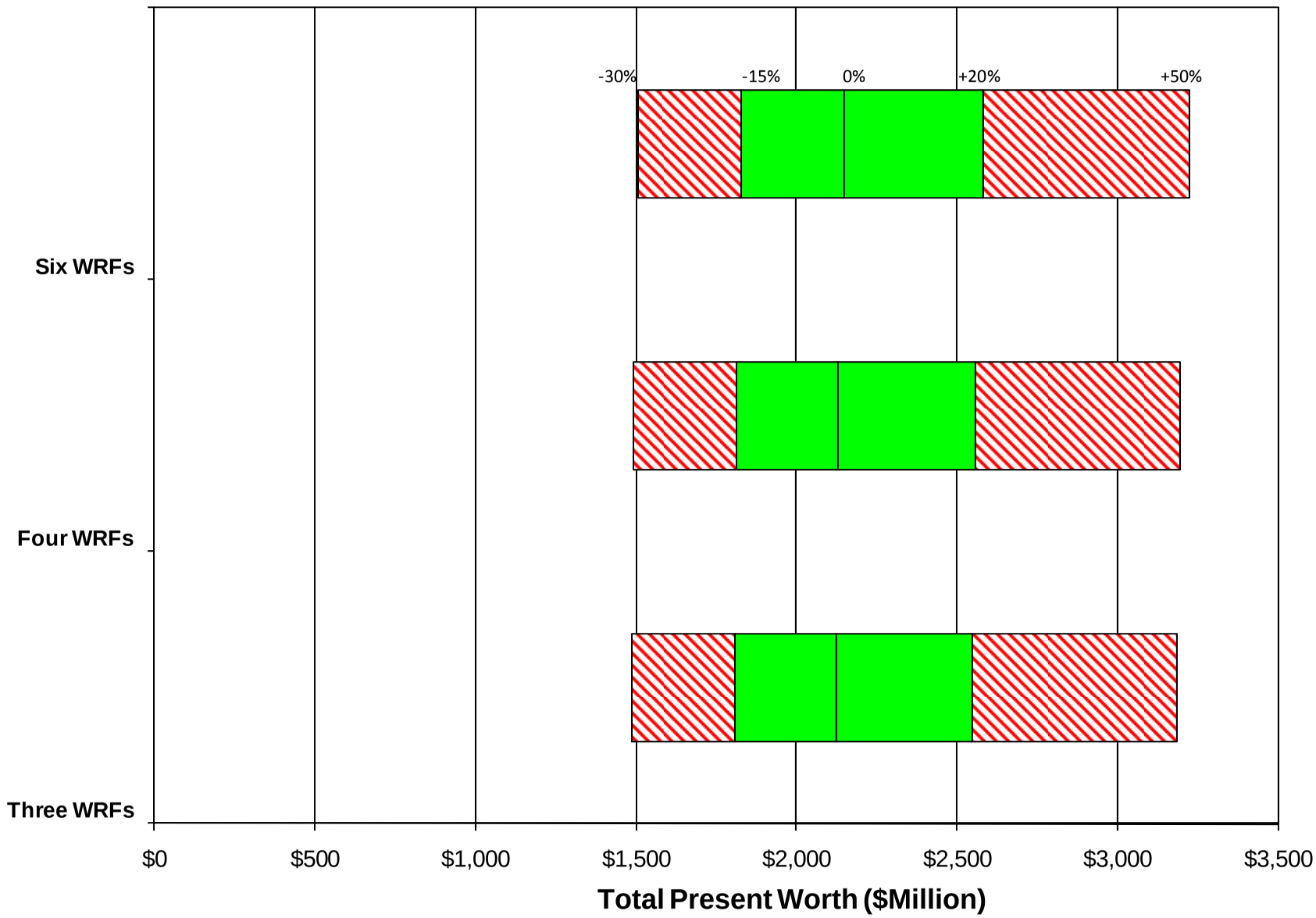
July 2009	**Wastewater, Reclaimed Water, and Recharge Infrastructure Alternatives**	**Figure 6-3**



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INTEGRATED WATER MASTER PLAN: WATER INFRASTRUCTURE

Wastewater, Reclaimed Water, and Recharge Infrastructure Alternatives – Total Present Worth

MALCOLM PIRNIE

July 2009

Figure 6-4

6.3.3. Non-Economic Evaluation

Because costs of the wastewater, reclaimed water, and recharge infrastructure alternatives were essentially the same, non-economic factors were also considered when selecting an alternative for master planning.

The primary advantage of 3 WRFs was that there were fewer WRFs to be funded, constructed, and operated. Another advantage was that the lift stations in the northern areas could be eliminated. However, as indicated above, the advantage of fewer WRFs was entirely offset by the need to build bigger collection system piping to convey all the wastewater from the northern areas to the WRFs in the south. The larger collection piping may also cause concerns, particularly in the early years, because of corrosion and odors associated with conveying wastewater long distances at low flow velocities. Installing multiple parallel pipelines as development warrants can mitigate these concerns; however, the cost would increase. Another disadvantage of 3 WRFs was the need for larger reclaimed water distribution piping and pumping to return reclaimed water to the northern areas; this disadvantage was exacerbated by the fact that there were substantial elevation differences that would have to be overcome by pumping. The large wastewater and reclaimed water piping could also be less accommodating to developments that occur at remote locations early on as they would have to build the larger and longer piping to receive wastewater and reclaimed water service. This could again be mitigated to some extent by installing smaller, parallel piping, but at an additional cost.

The primary advantages of 6 WRFs were the need for smaller piping for both wastewater collection and reclaimed water distribution and for less reclaimed water pumping. Another advantage of 6 WRFs was that it could be more flexible for development as the WRF and the infrastructure could be built to better match actual growth within each individual WRF service area. There would also be less of a need for remote developments to fund larger and longer pipelines, especially in the near term. The primary disadvantage of 6 WRFs was that there were more WRFs to be funded, constructed, and operated.

6.3.4. Selected Alternative

Based on the comparison of alternatives described above, the 6 WRFs alternative was the recommended infrastructure alternative for the wastewater, reclaimed water, and recharge systems. The analysis indicated that there were no appreciable differences in the long-term costs of all alternatives evaluated, but this alternative provided the following benefits:

- It could be more accommodating to development as there would be more flexibility in phasing the WRFs and infrastructure as development occurs within each WRF service area.

- It reduced the need for larger conveyance and distribution piping and also reduced pumping requirements for the reclaimed water.
- It followed the recommendation of the previous master plan that the City has been following and implementing since 2004.

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7. Recommended Infrastructure Master Plans

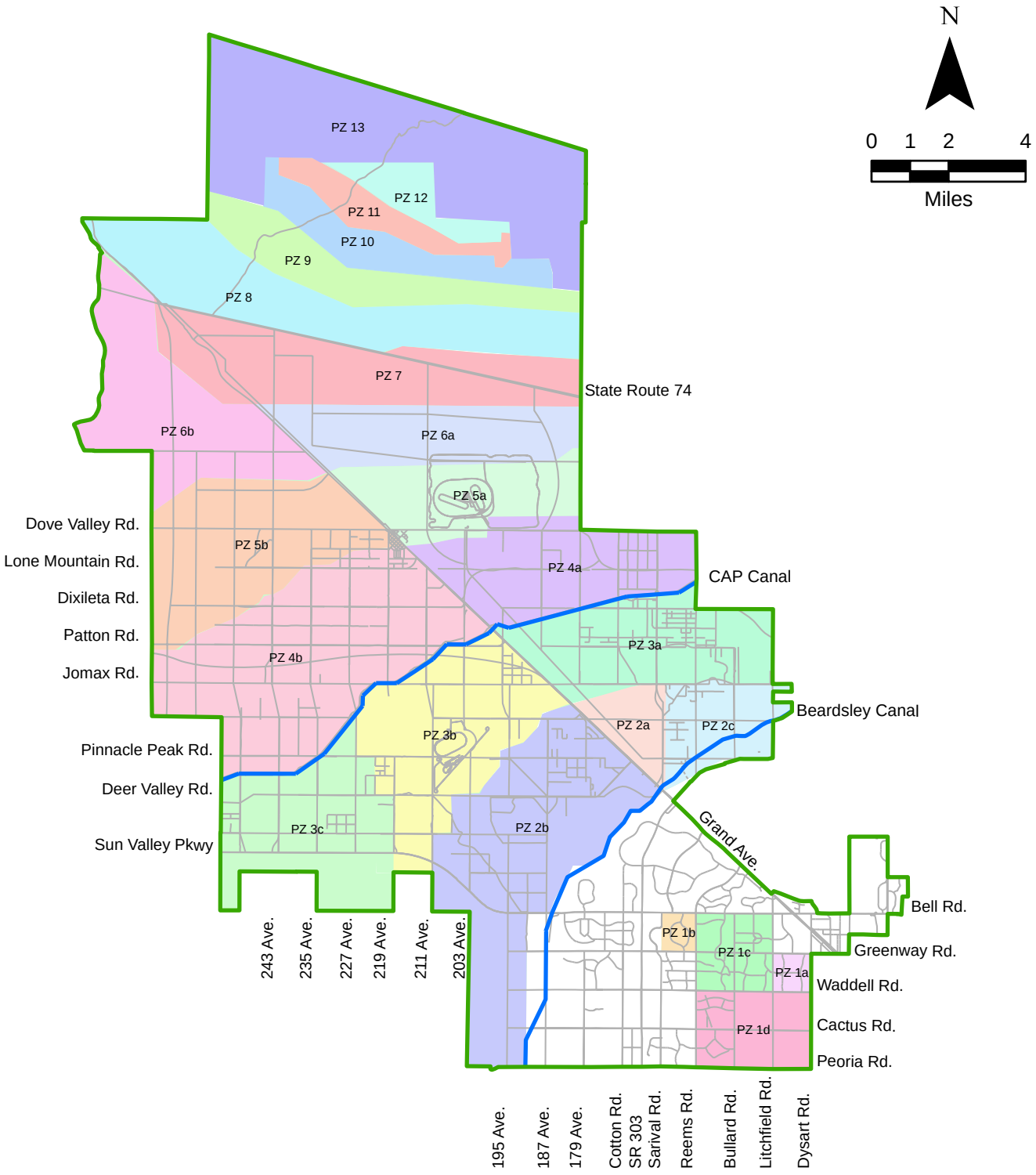
The work conducted in the *Integrated Water Master Plan* has clearly identified the need for the City to take action to expand its water infrastructure to maintain the level of service expected by residents and businesses and to keep up with projected growth. This section describes the refinements made to the selected infrastructure alternatives described in Section 6 and presents the recommended master plans for each infrastructure component. This section also provides additional recommended actions to improve future planning processes and to facilitate implementation of the recommended master plans.

The master plans include recommended infrastructure improvements for two time periods: near-term (2009 – 2020) and long-term (2021 – build-out). The recommended infrastructure improvements were made based on the information available at the time and discussions with the City. Planned infrastructure locations are approximate and were made for master planning purposes only. Actual alignments, interim solutions, and modifications to the strategies may be considered on a case-by-case basis as the system actually develops.

7.1. Refinements to Selected Infrastructure Alternatives

After the preferred water infrastructure (drinking water, wastewater, reclaimed water, and recharge) alternatives were selected (Section 6), refinements were made to further optimize the systems. Thus, the recommended master plan components and costs presented in this section do not entirely match the selected infrastructure alternatives presented and described in Section 6. The following key refinements were made:

- All infrastructure systems were updated to reflect the final system performance and design criteria described in Section 5.
- All systems were updated to reflect the "mid-population" demand scenario as finalized in Section 8 of the Water Resources component of the *Integrated Water Master Plan*. This includes modifications to the reclaimed water system to accommodate additional landscape demands not included in the initial alternatives evaluation and reclaimed water demands from the Prasada development in SPA 1.
- The location and service areas for three, currently planned WSFs in SPA 3 and the Rancho Mercado WSF in SPA 2 were updated in the drinking water hydraulic model. This included adding two WSFs and relocating the remaining WSF to locations provided by the City. Recommended pressure zone boundaries were also modified to reflect changes in the WSF locations (Figure 7-1), and demands were re-allocated to represent the new service areas.



Legend

- Municipal Planning Area
- Pressure Zones
- Streets
- Canals

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Recommended Drinking Water and Reclaimed Water Future Pressure Zones

July 2009

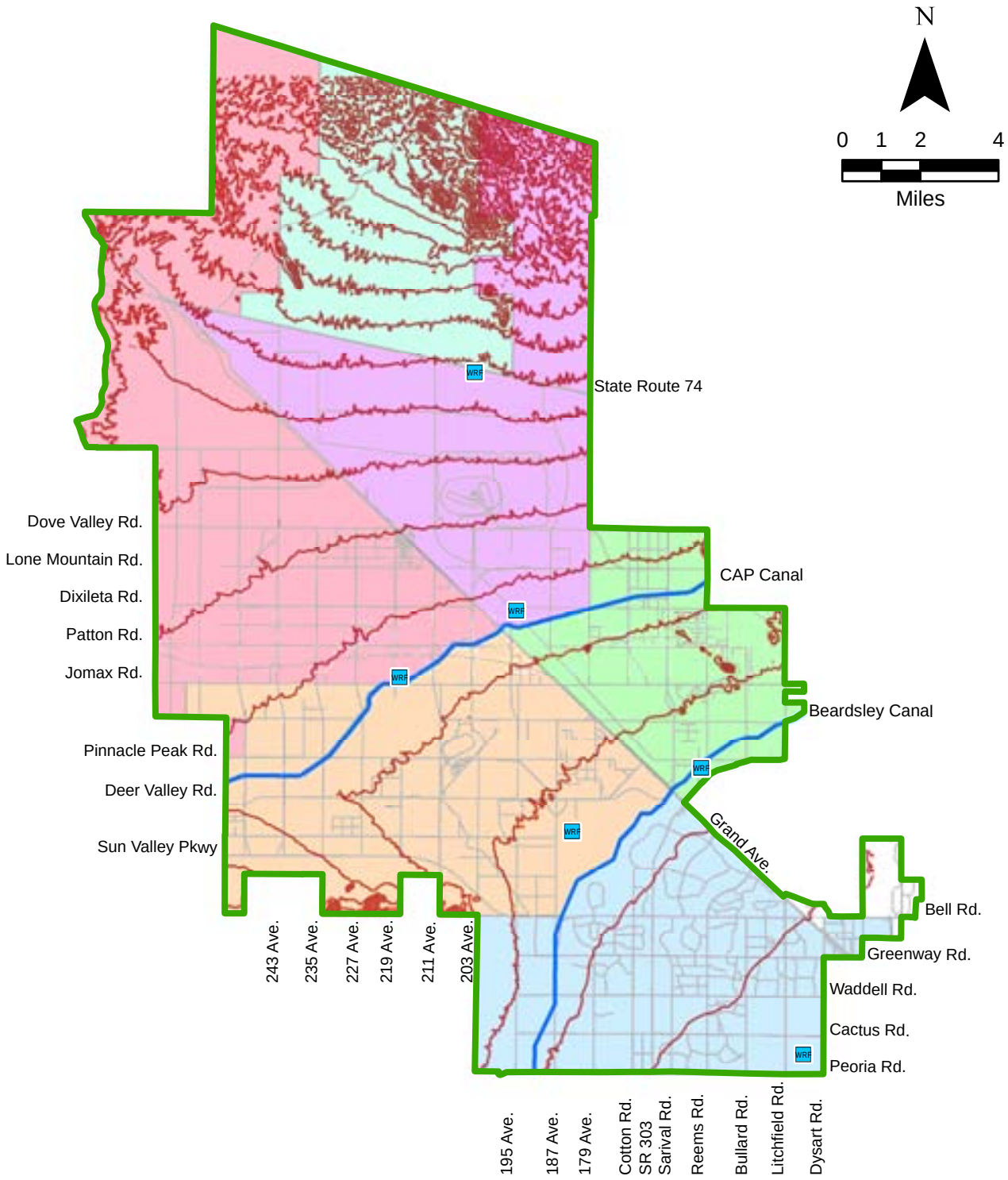
Figure 7-1

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure 7-1 Recommended Future Pressure Zones.mxd

- To minimize unnecessary pumping in the wastewater collection system, some lift stations located in the northern SPAs were eliminated and recommended drainage basins were modified (Figure 7-2) from the original SPA boundaries (Figure 3-2) to allow these changes. The SPA 5 WRF location was also moved to the location provided by the City.
- The SPA 2 drainage basin and collection system pipe were updated to reflect alignments described in the SPA 2 Wastewater Master Plan Amendment (RBF, 2007). Asante and Asante North collection system pipe alignments were incorporated into the future plans; however, sufficient data were not available to model these systems.
- SPA 3 collection system piping along Beardsley Road was updated to reflect alignments described in the West Surprise Landowners Group Master Wastewater Study (CMX, 2006). Because changes were made to the drainage basin in the northern portion of SPA 3, collection system pipelines in this section were not updated.
- The maximum operating pressure for the reclaimed water system was increased from 80 psi to 100 psi based on the final system performance and design criteria. Similar to the drinking water system model, the planned modified WSF locations in SPAs 2 and 3 were also updated in the reclaimed water system model. The pressure zone boundaries were also updated, and demands were re-allocated to represent the new service areas.
- To reduce pressures and optimize the reclaimed water transmission main system, additional booster stations were added along long transmission pipeline (pipes from WRFs to WSFs) segments with large elevation gradients.
- With the adjustments made to the WRF drainage basins, the amount of water to be recharged in SPA 6 was greatly reduced. To consolidate facilities, excess reclaimed water from SPA 6 during winter months was diverted to the SPA 4 recharge facility, and the SPA 6 recharge facility was eliminated. To supply SPA 6 with additional reclaimed water during maximum day conditions, booster pumps and transmission mains were added to move water from SPAs 4 and 5 to SPA 6. Three additional reclaimed water recovery wells were added near the SPA 4 recharge facility to supply additional reclaimed water to SPA 6 as well.
- Recharge facilities were resized to account for the City's planned injection wells in SPA 1.

7.2. Near-Term and Long Term Phasing Methodology

In order to develop the recommended near-term and long-term system improvements, the build-out system models were scaled back to reflect the anticipated development and population in 2020. To determine the developed areas for 2020, GIS data were used to identify areas where there was a planned development (obtained from City data), and areas that were estimated to be greater than 20 percent developed were determined from MAG population data (Figure 7-3). The percent developed in 2020 was based on the best



NOTE: Refer to Figure 3-2 for the wastewater service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Drainage Basins
- Canals
- Streets
- 100-ft Elevation Contours
- Water Reclamation Facilities

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Recommended Wastewater Drainage Basins

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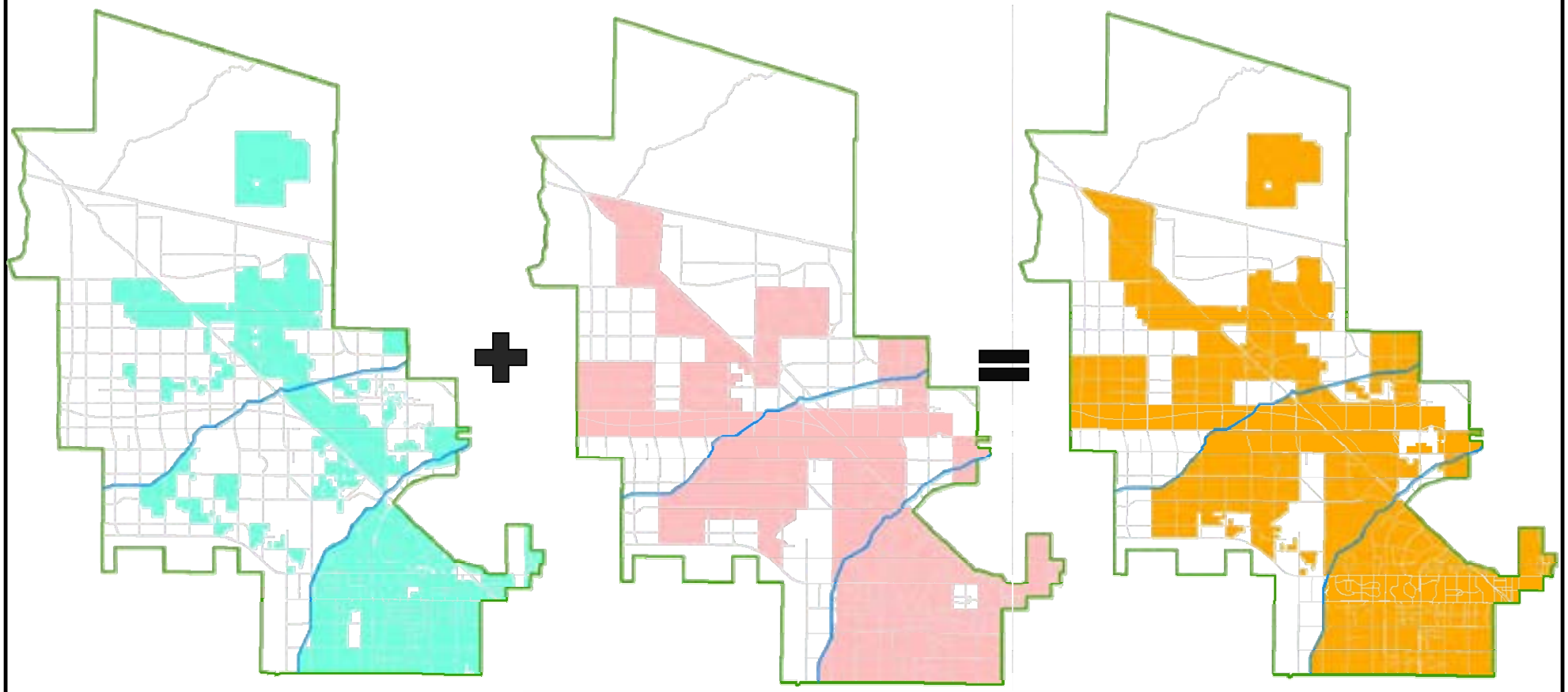
Figure 7-2

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure 7-2 Recommended Wasetwater Drainage Basins.mxd



Existing and Planned Developments (Obtained from City Data)

Areas Greater Tan 20 Percent Developed (Based on MAG Population Projections)

2020 Developed Areas (Used for Infrastructure Phasing)

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INTEGRATED WATER MASTER PLAN: WATER INFRASTRUCTURE

Developed Areas in 2020

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Figure 7-3

information available at the time of the analysis. With development timing in a flux, actual 2020 developments may vary, but were considered appropriate for this level of planning. Based on MAG population projections, the population in 2020 was anticipated to be approximately 240,000. It was estimated that the areas identified on Figure 7-3 would house approximately 94 percent of this population.

Any infrastructure lying outside of this area was removed, and the remaining infrastructure components were sized to meet 2020 (near-term) demands/flows as determined by the Water Resource Demand Module. Table 7-1 summarizes the 2020 demands and flows as compared to the build-out demands and flows.

Table 7-1.
Drinking Water, Wastewater, and Reclaimed Water Projections[1]

SPA/ Drainage Basin	Drinking Water Demand		Wastewater Flow		Reclaimed Water Available[2]		Reclaimed Water Demand	
	2020 (mgd)	Build-out (mgd)	2020 (mgd)	Build-out (mgd)	2020 (mgd)	Build-out (mgd)	2020 (mgd)	Build-out (mgd)
1	7.3	8.8	17.4	22.8	15.6	20.5	2.5	2.7
2	4.8	13.7	3.1	10.1	2.8	9.1	0.9	2.8
3	9.5	28.0	5.6	19.4	5.1	17.4	0.9	4.0
4	3.5	19.1	1.7	13.8	1.5	12.4	0.5	5.9
5	6.4	23.6	3.9	15.7	3.5	14.1	1.2	5.7
6	0.5	16.3	0.07	5.4	0.06	4.9	0.2	7.2
Totals	**32.0**	**109.5**	**31.8**	**87.2**	**28.6**	**78.4**	**6.1**	**28.4**

NOTES:
(1) Based on mid-population scenario described in the Water Resources component of the *Integrated Water Master Plan*.
(2) Reclaimed water not used for irrigation will be recharged.

Lastly, the additional infrastructure needed to meet build-out (long-term) demands/flows was added back to the models. The system modeling indicated that some of the near-term infrastructure would need to be improved for build-out conditions. Because the span of time between near-term and long-term was largely unknown, the frequency of infrastructure upgrades (including whether pipes should be paralleled or replaced) could not be definitively determined. Thus, the near-term infrastructure that needs to be improved for long-term time period were shown as equivalent capacities for the long-term period.

7.3. Basis of Costs

The capital cost estimates presented herein were based on available existing studies, recent projects with similar components, manufacturer's budget estimates, standard construction cost estimating manuals, and engineering judgment. The level of accuracy for the cost estimates corresponded to the Class 4 estimate as defined by the Association

for the Advancement of Cost Engineering (AACE) International. This level of engineering cost estimating was approximate and generally made without detailed engineering data and site layouts, but was appropriate for preliminary budget-level estimating. The accuracy range of a Class 4 estimate was minus 15 to plus 20 percent in the best case and minus 30 percent to plus 50 percent in the worst case.

Appendix G contains the unit capital cost information and other assumptions used for the cost estimates herein. The unit costs included materials of construction, installation, contractor costs (overhead, profit, bonding, mobilization), and engineering. All costs included a 20 percent factor for engineering and construction administration and 30 percent for project contingencies. All costs were in January 2009 dollars referenced to an Engineering News Record Construction Cost Index (ENR CCI) of 8,549.

7.4. Recommended Drinking Water Master Plan

7.4.1. Infrastructure Phasing

The recommended near-term and long-term drinking water infrastructure improvements are shown on Figures 7-4 and 7-5, respectively. Table 7-2 presents a listing of the recommended improvements and identifies the estimated capital costs to plan, design, and construct the improvements.

The key drinking water improvements listed in Table 7-2 included improvements at existing WSFs in SPAs 1 and 2, 13 new WSFs (each with wells, assumed well transmission pipelines, storage tanks, and booster stations), one offsite storage reservoir, 4 inline booster stations, and distribution system pipelines. If pressure zones are implemented as recommended on Figures 7-4 and 7-5, no large PRVs would be needed for the drinking water system.

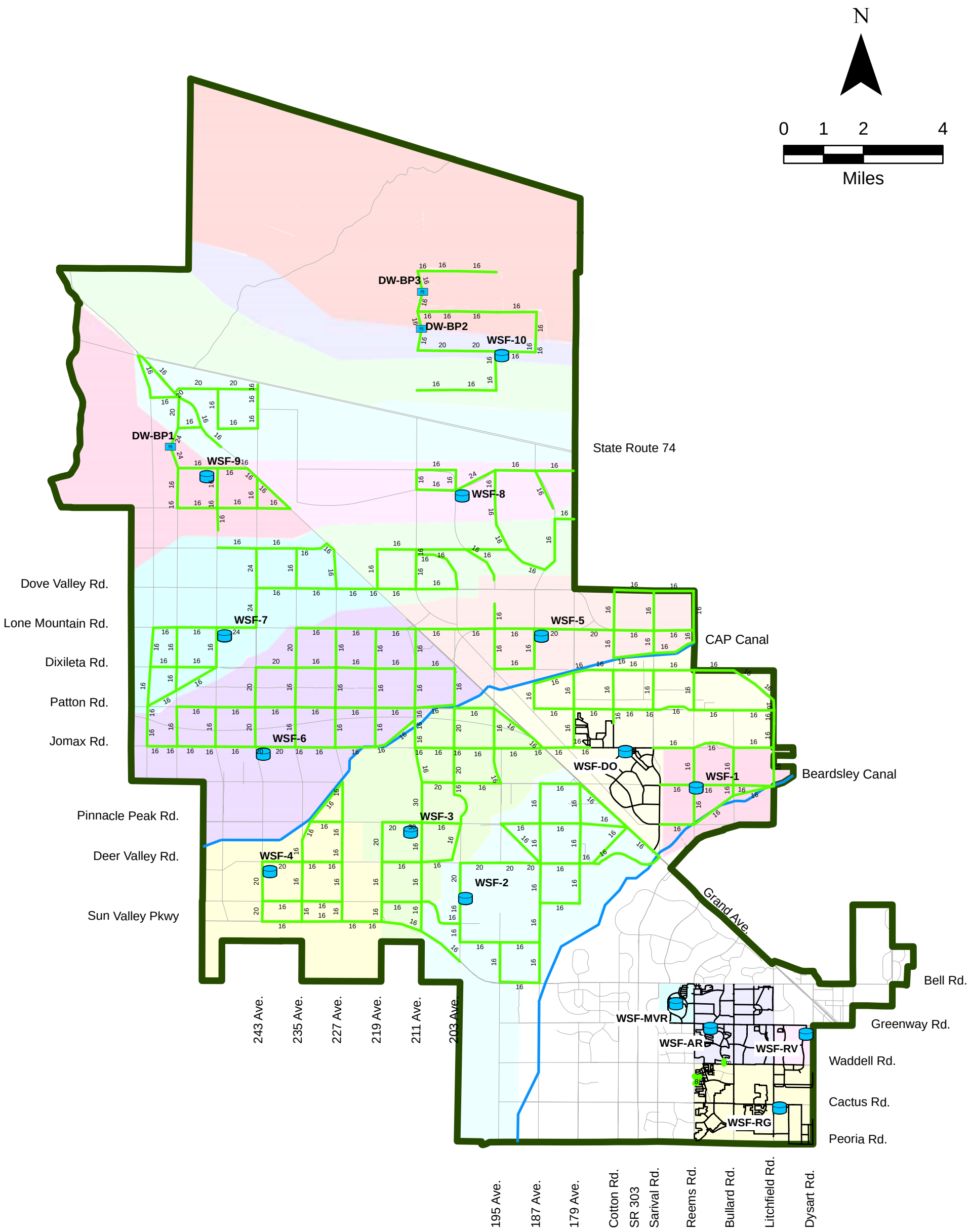
As indicated previously, the recommended long-term infrastructure (Figure 7-5) was presented as equivalent capacities for each short-term distribution pipeline that needed improvements for the long-term.

Because booster station pumping capacity is both a function of head and flow, pumps in the table were shown as total capacity required. With variable speed pumps, it is likely that additional pumps can be added to the system without replacing the existing ones. Incremental improvements were presented for the remaining infrastructure (WRFs, WSFs, storage reservoirs, wells, and arsenic treatment). Each new well was assumed to have a capacity of 1,500 gpm. Based on available information (as discussed in the Water Resources component of the *Integrated Water Master Plan*), arsenic treatment capacity was assumed to be 70 percent of the groundwater pumped. To prevent the possibility of land restrictions as the City approaches build-out, all land was included as part of the near-term improvements.

7.4.2. Additional Recommendations

The following additional recommendations are made to facilitate future planning and implementation of the recommended drinking water master plan:

- Continue to periodically update the *Integrated Water Master Plan* every three to five years. Growth within the City's MPA is dynamic, and as actual development occurs, the projected water demands and drinking water infrastructure needs will change.
- Continue to refine the dwelling unit information in the City's GIS. There were some discrepancies found with the dwelling unit counts, which affected estimates of water demand factors.
- Work with AAWC to develop a refined water customer billing database for at least the last five years. Approximately 10 percent of the water meters could not be geographically located. The goal of these actions should be to refine the water demand factors in the Demand Module.
- Increase the set point pressure for the variable frequency drive pumps at the Mountain Vista Ranch WSF to achieve needed fire flows throughout its service area. All other existing system deficiencies identified in Section 5 are addressed in the recommended system improvements.
- In future discussions with CAWCD, request that as much as possible, the City's CAP allocations should be recharged at the Hieroglyphic Mountains facility.
- Reexamine current developer agreement structures to identify the means to accommodate fewer, larger WSFs.
- Carefully site and design future WSFs based on the most current information on development patterns and existing infrastructure.
- Conduct hydrogeologic investigations in the near-term to identify the most suitable areas for well development and start locating well sites for the recommended WSFs. Future production well sites are not located in the information above.
- Continue reevaluating the option of constructing a CAP WTP in all future updates of the *Integrated Water Master Plan* as additional information becomes available on actual groundwater quality (i.e., the need for groundwater treatment).



NOTE: Refer to Figure 3-1 for the water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilities
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Drinking Water Infrastructure Improvements

July 2009 | **Figure 7-4**

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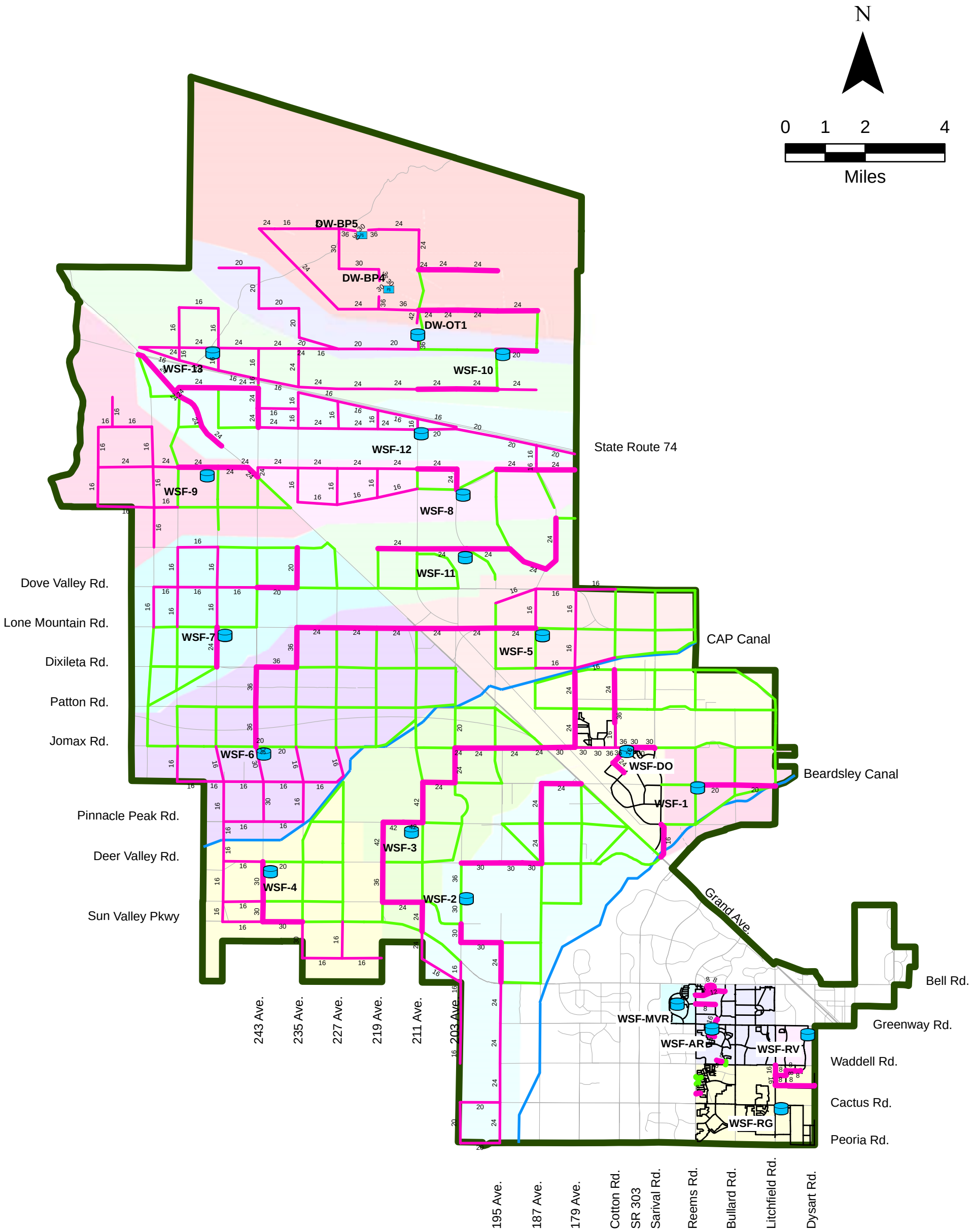

NOTE: Refer to Figure 3-1 for the water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilities
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)
- 2021 - Build-out (New)
- 2021 - Build-out (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Drinking Water Infrastructure Improvements

July 2009 | **Figure 7-5**

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Table 7-2.
Recommended Drinking Water Infrastructure Improvements Schedule

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
Water Supply Facilities (Pressure Zone)						
Ashton Ranch, WSF-AR (PZ-1c)			**$ -**			**$ 800,000**
Land	-		$ -	-		$ -
Production Wells	-		$ -	-		$ -
Storage Reservoirs	-		$ -	-		$ -
Booster Pump Stations	-		$ -	6,900 gpm	140 TDH	$ 800,000
Arsenic Treatment	-		$ -	-		$ -
Transmission Mains	-		$ -	-		$ -
Roseview, WSF-RV (PZ-1a)			**$ 4,210,000**			**$ -**
Land	0.3 acres		$ 10,000	-		$ -
Production Wells	1 wells		$ 2,200,000	-		$ -
Storage Reservoirs	-		$ -	-		$ -
Booster Pump Stations	-		$ -	-		$ -
Arsenic Treatment	1,050 gpm		$ 2,000,000	-		$ -
Transmission Mains	-		$ -	-		$ -
Desert Oasis, WSF-DO (PZ-2a, 3a)			**$ 9,500,000**			**$ 22,900,000**
Land	1.5 acres		$ 100,000	-		$ -
Production Wells	2 wells		$ 4,400,000	4 wells		$ 8,700,000
Storage Reservoirs	-		$ -	2 MG		$ 2,400,000
Booster Pump Stations	-		$ -	9,000 gpm	220 TDH	$ 800,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	4,200 gpm		$ 7,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
20 in	-		$ -	5,280 LF		$ 2,100,000
Rancho Mercado, WSF-1 (PZ-2c)			**$ 17,300,000**			**$ 19,900,000**
Land	5.5 acres		$ 200,000	-		$ -
Production Wells	3 wells		$ 6,500,000	3 wells		$ 6,500,000
Storage Reservoirs	1 MG		$ 2,100,000	2 MG		$ 3,500,000
Booster Pump Stations	4,827 gpm	144 TDH	$ 2,500,000	10,700 gpm	168 TDH	$ 1,900,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	3,150 gpm		$ 5,900,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
20 in	2,640 LF		$ 1,000,000	2,640 LF		$ 1,000,000
WSF-2 (PZ-2b)			**$ 23,200,000**			**$ 43,300,000**
Land	6.8 acres		$ 300,000	-		$ -
Production Wells	4 wells		$ 8,700,000	7 wells		$ 15,300,000
Storage Reservoirs	2 MG		$ 3,000,000	5 MG		$ 5,000,000
Booster Pump Stations	6,332 gpm	110 TDH	$ 2,100,000	22,000 gpm	163 TDH	$ 3,700,000
Arsenic Treatment	3,150 gpm		$ 5,900,000	7,350 gpm		$ 13,700,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	10,560 LF		$ 2,100,000
20 in	5,280 LF		$ 2,100,000	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
30 in	-		$ -	2,640 LF		$ 1,400,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-3 (PZ-3b)			**$ 36,600,000**			**$ 39,400,000**
Land	7.0 acres		$ 300,000	-		$ -
Production Wells	6 wells		$ 13,100,000	6 wells		$ 13,100,000
Storage Reservoirs	3 MG		$ 4,400,000	4 MG		$ 4,400,000
Booster Pump Stations	9,138 gpm	130 TDH	$ 2,500,000	25,000 gpm	195 TDH	$ 3,700,000
Arsenic Treatment	5,250 gpm		$ 9,800,000	6,300 gpm		$ 11,700,000
Transmission Mains						
12 in	10,560 LF		$ 2,100,000	10,560 LF		$ 2,100,000
24 in	10,560 LF		$ 4,400,000	10,560 LF		$ 4,400,000
WSF-4 (PZ-3c)			**$ 17,300,000**			**$ 31,600,000**
Land	6.0 acres		$ 300,000	-		$ -
Production Wells	3 wells		$ 6,500,000	5 wells		$ 10,900,000
Storage Reservoirs	1 MG		$ 2,000,000	4 MG		$ 4,800,000
Booster Pump Stations	7,590 gpm	157 TDH	$ 2,500,000	15,000 gpm	200 TDH	$ 2,400,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	7,920 LF		$ 1,600,000
20 in	2,640 LF		$ 1,000,000	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
WSF-5 (PZ-4a)			**$ 11,500,000**			**$ 31,400,000**
Land	5.8 acres		$ 200,000	-		$ -
Production Wells	2 wells		$ 4,400,000	5 wells		$ 10,900,000
Storage Reservoirs	1 MG		$ 1,700,000	3 MG		$ 4,200,000
Booster Pump Stations	4,126 gpm	135 TDH	$ 2,100,000	12,800 gpm	156 TDH	$ 2,800,000
Arsenic Treatment	1,050 gpm		$ 2,000,000	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	7,920 LF		$ 1,600,000
20 in	-		$ -	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
WSF-6 (PZ-4b)			**$ 35,900,000**			**$ 56,600,000**
Land	7.8 acres		$ 300,000	-		$ -
Production Wells	6 wells		$ 13,100,000	9 wells		$ 19,600,000
Storage Reservoirs	4 MG		$ 4,800,000	6 MG		$ 5,600,000
Booster Pump Stations	10,100 gpm	138 TDH	$ 2,800,000	30,000 gpm	168 TDH	$ 3,700,000
Arsenic Treatment	5,250 gpm		$ 9,800,000	9,450 gpm		$ 17,600,000
Transmission Mains						
12 in	7,920 LF		$ 1,600,000	26,400 LF		$ 5,300,000
20 in	2,640 LF		$ 1,000,000	5,280 LF		$ 2,100,000
24 in	2,640 LF		$ 1,100,000	-		$ -
30 in	2,640 LF		$ 1,400,000	5,280 LF		$ 2,700,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-7 (PZ-5b)			**$ 17,400,000**			**$ 31,300,000**
Land	6.0 acres		$ 300,000	-		$ -
Production Wells	3 wells		$ 6,500,000	5 wells		$ 10,900,000
Storage Reservoirs	2 MG		$ 2,700,000	3 MG		$ 4,000,000
Booster Pump Stations	5,802 gpm	137 TDH	$ 1,900,000	14,700 gpm	189 TDH	$ 2,900,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	7,920 LF		$ 1,600,000
20 in	2,640 LF		$ 1,000,000	2,640 LF		$ 1,000,000
24 in	-		$ -	2,640 LF		$ 1,100,000
WSF-8 (PZ-6a)			**$ 15,900,000**			**$ 5,700,000**
Land	5.0 acres		$ 200,000	-		$ -
Production Wells	3 wells		$ 6,500,000	1 wells		$ 2,200,000
Storage Reservoirs	1 MG		$ 2,100,000	1 MG		$ 900,000
Booster Pump Stations	4,863 gpm	122 TDH	$ 1,600,000	5,000 gpm	180 TDH	$ 100,000
Arsenic Treatment	2,100 gpm		$ 3,900,000	1,050 gpm		$ 2,000,000
Transmission Mains						
12 in	7,920 LF		$ 1,600,000	2,640 LF		$ 500,000
WSF-9 (PZ-6b)			**$ 11,000,000**			**$ 12,400,000**
Land	5.0 acres		$ 200,000	-		$ -
Production Wells	2 wells		$ 4,400,000	2 wells		$ 4,400,000
Storage Reservoirs	1 MG		$ 1,400,000	1 MG		$ 2,000,000
Booster Pump Stations	3,608 gpm	165 TDH	$ 1,900,000	5,500 gpm	145 TDH	$ 1,000,000
Arsenic Treatment	1,050 gpm		$ 2,000,000	2,100 gpm		$ 3,900,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
WSF-10 (PZ-9)			**$ 10,500,000**			**$ 13,200,000**
Land	5.0 acres		$ 200,000	-		$ -
Production Wells	2 wells		$ 4,400,000	2 wells		$ 4,400,000
Storage Reservoirs	1 MG		$ 1,100,000	2 MG		$ 2,400,000
Booster Pump Stations	3,231 gpm	184 TDH	$ 1,700,000	5,950 gpm	185 TDH	$ 1,400,000
Arsenic Treatment	1,050 gpm		$ 2,000,000	2,100 gpm		$ 3,900,000
Transmission Mains						
12 in	5,280 LF		$ 1,100,000	5,280 LF		$ 1,100,000
WSF-11 (PZ-5a)			**$ 200,000**			**$ 39,600,000**
Land	5.8 acres		$ 200,000	-		$ -
Production Wells	-		$ -	7 wells		$ 15,300,000
Storage Reservoirs	-		$ -	4 MG		$ 4,400,000
Booster Pump Stations	-		$ -	12,900 gpm	154 TDH	$ 3,000,000
Arsenic Treatment	-		$ -	6,300 gpm		$ 11,700,000
Transmission Mains						
12 in	-		$ -	10,560 LF		$ 2,100,000
20 in	-		$ -	7,920 LF		$ 3,100,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-12 (PZ-7)			**$ 200,000**			**$ 34,800,000**
Land	5.5 acres		$ 200,000	-		$ -
Production Wells	-		$ -	6 wells		$ 13,100,000
Storage Reservoirs	-		$ -	4 MG		$ 4,800,000
Booster Pump Stations	-		$ -	10,600 gpm	206 TDH	$ 2,900,000
Arsenic Treatment	-		$ -	5,250 gpm		$ 9,800,000
Transmission Mains						
12 in	-		$ -	10,560 LF		$ 2,100,000
20 in	-		$ -	5,280 LF		$ 2,100,000
WSF-13 (PZ-8)			**$ 200,000**			**$ 28,200,000**
Land	5.3 acres		$ 200,000	-		$ -
Production Wells	-		$ -	5 wells		$ 10,900,000
Storage Reservoirs	-		$ -	3 MG		$ 3,800,000
Booster Pump Stations	-		$ -	8,001 gpm	171 TDH	$ 2,600,000
Arsenic Treatment	-		$ -	4,200 gpm		$ 7,800,000
Transmission Mains						
12 in	-		$ -	10,560 LF		$ 2,100,000
20 in	-		$ -	2,640 LF		$ 1,000,000
Off-Site Storage Tanks						
Land	4.0 acres		$ 200,000	-		$ -
DW-OT1	-		$ -	16 MG		$ 13,500,000
Distribution Booster Pump Stations			**$ 5,100,000**			**$ 8,300,000**
Land	1.5 acres		$ 100,000	-		$ -
DW-BP1	3,452 gpm	144 TDH	$ 1,800,000	-		$ -
DW-BP2	3,113 gpm	191 TDH	$ 1,600,000	17,600 gpm	263 TDH	$ 3,400,000
DW-BP3	3,030 gpm	163 TDH	$ 1,600,000	-		$ -
DW-BP4	-		$ -	10,500 gpm	152 TDH	$ 2,900,000
DW-BP5	-		$ -	6,000 gpm	166 TDH	$ 2,000,000
Distribution System Pipelines			**$ 373,100,000**			**$ 414,000,000**
8 in	1,800 LF		$ 200,000	20,204 LF		$ 2,700,000
12 in	-		$ -	356 LF		$ 100,000
16 in	1,171,800 LF		$ 316,000,000	405,587 LF		$ 109,400,000
20 in	119,100 LF		$ 46,600,000	99,465 LF		$ 39,000,000
24 in	21,700 LF		$ 9,000,000	423,329 LF		$ 176,300,000
30 in	2,600 LF		$ 1,300,000	78,369 LF		$ 40,400,000
36 in	-		$ -	55,535 LF		$ 33,600,000
42 in	-		$ -	18,033 LF		$ 12,500,000
GRAND TOTAL			**$ 588,900,000**			**$ 847,100,000**

NOTES:
WSF – water supply facility; DW – drinking water; PZ – pressure zone; OT – off-site tank; BP – booster pump
(1) January 2009 costs (ENR CCI = 8,549). Unit capital costs include engineering/design, materials of construction, installation, and contractor overhead and profit.

7.5. Recommended Wastewater Master Plan

7.5.1. Infrastructure Phasing

The recommended near-term and long-term wastewater infrastructure improvements are shown on Figures 7-6 and 7-7, respectively. Table 7-3 presents a listing of the recommended improvements and identifies the estimated capital costs to plan, design, and construct the improvements.

The key wastewater improvements listed in Table 7-3 included WRF capacity expansions at the existing South WRF and five additional WRFs, improvements at the existing lift station and four new lift stations, and approximately 300 miles of new pipelines (including force mains and gravity collection system piping). At build-out, the total capacity of the six WRFs was calculated to be 87 mgd, based on annual average flows. Cost estimates for the WRFs were based on use of the membrane bio-reactor (MBR) technology.

7.5.2. Additional Recommendations

The following additional recommendations were made to facilitate future planning and implementation of the recommended wastewater master plan:

- Continue to periodically update the *Integrated Water Master Plan* every three to five years. Growth within the City MPA is dynamic, and as actual development occurs, the projected wastewater flows and wastewater infrastructure needs will change.
- Carefully site and design future WRFs based on the most current information on development patterns and existing infrastructure. Interim solutions (i.e., pumping between drainage basins, phasing of facilities, etc.) should be considered if they meet the needs of the City, the community, and developers.
- Continue to refine the dwelling unit information in the City's GIS, there were some discrepancies found with the dwelling unit counts, which affected estimates of wastewater flow factors.
- Continue to document WRF influent flow data and collection system flow data from future flow monitoring studies with the objective of refining the wastewater flow factors in the Demand Module.
- Plug the diversion to Cactus Road in the 27-inch trunk sewer in Reems Road to mitigate surcharging of trunk sewers downstream of the Cactus Road trunk sewer.
- Verify collection system invert elevations and actual construction details at all locations identified as existing deficiencies in Section 5, particularly at the following locations: 1) intersection of Bell Road and Sunrise Boulevard, and 2) pipe connections to the existing pump station on Greenway Road. All other existing system deficiencies identified are addressed in the recommended system improvements.

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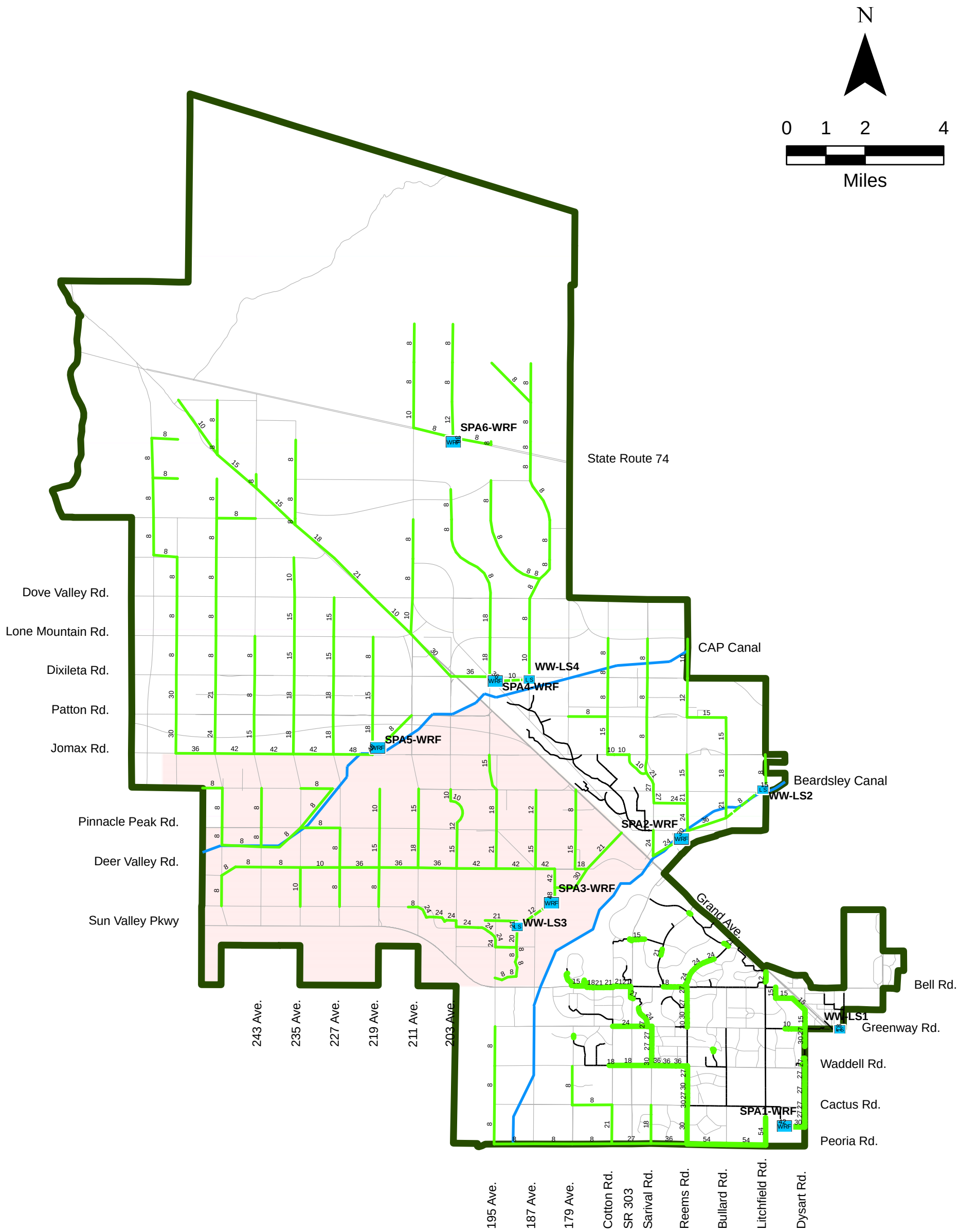

NOTE: Refer to Figure 3-2 for the sewer service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Drainage Basins
- Canals
- Streets
- Water Reclamation Facilities
- Lift Stations

Force Mains

- Existing
- 2009 - 2020 (New)

Gravity Sewers

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Wastewater Infrastructure Improvements

July 2009 | **Figure 7-6**

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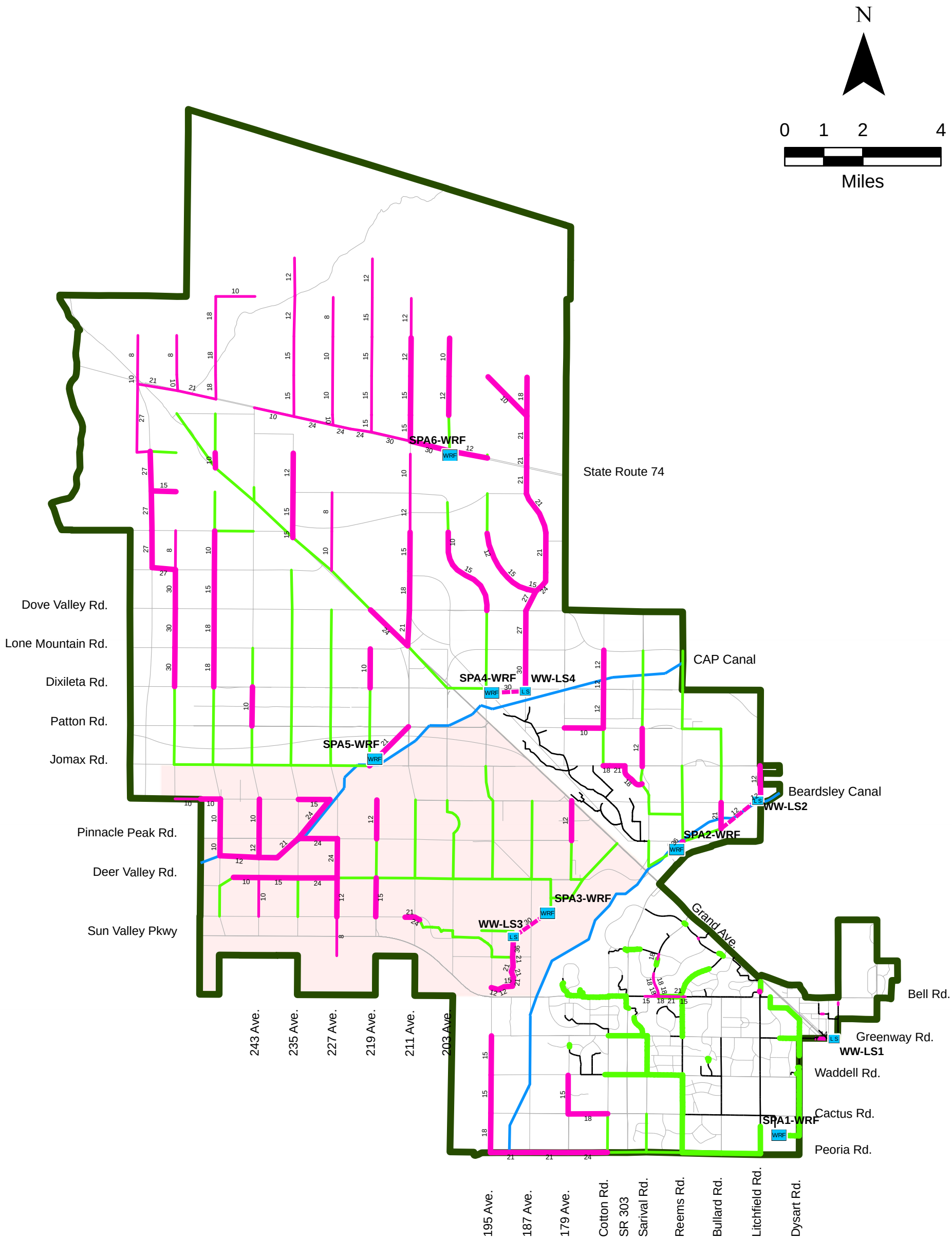

NOTE: Refer to Figure 3-2 for the sewer service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Drainage Basins
- Canals
- Streets
- Water Reclamation Facilities
- Lift Stations

Force Mains

- Existing
- 2021 - Build-out (Improved)

Gravity Sewers

- Existing
- 2009 - 2020 (New)
- 2009 - 2020 (Improved)
- 2021 - Build-out (New)
- 2021 - Build-out (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Wastewater Infrastructure Improvements

July 2009 | **Figure 7-7**

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Table 7-3.
Recommended Wastewater Infrastructure Improvements Schedule

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
Water Reclamation Facilities[2]						
SPA-2			**$ 42,800,000**			**$ 87,900,000**
SPA2-WRF	3.1 mgd		$ 38,900,000	7.0 mgd		$ 87,900,000
Land	93 acres		$ 3,900,000	-		$ -
SPA-3			**$ 74,400,000**			**$ 173,200,000**
SPA3-WRF	5.6 mgd		$ 70,300,000	13.8 mgd		$ 173,200,000
Land	96 acres		$ 4,100,000	-		$ -
SPA-4			**$ 25,300,000**			**$ 151,900,000**
SPA4-WRF	1.7 mgd		$ 21,300,000	12.1 mgd		$ 151,900,000
Land	94 acres		$ 4,000,000	-		$ -
SPA-5			**$ 52,900,000**			**$ 148,100,000**
SPA5-WRF	3.9 mgd		$ 48,900,000	11.8 mgd		$ 148,100,000
Land	95 acres		$ 4,000,000	-		$ -
SPA-6			**$ 5,100,000**			**$ 66,500,000**
SPA6-WRF	0.1 mgd		$ 1,300,000	5.3 mgd		$ 66,500,000
Land	91 acres		$ 3,800,000	-		$ -
Lift Stations			**$ 5,640,000**			**$ 23,700,000**
Land	1 acres		$ 40,000	-		$ -
WW-LS2	505 gpm	45 TDH	$ 1,700,000	1,833 gpm	80 TDH	$ 6,300,000
WW-LS3	1,504 gpm	50 TDH	$ 2,400,000	9,861 gpm	20 TDH	$ 8,000,000
WW-LS4	444 gpm	40 TDH	$ 1,500,000	11,599 gpm	32 TDH	$ 9,400,000
Force Mains			**$ 3,100,000**			**$ 6,300,000**
8 in	6,267 LF		$ 1,000,000	-		$ -
10 in	4,572 LF		$ 900,000	-		$ -
12 in	5,615 LF		$ 1,200,000	6,267 LF		$ 1,400,000
20 in	-		$ -	-		$ -
30 in	-		$ -	10,187 LF		$ 4,900,000
8 in	6,267 LF		$ 1,000,000	-		$ -
Gravity Sewers			**$ 192,500,000**			**$ 124,100,000**
8 in	388,046 LF		$ 44,500,000	31,746 LF		$ 3,600,000
10 in	67,134 LF		$ 9,000,000	105,614 LF		$ 14,200,000
12 in	18,925 LF		$ 3,000,000	99,573 LF		$ 15,800,000
15 in	114,611 LF		$ 21,400,000	105,769 LF		$ 19,700,000
18 in	73,695 LF		$ 16,400,000	55,047 LF		$ 12,300,000
21 in	52,690 LF		$ 13,900,000	74,925 LF		$ 19,800,000
24 in	45,992 LF		$ 13,200,000	49,578 LF		$ 14,200,000
27 in	32,725 LF		$ 10,300,000	38,213 LF		$ 12,000,000
30 in	45,547 LF		$ 15,600,000	32,304 LF		$ 11,000,000
36 in	44,903 LF		$ 17,800,000	3,668 LF		$ 1,500,000
42 in	32,231 LF		$ 14,600,000	-		$ -
48 in	8,926 LF		$ 4,500,000	-		$ -
54 in	14,270 LF		$ 8,300,000	-		$ -
GRAND TOTAL			**$ 401,740,000**			**$ 781,700,000**

NOTES:
WRF – water reclamation facility; WW – wastewater; LS – lift station
(1) January 2009 costs (ENR CCI = 8,549). Unit capital costs include engineering/design, materials of construction, installation, and contractor overhead and profit.
(2) WRF land requirements assume odor and noise control are not provided.

7.6. Recommended Reclaimed Water and Recharge Master Plans

7.6.1. Infrastructure Phasing (Large Irrigation Users)

The reclaimed water system consisted of two modeled systems: transmission mains from the WRFs to the WSFs and distribution system pipelines from the WSFs to reuse customers:

- The recommended near-term and long-term reclaimed water transmission main improvements are shown on Figures 7-8 and 7-9, respectively.
- The recommended near-term and long-term reclaimed water distribution system improvements are shown on Figures 7-10 and 7-11, respectively.

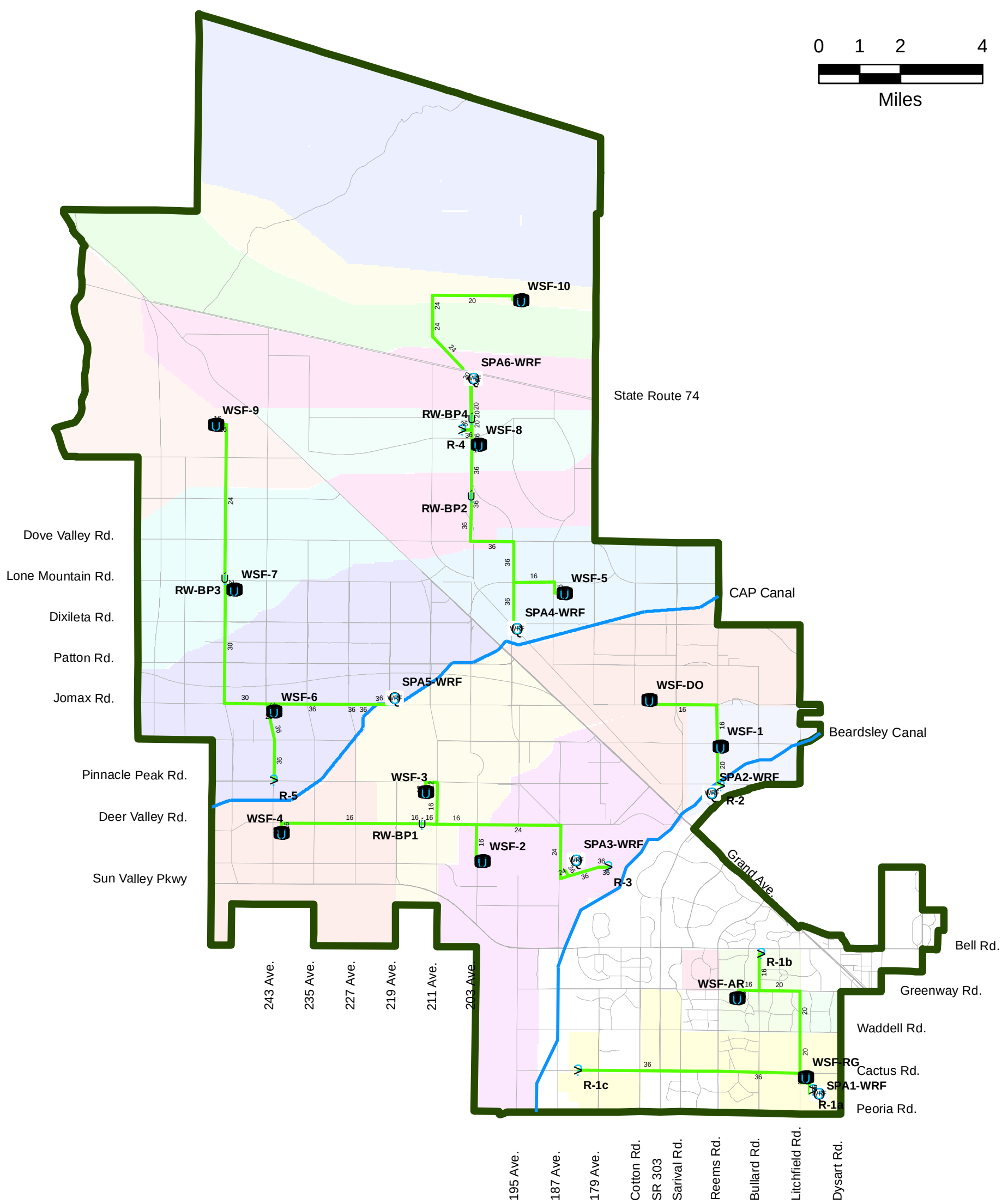
Table 7-4 presents a listing of the recommended improvements and identifies the estimated capital costs to plan, design, and construct the improvements.

The key reclaimed water and recharge improvements listed in Table 7-4 included improvements at the existing WSFs in SPAs 1 and 2, reclaimed water facilities at the 13 new WSFs (reclaimed water storage tanks and booster stations), nine inline booster stations, one offsite storage tank, five additional surface recharge facilities (total acreage of approximately 860 acres), and the transmission and distribution system pipelines. If pressure zones are implemented as recommended on Figures 7-8 through 7-11, 17 PRVs would be needed to accommodate excessive pressure areas.

7.6.2. Potential to Serve Maximum Reuse

As discussed and recommended in the Water Resources component of the *Integrated Water Master Plan*, the reclaimed water model was master-planned to serve only the largest irrigation users. The ability of the master-planned reclaimed water system to accommodate all potential water reuses identified (maximum reuse, including all residential and commercial outside uses) was evaluated. This was accomplished by loading the master-planned system with the potential maximum reuse demands as determined by the Demand Module and modeling the performance of the system under peak demand conditions.

The system to serve only the large irrigation uses was designed to supply a peak hour demand of 142 mgd (28 mgd annual average). However, the maximum reuse demand condition would require supplying a peak hour demand of 335 mgd (67 mgd annual average), a nearly threefold increase in demand. Nearly every pipe, pump, and storage reservoir in the master-planned reuse system would have to be significantly improved to accommodate the increase in demand. As such, there were no specific areas in the master-planned reuse system that could be feasibly upgraded without drastically modifying the entire system. Consequently, no adjustments to fortify the master-planned reclaimed water system are recommended at this time.



NOTE: Refer to Figure 3-1 for the reclaimed water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Reclamation Facilities
- Water Supply Facilitiies
- Surface Spreading Basins
- Transmission Main Booster Stations

Transmission Mains

- 2009 - 2020 (New)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Reclaimed Water Transmission Main Improvements

July 2009 | **Figure 7-8**

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure 7-8 2020 RW Trans Improvements.mxd

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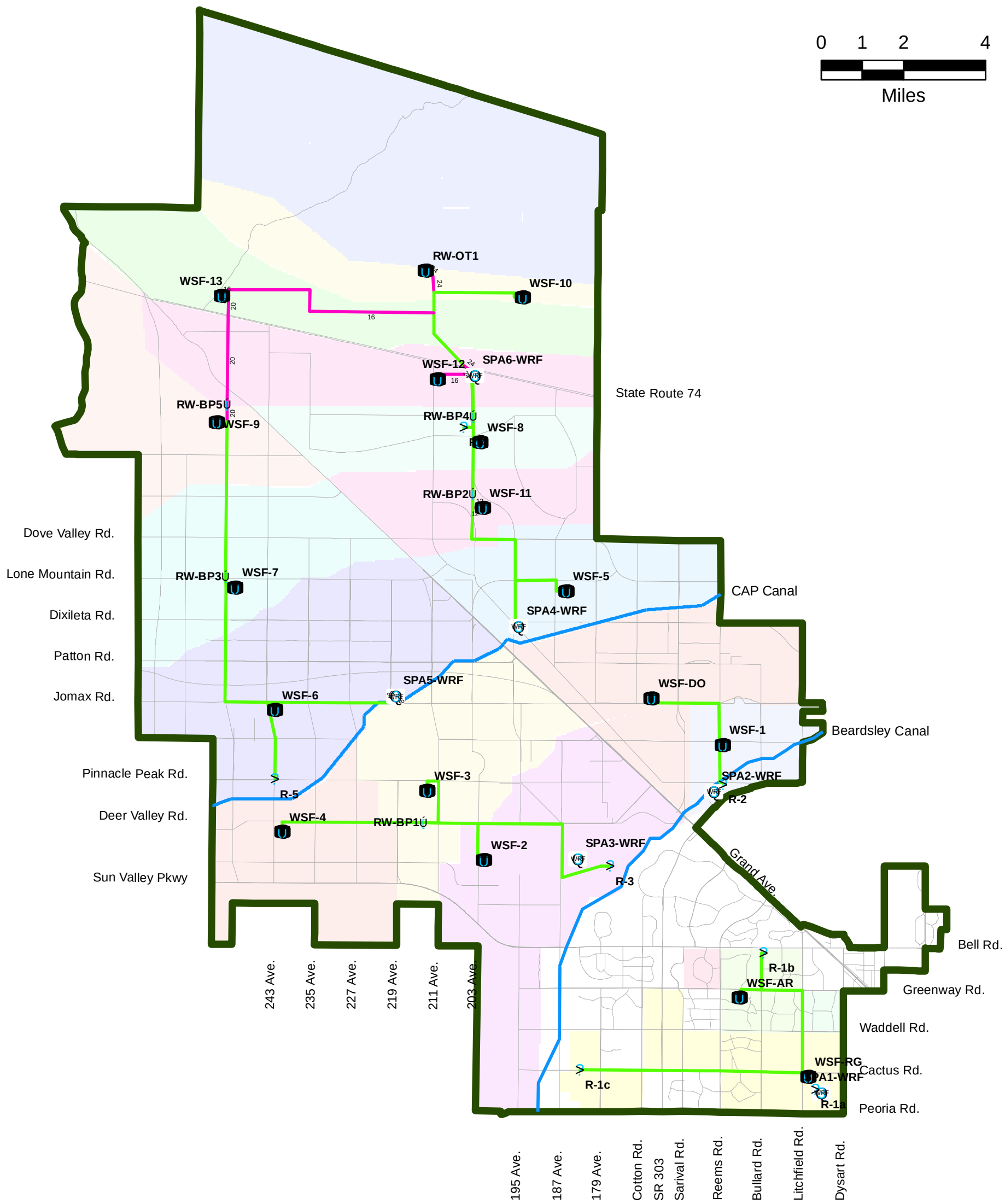

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Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Reclamation Facilities
- Water Supply Facilitiies
- Surface Spreading Basins
- Transmission Main Booster Stations

Transmission Mains

- 2009 - 2020 (New)
- 2021 - Build-out (New)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Reclaimed Water Transmission Main Improvements

July 2009 | **Figure 7-9**

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure 7-9 BO RW Trans Improvements.mxd

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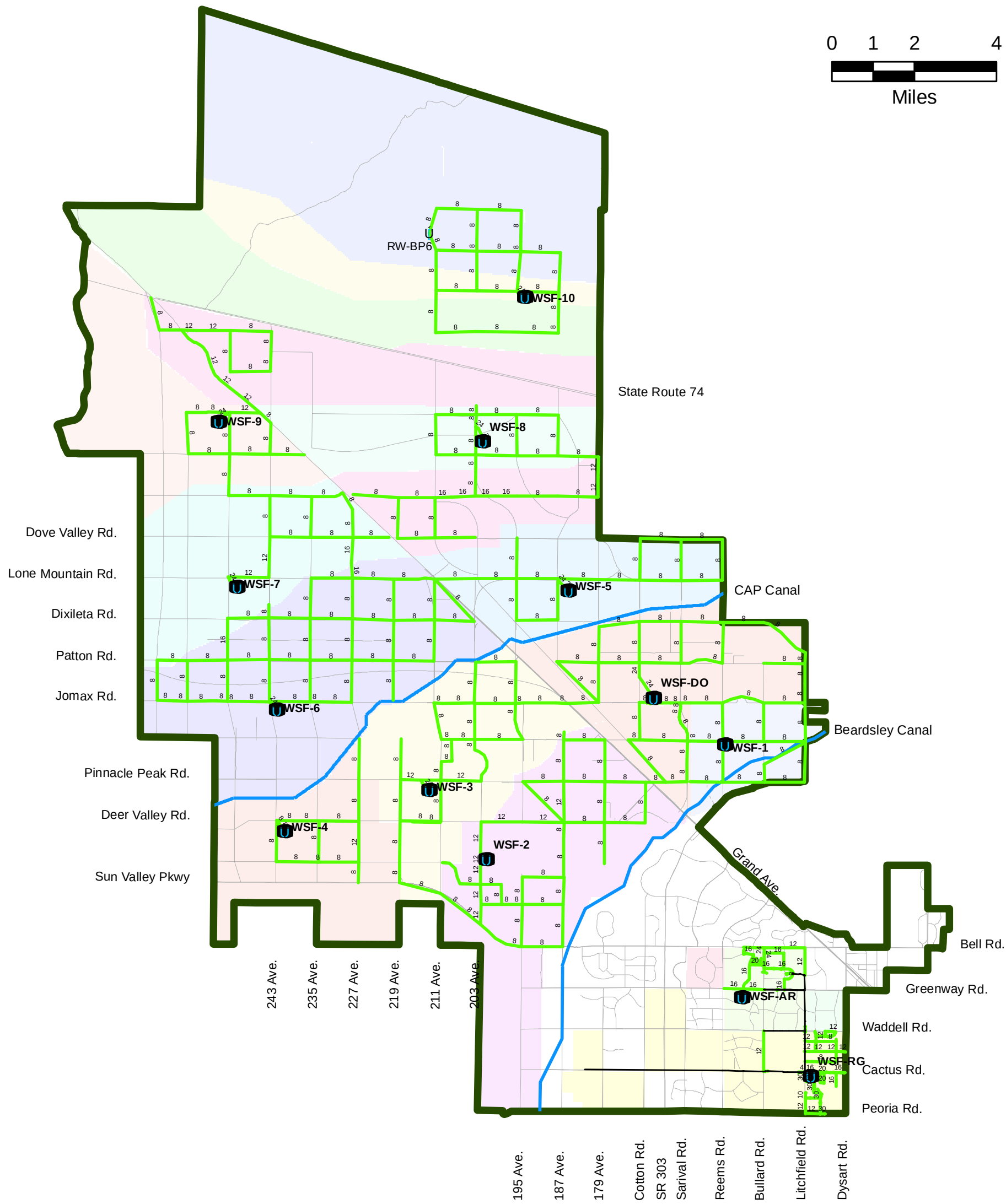

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Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilitiies
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Near Term (2009 - 2020) Reclaimed Water Distribution System Improvements

July 2009 | **Figure 7-10**

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure 7-10 2020 RW Dist Improvements.mxd

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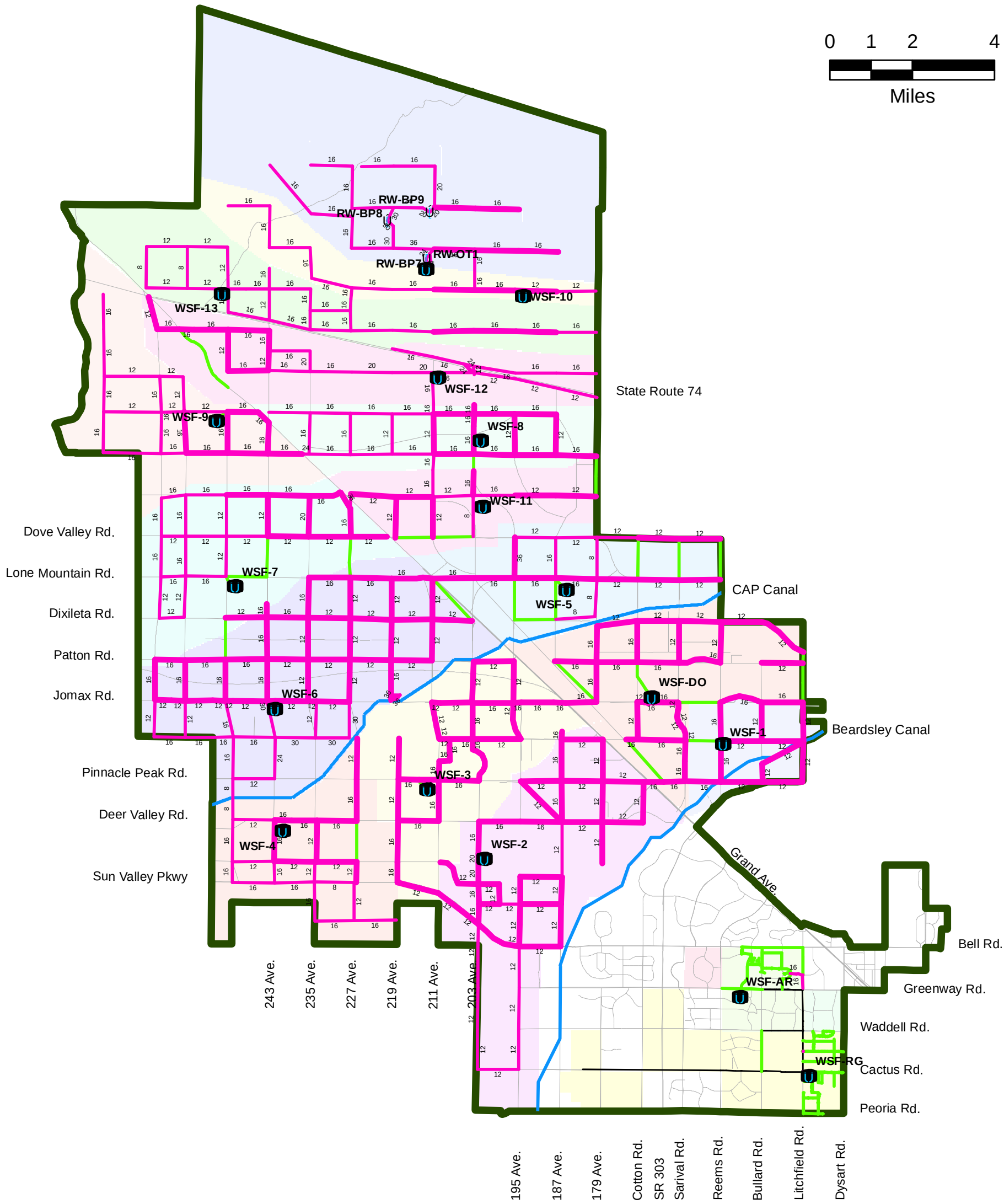

NOTE: Refer to Figure 3-1 for the reclaimed water service provider boundaries and the locations of the existing Special Planning Areas. Planned infrastructure locations are approximate and for master planning purposes only.

Legend

- Municipal Planning Area
- Service Areas
- Canals
- Streets
- Water Supply Facilitiies
- Distribution System Booster Stations

Distribution System Pipelines

- Existing
- 2009 - 2020 (New)
- 2021 - Build-out (New)
- 2021 - Build-out (Improved)

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Long Term (2021 - Build-out) Reclaimed Water Distribution System Improvements

July 2009 | **Figure 7-11**

M:\4957002\GIS\Project_MXDs\R-2_Final\Figure 7-11 BO RW Dist Improvements.mxd

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Table 7-4.
Recommended Reclaimed Water and Recharge Infrastructure Improvements Schedule

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
Water Supply Facilities (Pressure Zone)						
Ashton Ranch, WSF-AR (PZ-1c)			**$ 3,700,000**			**$ -**
Storage Reservoir	1.4 MG		$ 2,100,000	-		$ -
Booster Pumps	4,930 gpm	161 TDH	$ 1,600,000	4,930 gpm	161 TDH	$ -
Rancho Gabriella, WSF-RG (PZ-2d)			**$ 3,100,000**			**$ 660,000**
Storage Reservoir	1.0 MG		$ 1,400,000	.35 MG		$ 530,000
Booster Pumps	3,330 gpm	208 TDH	$ 1,700,000	3,572 gpm	194 TDH	$ 130,000
Desert Oasis, WSF-DO (PZ-2a, 3a)			**$ 2,100,000**			**$ 4,600,000**
Storage Reservoir	.7 MG		$ 1,000,000	1.4 MG		$ 2,100,000
Booster Pumps	836 gpm	71 TDH	$ 400,000	1,584 gpm	75 TDH	$ 400,000
	1,409 gpm	197 TDH	$ 700,000	5,506 gpm	180 TDH	$ 2,100,000
Rancho Mercado, WSF-1 (PZ-2c)			**$ 900,000**			**$ 1,700,000**
Storage Reservoir	.3 MG		$ 400,000	.5 MG		$ 800,000
Booster Pumps	892 gpm	111 TDH	$ 500,000	2,713 gpm	110 TDH	$ 900,000
WSF-2 (PZ-2b)			**$ 1,300,000**			**$ 3,400,000**
Storage Reservoir	.4 MG		$ 600,000	1.1 MG		$ 1,600,000
Booster Pumps	1,279 gpm	108 TDH	$ 700,000	6,736 gpm	176 TDH	$ 1,800,000
WSF-3 (PZ-3b)			**$ 900,000**			**$ 700,000**
Storage Reservoir	.3 MG		$ 400,000	.2 MG		$ 300,000
Booster Pumps	876 gpm	158 TDH	$ 500,000	1,667 gpm	119 TDH	$ 400,000
WSF-4 (3c)			**$ 900,000**			**$ 4,500,000**
Storage Reservoir	.3 MG		$ 400,000	1.4 MG		$ 2,100,000
Booster Pumps	919 gpm	107 TDH	$ 500,000	5,611 gpm	177 TDH	$ 2,400,000
WSF-5 (PZ-4a)			**$ 700,000**			**$ 4,000,000**
Storage Reservoir	.2 MG		$ 300,000	1.2 MG		$ 1,800,000
Booster Pumps	759 gpm	180 TDH	$ 400,000	5,009 gpm	119 TDH	$ 2,200,000
WSF-6 (PZ-4b)			**$ 1,800,000**			**$ 5,500,000**
Storage Reservoir	.5 MG		$ 800,000	2.1 MG		$ 3,100,000
Booster Pumps	1,837 gpm	216 TDH	$ 1,000,000	9,023 gpm	153 TDH	$ 2,400,000
WSF-7 (PZ-5b)			**$ 1,000,000**			**$ 3,600,000**
Storage Reservoir	.3 MG		$ 500,000	1.1 MG		$ 1,600,000
Booster Pumps	1,028 gpm	193 TDH	$ 500,000	4,832 gpm	205 TDH	$ 2,000,000
WSF-8 (PZ-6a)			**$ 900,000**			**$ 4,600,000**
Storage Reservoir	.3 MG		$ 400,000	1.4 MG		$ 2,100,000
Booster Pumps	954 gpm	125 TDH	$ 500,000	5,726 gpm	139 TDH	$ 2,500,000
WSF-9 (PZ-6b)			**$ 1,100,000**			**$ 4,600,000**
Storage Reservoir	.3 MG		$ 500,000	1.4 MG		$ 2,100,000
Booster Pumps	1,151 gpm	239 TDH	$ 600,000	5,991 gpm	166 TDH	$ 2,500,000
WSF-10 (PZ-9)			**$ 640,000**			**$ 2,600,000**
Storage Reservoir	.20 MG		$ 290,000	.8 MG		$ 1,200,000
Booster Pumps	675 gpm	205 TDH	$ 350,000	3,432 gpm	202 TDH	$ 1,400,000
WSF-11 (PZ-5a)			**$ -**			**$ 3,200,000**
Storage Reservoir	-		$ -	1.0 MG		$ 1,500,000
Booster Pumps	-		$ -	3,353 gpm	118 TDH	$ 1,700,000
WSF-12 (PZ-7)			**$ -**			**$ 4,700,000**
Storage Reservoir	-		$ -	1.8 MG		$ 2,700,000
Booster Pumps	-		$ -	6,163 gpm	161 TDH	$ 2,000,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
WSF-13 (PZ-8)			**$ -**			**$ 5,900,000**
Storage Reservoir	-		$ -	2.2 MG		$ 3,400,000
Booster Pumps	-		$ -	7,742 gpm	166 TDH	$ 2,500,000
Off-Site Storage Tanks						
RW-OT1	.20 MG		$ 300,000	4.0 MG		$ 5,300,000
Reclaimed Water System PRVs			**$ 12,900,000**			**$ 7,600,000**
8 in	7	1.1 mgd	$ 4,200,000	1	1.1 mgd	$ 600,000
16 in	5	4.5 mgd	$ 8,700,000	4	4.5 mgd	$ 7,000,000
High Service Pumps			**$ 5,700,000**			**$ 14,700,000**
SPA1-WRF	-	-	$ -	17,107 gpm	228 TDH	$ 2,500,000
SPA2-WRF	2,314 gpm	261 TDH	$ 1,200,000	7,560 gpm	205 TDH	$ 1,700,000
SPA3-WRF	4,213 gpm	282 TDH	$ 2,200,000	14,524 gpm	286 TDH	$ 2,800,000
SPA4-WRF	1,279 gpm	222 TDH	$ 700,000	10,332 gpm	293 TDH	$ 2,500,000
SPA5-WRF	2,942 gpm	289 TDH	$ 1,500,000	11,786 gpm	300 TDH	$ 2,900,000
SPA6-WRF	270 gpm	220 TDH	$ 100,000	4,615 gpm	286 TDH	$ 2,300,000
Distribution and Transmission Boosters Pumps			**$ 1,100,000**			**$ 17,600,000**
RW-BP1	368 gpm	216 TDH	$ 200,000	2,245 gpm	88 TDH	$ 1,000,000
RW-BP2	972 gpm	122 TDH	$ 500,000	10,332 gpm	134 TDH	$ 2,600,000
RW-BP3	464 gpm	213 TDH	$ 200,000	6,186 gpm	320 TDH	$ 1,900,000
RW-BP4	218 gpm	272 TDH	$ 100,000	4,615 gpm	17 TDH	$ 2,400,000
RW-BP5	-	-	$ -	3,790 gpm	314 TDH	$ 2,000,000
RW-BP6	171 gpm	347 TDH	$ 100,000	-	-	$ -
RW-BP7	-	-	$ -	13,812 gpm	261 TDH	$ 3,200,000
RW-BP8	-	-	$ -	8,573 gpm	139 TDH	$ 2,800,000
RW-BP9	-	-	$ -	5,152 gpm	97 TDH	$ 1,700,000
Reclaimed Water Transmission Mains			**$ 80,000,000**			**$ 81,600,000**
8 in	81,357 LF		$ 11,000,000	-		$ -
12 in	56,917 LF		$ 11,500,000	-		$ -
16 in	13,824 LF		$ 3,700,000	84,357 LF		$ 22,700,000
20 in	46,477 LF		$ 18,200,000	16,834 LF		$ 6,600,000
24 in	26,476 LF		$ 11,000,000	20,308 LF		$ 8,500,000
30 in	LF		$ -	20,221 LF		$ 10,400,000
36 in	40,722 LF		$ 24,600,000	55,234 LF		$ 33,400,000
Reclaimed Water Distribution Mains			**$ 204,500,000**			**$ 417,400,000**
8 in	1,130,492 LF		$ 152,400,000			$ -
10 in	514 LF		$ 100,000	LF		$ -
12 in	127,649 LF		$ 25,800,000	699,846 LF		$ 141,500,000
14 in			$ -	LF		$ -
16 in	53,759 LF		$ 14,500,000	884,835 LF		$ 238,600,000
18 in			$ -	LF		$ -
20 in	6,039 LF		$ 2,400,000	27,371 LF		$ 10,700,000
24 in	12,350 LF		$ 5,100,000	14,244 LF		$ 5,900,000
30 in	8,159 LF		$ 4,200,000	22,969 LF		$ 11,800,000
36 in	LF		$ -	14,780 LF		$ 8,900,000
Recharge						
R-1c			**$ 15,200,000**			**$ 6,400,000**
Land	146 acres		$ 6,200,000	-		$ -
Spreading Basin	8.0 mgd		$ 9,000,000	5.9 mgd		$ 6,400,000
R-2			**$ 9,200,000**			**$ 8,100,000**
Land	116 acres		$ 4,900,000	-		$ -
Spreading Basin	3.3 mgd		$ 4,300,000	7.6 mgd		$ 8,100,000

Project	2009 - 2020 (Near-Term)			2021 - Build-out (Long-Term)		
	Size/Capacity		Cost[1]	Size/Capacity		Cost[1]
R-3			**$ 16,200,000**			**$ 15,300,000**
Land	215 acres		$ 9,100,000	-		$ -
Spreading Basin	6.1 mgd		$ 7,100,000	14.8 mgd		$ 15,300,000
R-4			**$ 9,300,000**			**$ 13,600,000**
Land	155 acres		$ 6,600,000	-		$ -
Spreading Basin	1.8 mgd		$ 2,700,000	13.0 mgd		$ 13,600,000
R-5			**$ 15,100,000**			**$ 18,900,000**
Land	232 acres		$ 9,800,000	-		$ -
Spreading Basin	4.3 mgd		$ 5,300,000	18.5 mgd		$ 18,900,000
Recharge Recovery						
Recovery Wells (R-4)	-		$ -	3 wells		$ 6,500,000
GRAND TOTAL			**$ 388,500,000**			**$ 667,300,000**

NOTES:
WSF – water supply facility; WRF – water reclamation facility; R – recharge; RW – reclaimed water; PZ – pressure zone; OT – off-site tank; BP – booster pump
(1) January 2009 costs (ENR CCI = 8,549). Unit capital costs include engineering/design, materials of construction, installation, and contractor overhead and profit.

7.6.3. Additional Recommendations

The following additional recommendations were made to facilitate future planning and implementation of the recommended reclaimed water and recharge master plan:

- Continue to periodically update the *Integrated Water Master Plan* every three to five years. Growth within the City MPA is dynamic and as actual development occurs, the projected reclaimed water demands, reclaimed water availability, and reclaimed water infrastructure needs will change.
- Carefully design future reclaimed water supply facilities based on the most current information on development patterns and existing infrastructure. Interim solutions (i.e., interconnects, phasing of facilities, etc.) should be considered if they meet the needs of the City, the community, and developers.
- Start documenting reclaimed water demands with the objective of refining the reuse demand factors in the Demand Module.
- Start documenting WRF influent and effluent flows with the objective of refining the reclaimed water production factor in the Demand Module.
- Conduct hydrogeologic assessments, groundwater recharge, and water quality studies throughout the City's planning area. The primary purpose of the studies would be to remove the uncertainties related to 1) recharge capabilities and locations, 2) potential for future treatment of groundwater supplies, and 3) identification of suitable future production well sites.

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SURPRISE
ARIZONA

FINAL Report

Integrated Water Master Plan
Water Infrastructure

JULY 2009

Electronic copy of final document; sealed original document is with Timothy Francis, Cert. #22684.

4957-002

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Integrated Water Master Plan

Water Infrastructure

July 2009

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4957-002

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A. System Performance and Design Criteria

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Table A-1. Comparison of Drinking Water Infrastructure Design Criteria

City		City of Phoenix	City of Peoria	Arizona American Water	City of Goodyear	AWWA Distribution System Handbook	AWWA Manuals	City of Surprise Current	City of Surprise Recommended
Peaking Factors	**Max Day Demand/Average Day Demand**	2	1.6	1.8	1.7	1.5-3.5	-	2	2
	Peak Hour Demand/Average Day Demand	3.4	3.2	3	2.89	2.0-7.0	-	3	3
Wells/Production Facility	**Production Capacity**	1.1 X Maximum Day	1.1 X Maximum Day	Maximum Day Demand	Maximum Day Demand	Maximum Day Demand	-	1.25 X Maximum Day Demand	Maximum Day Demand
	Firm Capacity	-	-	Must meet the max day demand for an entire booster station with one well out of service	-	Must meet maximum day demand with largest well out of service	-	-	Must meet maximum day demand with largest well out of service.
Arsenic Treatment	**Treatment Capacity**	-	-	-	-	-	-	Average Day Demand	Maximum Day Demand
Storage Facility	**Equalizing Storage**	Minimum of 20% of max day flow	20 % of maximum day demand	30 % of maximum day demand	EQ = (Peak Hour Demand – Max Day Demand) x 6 hours	25 % of max day demand	10-15 % of the average demand	1.2 X Avg Day Demand	20 % of Max Day Demand
	Fire Storage	Fire Flow X Duration	$G = 1{,}020\ (P)^{1/2}\ (1 - 0.01\ P^{1/2})$*	Fire Flow X Duration	Fire Flow X Duration	Fire Flow X Duration	Flow Duration X Fire Flow (M 31)		Fire Flow X Duration
	Emergency Storage	10% of max day flow	10 % of maximum day demand.	10 % of maximum day demand	Larger of 2 X EQ or EQ + Fire Flow	Dependent on the owner	Refer M19		10 % of Max Day Demand
Pipe Sizing – **Distribution (WSF to End User)**	**Velocity**	< 5 ft/s	≤ 5 ft/s for pipes < 36 inches diameter	less than 10 ft/s	< 10 ft/s	-	< 5 ft/s	< 5 ft/s	< 5 ft/s
	Headloss	< 10 ft/1,000 ft	2 to 7 ft/1,000 ft	< 10 ft/1,000 ft	2-3 ft/1,000 ft	-	< 6 ft/1,000 ft	<10 ft/ 1,000 ft	<10 ft/ 1,000 ft
	Design Criteria	Max Day+ Fire Flow	Larger of the Maximum day demand plus fire flow, or Peak hour demand.	-	Peak hour	-	Max Day + Fire Flow	Max Day + Fire Flow	Larger of peak hour demand or maximum day plus fire flow
Fire Flow Condition	**Velocity (during Max Day + Fire Flow)**	< 10 ft/s	<10 ft/s	-	-	-	-	-	
Transmission (Wells to WSF)	**Velocity**	< 5 ft/s	≤ 6 ft/s for pipes ≥ 36 inches diameter	> 2 ft/s and < 6 ft/sec	< 10 ft/s	-	< 5 ft/s	-	<5 ft/s
	Headloss	<6 ft/1,000 ft	1 to 2.5 ft/1,000 ft	< 10 ft/1,000 ft	2-3 ft/1,000 ft	-	< 2 ft/1,000 ft	<10 ft/ 1,000 ft	< 2 ft / 1,000 ft
	Design Criteria	Max Day+ Fire Flow	Larger of the Maximum day demand plus fire flow, or Peak hour demand.		Peak Hour	-	Peak hour or Max storage replenishment rate	Max Day + Fire Flow	Max Day
Fire Flow	**Single Family Residential**	1,000 gpm	1,000-1,500 gpm for 2 hrs	1,500 gpm for 2 hours	1,000 gpm X 3 hours	500 - 2,000 gpm	-	2,000 gpm for 2 hours	2,000 gpm for 2 hours
	Multi Family Residential	1,500 gpm	1,500-2,500 gpm for 2 hrs			1,500-3,000 gpm	-	2,000 gpm for 2 hours	2,000 gpm for 2 hours
	Commercial	3,000 gpm	3,000-8,000 gpm for 3 -4 hours	3,000 gpm for 3 hours (minimum)	3,500 gpm X 4 hours	2,500-5,000 gpm	-	3,000 gpm for 3 hours	3,000 gpm for 3 hours
	Industrial	5,000 gpm	4,000-10,000 gpm for 4 hours			3,500-10,000 gpm	-	3,000 gpm for 3 hours	3,000 gpm for 3 hours
System Pressure	**Maximum Pressure**	100 psi	100 psi at peak hour demand	90 psi	100 psi	65-75 psi service	-	80 psi	100 psi
	Max Day/Peak Hour Conditions	Between 50 psi and 100 psi	Between 50 and 100 psi with minimum 40 psi service pressure	40 psi minimum (for maximum day)	50 psi minimum	25-35 psi minimum	-	40 to 80 psi	40 psi to 100 psi
	Fire Flow Conditions	25 psi minimum	20 psi minimum at max day + fire flow	20 psi minimum at max day + fire flow	20 psi minimum	20 psi minimum	-	20 psi minimum	20 psi minimum
Booster Station	**With Storage**	Design for Max Day	Maximum day Demand, plus 10%	Larger of peak hour demand or maximum day plus fire flow	Peak Hour	-	Constant Speed Pumps, Must meet all extreme and average flow conditons	-	Larger of peak hour demand or maximum day plus fire flow
	Without Storage	Design for Peak Hour for Max day + Fire Flow	Larger of peak hour demand or maximum day plus fire flow, plus 10%			-	Variable Speed Pumps, Must meet all extreme and average flow conditons	-	
	FIRM Capacity	Largest Pump out-of-service	Largest Pump out-of-service	Largest Pump out-of-service	Largest Pump out-of-service	-	Largest Pump out-of-service	-	Largest Pump out of service

Note:*G = fire demand rate, gal/min; P = population in thousands

Table A-2. Comparison of Wastewater Collection System Design Criteria

City			City of Phoenix	City of Peoria	Arizona American Water	City of Goodyear	City of Surprise (Current)	City of Surprise (Recommended)
Peaking Factor	**Peak Flow**	**Dry Weather**	$1 + 14/(4+ P^{1/2})$	$1 + 14/(4+ P^{1/2})$	3 (Peak Hour)	-	< 12-inch = 4 ≥ 12-inch = 2.5	< 12 inch = 4 ≥ 12 inch = 3
		Wet Weather	-	1.17 -1.3	-	-		
Collection System Pipes	**Gravity**	**Design Criteria**	Peak Flow	-	-	-	-	Peak Flow
		Manning's Coefficient	0.013	0.013	0.013	-	0.013	0.013
		Minimum Velocity	2.1 ft/s to 3.4 ft/s for 8 inch to 120 inch diameter pipes	2 ft/s when the pipe is flowing half full	2 ft/s at peak hour and in trunklines at average daily flow	2.5 ft/s	2 ft/s when flowing full	2 ft/s when flowing full
		Maximum Velocity	9 ft/s when flowing full	8 ft/s	10 ft/s	10 ft/s	9 ft/s	9 ft/s
		Minimum Pipe Size	8 inch	8 inch	8 inch	-	8 inch	8 inch
	Force Main	**Design Criteria**	Peak Flow	normal operating velocities between 3 and 7 ft/s to provide scour velocity	-	Max Velocity - 6 ft/s Minimum Velocity - 2.5 ft/s	-	Max Velocity - 8 ft/s Minimum Velocity - 3 ft/s
Depth Ratio	**Peak Dry Weather**	**Future pipes**	< 0.8 for peak hour	0.8 during peak hour flows for >= 12 inches, 0.5 for smaller diameters	0.75 maximum for peak hour	0.6	-	0.8
		Existing pipes		0.9 at peak hour flows			-	
	Peak Wet Weather	**Future pipes**		0.9 for 12 inches and higher		0.65	-	
		Existing pipes		< 1			-	
Lift Stations	**Firm Capacity**		-	Largest pump out of service	-	-	-	Largest pump out of service
	Design Criteria		-	Peak Day Flow	-	-	-	Firm Capacity Exceeds Peak Flow

Note: P = Population/1000

Table A-3. Comparison of Reclaimed Water Infrastructure Design Criteria

Design Parameters			Tucson Water, Tucson, AZ	City of Raleigh, NC	City of Goodyear, AZ	City of Surprise, AZ (Current)	City of Surprise, AZ (Recommended)
Peaking Factors		Maximum Day Demand/ Average Day Demand	2.64	-	1.7	2	2
		Peak Hour Demand/ Average Day Demand	7.9	-	4.1	6	5
Storage Facility			Maximum Day Demand	-	1.5-2.0 x Equalization Volume	Average Day Demand	Average Day Demand
Pipe Sizing	Distribution	Velocity	< 5 ft/s	-	< 5 ft/s	< 5 ft/s	< 5 ft/s
		Headloss	<10 ft/ 1,000 ft	<5 ft/ 1,000 ft	-	<10 ft/ 1,000 ft	<10 ft/ 1,000 ft
		Design Criteria	-	Peak hour of maximum day	Peak hour of maximum day	Peak hour of maximum day	Peak hour Demand
	Transmission	Velocity	-	-	< 5 ft/s	-	< 5 ft/s
		Headloss	-	-	-	-	<10 ft/ 1,000 ft
		Design Criteria	-	-	-	-	Access Reclaimed Water Available
	Recharge Mains	Velocity	-	-	< 5 ft/s	-	< 5 ft/s
		Headloss	-	-	-	-	<10 ft/ 1,000 ft
		Design Criteria	-	-	-	Maximum Recharge Demand	Maximum Reclaimed Water Available
System Pressure		Maximum Pressure	75 psi	Same as potable system	65 psi	100 psi	100 psi
		Minimum Pressure (Peak Hour Conditions)	-	25 psi	22 psi		25 psi
Booster Station Design Criteria		at WSF	Maximum Day	-	-	Peak Hour	Peak Hour
		at Distribution System	-	-	Peak Hour		
		at WRF	-	-	-	-	Maximum Recharge
		at Transmission Mains Boosting to WSF only	-	-	-	-	Maximum Day Demand

Table A-4. Comparison of Spreading Basin Design Criteria

Parameter	Crites et al., 2000[1]	Hieroglyphics Recharge Facility	El Mirage Recharge Basins	Assumed Standard
Loading Rate (ft/year)	200	730[2]	1,241	122
Loading Rate: Infiltration Rate (%)	27	--	--	33
Infiltration Rate (ft/day)	2	2	4	1
Wet/Dry Ratio	0.75	>8.0[2]	1.0	0.5
Application Period (days)	1-3	Nearly continuous	4	4
Drying Period (days)	4-10	0	4	8
Number of Basins (#)	4-5	7	3	3
Basin Depth (ft)	Minimum 1 ft freeboard	>6	5	5
Sidewall Slope (Rise:Run)	1:2 to 1:3	--	1:3	1:3
Ramp Gradient (%)	10-20	--	10	10
Distance Between Basins (ft)	10-12	--	8	12

NOTES:

(1) As cited in the USEPA Process Design Manual: Land Treatment of Municipal Wastewater Effluents (September 2006).

(2) A constant wet/dry ratio was not applied. Instead, basins were dried when the infiltration rate decreased. In some cases, wet application periods were greater than six weeks.

B. Drinking Water System Model Development and Calibration

This appendix contains the technical memorandum summarizing the following tasks in its entirety:

- Task 4.3 – Fire Flow Testing
- Task 4.4 – Flow Model

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City of Surprise, Arizona
Water Services Department • 12425 West Bell Road • Surprise, AZ 85374-9002

Integrated Water Master Plan

Water Infrastructure Technical Memorandum:

Task 4.3 -- Fire Flow Testing
Task 4.4 – Flow Model

November 2008

Report Prepared By:

Malcolm Pirnie, Inc.

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4957-005

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Appendices

A. Fire Flow Test Results

1. Introduction

1.1. Background

The City of Surprise (City) Water Services Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

The City is expecting to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007). To prepare for this growth and additional growth as the City approaches build-out, the City prepared a *Water Resources Master Plan* and an *Infrastructure Master Plan* in June 2004. The Water Resources Master Plan was developed to ensure that the City's water supplies were adequate to meet the current and projected demands. The Infrastructure Master Plan addressed water, wastewater, reclaimed water, and groundwater recharge infrastructure. The master plans considered a municipal planning area (MPA) of 228 square miles that was broken up into five special planning areas (SPAs): SPA 1 through SPA 5. The master plans, however, did not consider the sixth, 71 square-mile expansion area in the north, SPA 6, that has since been added to the City's MPA.

The existing water resources and infrastructure master plans are in need of updating; they are now four years old, and considerable changes have been experienced in growth and development patterns, as well as the addition of SPA 6 to the City's MPA. In December 2007, the City retained Malcolm Pirnie, Inc., in association with Replenishment Services, LLC and ASU Decision Theater, to update the master plans into an *Integrated Water Master Plan*.

1.2. Project Purpose and Scope

The purpose of the *Integrated Water Master Plan* project is to provide a long-term guidance document for the orderly improvement and growth of the City's water supply portfolio and drinking water, wastewater, reclaimed water, and groundwater recharge infrastructure. Table 1-1 provides a summary of the scope of work technical tasks for each master plan component of the *Integrated Water Master Plan* project.

The purpose of the Water Resources Master Plan component is to identify the projected water demands as the City continues to grow and to develop a water resources strategy that will meet the demands in a cost-effective and sustainable manner. To prepare for the infrastructure master plan updates, the Water Resources Master Plan component also

includes updates to projections of wastewater flows, reclaimed water availability, and reclaimed water demands in an integrated fashion. Finally, the Water Resources Master Plan component includes a review and evaluation of water reuse options and reuse program alternatives as a critical element of the City's water resource portfolio.

The purpose of the Recharge Master Plan component is to support the Water Resources Master Plan by evaluating options and program alternatives to recharge reclaimed water supplies, and to develop a comprehensive plan and infrastructure improvements that allows the City to recharge reclaimed water in a legal, cost-effective, and sustainable manner.

The purpose of the Water Infrastructure, Wastewater, and Reclaimed Water Master Plan components is to enhance the existing plans where reasonable and to provide the City with comprehensive master plans that allow the City to manage its infrastructures in an effective and efficient manner and to provide for infrastructure expansions.

Table 1-1.
Integrated Water Master Plan Technical Scope of Work Tasks

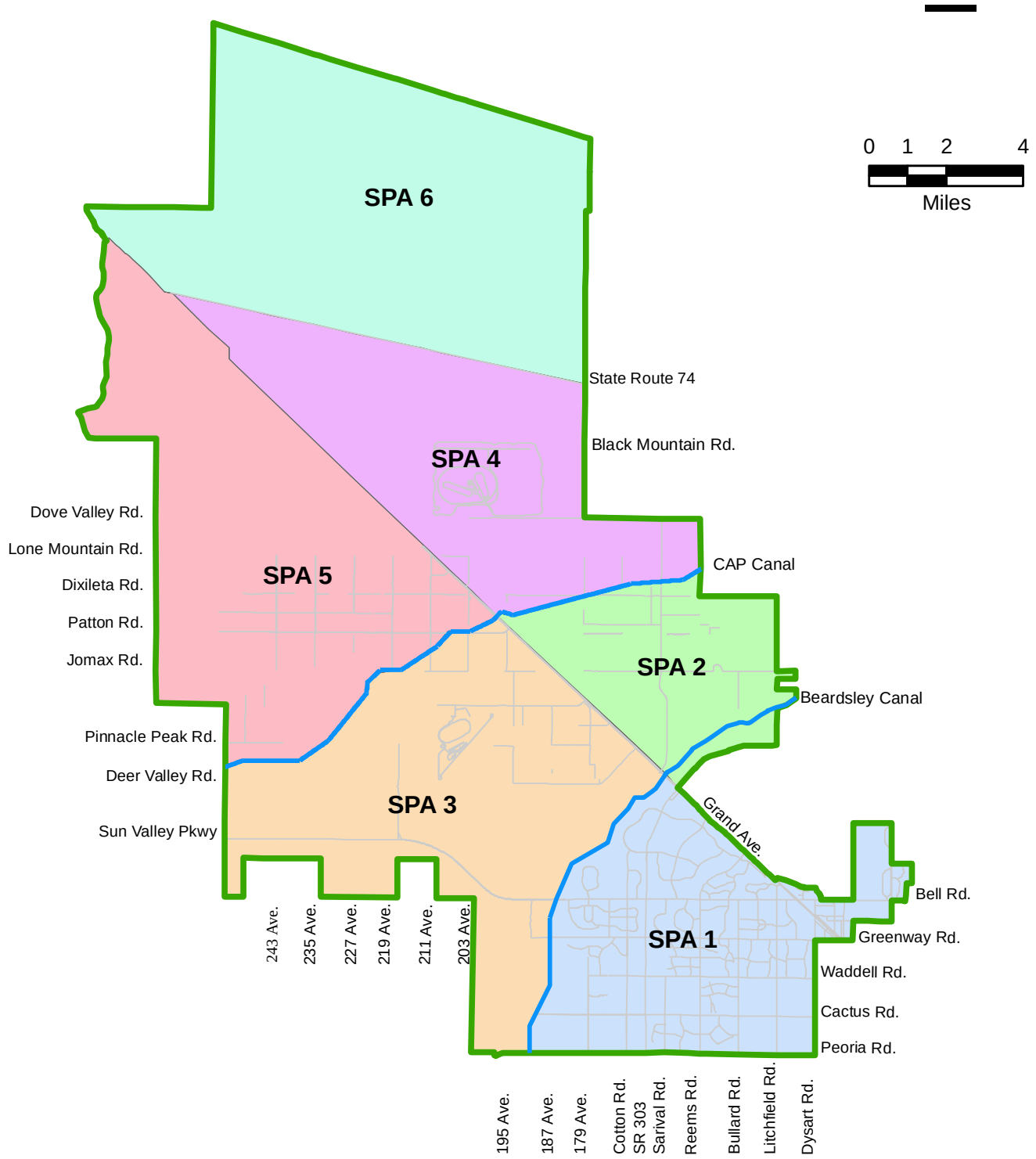
Water Resources Master Plan	**Drinking Water Infrastructure Master Plan**
2.1 Review of Regulations and Guidelines	4.1 Review of Regulations and Guidelines
2.2 Review of Background Information	4.2 Review of Background Information
2.3 Supplies	4.3 Fire Flow Testing
2.4 CAGRD Replenishment Obligations	4.4 Flow Model
2.5 Demand and Flow Factors	4.5 Evaluation of the Existing System
2.6 Demand Module	4.6 Improvements to the Existing System
2.7 Additional Water Supplies	4.7 Drinking Water Infrastructure Master Plan Report
2.8 Reclaimed Water Management	**Wastewater Master Plan**
2.9 Dual Water System Evaluation	5.1 Review of Regulations and Guidelines
2.10 Water Resource Model	5.2 Review of Background Information
2.11 Water Resource Scenarios	5.3 Wastewater Collection System Monitoring
2.12 Water Resource Management	5.4 Flow Model
2.13 Assured Water Supply Management	5.5 Evaluation of the Existing System
2.14 Water Resources Master Plan Report	5.6 Improvements to the Existing System
Recharge Master Plan	5.7 Wastewater Master Plan Report
3.1 Regulations and Background Information	**Reclaimed Water Master Plan**
3.2 Recharge Methods and Evaluation	6.1 Review of Background Information
3.3 Recharge Improvements	6.2 Flow Model
3.4 Build-out of the Recharge System	6.3 Evaluation of the Existing System
3.5 Recharge Master Plan Report	6.4 Improvements to the Existing System
	6.5 Reclaimed Water Master Plan Report

1.3. Purpose of Technical Memorandum

The purpose of this technical memorandum is to summarize the work conducted in Water Infrastructure Master Plan Tasks 4.3 (Fire Flow Testing) and 4.4 (Flow Model). The technical memorandum includes descriptions of how the water infrastructure flow model was developed, the hydrant flow testing that was conducted, and the process used to calibrate the flow model using the hydrant test results. In future tasks, the calibrated model will be used to evaluate the existing system and future scenarios to determine necessary water infrastructure improvements.

1.4. Study Area

The study area for this project, illustrated on Figure 1-1, includes all of the City's municipal planning area (MPA). The MPA has been divided into six SPAs for convenience of reclaimed water planning; i.e., the SPAs comprise logical drainage areas for existing, planned, and potential water reclamation facilities.



Legend

- Streets
- Canals
- Municipal Planning Area
- Special Planning Areas

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CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Study Area

November 2008

Figure 1-1

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2. Model Development

The City's water distribution system was modeled using personal computer based modeling software and related databases. The modeled system served as a tool to aid in determining the adequacy of the existing system to support varying supply and demand conditions and to identify water system modifications and expansions necessary to meet future demand. This section describes the development of the City's existing drinking water distribution system model.

2.1. Data Sources

The primary sources of information for the current modeling effort were the most current geographical information system (GIS) shapefiles provided by the City and the hydraulic model that was created for the City's previous Water Infrastructure Master Plan. Supplemental information for the model was collected during field visits conducted in May 2008 and through interviews with City staff. Water demands were obtained from the Water Resource Demand Module (Demand Module) developed previously as a part of Water Resources Master Plan Tasks 2.5 (Demand Factors) and 2.6 (Demand Module).

2.2. Generic Model Description

The City's water distribution system pipelines, storage tanks, boosters, and valves were modeled using Bentley WaterCAD® V8 XM edition. The software uses an iterative procedure to determine the steady state system response to a given supply and demand scenario. The software is also capable of performing extended period simulations for known diurnal patterns of supply and demand and can simulate water quality fluctuations within the distribution systems. A steady state model was developed for the current master planning effort. The results obtained from such quantitative analyses are considered conservative for evaluating the existing system and planning for future improvements and system developments.

2.2.1. Transmission Pipelines

The City's existing potable water distribution transmission system consists of polyvinyl chloride (PVC) and ductile iron (DI) pipes, ranging in diameter from 1 inch through 30 inches. Most pipelines in the system followed existing streets and public rights-of-way.

The City's existing potable water distribution system was represented by more than 7,500 pipes in the GIS database. A skeletonized network of pipes was represented in the existing water system model provided. Skeletonization is typically performed using

standard modeling procedures to remove pipes that do not change or affect the hydraulics of the system. All of the major transmission lines, 10-inch or greater, were represented in the existing model. Table 2-1 provides the statistics on percentage of pipes represented in the model. A map of the modeled pipes is shown on Figure 2-1 and Figure 2-2 for SPA 1 and SPA 2, respectively. In total, the pipes in the model accounted for 49 percent of the total pipe length and 70 percent of the total water volume in the distribution system.

Table 2-1.
Summary of Modeled Pipes

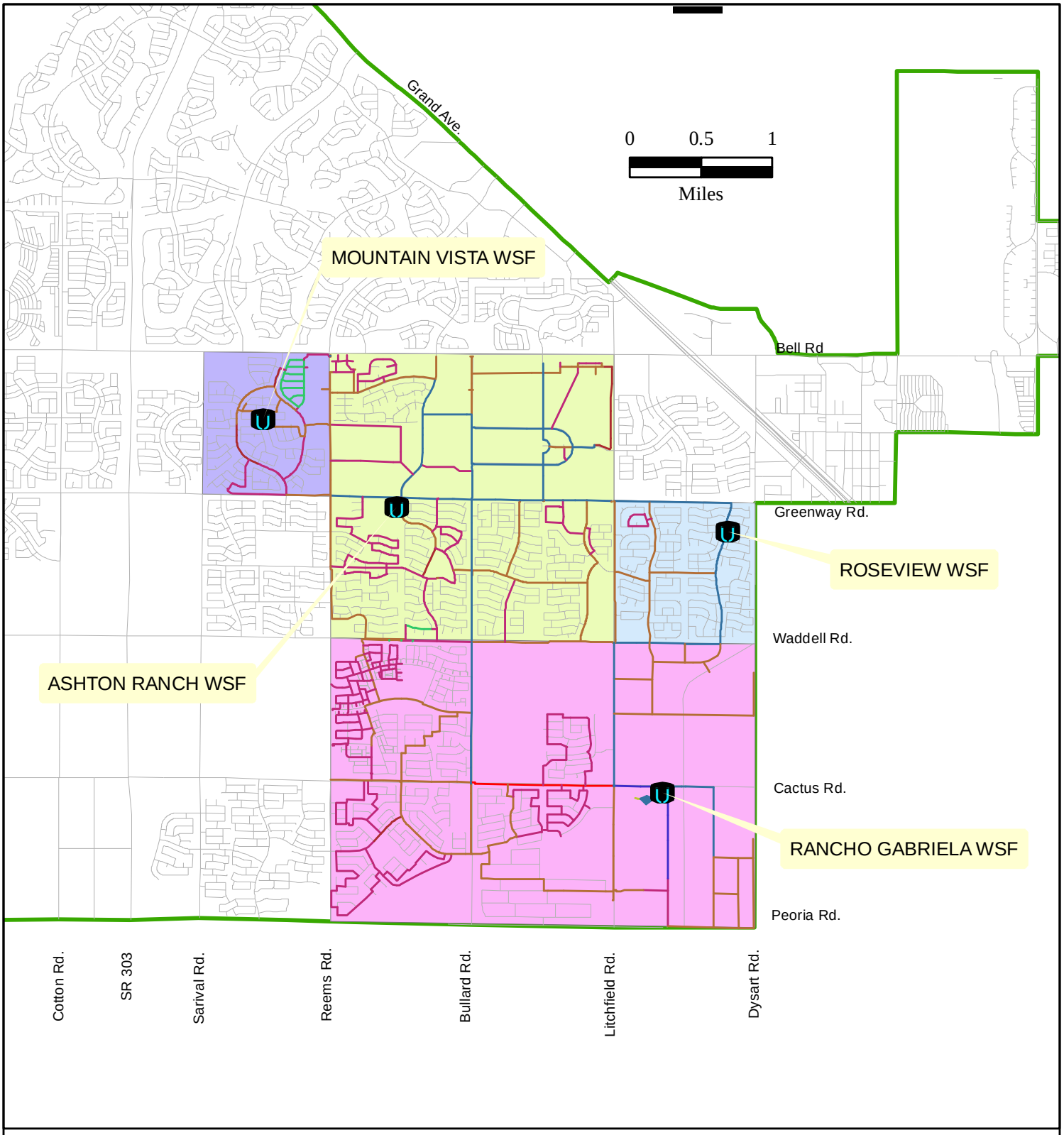
Pipe Diameter (in)	Length (feet)			Volume (gallons)		
	Total	In Model	% in Model	Total	In Model	% in Model
1	133	0	0	5	0	0
2	748	0	0	122	0	0
3	1,648	0	0	605	0	0
4	7,557	0	0	4,933	0	0
6	93,019	23,291	25	136,617	34,207	25
8	621,290	177,187	29	1,622,195	462,637	29
10	11,839	11,839	100	48,298	48,300	100
12	166,538*	166,568	100	978,374	978,550	100
16	115,555	115,555	100	1,206,862	1,206,857	100
20	5,515	5,515	100	89,998	89,998	100
24	5,618	5,618	100	132,018	132,018	100
Total	1,029,459	505,573	49	4,220,028	2,952,568	70

Note: *Some pipes with incorrect diameters in the City's GIS were corrected in the model based on information provided by the City

2.2.2. Model Nodes

Model nodes can serve a number of functions and contain vital information concerning supply, demand, and physical characteristics of certain facilities. Two types of nodes were used in the modeled distribution system: boundary nodes and junction nodes.

Tanks and reservoirs were classified as boundary nodes. The storage facilities in the system were represented as cylindrical tanks with a known diameter and height. The base elevations of the tanks were verified with the City. The initial tank level represented the known hydraulic grade line (HGL) in the model. Junction nodes occur at all pipeline endpoints that were not represented by a tank or reservoir. Each junction has specific information that identified the node's elevation, demand, and demand type. Each node in the model was assigned an elevation that corresponds to the local surface elevation relative to the mean sea level, based on the most recent United States Geological Survey (USGS) five-foot interval topographical data.



Legend

Streets

Water Supply Facility

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16
- 20
- 24
- 30

WSF Service Area

- Mountain Vista Ranch
- Ashton Ranch
- Rancho Gabriela
- Roseview

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CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

SPA 1 Modeled Water Distribution System (Skeletonized)

November 2008

Figure 2-1

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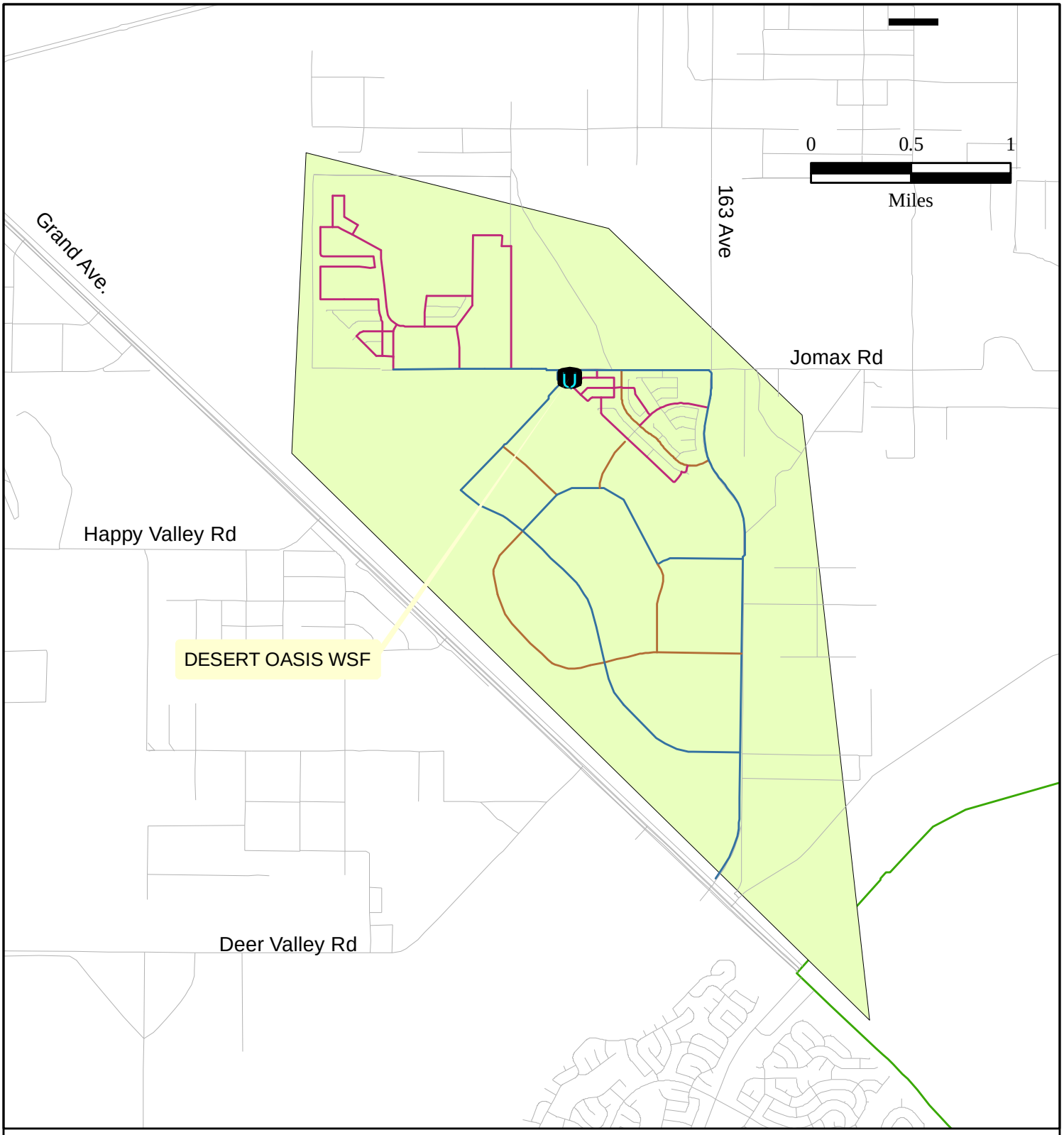

Legend

Streets

Water Supply Facility

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16
- 20
- 24
- 30

WSF Service Area

Desert Oasis

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CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

SPA 2 Modeled Water Distribution System (Skeletonized)

November 2008

Figure 2-2

M:\4957005\GIS\Project_MXDs\Tech Memo 2\Figure 2_2_SPA2_Modeled Distribution System Pipes.mxd

2.2.3. Pumps

Each pump in the system was modeled using a single design point pump curve. The point represented the designed flow and head for the pump. The design point information for each pump was noted from the manufacturer's tag on the pumps during the field visit and was verified by City Staff. The elevation of the pump was assumed to be the same as the base elevation of the tank.

2.2.4. Valves

The City has pressure reducing valves (PRVs) at various locations within the distribution system. PRVs were used in the distribution system to prevent the downstream hydraulic grade from exceeding a preset value. The elevation, diameter, and existing pressure setting value for each PRV were verified with City staff.

2.2.5. Water Demand Allocation

The total existing (2007) water demand included demands for indoor use (e.g., plumbing fixtures), outdoor use (e.g., residential and commercial outdoor irrigation), and landscape use (e.g., large turf and xeriscape areas such as parks and schools). In 2007, the annual average demand for the existing City water service area (i.e., not including Arizona American Water Company and El Mirage) was 6.97 mgd, based on customer billing data. The nearest-node demand allocation method was used to allocate the demand to the modeled junctions. This method used the spatial analysis capabilities of GIS to assign the water usage demand polygons from the Demand Module to the nearest demand node.

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3. Model Calibration

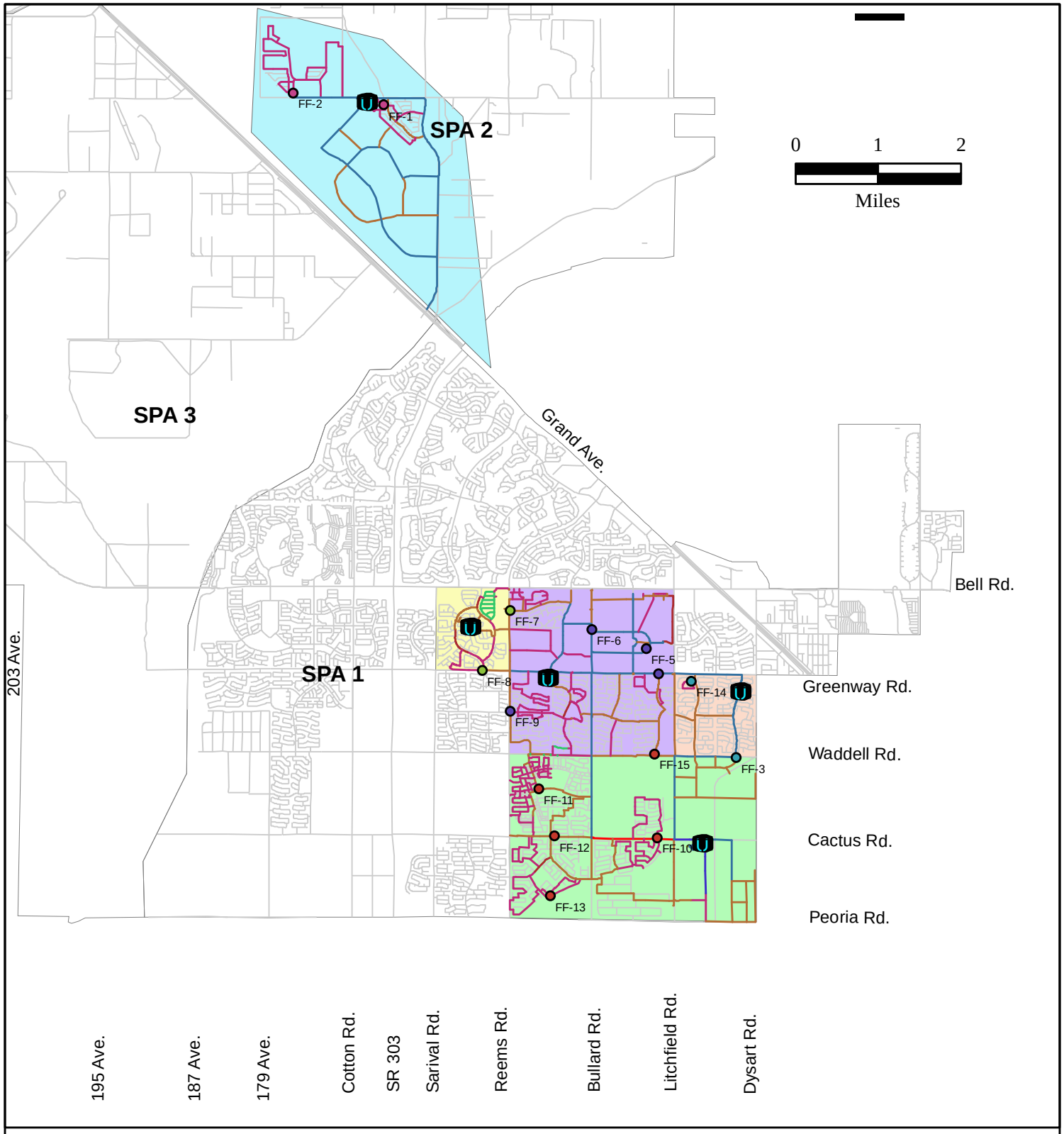
This section describes how the City's existing water system model was calibrated. Model calibration was necessary before conducting a system analysis to ensure that the model setup represents the actual system with sufficient accuracy. The level of calibration depends on the intended use of the model. The model developed for this project was a steady-state model with primary use as a master planning tool. Flow and pressure information gathered from fire hydrant tests performed throughout the system were used to calibrate the model.

3.1. Fire Flow Testing

Fire flow tests were conducted to determine the pressure and flow at several locations within the distribution system. The primary objectives of fire flow testing are to determine the general condition of the distribution system and to determine how much water is available for fighting fires. These tests simulate high flow conditions, thereby allowing the system to be analyzed under extreme conditions. The results from fire hydrant tests can be used to calibrate a hydraulic model as they provide pressure data during static and stressed conditions.

A typical fire flow test involves two or more hydrants: a residual hydrant where the residual pressure is measured and one or more flow hydrants, selected downstream of the residual hydrant. The first step of the process is to read the static pressure at the chosen residual hydrant. A flow hydrant near the residual hydrant is then opened and allowed to flow. Once the flow stabilizes, simultaneous readings for pressure at the residual hydrant and flow at the flow hydrant are taken. Thus, each test provides a static water pressure reading, a residual water pressure reading, and a pitot reading to determine the flow available through a hydrant.

Fifteen hydrants were chosen for fire flow tests based on the information from the existing model, GIS-based water infrastructure, and consultation with the City. The fire flow locations are shown on Figure 3-1 and summarized in Table 3-1. The location and number of hydrants chosen depended on the size of the water supply facility (WSF) service area and on the characteristics that needed to be captured in the test. The Rancho Gabriela WSF had the largest service area, hence five fire flow test locations were chosen for this system. The Ashton Ranch WSF had the next biggest service area, and four test locations were selected in that system. The other WSF systems had two locations each. The test hydrant locations within each service area were selected based on flow direction



Legend

Streets

Water Supply Facility

Fire Flow Locations

- Ashton Ranch
- Desert Oasis
- Mountain Vista
- Rancho Gabriela
- Roseview

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16
- 20
- 24
- 30

WSF Service Area

- Mountain Vista Ranch
- Ashton Ranch
- Desert Oasis
- Rancho Gabriela
- Roseview

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CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Fire Flow Locations

November 2008

Figure 3-1

M:\4957005\GIS\Project_MXDs\Tech Memo 2\Figure 3_1_FireFlow Locations.mxd

and proximity of the hydrant to high demand areas such as dense residential areas or major commercial areas.

Table 3-1.
Fire Flow Locations

Location ID	Location	Hydrant ID	Service Area
FF-1	N 167th Av and W Tether Trail	WTFH4N2WNW010021	Desert Oasis
FF-2	W Spur Dr and N 175 Lane	WTFH5N2WSW350016	Desert Oasis
FF-3	133rd and Waddell/Thunderbird	WTFH3N1WNE150006	Roseview
FF-4	140th and Greenway Rd	WTFH3N1WNE090013	Ashton Ranch
FF-5	142nd by Court House	WTFH3N1WSE040009	Ashton Ranch
FF-6	Bullard and 1/2 mile north of Greenway	WTFH3N1WNW040003	Ashton Ranch
FF-7	Reems Rd and 2 Blocks South of Bell Rd	WTFH3N1WNW050002	Mountain Vista
FF-8	Greenway Rd and Mountain Vista Ranch Rd	WTFH3N1WNE070040	Mountain Vista
FF-9	Reems Rd and 1/2 mile south of Greenway	WTFH3N1WNW080043	Ashton Ranch
FF-10	140th Ave and Cactus Rd	WTFH3N1WSE160011	Rancho Gabriela
FF-11	NE Corner of W Sweetwater Av and N Founder Park Blvd	WTFH3N1WNW170013	Rancho Gabriela
FF-12	W Cactus and 2 Blocks East of N 151st Ave	WTFH3N1WSE170006	Rancho Gabriela
FF-13	W Gabriela Dr, South of N 151 LN and W Becker Rd	WTFH3N1WSE200002	Rancho Gabriela
FF-14	NW Corner of W Acapulco Lane and N 137th Lane	WTFH3N1WNW100020	Roseview
FF-15	Waddell Rd and 140th Ave, North East Corner	WTFH3N1WSE090052	Rancho Gabriela

The fire flow tests were conducted on two days during the second week of June 2008. Areas with high construction activities were tested on Sunday to minimize the effect of construction water on the flow testing. The fire flow testing followed the schedule below:

- Day 1: Sunday June 8th – Location IDs FF- 1, 2, 4, 5, 6, 7, and 8
- Day 2: Monday June 9th – Location IDs FF- 3, 9, 10, 11, 12, 13, 14, and 15

3.2. Fire Flow Test Results

The fire flow tests were conducted three times throughout the day at each location to capture the variation in available flow during these times. Table 3-2 shows the average of the three fire flow tests results at each location. The results for the individual tests are presented in Appendix A.

Table 3-2.
Summary of Fire Flow Test Results

Fire Flow Location	Residual Hydrant		Flow Hydrant	
	Static Pressure (psi)	Residual Pressure (psi)	Flow (gpm)	Max Flow @ 20 psi residual pressure (gpm)
FF-1	75	67	1,237	3,317
FF-2	99	87	1,417	3,819
FF-3	85	70	1,310	3,115
FF-4	76	61	1,213	2,451
FF-5	81	71	1,272	3,389
FF-6	77	69	1,150	3,332
FF-7	61	55	1,134	3,042
FF-8	83	73	1,339	3,721
FF-9	80	69	1,303	3,204
FF-10	88	76	1,360	3,509
FF-11	72	60	1,209	2,725
FF-12	80	66	1,170	2,690
FF-13	85	70	1,288	2,917
FF-14	74	56	1,166	2,133
FF-15	94	75	1,376	2,902

3.3. Model Calibration

The City's water distribution system model was calibrated using the fire flow test results described in the previous section. The model was assumed to be calibrated for master planning purposes if the pressure predicted by the model was within ±10 percent of pressure measured at the calibration data points, or fire flow locations. In the event that these ranges were not achieved, possible explanations were explored for correction. However, it is typically not imperative to meet all calibration guidelines in order to have a fully calibrated model.

The following steps were used in calibrating the City's water distribution system hydraulic model:

- Allocate demands to the nodes
- Adjust the status and operating conditions of the modeled system facilities to reflect their status during the fire flow testing
- Adjust the network parameters to calibrate the model

3.3.1. Demand Allocation

The load builder wizard in WaterCAD® was used to allocate the base demands to nodes in the City's hydraulic model using the nearest node method. This demand allocation method assigns demands to the closest junction. The input to the load builder wizard was the demands developed by the Demand Module. The "existing demands" in the Demand Module were based on customer billing data and historical production data. Thus, the base demand allocated to the model nodes portrays the current demand in City's distribution system.

After assigning the base demand to the model nodes, fire flow demands were individually applied to the appropriate nodes as a single fixed demand. A new demand alternative was created in the model for each fire flow test.

3.3.2. Adjustment of Facilities Status

Operation data from the each WSF were collected before, during, and after the fire flow tests. The information included the tank water levels, number of operating pumps, the discharge pressure at the WSF, and flow from the WSF. The modeled system facilities were modified to reflect their status during the time period when the fire flow tests were conducted. Specific modifications included the open/closed status of the pipes, operating status of the pumps, and discharge pressure setting in the PRVs.

In general, all modeled pipelines within the distribution system were assumed to be open, except for the pipes connecting the different WSF service areas. These connecting pipes were assumed to be closed such that each WSF service area could be isolated and modeled as an independent distribution system.

3.3.3. Adjustment of Network Parameters

Network parameters such as pipe roughness and valve settings can be adjusted to make the model predictions in close accordance to the field observations. Pipeline roughness coefficients (C- factors) were adjusted globally to improve the correlation of the measured data to the model output. C-factors of 120 for DI pipes and 140 for PVC pipes were initially assumed. The calibration results showed that further adjustments to the C-factors were not necessary.

One PRV in the Desert Oasis system was currently modeled. The modeled set point for this PRV was adjusted to match the pressures measured during the fire flow tests in that WSF service area.

3.3.4. Calibration Results

A comparison of modeled and measured fire flow data are presented in Table 3-3. Modeled system pressures during fire flow tests were, on average, within 10 percent of the field measured values, and modeled flows at WSFs were, on average, within 13 percent of the field measured values. The exact elevation of the pressure gauges at the hydrants was not noted in the field and was assumed to be 5 to 10 feet above the pipeline. This might have introduced a difference between the measured and modeled pressures.

Table 3-3.
Calibration Comparison for the Node Pressures

Location	WSF	Residual Pressure				
		Measured (psi)	Modeled (psi)	Difference (psi)	Percent Difference	Calibration Goal Met?
FF-1	Desert Oasis	66	60	6	9	Yes
FF-2	Desert Oasis	87	89	2	3	Yes
FF-3	Rancho Gabriella	70	67	3	5	Yes
FF-4	Ashton Ranch	61	87	26	43	No
FF-5	Ashton Ranch	71	80	9	13	Yes
FF-6	Ashton Ranch	69	75	6	9	Yes
FF-7	Ashton Ranch	55	61	7	12	Yes
FF-8	Mountain Vista	73	61	13	17	No
FF-9	Ashton Ranch	69	71	3	4	Yes
FF-10	Rancho Gabriella	76	78	2	2	Yes
FF-11	Rancho Gabriella	58	59	0	1	Yes
FF-12	Rancho Gabriella	66	66	1	1	Yes
FF-13	Rancho Gabriella	70	66	4	6	Yes
FF-14	Roseview	56	49	6	11	Yes
FF-15	Ashton Ranch	75	82	7	10	Yes

The model calibration results indicated that the model provided a good estimate of the operating conditions of the City's existing water distribution system. Thirteen out of 15 hydrant locations met the pressure calibration goals. FF-4 and FF-8 did not meet the calibrations goals. This could be attributed to the following:

- The actual pressure in FF-4 was much lower than the modeled pressure. This could have been the result of an unidentified PRV in the line which reduced the pressure.
- The fire flow test at FF-8 might have been conducted on the hydrant linked to wrong pipeline on Greenway Road.

During the calibration, it was also revealed that some of the fire flow hydrants were located in different WSF service areas than assumed before the fire testing was performed. Updated GIS information was not received until after fire flow tests were

performed, so the information could not be updated before the fire flow testing. Based on the updated GIS information, FF-7 actually lied in the Ashton Ranch service area instead of the Mountain Vista service area and, similarly, FF-3 lied in the Rancho Gabriella service area instead of the Roseview service area. The accuracy of the model, however, was considered sufficient to perform system-wide evaluations for master planning purposes, including responses during extreme stress conditions such as fire flow or peak hour demands.

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A. Fire Flow Test Results

WESTERN STATES FIRE PROTECTION CO.

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Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-1 / #WTFH4N2WNW010021 / N. 167TH AV & TETHER TR.

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 200'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 78.00

Residual Pressure: 67

Pitot Reading: 55.00

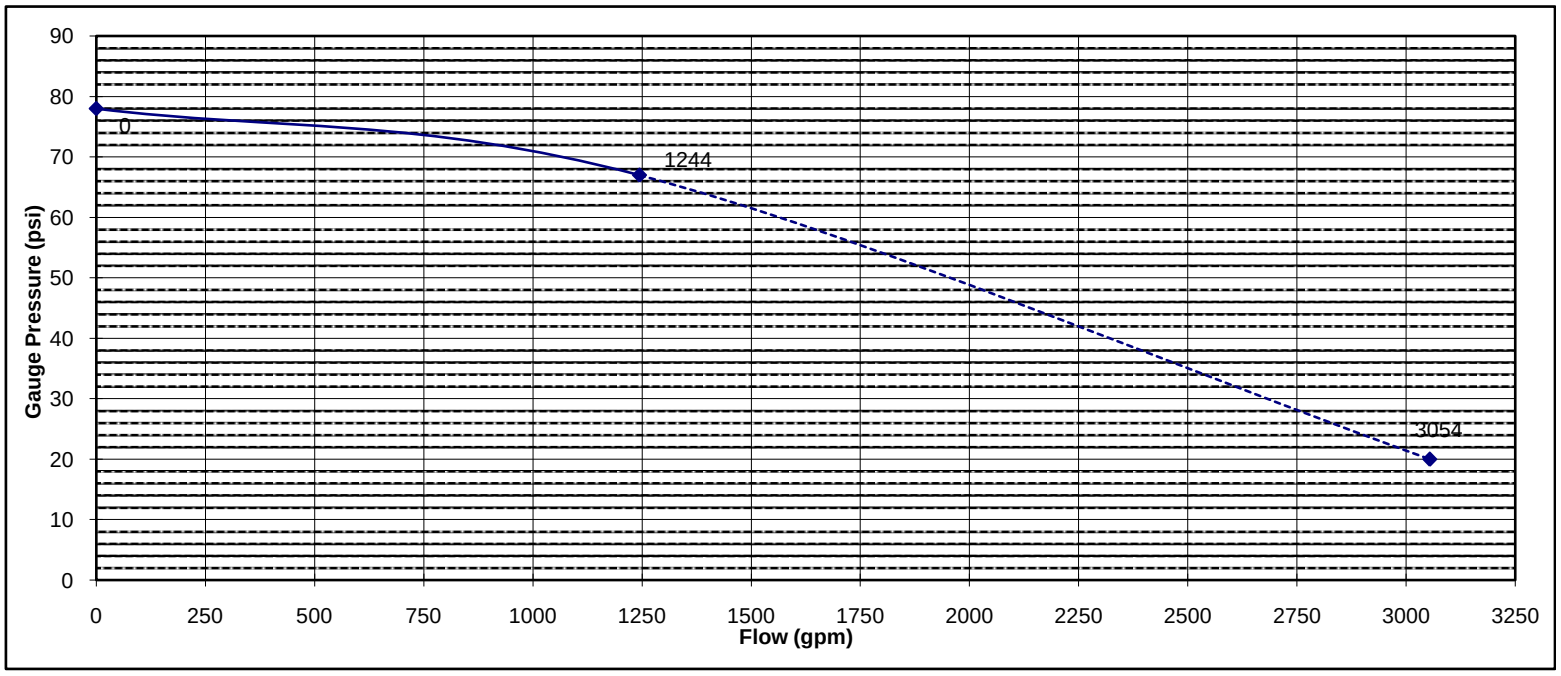
Flow: 1244.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	78	psi @	0	gpm
Residual pressure of	67	psi @	1244.4	gpm
Available flow @	20	psi --	3053.9	gpm

Flow at 20 psi: 3053.9 gpm



Comments:

NOTES:

1. Flowing hydrant is assumed to be on a circulating main or downstream of the pressure test hydrant on a dead-end system.
2. Flow analysis assumes a gravity flow system with no distribution pumps and having no demand, other than the test
3. The distance between hydrants, elevations & main diameters are for information only.

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2026 West Lone Cactus Drive
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Fax (602) 272-7972

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-1 / #WTFH4N2WNW010021 / N. 167TH AV & TETHER TR.

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 200'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 70.00

Residual Pressure: 61

Pitot Reading: 55.00

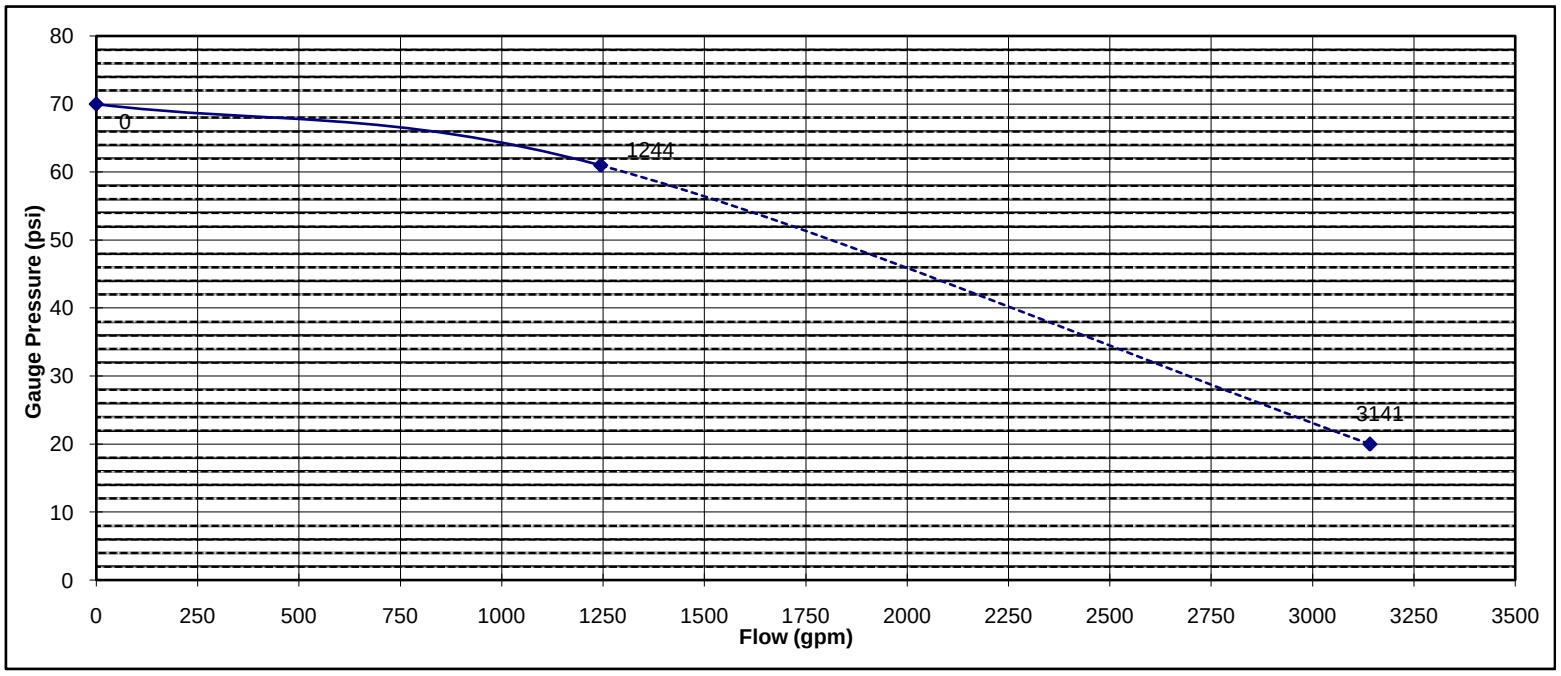
Flow: 1244.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	70	psi @	0	gpm
Residual pressure of	61	psi @	1244.4	gpm
Available flow @	20	psi --	3141.3	gpm

Flow at 20 psi: 3141.3 gpm



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FF-1 / #WTFH4N2WNW010021 / N. 167TH AV & TETHER TR.

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 200'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 76.00

Residual Pressure: 69

Pitot Reading: 53.00

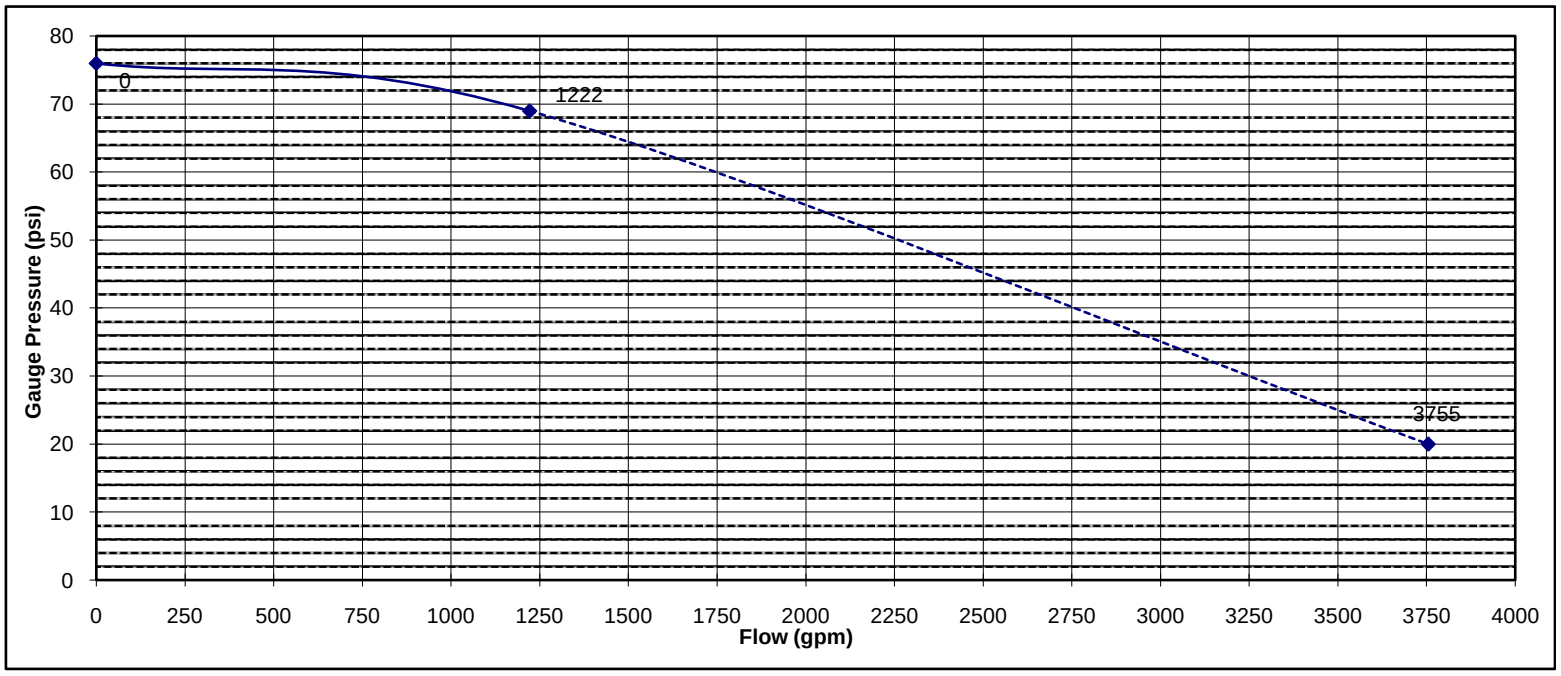
Flow: 1221.6 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	76	psi @	0	gpm
Residual pressure of	69	psi @	1221.6	gpm
Available flow @	20	psi --	3754.8	gpm

Flow at 20 psi: 3754.8 gpm



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FF-2 / WTFH5N2WSW350016 / W SPUR DR & N 175TH LN

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 12"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 100.00

Residual Pressure: 87

Pitot Reading: 72.00

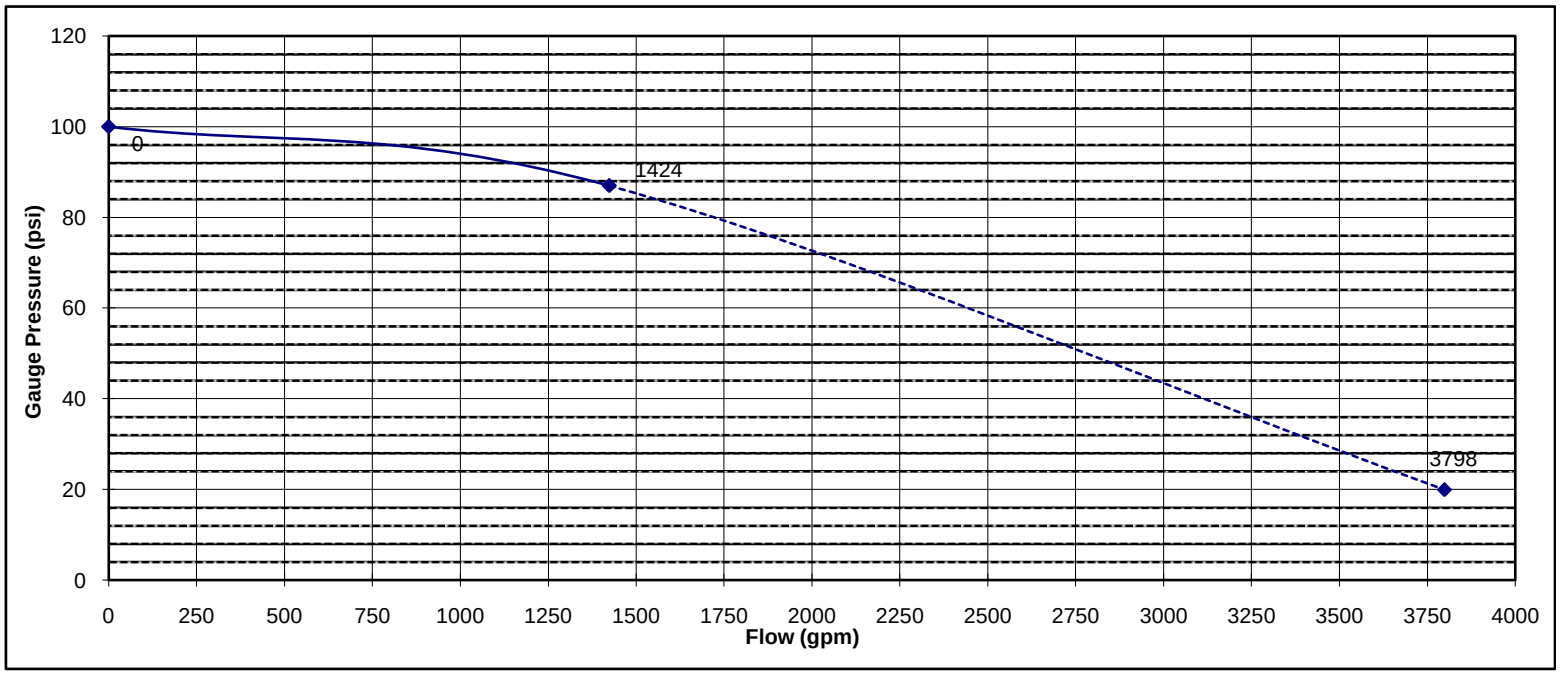
Flow: 1423.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	100	psi @	0	gpm
Residual pressure of	87	psi @	1423.8	gpm
Available flow @	20	psi --	3798.2	gpm

Flow at 20 psi: 3798.2 gpm



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DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 12"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 100.00

Residual Pressure: 88

Pitot Reading: 72.00

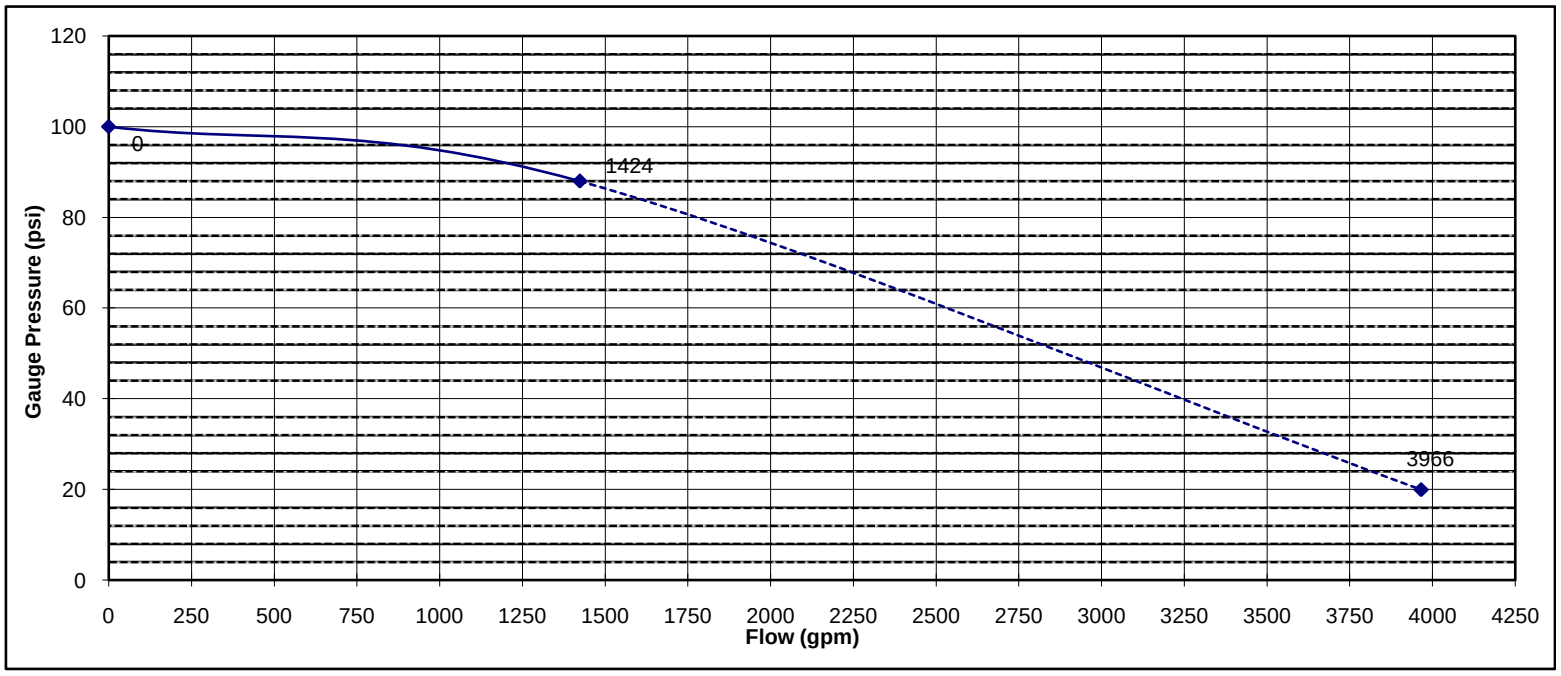
Flow: 1423.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	100	psi @	0	gpm
Residual pressure of	88	psi @	1423.8	gpm
Available flow @	20	psi --	3966.0	gpm

Flow at 20 psi: 3966.0 gpm



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FF-2 / WTFH5N2WSW350016 / W SPUR DR & N 175TH LN

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 12"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 98.00

Residual Pressure: 85

Pitot Reading: 70.00

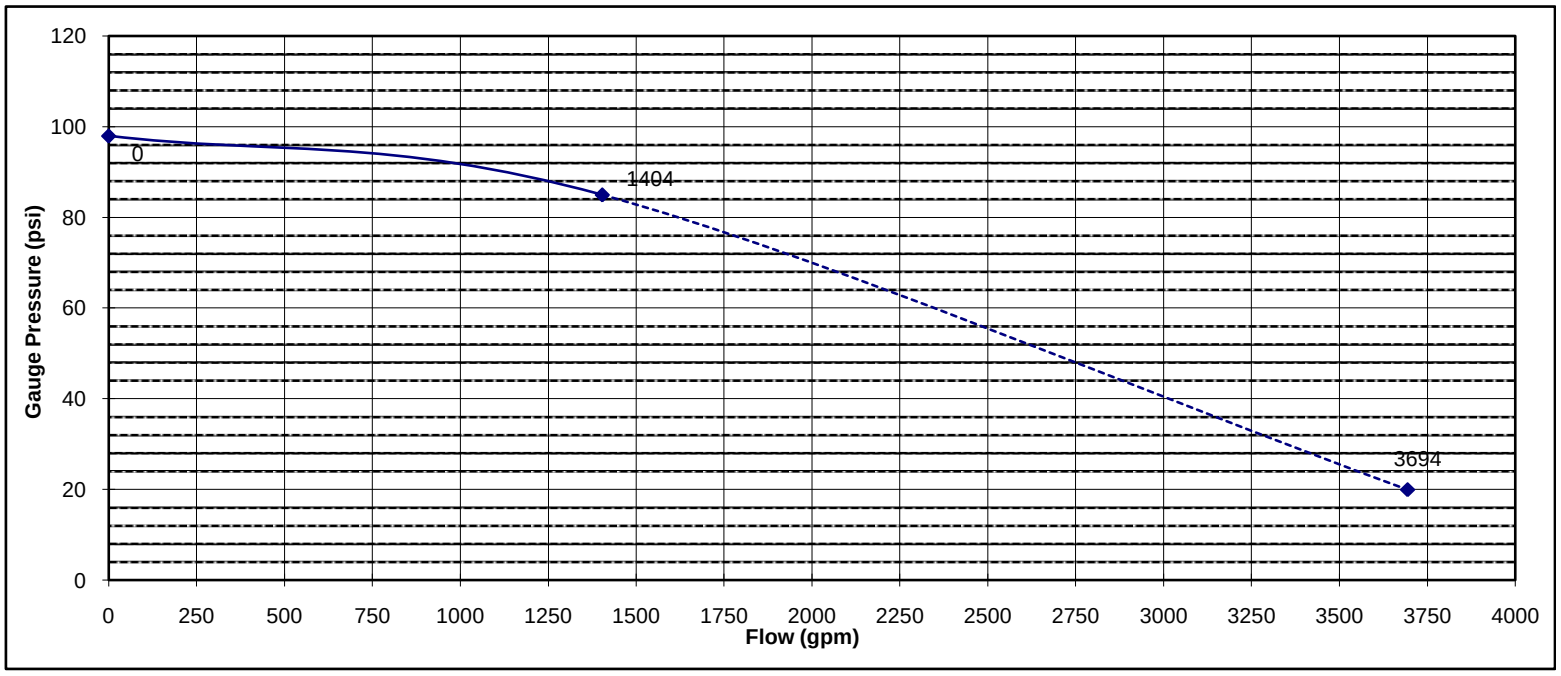
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	98	psi @	0	gpm
Residual pressure of	85	psi @	1403.9	gpm
Available flow @	20	psi --	3694.3	gpm

Flow at 20 psi: 3694.3 gpm



Comments:

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Phoenix, Az. 85008-6945
FF-3 / WTFH3N1WNE150006 / 133RD & WADDELL - TBIRD

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1
Coeff. of Discharge: 0.90

Static Pressure: 84.00

Residual Pressure: 76

Pitot Reading: 63.00

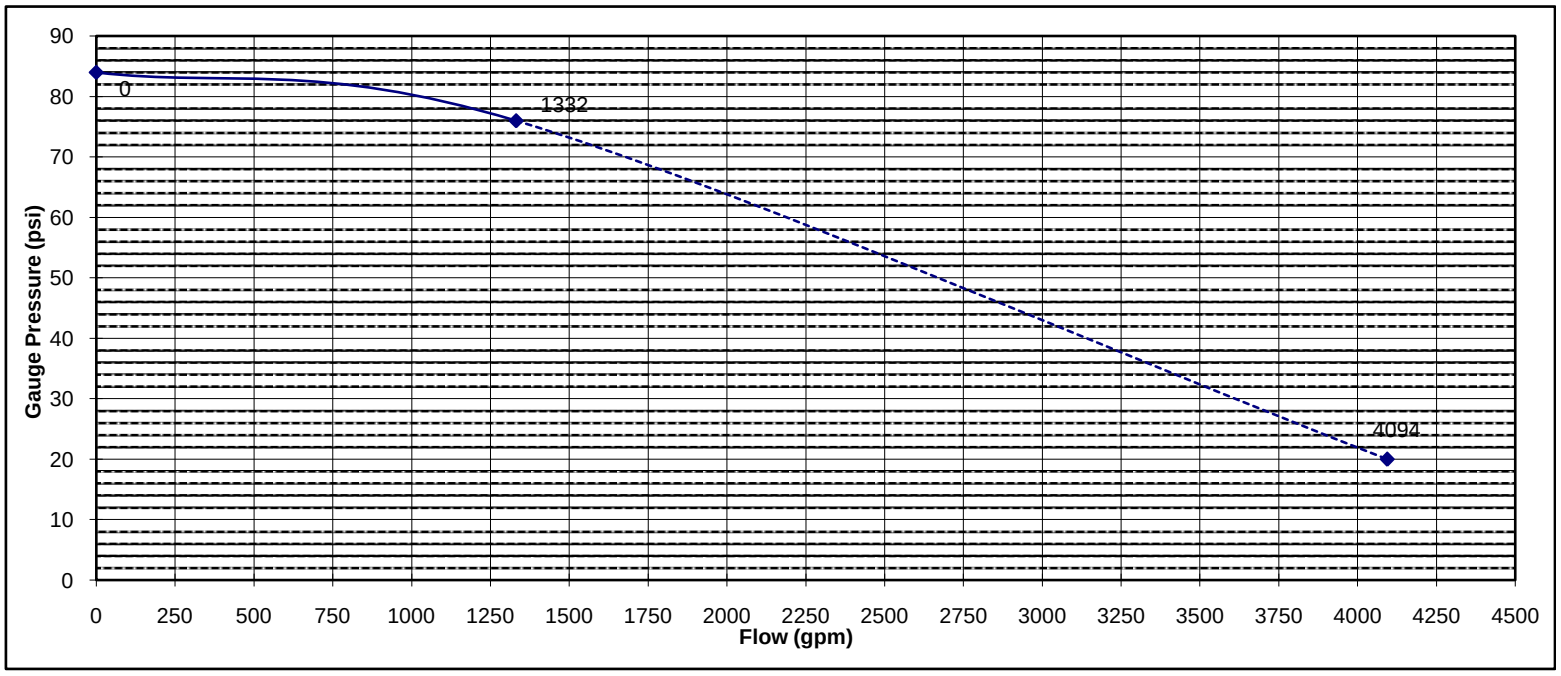
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	84	psi @	0	gpm
Residual pressure of	76	psi @	1331.8	gpm
Available flow @	20	psi --	4093.7	gpm

Flow at 20 psi: 4093.7 gpm



Comments:

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DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1
Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 70

Pitot Reading: 63.00

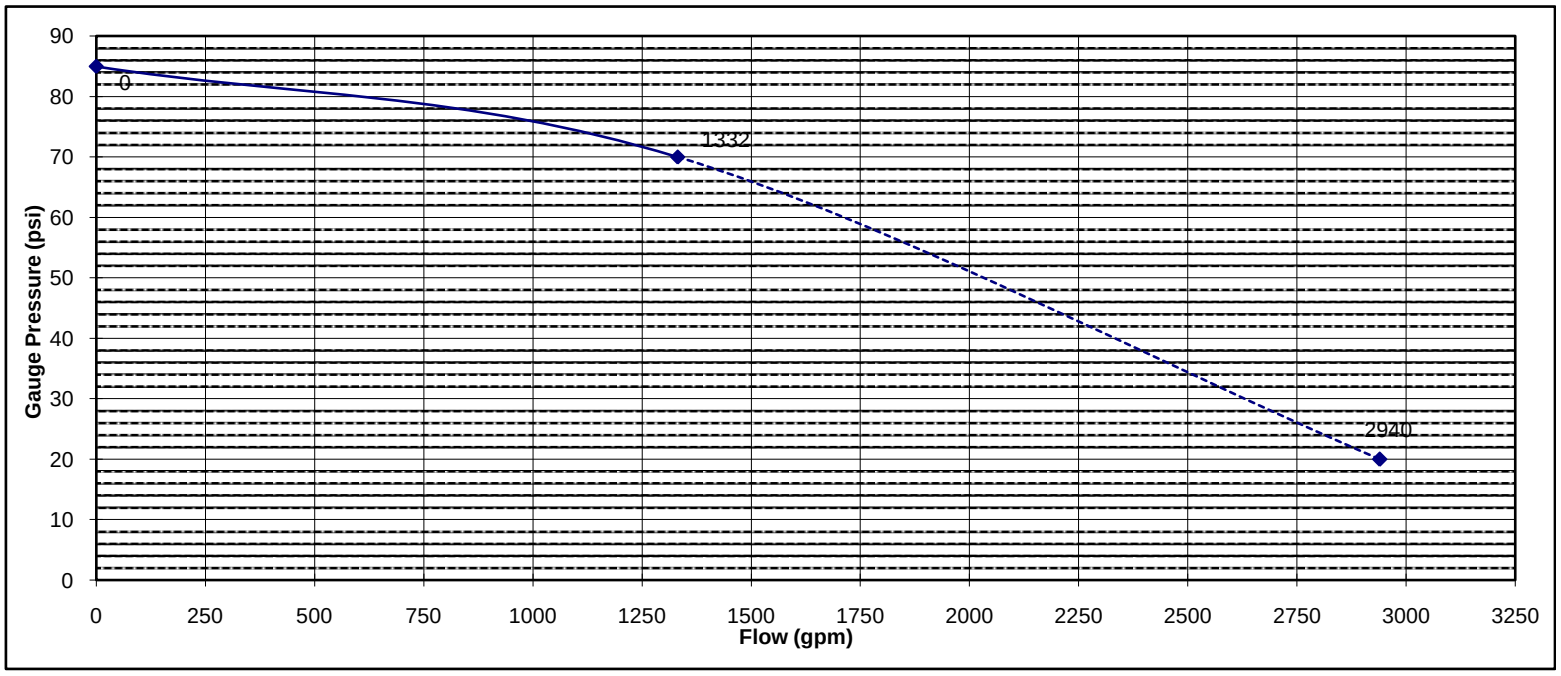
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	70	psi @	1331.8	gpm
Available flow @	20	psi --	2939.9	gpm

Flow at 20 psi: 2939.9 gpm



Comments:

NOTES:

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WESTERN STATES FIRE PROTECTION CO.
2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-3 / WTFH3N1WNE150006 / 133RD & WADDELL - TBIRD

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 87.00

Residual Pressure: 65

Pitot Reading: 57.00

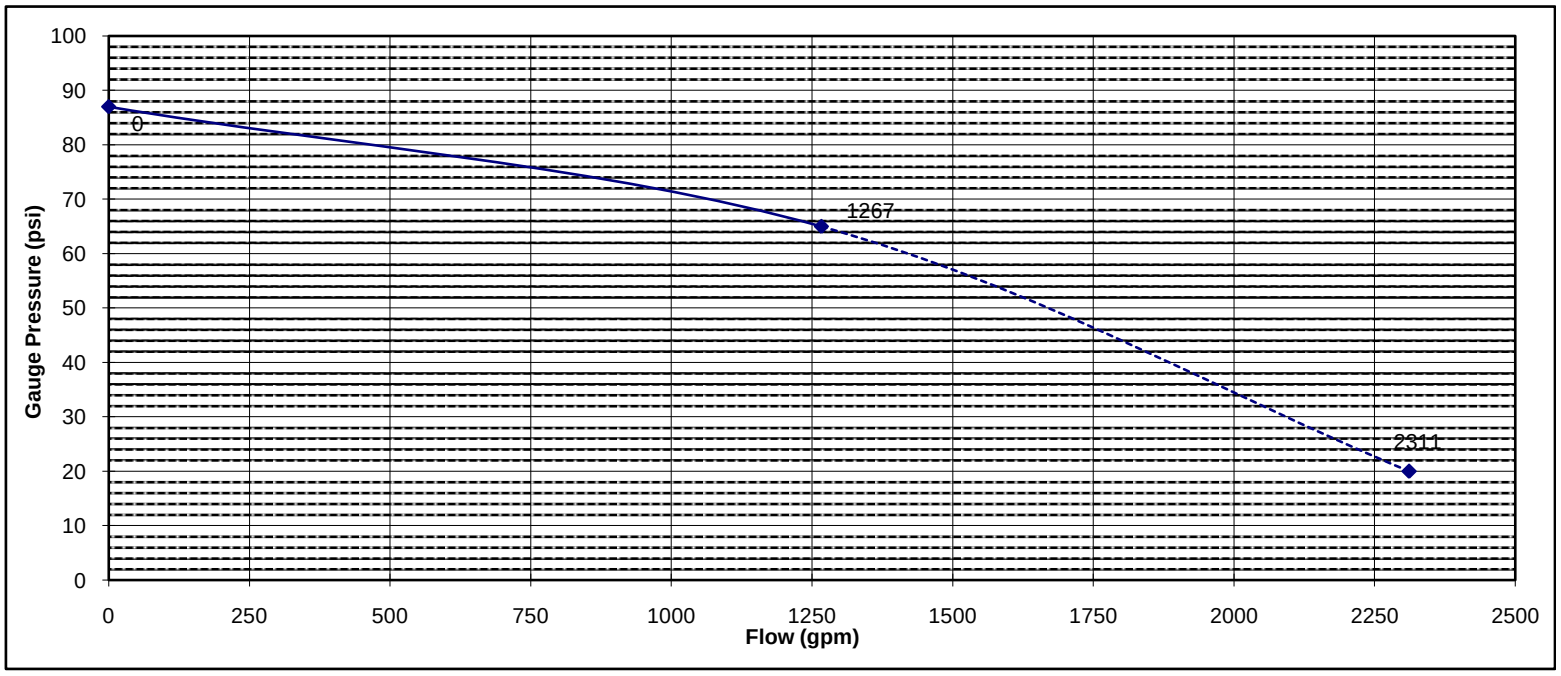
Flow: 1266.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	87	psi @	0	gpm
Residual pressure of	65	psi @	1266.8	gpm
Available flow @	20	psi --	2311.5	gpm

Flow at 20 psi: 2311.5 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-4 / WTFH3N1WNE090013 / 140TH & GREENWAY RD.

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 75.00

Residual Pressure: 60

Pitot Reading: 48.00

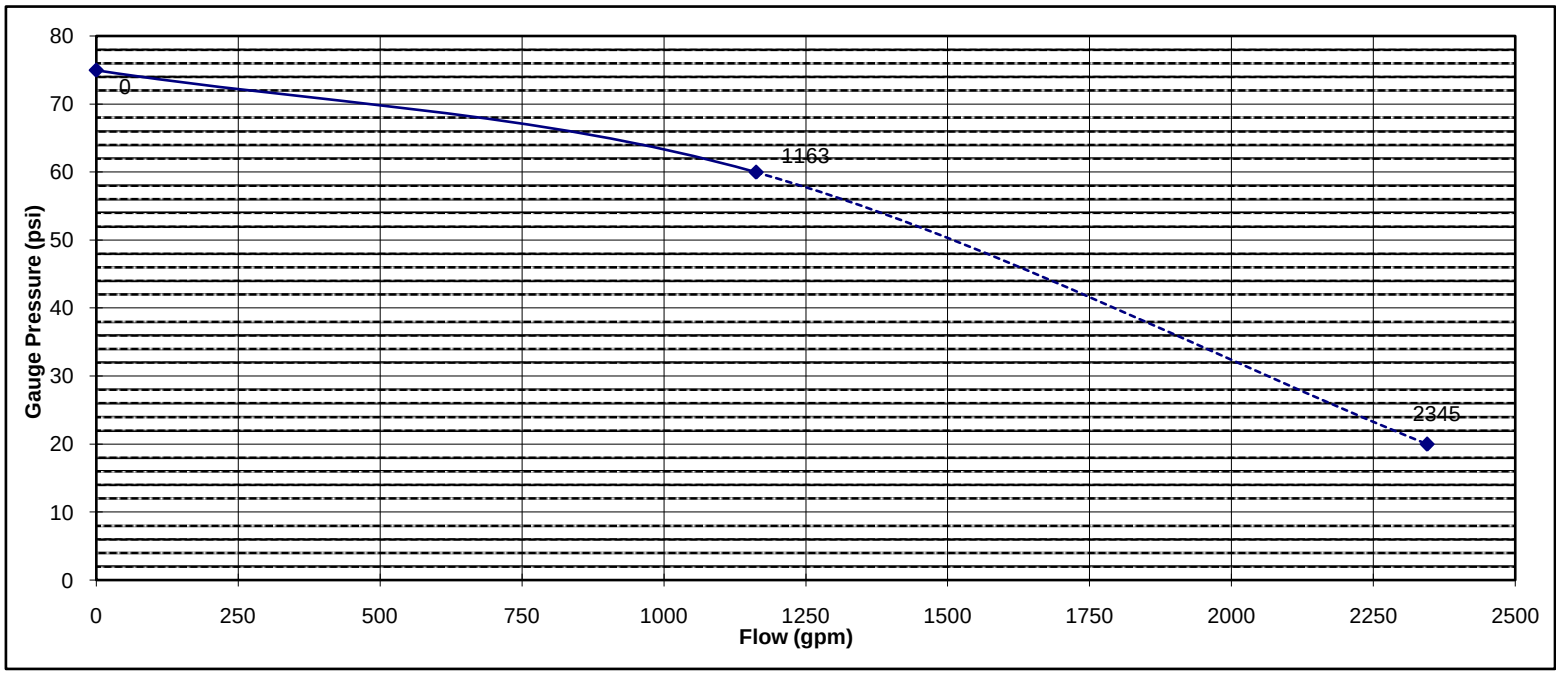
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	75	psi @	0	gpm
Residual pressure of	60	psi @	1162.5	gpm
Available flow @	20	psi --	2344.8	gpm

Flow at 20 psi: 2344.8 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-4 / WTFH3N1WNE090013 / 140TH & GREENWAY RD.

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 78.00

Residual Pressure: 63

Pitot Reading: 54.00

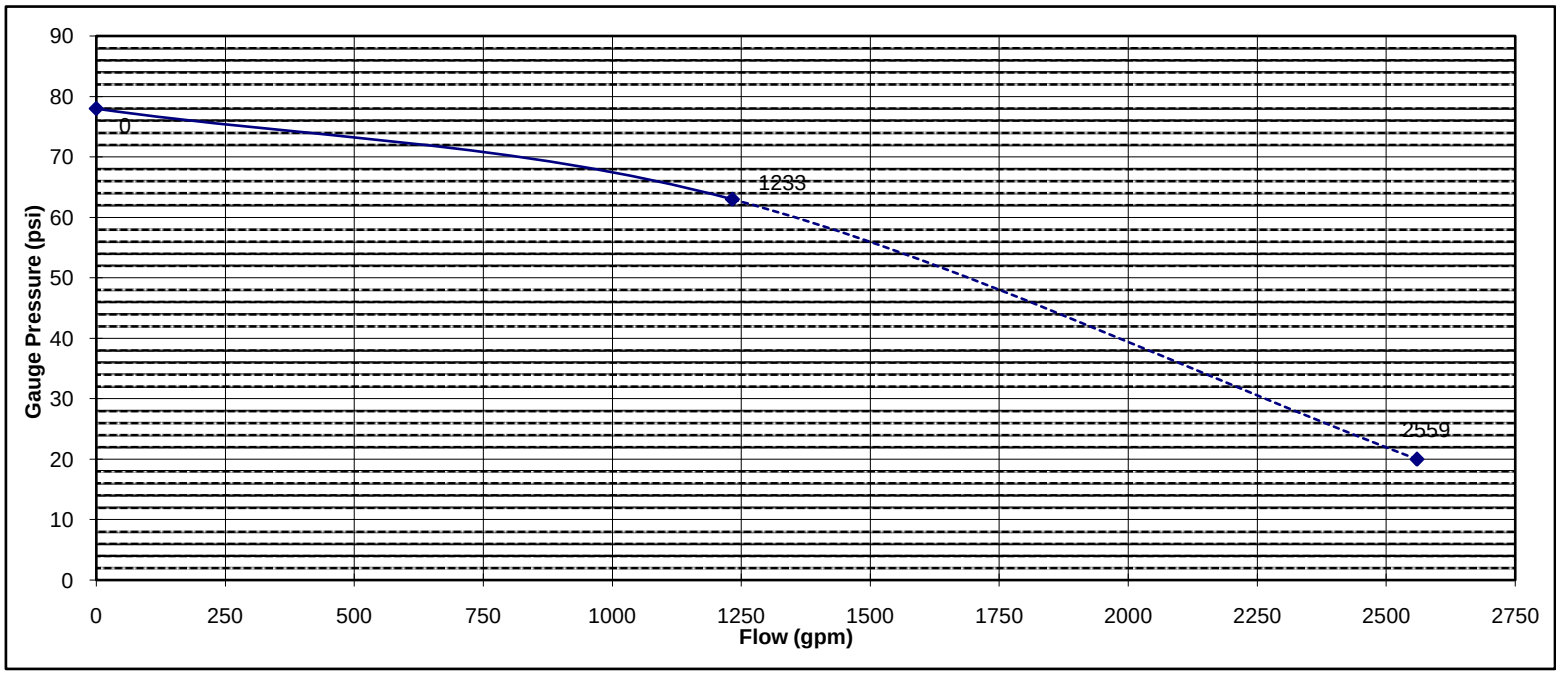
Flow: 1233.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	78	psi @	0	gpm
Residual pressure of	63	psi @	1233.0	gpm
Available flow @	20	psi --	2559.4	gpm

Flow at 20 psi: 2559.4 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-4 / WTFH3N1WNE090013 / 140TH & GREENWAY RD.

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 76.00

Residual Pressure: 60

Pitot Reading: 55.00

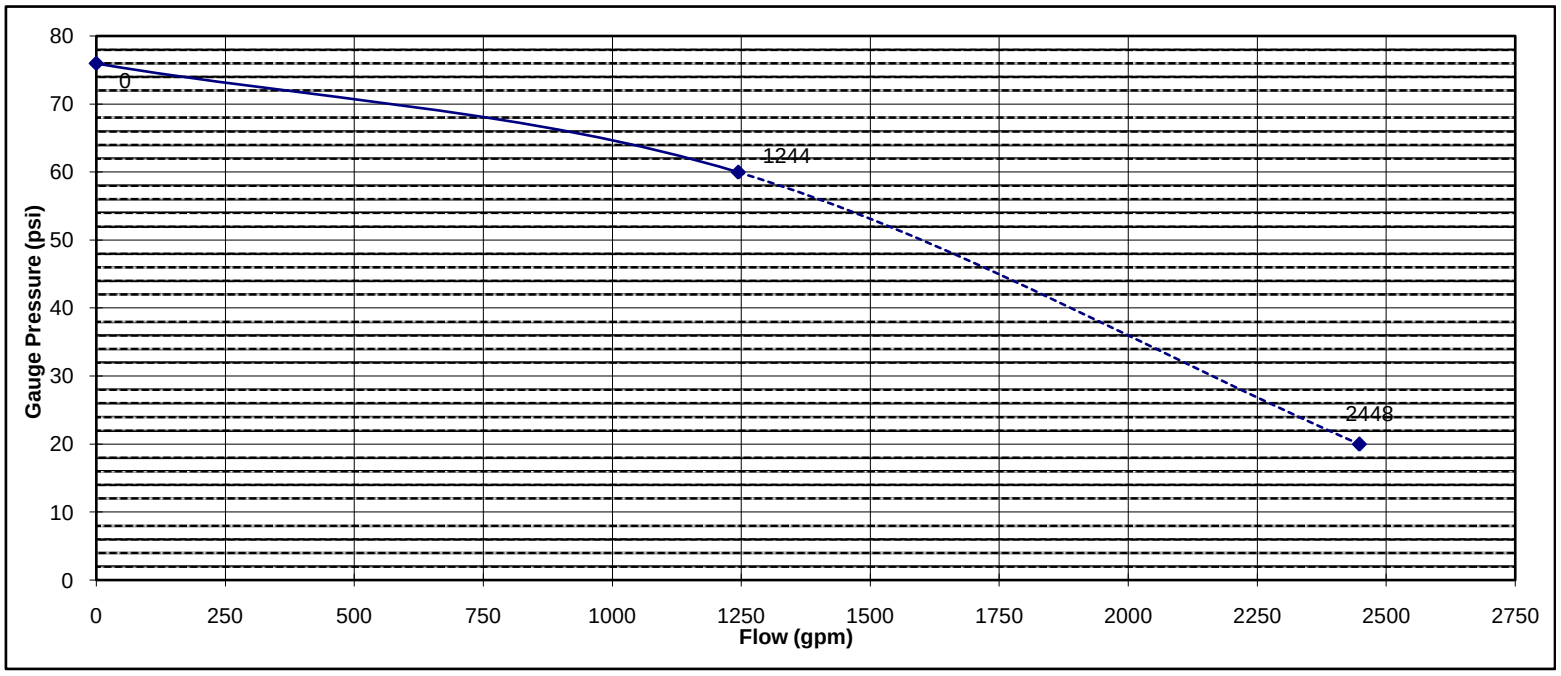
Flow: 1244.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	76	psi @	0	gpm
Residual pressure of	60	psi @	1244.4	gpm
Available flow @	20	psi --	2447.7	gpm

Flow at 20 psi: 2447.7 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-5 / WTFH3N1WSE040009 / 142ND BY COURTHOUSE

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 80.00

Residual Pressure: 70

Pitot Reading: 58.00

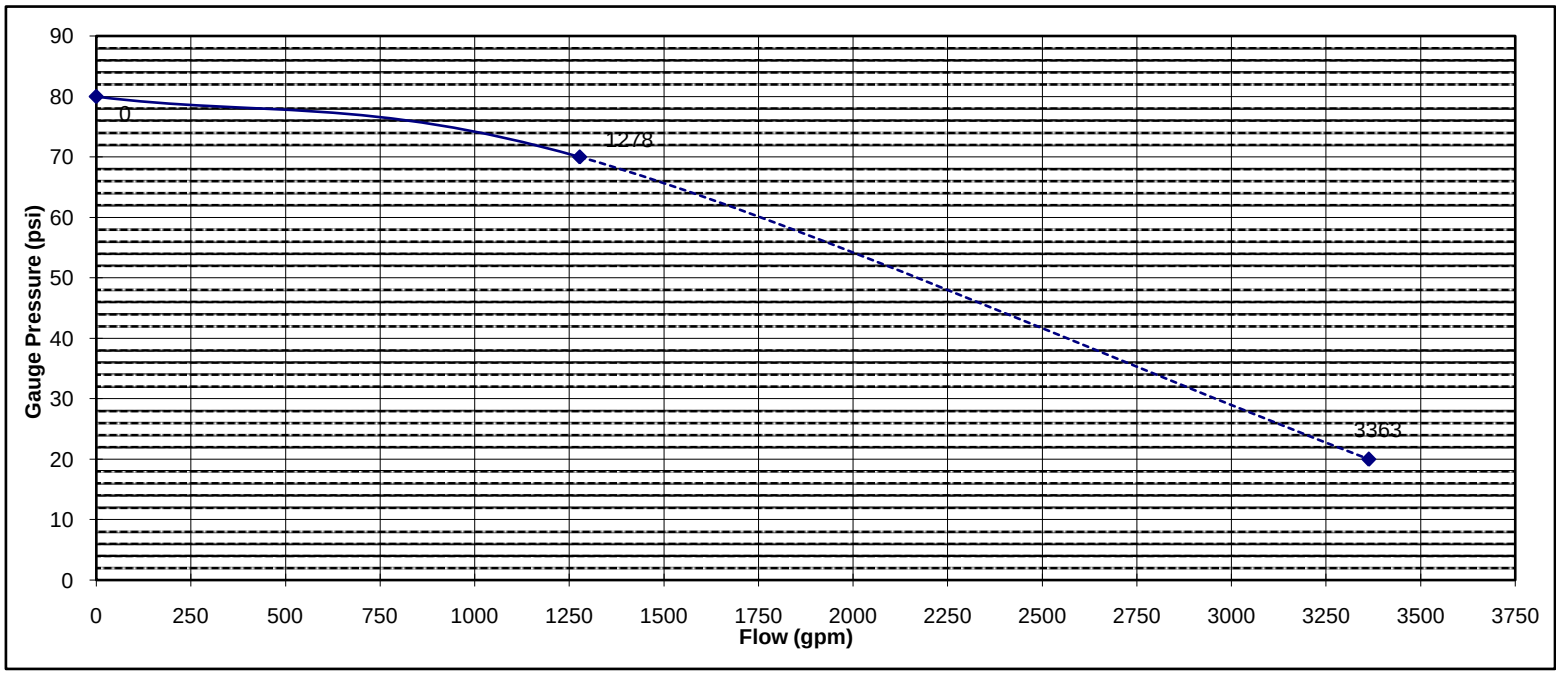
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	80	psi @	0	gpm
Residual pressure of	70	psi @	1277.9	gpm
Available flow @	20	psi --	3362.7	gpm

Flow at 20 psi: 3362.7 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-5 / WTFH3N1WSE040009 / 142ND BY COURTHOUSE

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 74

Pitot Reading: 56.00

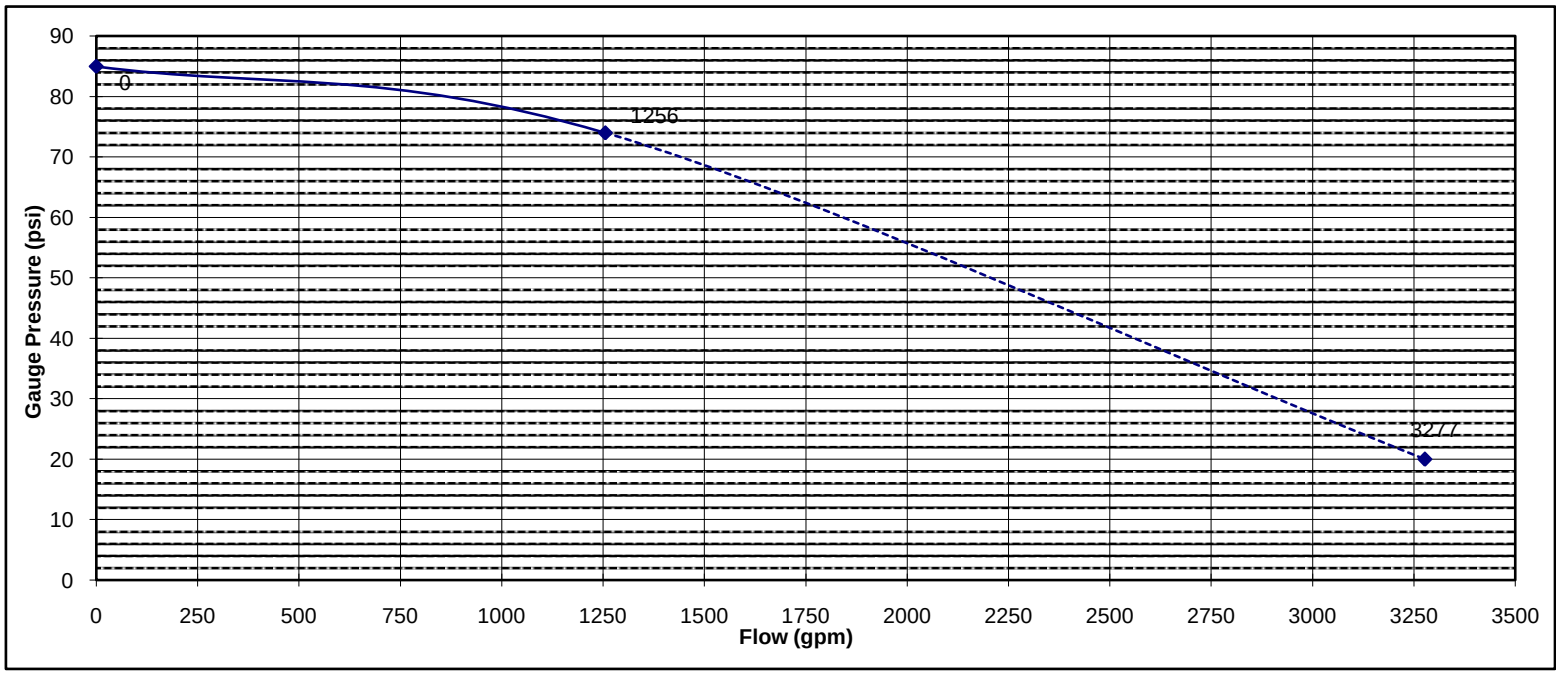
Flow: 1255.7 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	74	psi @	1255.7	gpm
Available flow @	20	psi --	3277.1	gpm

Flow at 20 psi: 3277.1 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-5 / WTFH3N1WSE040009 / 142ND BY COURTHOUSE

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 70

Pitot Reading: 58.00

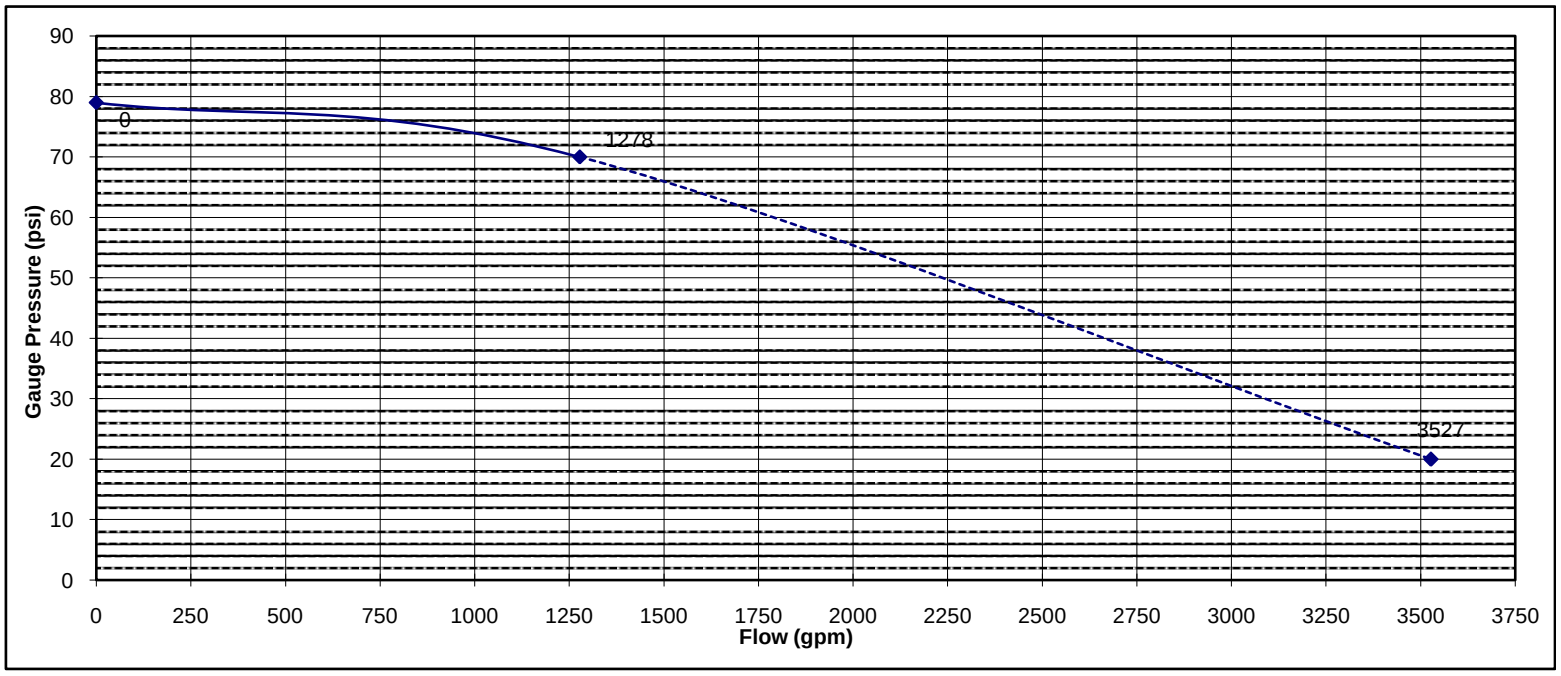
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	70	psi @	1277.9	gpm
Available flow @	20	psi --	3527.4	gpm

Flow at 20 psi: 3527.4 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-6 / WTFH3N1WNW040003 / BULLARD AND 1/2 MI N. OF GNWAY

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 74.00

Residual Pressure: 66

Pitot Reading: 48.00

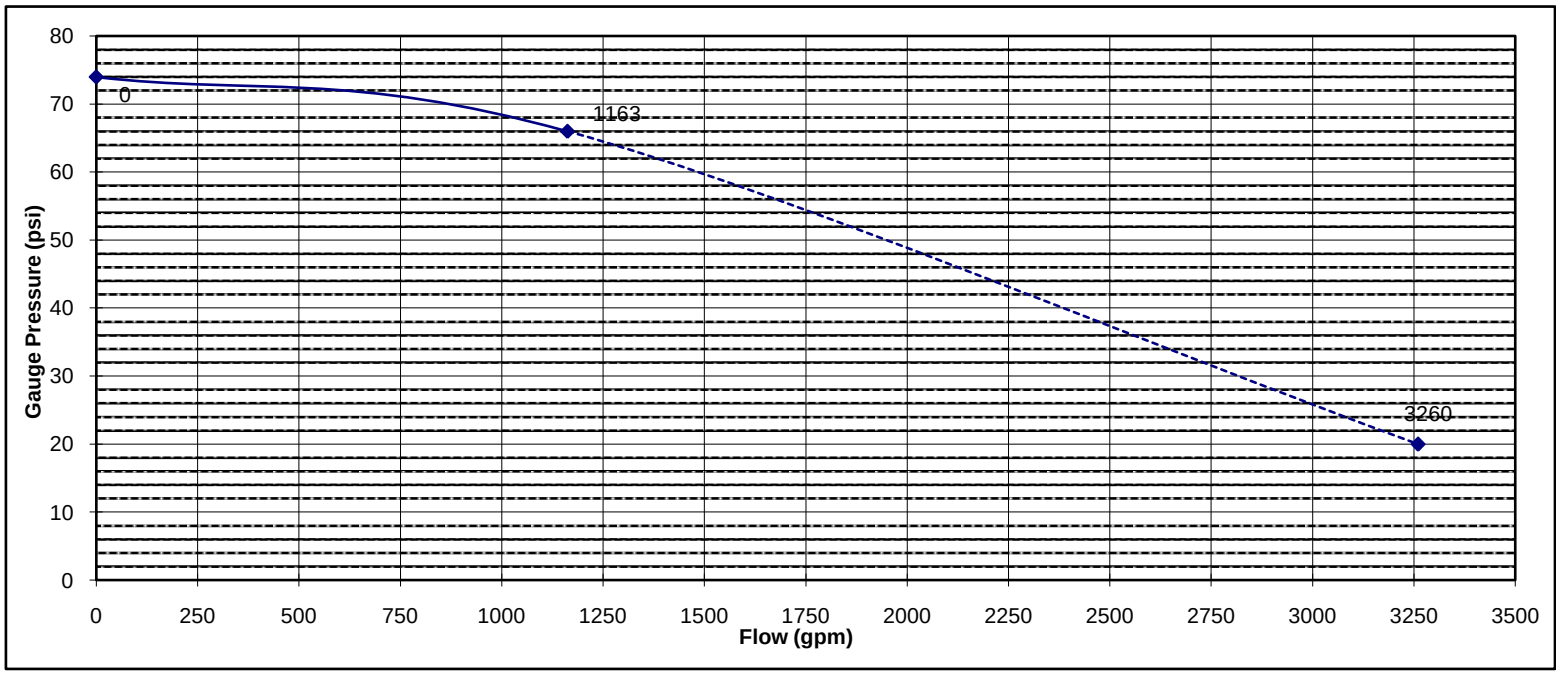
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	74	psi @	0	gpm
Residual pressure of	66	psi @	1162.5	gpm
Available flow @	20	psi --	3260.0	gpm

Flow at 20 psi: 3260.0 gpm



Comments:

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WESTERN STATES FIRE PROTECTION CO.

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-6 / WTFH3N1WNW040003 / BULLARD AND 1/2 MI N. OF GNWAY

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 70

Pitot Reading: 48.00

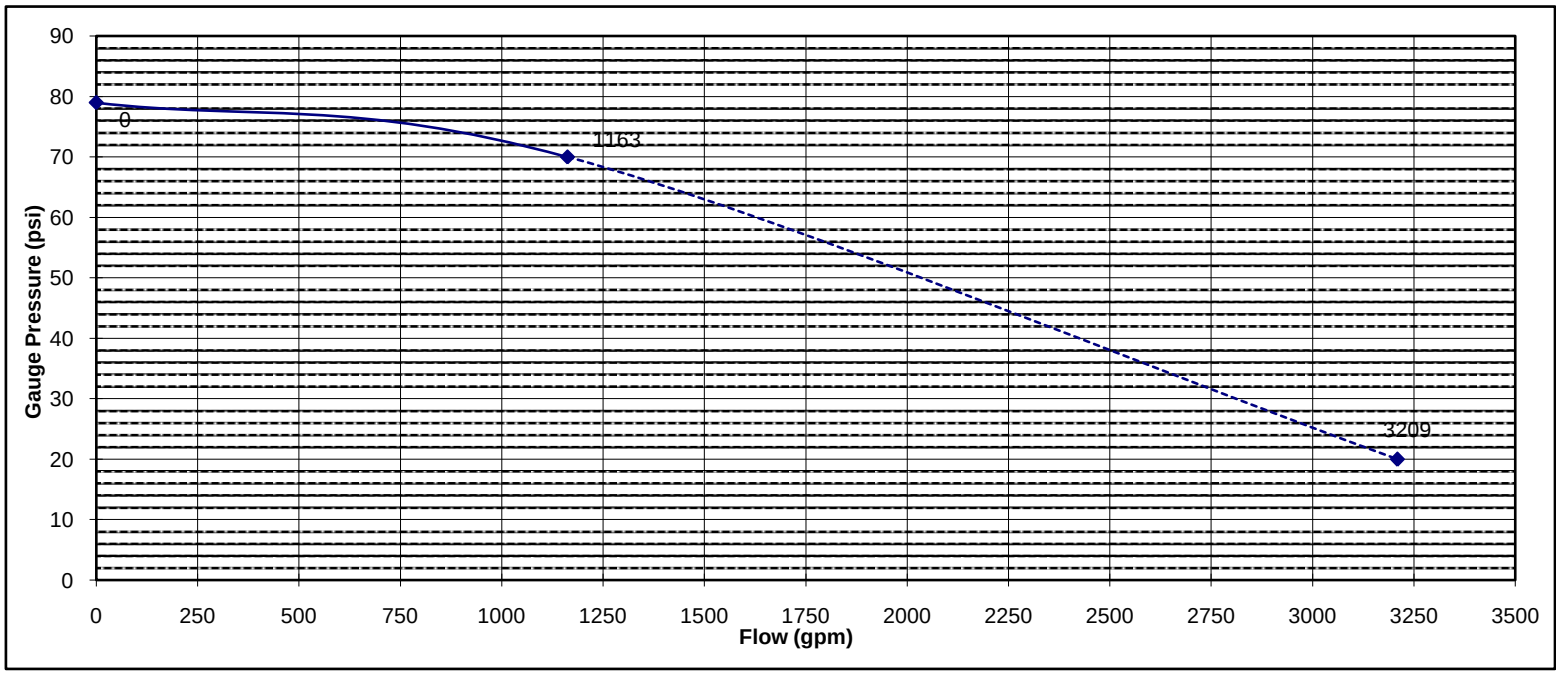
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	70	psi @	1162.5	gpm
Available flow @	20	psi --	3209.0	gpm

Flow at 20 psi: 3209.0 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-6 / WTFH3N1WNW040003 / BULLARD AND 1/2 MI N. OF GNWAY

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 78.00

Residual Pressure: 71

Pitot Reading: 45.00

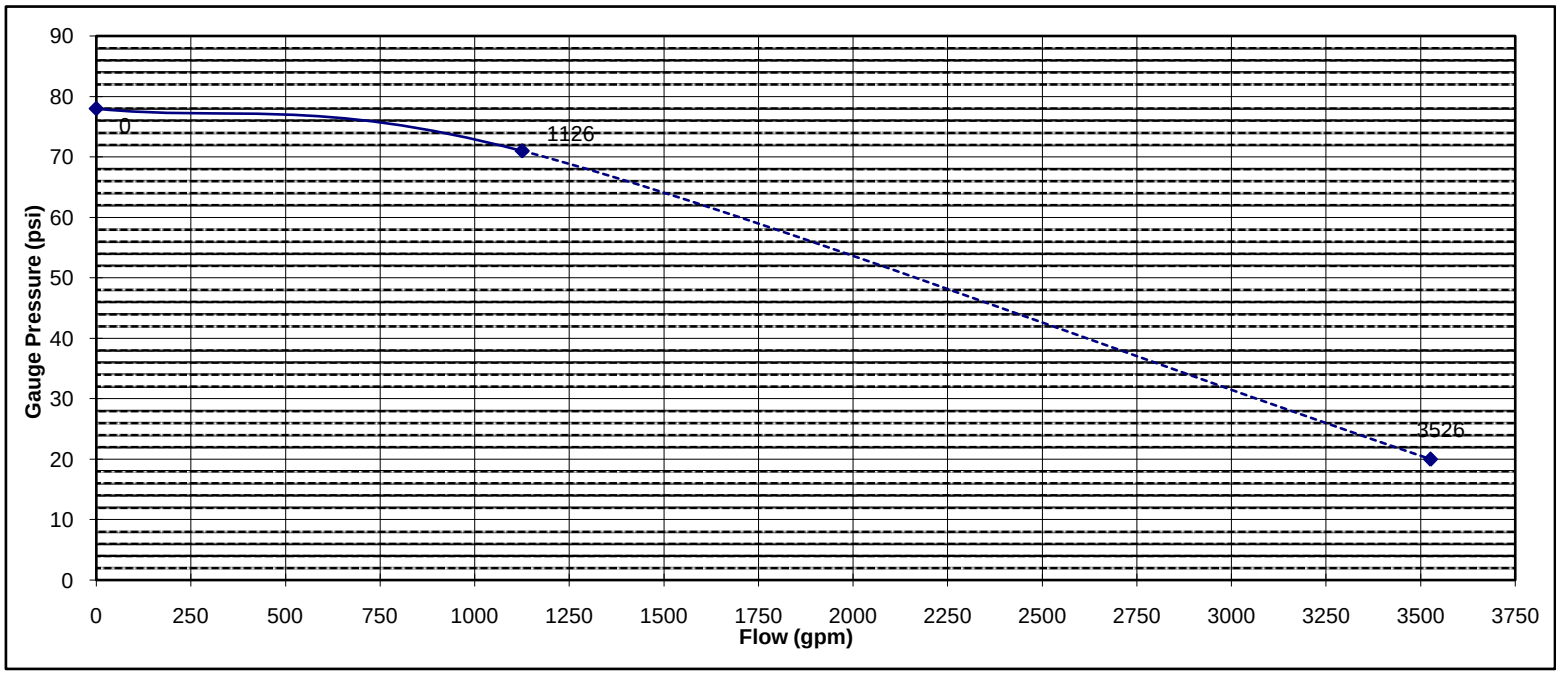
Flow: 1125.6 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	78	psi @	0	gpm
Residual pressure of	71	psi @	1125.6	gpm
Available flow @	20	psi --	3526.0	gpm

Flow at 20 psi: 3526.0 gpm



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Phoenix, AZ 85027
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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-7 / WTFH3N1WNW050002 / REEMS AND 2 BLKS S. OF BELL RD.

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 60.00

Residual Pressure: 54

Pitot Reading: 46.00

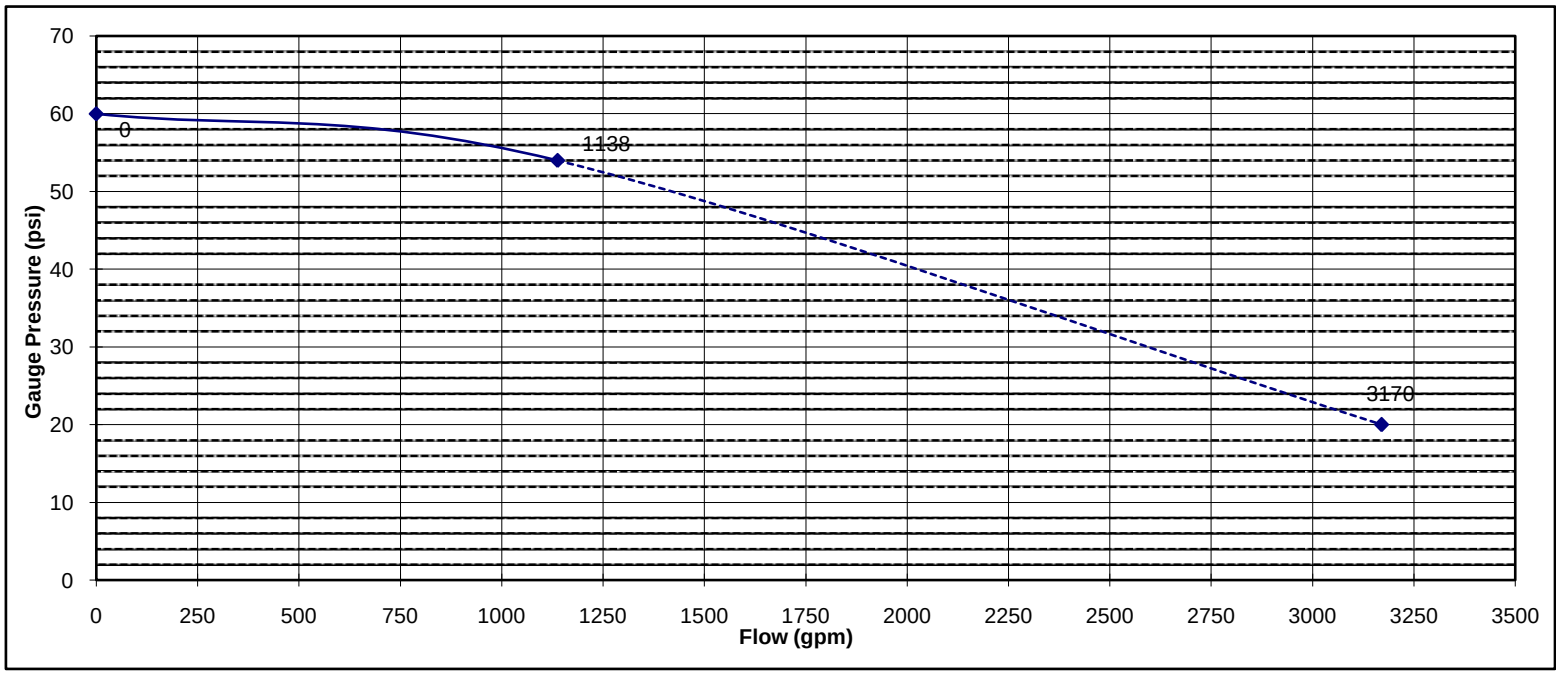
Flow: 1138.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	60	psi @	0	gpm
Residual pressure of	54	psi @	1138.0	gpm
Available flow @	20	psi --	3170.0	gpm

Flow at 20 psi: 3170.0 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-7 / WTFH3N1WNW050002 / REEMS AND 2 BLKS S. OF BELL RD.

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 62.00

Residual Pressure: 55

Pitot Reading: 46.00

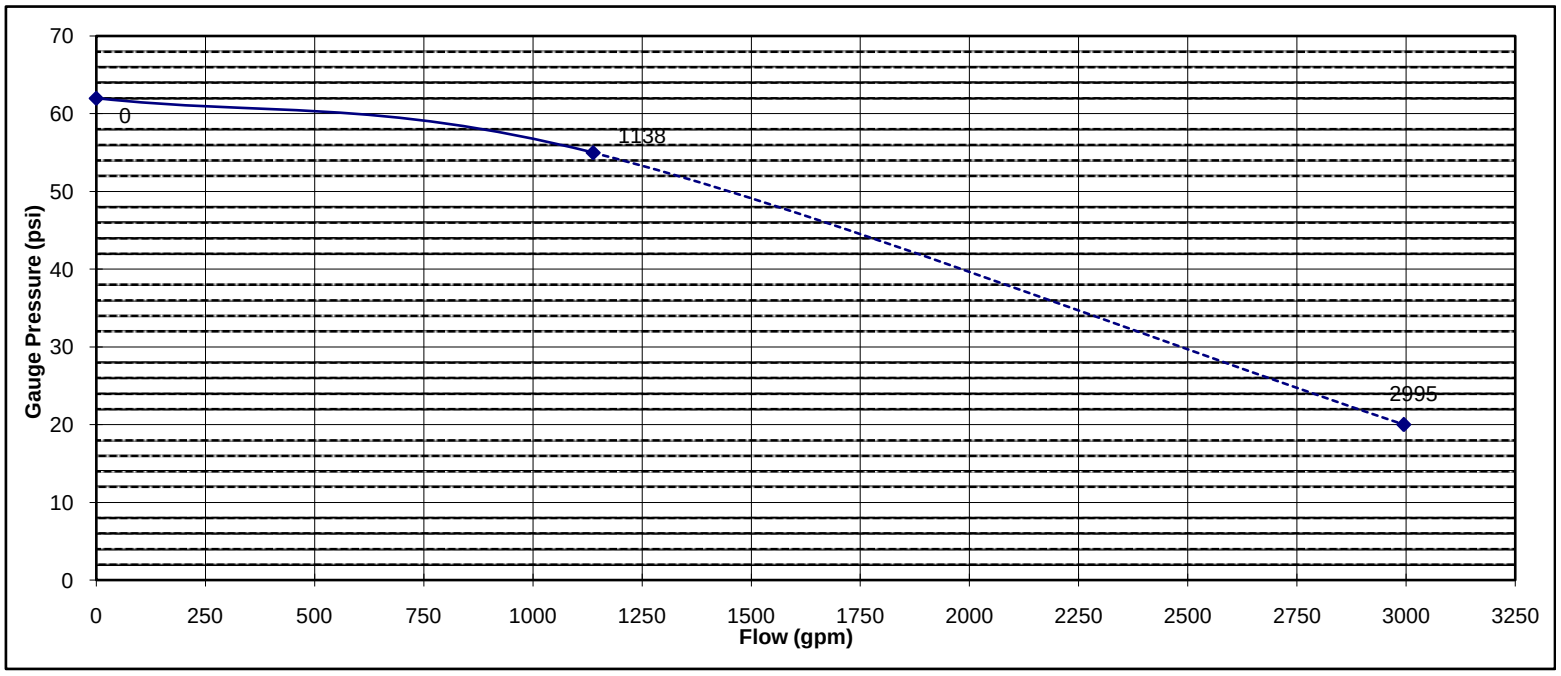
Flow: 1138.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	62	psi @	0	gpm
Residual pressure of	55	psi @	1138.0	gpm
Available flow @	20	psi --	2994.7	gpm

Flow at 20 psi: 2994.7 gpm



Comments:

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Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-7 / WTFH3N1WNW050002 / REEMS AND 2 BLKS S. OF BELL RD.

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 62.00

Residual Pressure: 55

Pitot Reading: 45.00

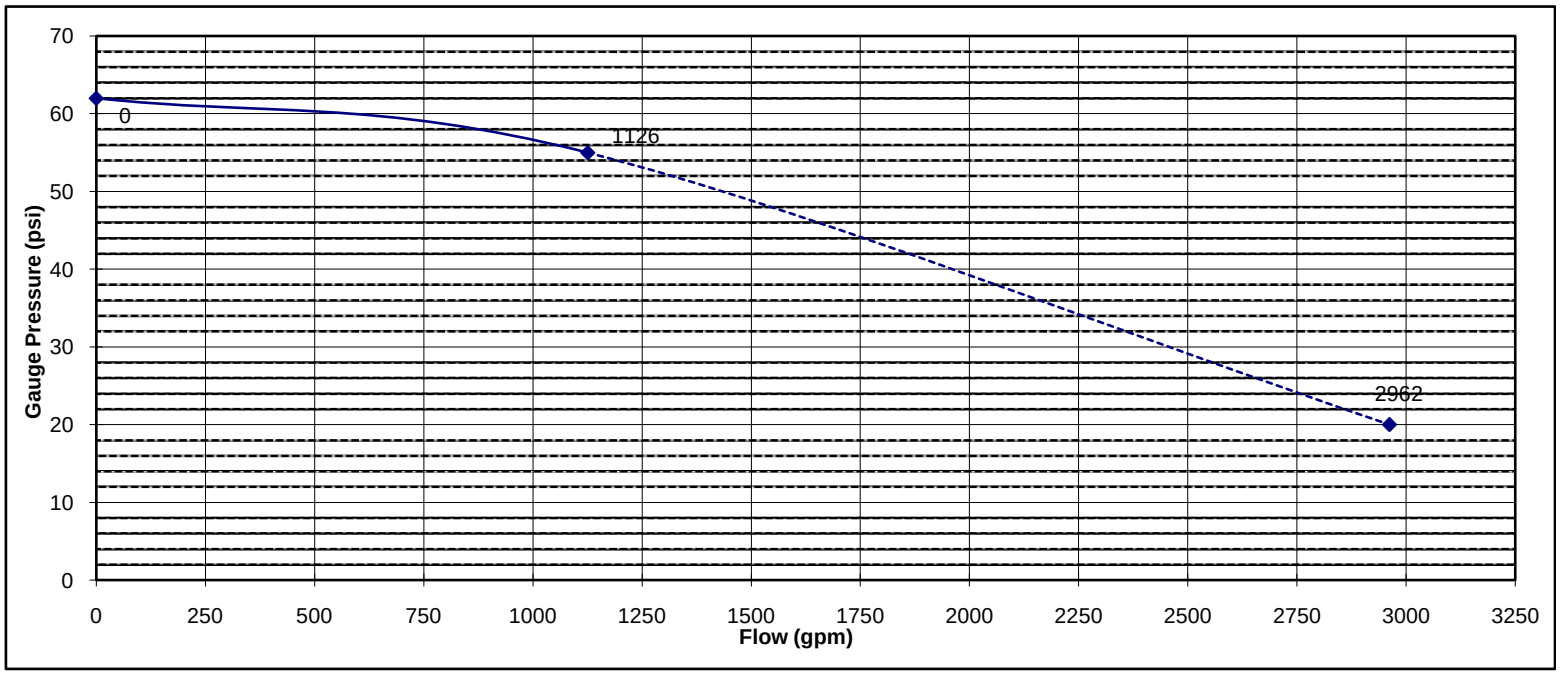
Flow: 1125.6 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	62	psi @	0	gpm
Residual pressure of	55	psi @	1125.6	gpm
Available flow @	20	psi --	2962.0	gpm

Flow at 20 psi: 2962.0 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-8 / WTFH3N1WNE070040 / GREENWAY RD & MTN VISTA RANCH

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 86.00

Residual Pressure: 74

Pitot Reading: 65.00

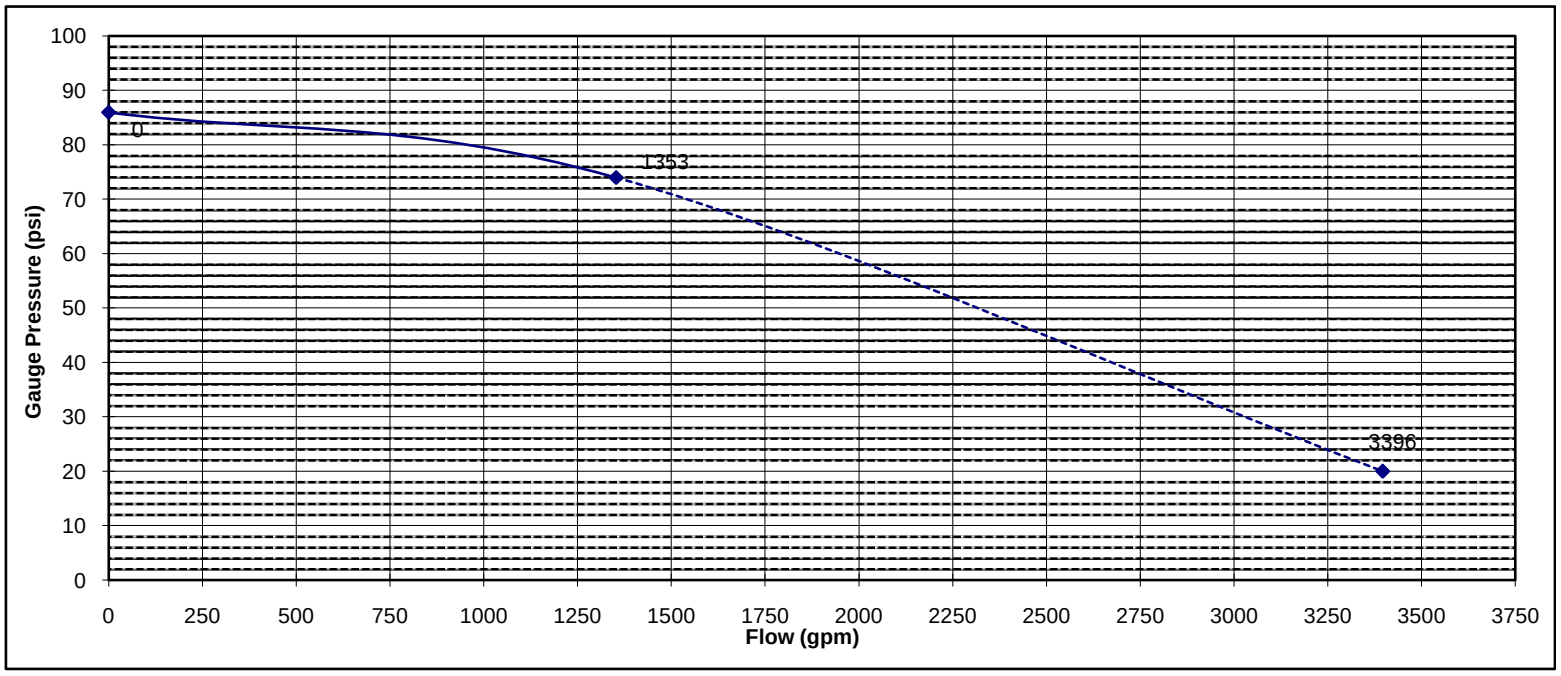
Flow: 1352.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	86	psi @	0	gpm
Residual pressure of	74	psi @	1352.8	gpm
Available flow @	20	psi --	3396.5	gpm

Flow at 20 psi: 3396.5 gpm



Comments:

NOTES:

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2. Flow analysis assumes a gravity flow system with no distribution pumps and having no demand, other than the test
3. The distance between hydrants, elevations & main diameters are for information only.

WESTERN STATES FIRE PROTECTION CO.

2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-8 / WTFH3N1WNE070040 / GREENWAY RD & MTN VISTA RANCH

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 81.00

Residual Pressure: 72

Pitot Reading: 63.00

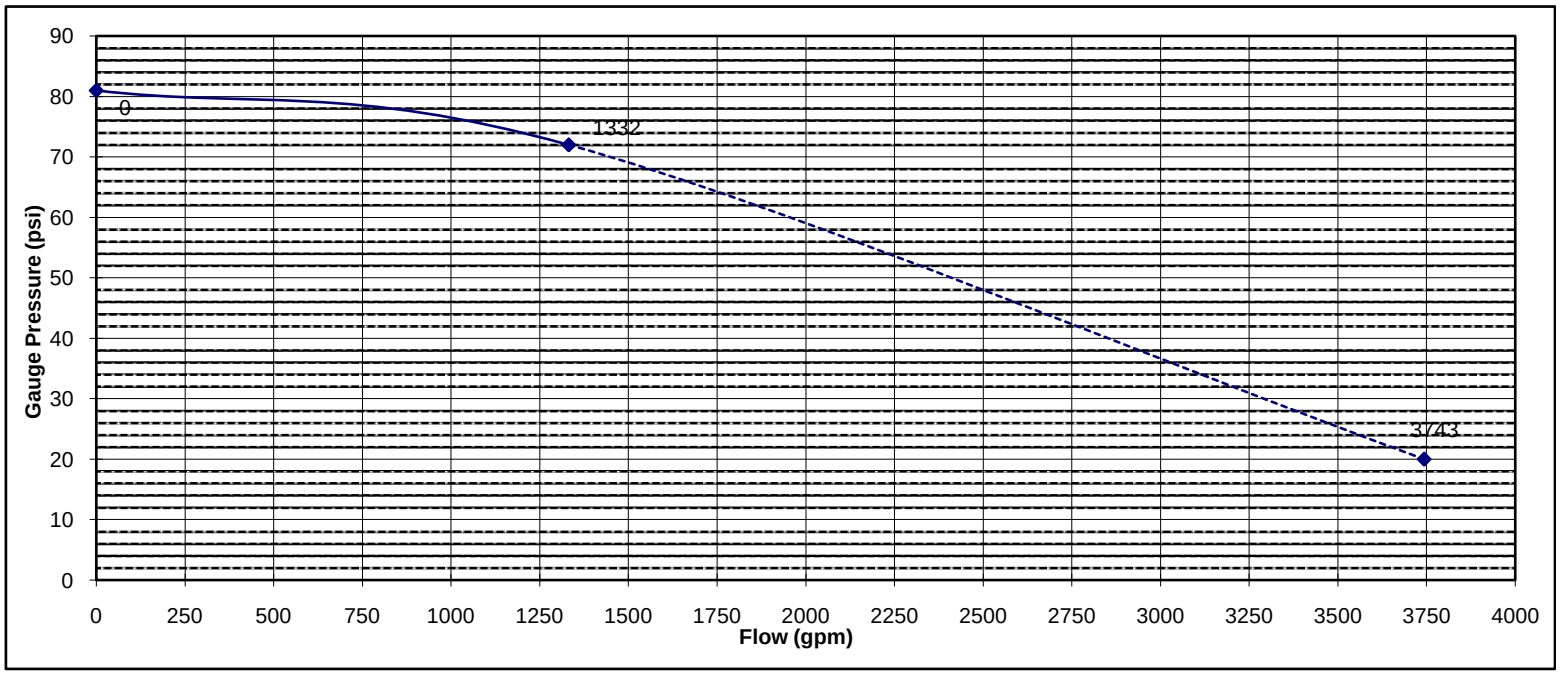
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	81	psi @	0	gpm
Residual pressure of	72	psi @	1331.8	gpm
Available flow @	20	psi --	3743.1	gpm

Flow at 20 psi: 3743.1 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-8 / WTFH3N1WNE070040 / GREENWAY RD & MTN VISTA RANCH

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 82.00

Residual Pressure: 74

Pitot Reading: 63.00

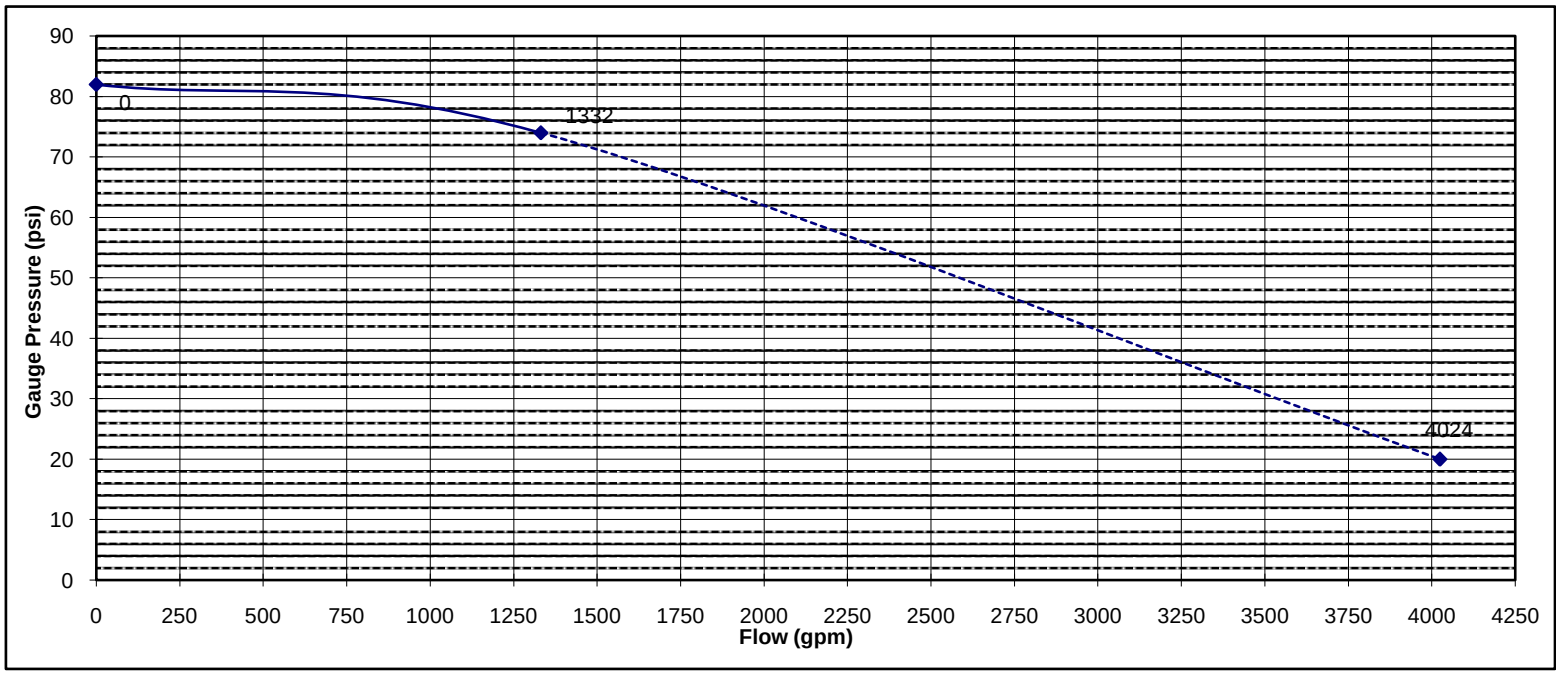
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	82	psi @	0	gpm
Residual pressure of	74	psi @	1331.8	gpm
Available flow @	20	psi --	4024.1	gpm

Flow at 20 psi: 4024.1 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-9 / WTFH3N1WNW080043 / REEMS & 1/2 MI S. OF GREENWAY

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1
Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 65

Pitot Reading: 63.00

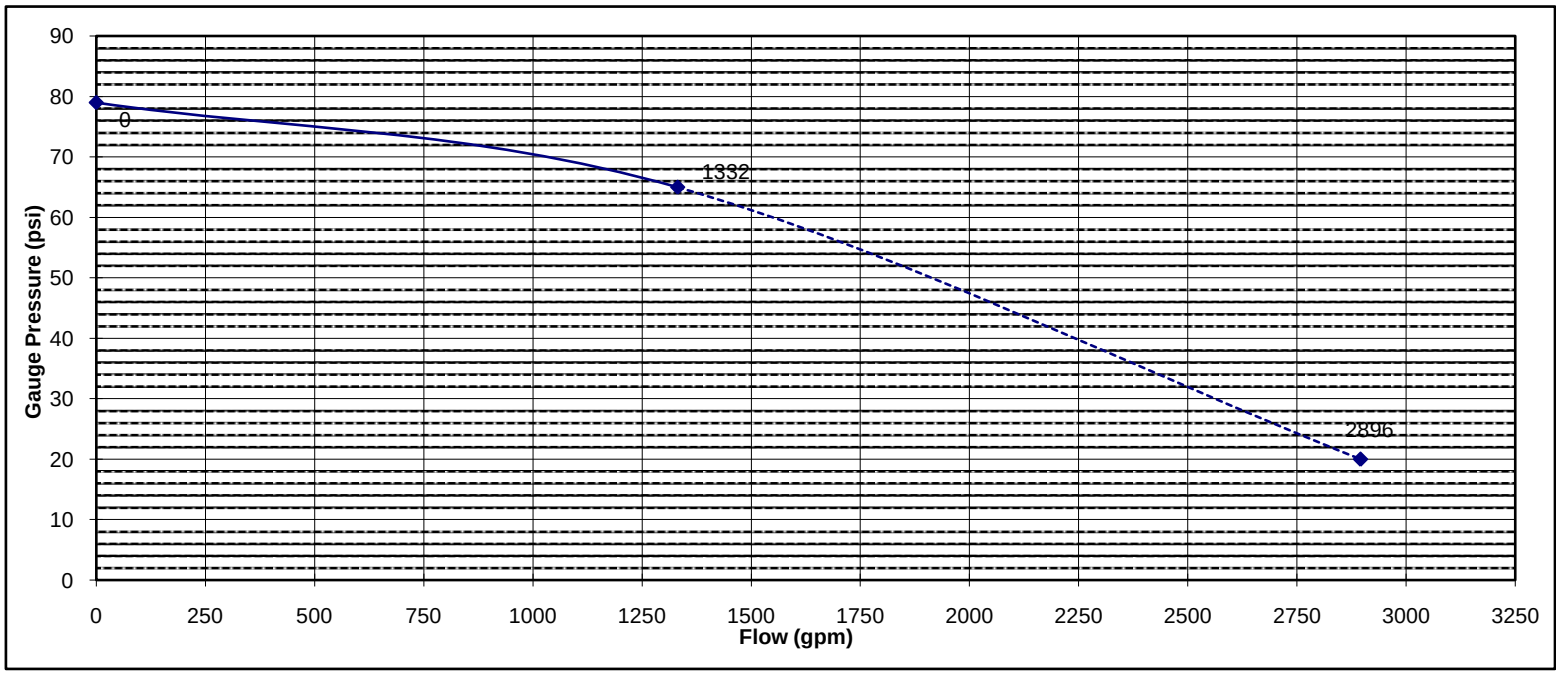
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	65	psi @	1331.8	gpm
Available flow @	20	psi --	2896.0	gpm

Flow at 20 psi: 2896.0 gpm



Comments:

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Phoenix, Az. 85008-6945
FF-9 / WTFH3N1WNW080043 / REEMS & 1/2 MI S. OF GREENWAY

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 70

Pitot Reading: 60.00

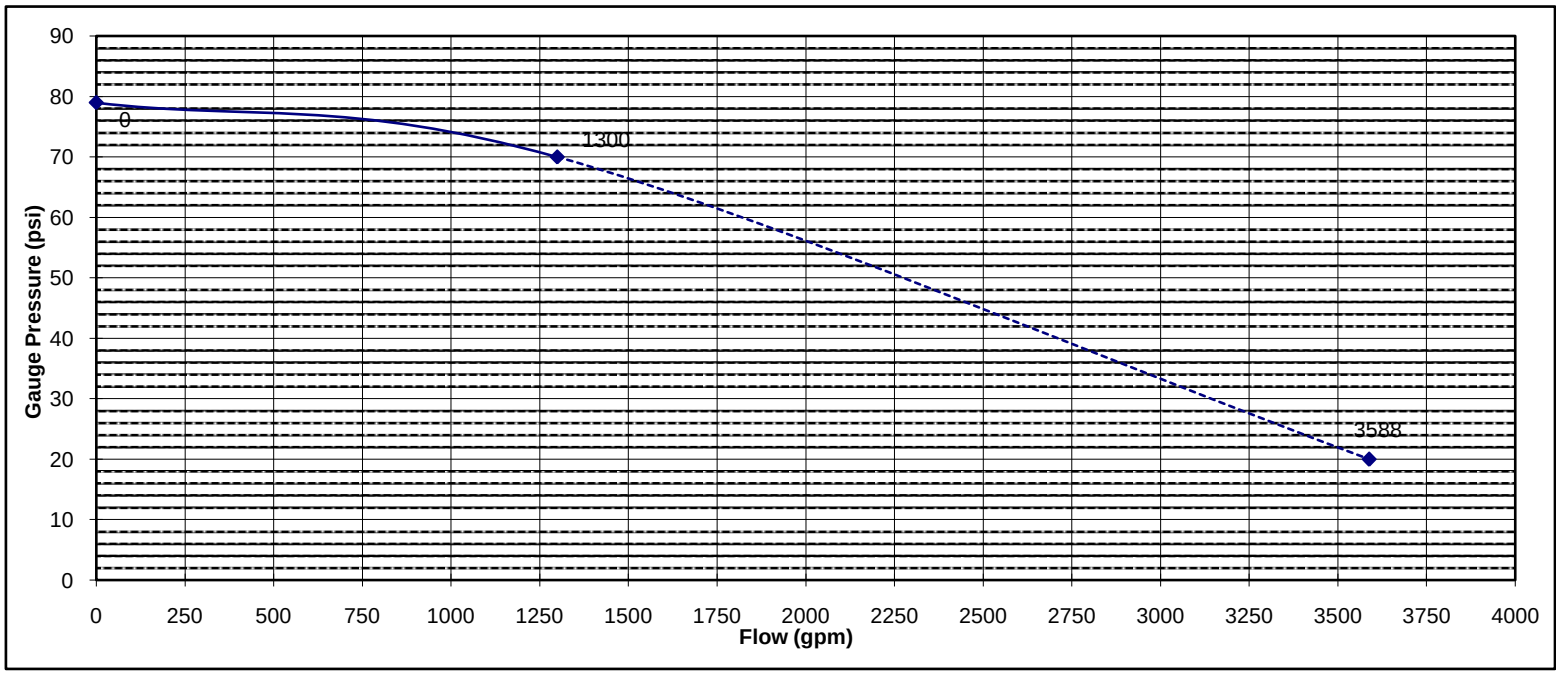
Flow: 1299.7 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	70	psi @	1299.7	gpm
Available flow @	20	psi --	3587.7	gpm

Flow at 20 psi: 3587.7 gpm



Comments:

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FF-9 / WTFH3N1WNW080043 / REEMS & 1/2 MI S. OF GREENWAY

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 83.00

Residual Pressure: 71

Pitot Reading: 58.00

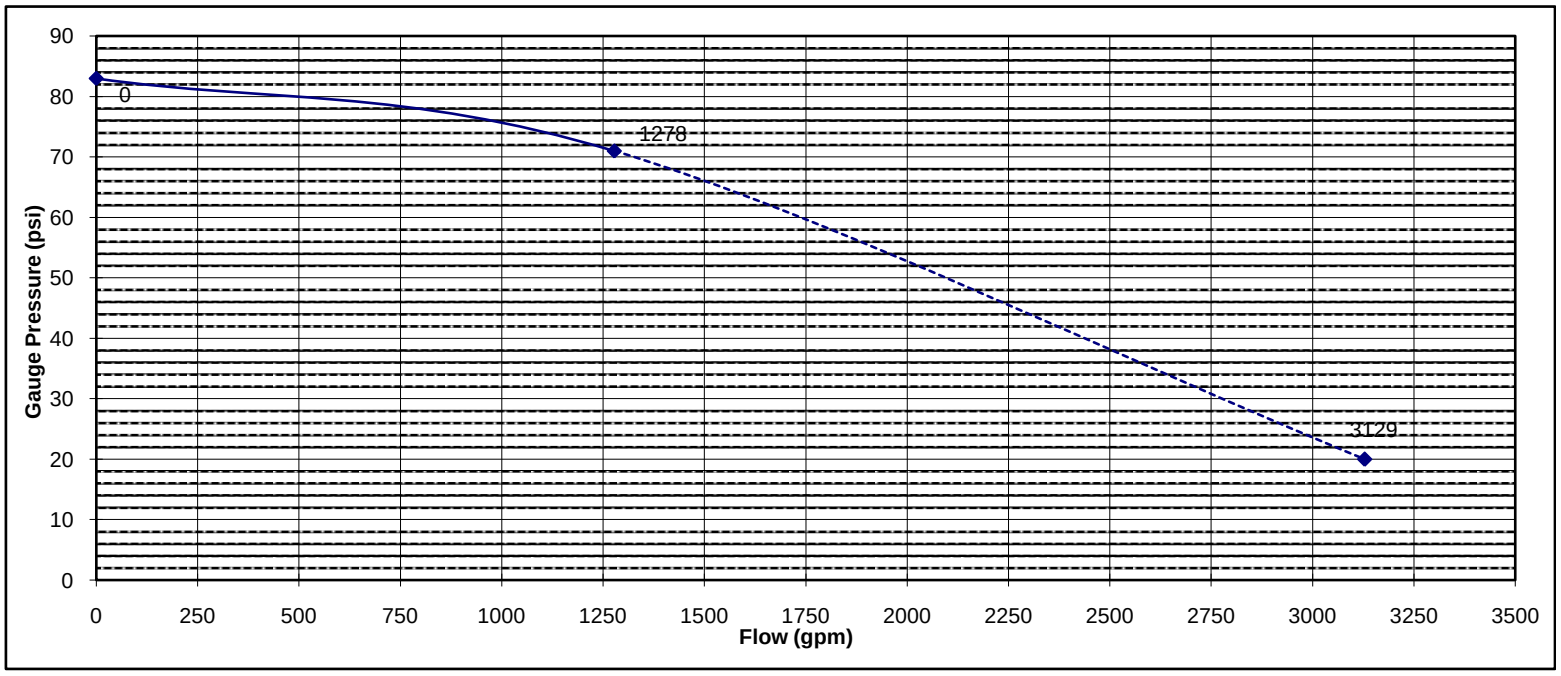
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	83	psi @	0	gpm
Residual pressure of	71	psi @	1277.9	gpm
Available flow @	20	psi --	3128.8	gpm

Flow at 20 psi: 3128.8 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-10 / WTFH3N1WSE160011 / 140TH AVE & CACTUS RD

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 91.00

Residual Pressure: 82

Pitot Reading: 70.00

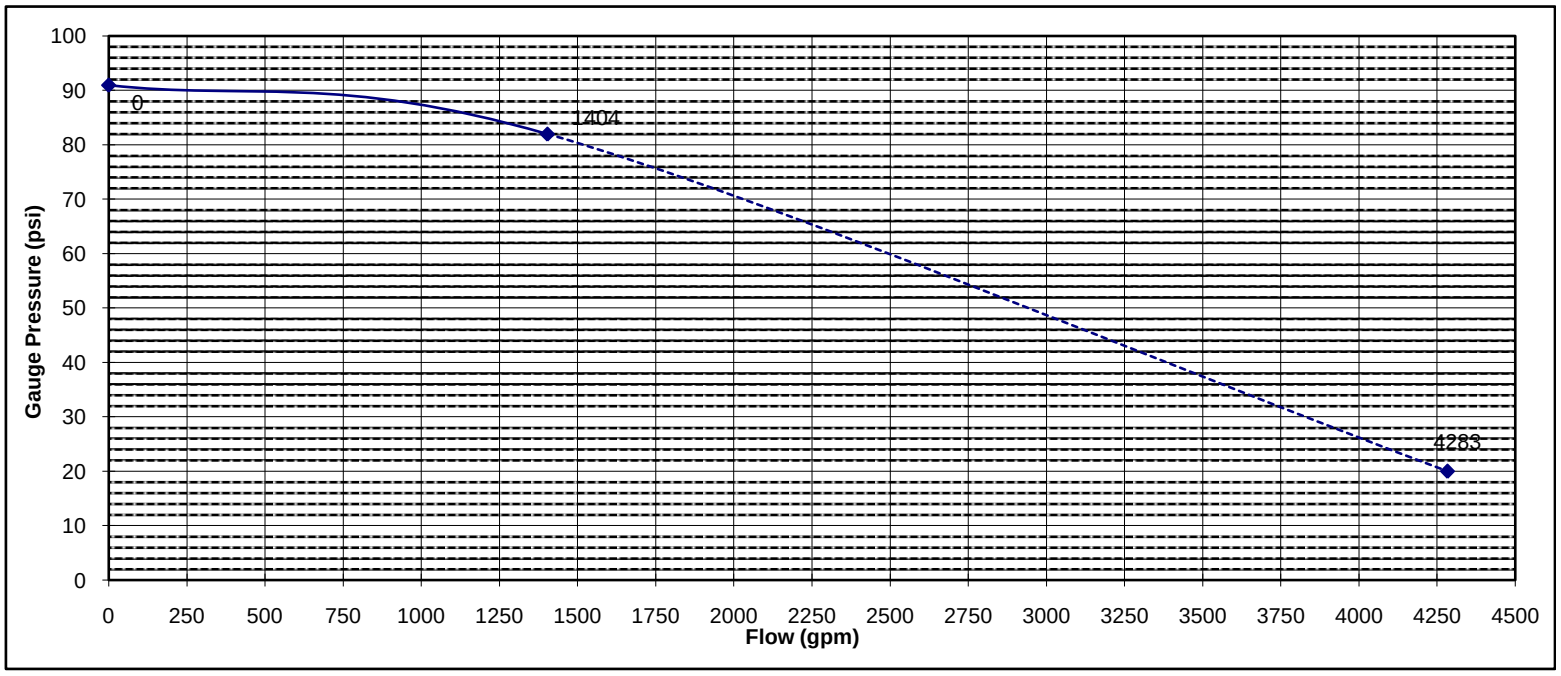
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	91	psi @	0	gpm
Residual pressure of	82	psi @	1403.9	gpm
Available flow @	20	psi --	4282.7	gpm

Flow at 20 psi: 4282.7 gpm



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FF-10 / WTFH3N1WSE160011 / 140TH AVE & CACTUS RD

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 86.00

Residual Pressure: 71

Pitot Reading: 63.00

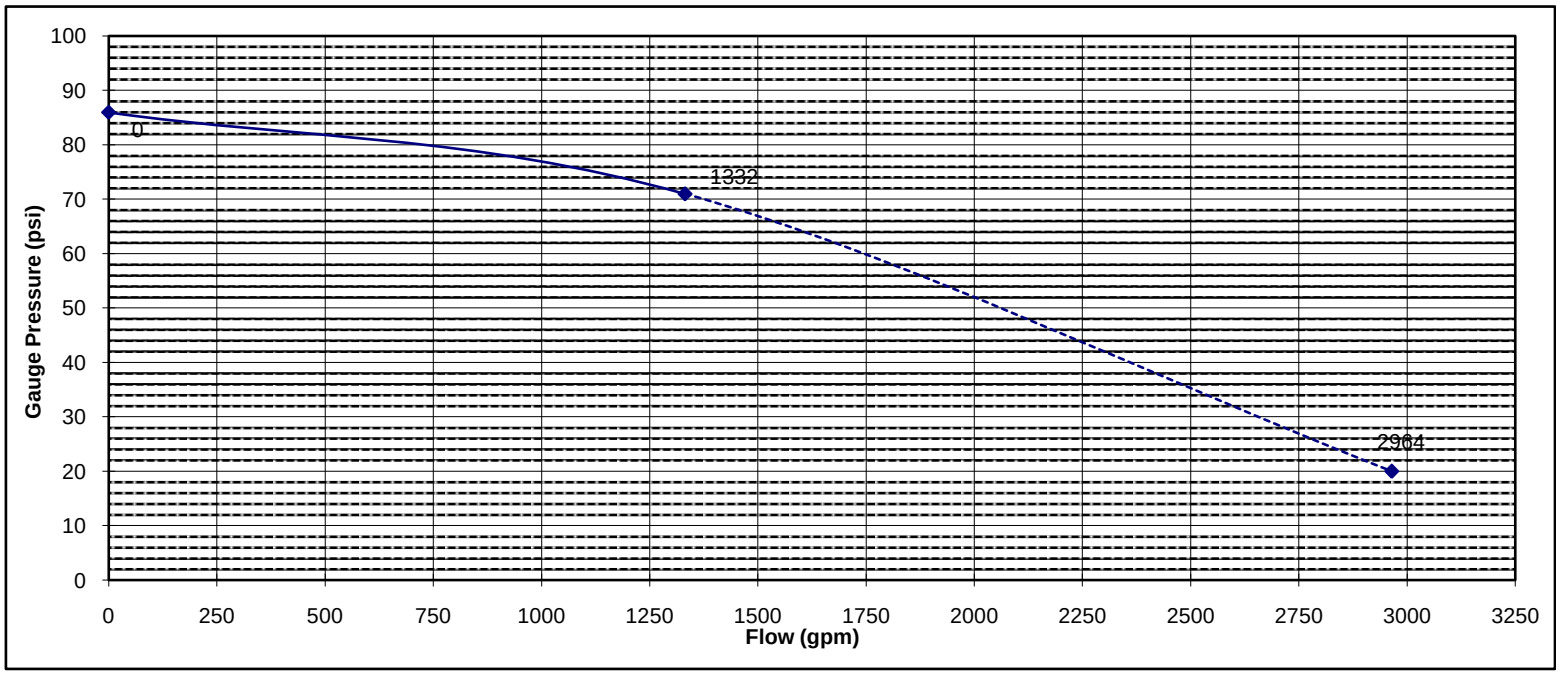
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	86	psi @	0	gpm
Residual pressure of	71	psi @	1331.8	gpm
Available flow @	20	psi --	2964.2	gpm

Flow at 20 psi: 2964.2 gpm



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FF-10 / WTFH3N1WSE160011 / 140TH AVE & CACTUS RD

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 88.00

Residual Pressure: 75

Pitot Reading: 64.00

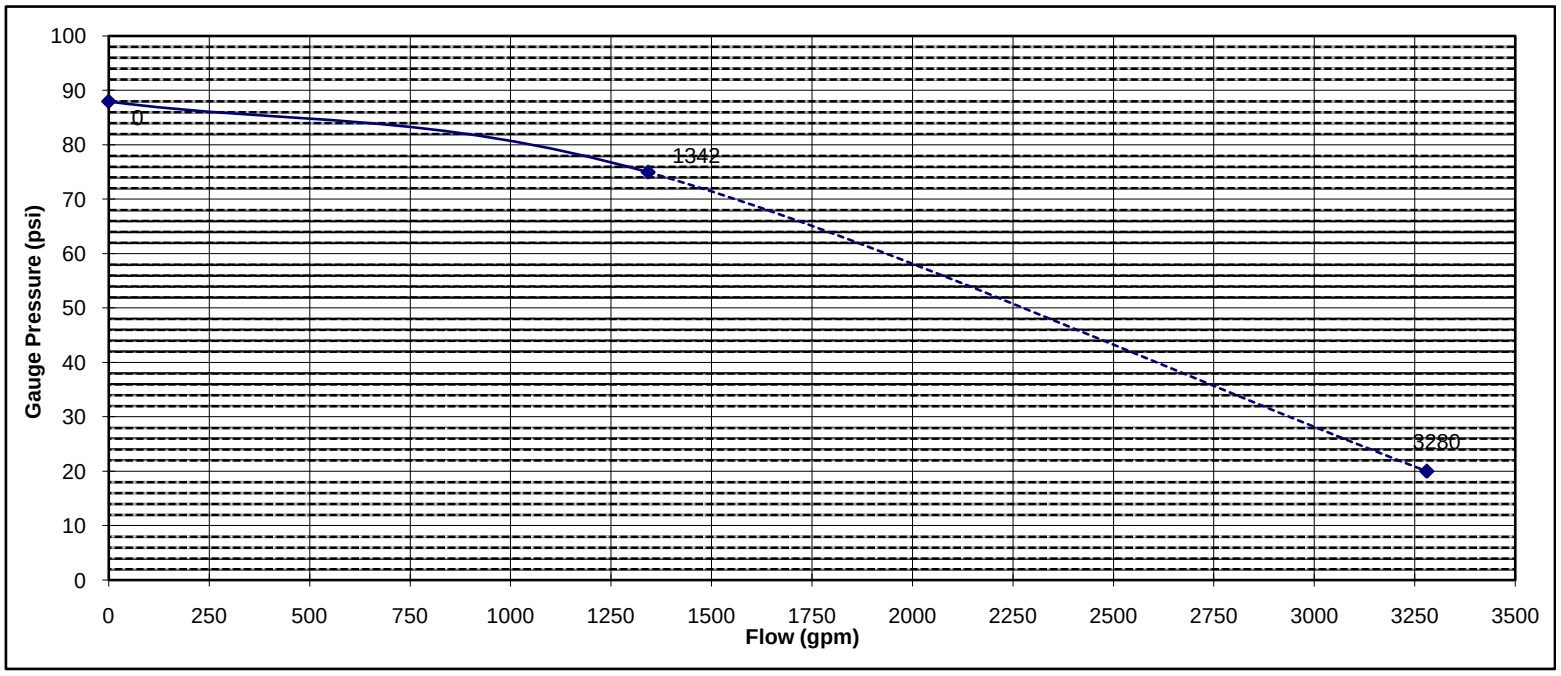
Flow: 1342.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	88	psi @	0	gpm
Residual pressure of	75	psi @	1342.4	gpm
Available flow @	20	psi --	3280.1	gpm

Flow at 20 psi: 3280.1 gpm



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Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-11 / WTFH3N1WNW170013 / NEC OF SWEETWATER & NFP BL

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 72.00

Residual Pressure: 64

Pitot Reading: 48.00

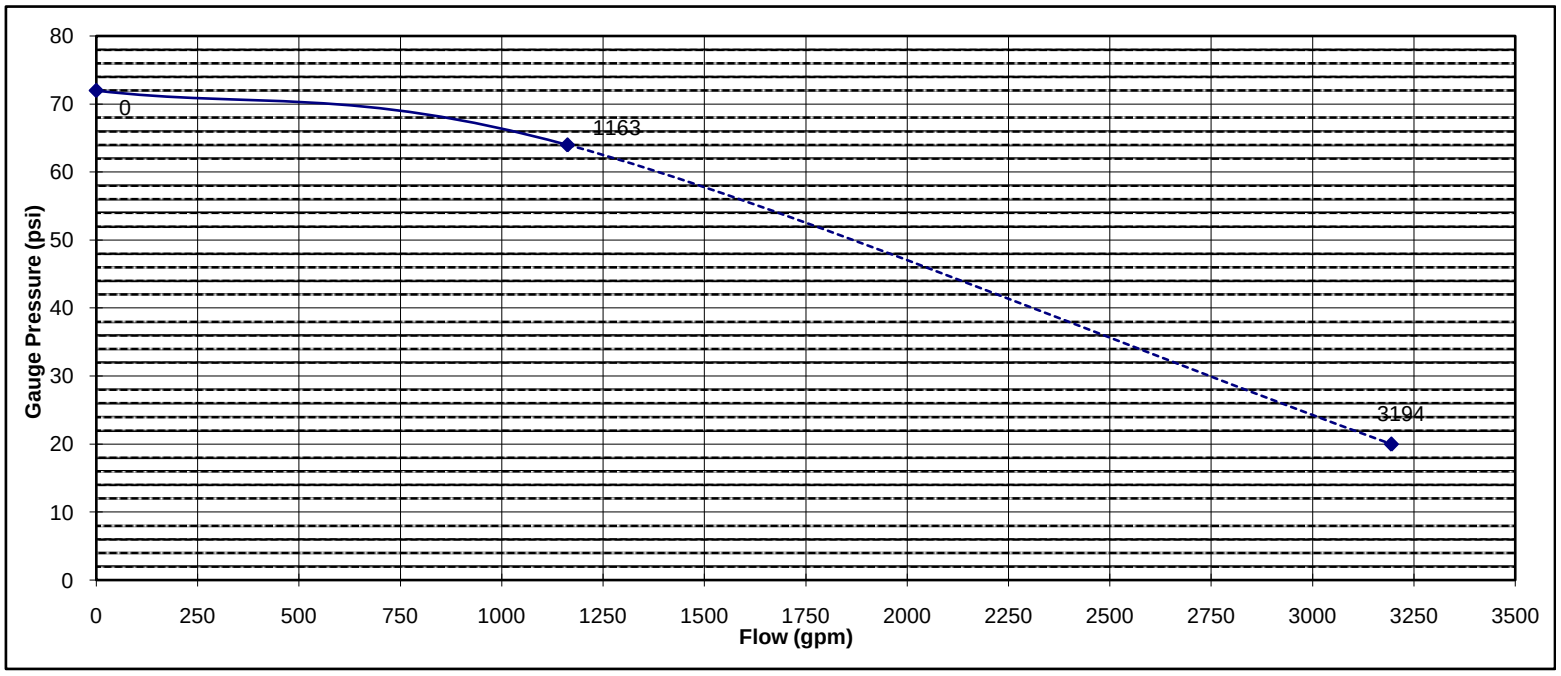
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	72	psi @	0	gpm
Residual pressure of	64	psi @	1162.5	gpm
Available flow @	20	psi --	3194.3	gpm

Flow at 20 psi: 3194.3 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-11 / WTFH3N1WNW170013 / NEC OF SWEETWATER & NFP BL

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 69.00

Residual Pressure: 55

Pitot Reading: 54.00

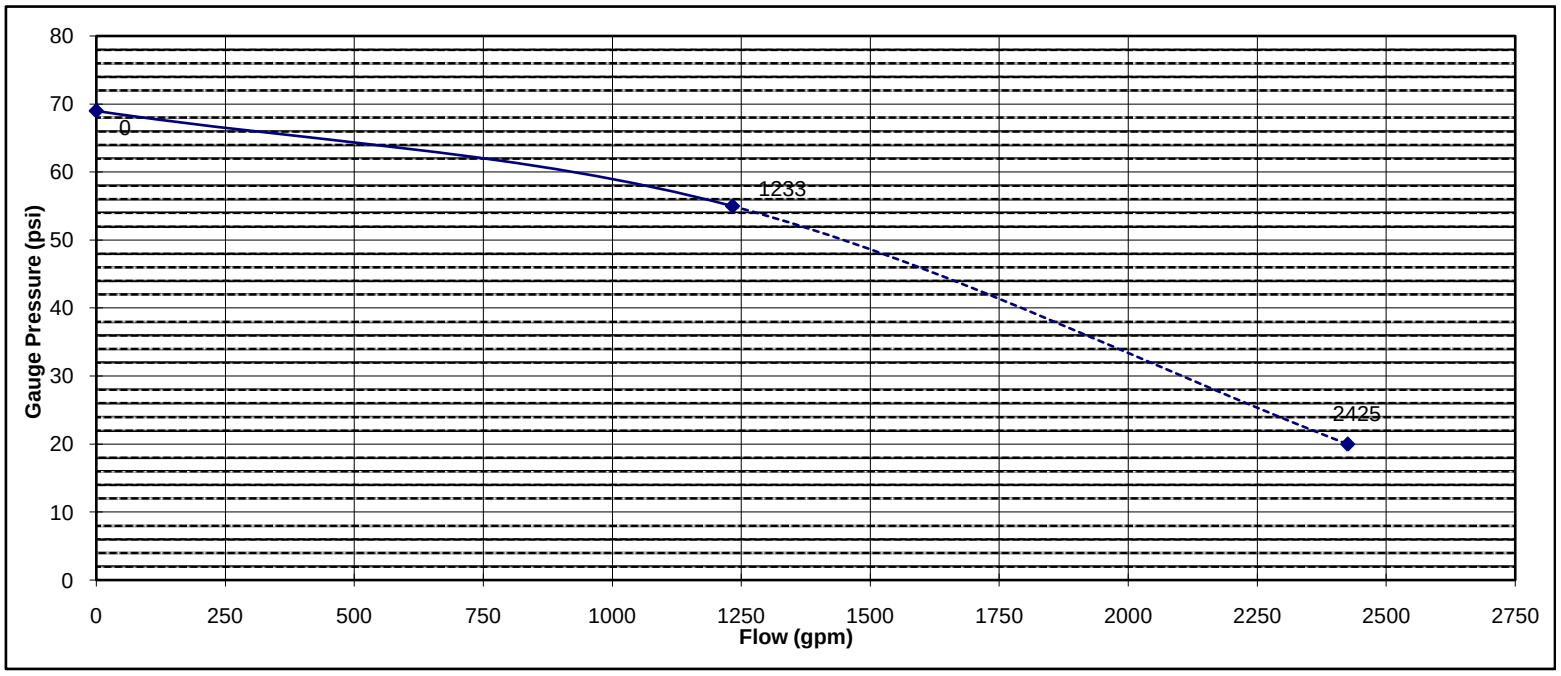
Flow: 1233.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	69	psi @	0	gpm
Residual pressure of	55	psi @	1233.0	gpm
Available flow @	20	psi --	2425.3	gpm

Flow at 20 psi: 2425.3 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-11 / WTFH3N1WNW170013 / NEC OF SWEETWATER & NFP BL

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 74.00

Residual Pressure: 60

Pitot Reading: 54.00

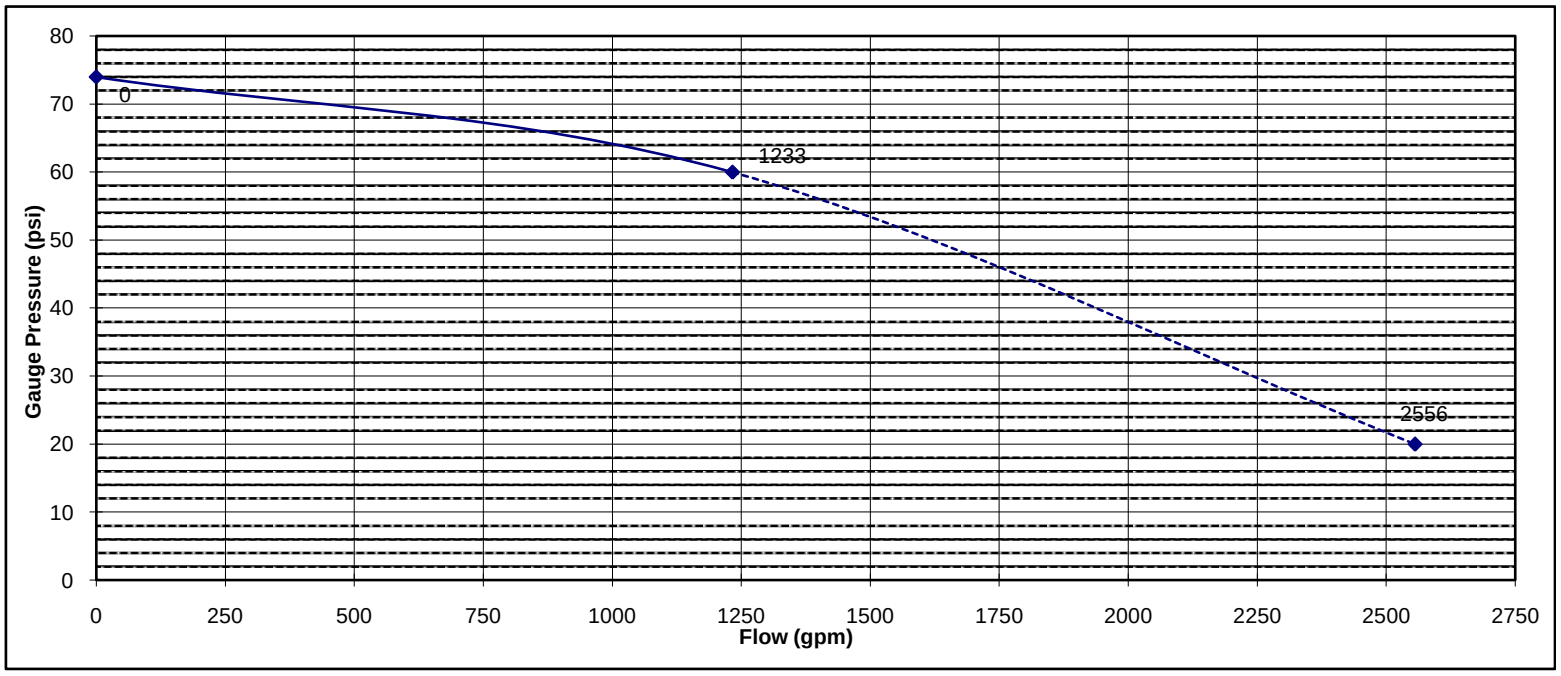
Flow: 1233.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	74	psi @	0	gpm
Residual pressure of	60	psi @	1233.0	gpm
Available flow @	20	psi --	2556.0	gpm

Flow at 20 psi: 2556.0 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-12 / WTFH3N1WSE170006 / W. CACTUS & 2 BLKS E. OF 151AVE

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 71

Pitot Reading: 48.00

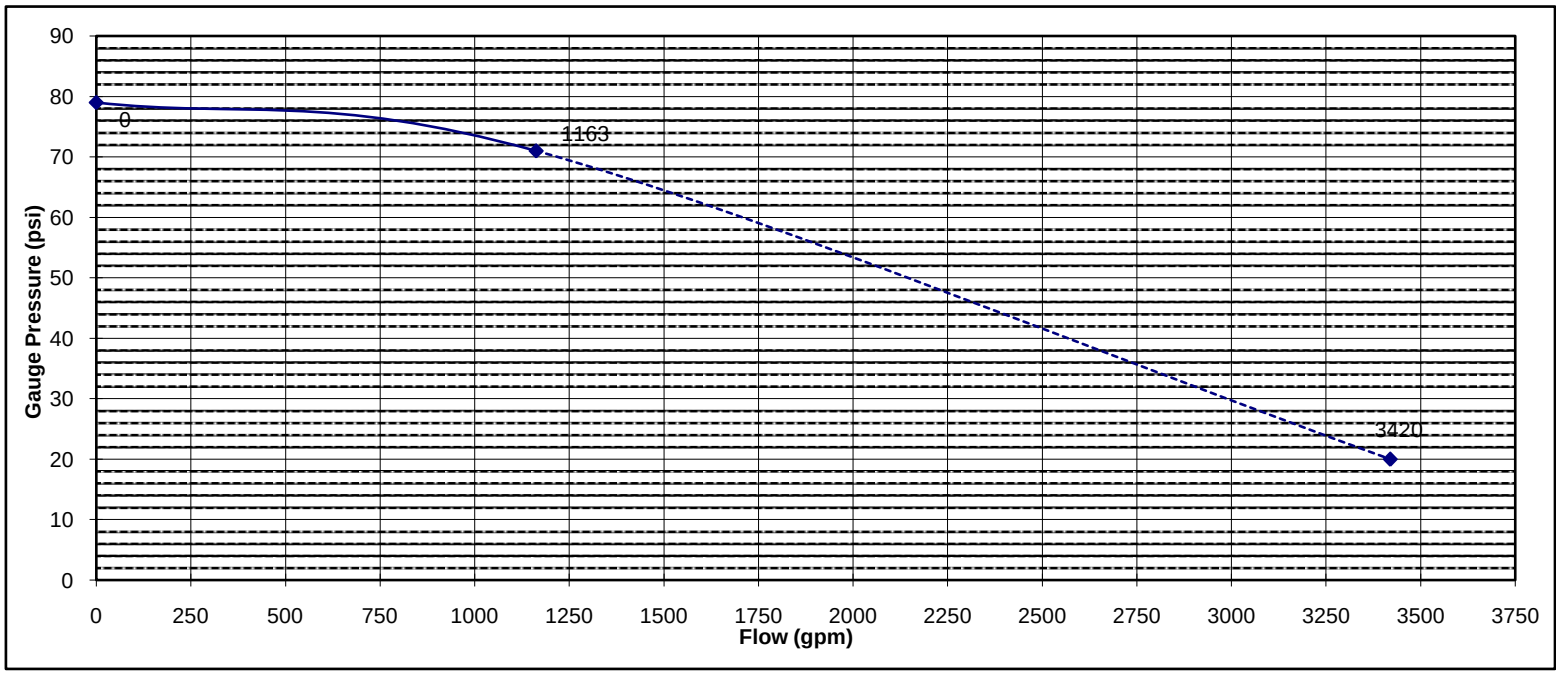
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	71	psi @	1162.5	gpm
Available flow @	20	psi --	3419.7	gpm

Flow at 20 psi: 3419.7 gpm



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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-12 / WTFH3N1WSE170006 / W. CACTUS & 2 BLKS E. OF 151AVE

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 80.00

Residual Pressure: 64

Pitot Reading: 50.00

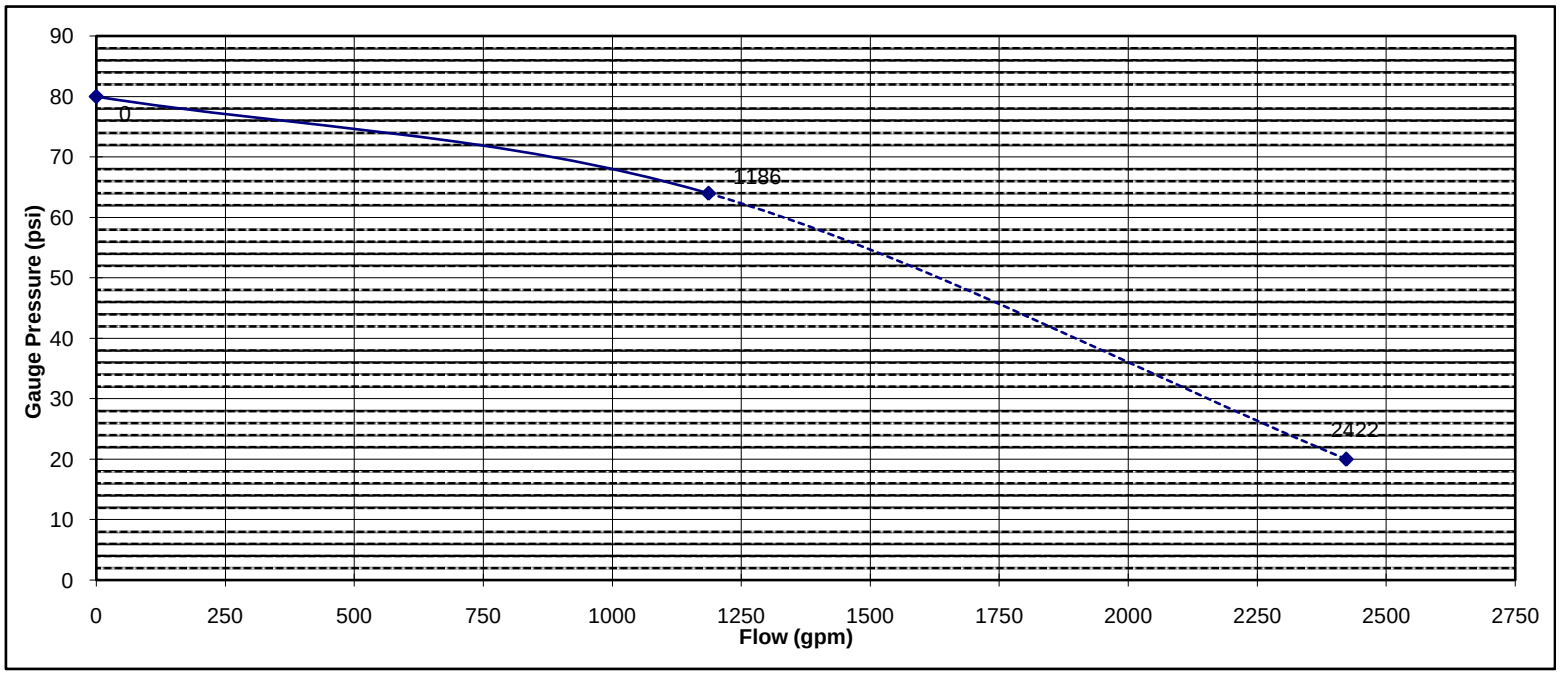
Flow: 1186.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	80	psi @	0	gpm
Residual pressure of	64	psi @	1186.5	gpm
Available flow @	20	psi --	2422.4	gpm

Flow at 20 psi: 2422.4 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-12 / WTFH3N1WSE170006 / W. CACTUS & 2 BLKS E. OF 151AVE

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 80.00

Residual Pressure: 62

Pitot Reading: 48.00

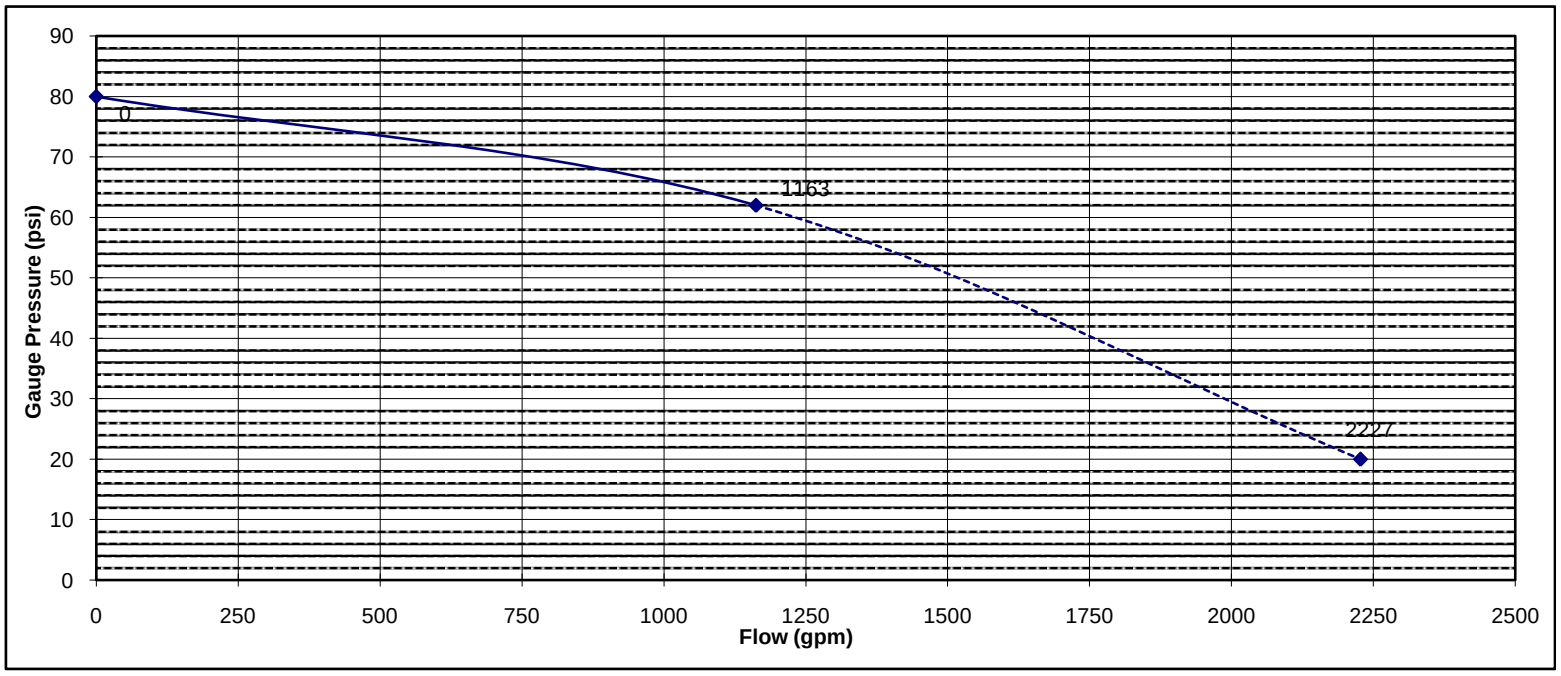
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	80	psi @	0	gpm
Residual pressure of	62	psi @	1162.5	gpm
Available flow @	20	psi --	2227.2	gpm

Flow at 20 psi: 2227.2 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-13 / WTFH3N1WSE200002 / W. GABRIELA, S. 151 LN & BECKER

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 75

Pitot Reading: 62.00

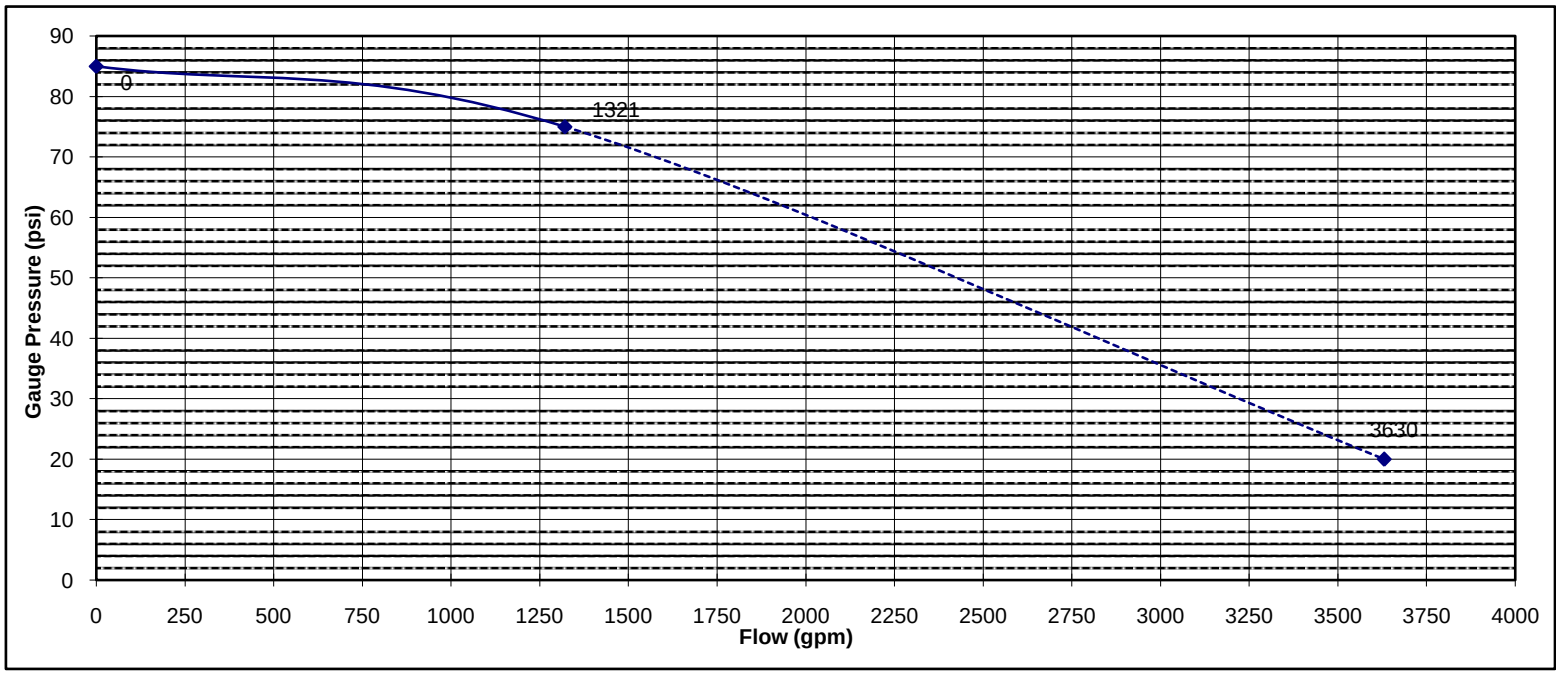
Flow: 1321.2 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	75	psi @	1321.2	gpm
Available flow @	20	psi --	3630.3	gpm

Flow at 20 psi: 3630.3 gpm



Comments:

NOTES:

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2. Flow analysis assumes a gravity flow system with no distribution pumps and having no demand, other than the test
3. The distance between hydrants, elevations & main diameters are for information only.

WESTERN STATES FIRE PROTECTION CO.

2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-13 / WTFH3N1WSE200002 / W. GABRIELA, S. 151 LN & BECKER

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 84.00

Residual Pressure: 64

Pitot Reading: 57.00

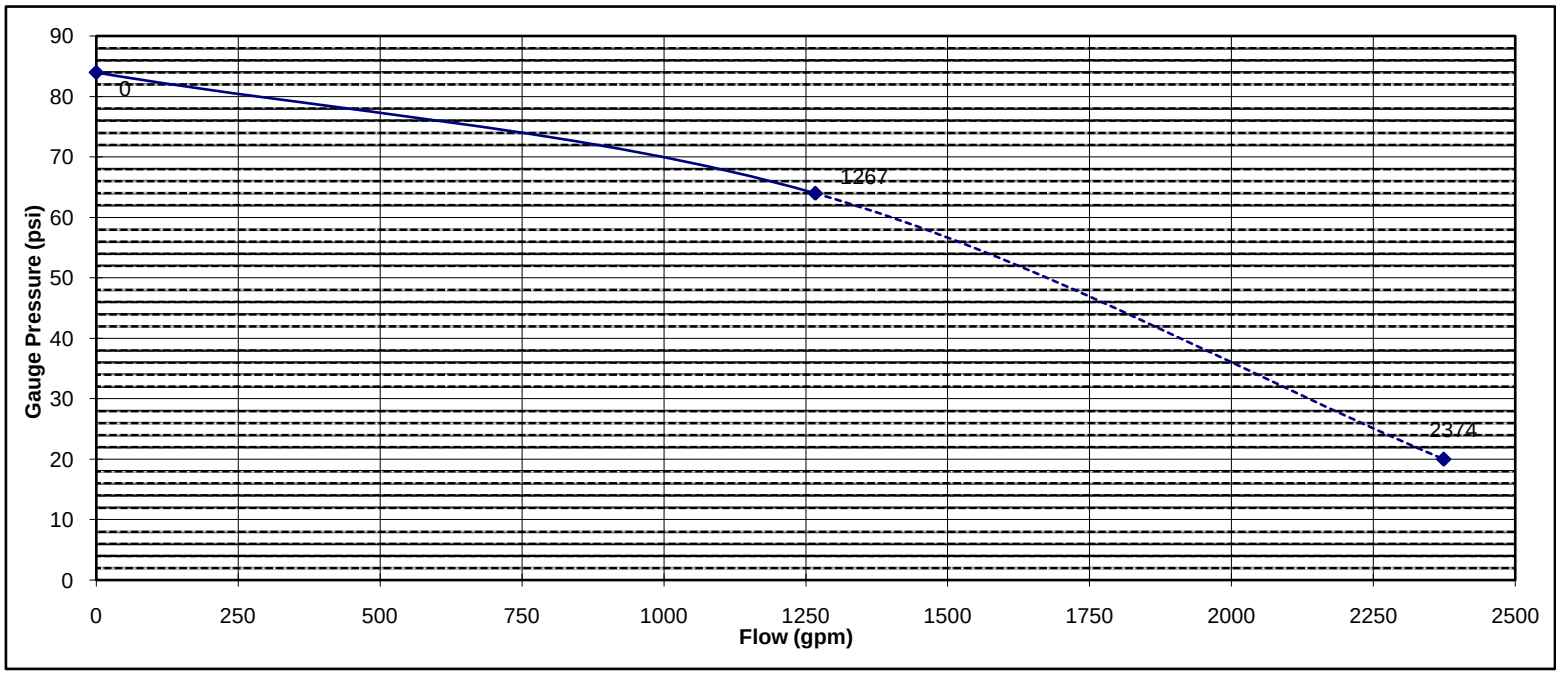
Flow: 1266.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	84	psi @	0	gpm
Residual pressure of	64	psi @	1266.8	gpm
Available flow @	20	psi --	2374.1	gpm

Flow at 20 psi: 2374.1 gpm



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Phoenix, Az. 85008-6945
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DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 86.00

Residual Pressure: 70

Pitot Reading: 58.00

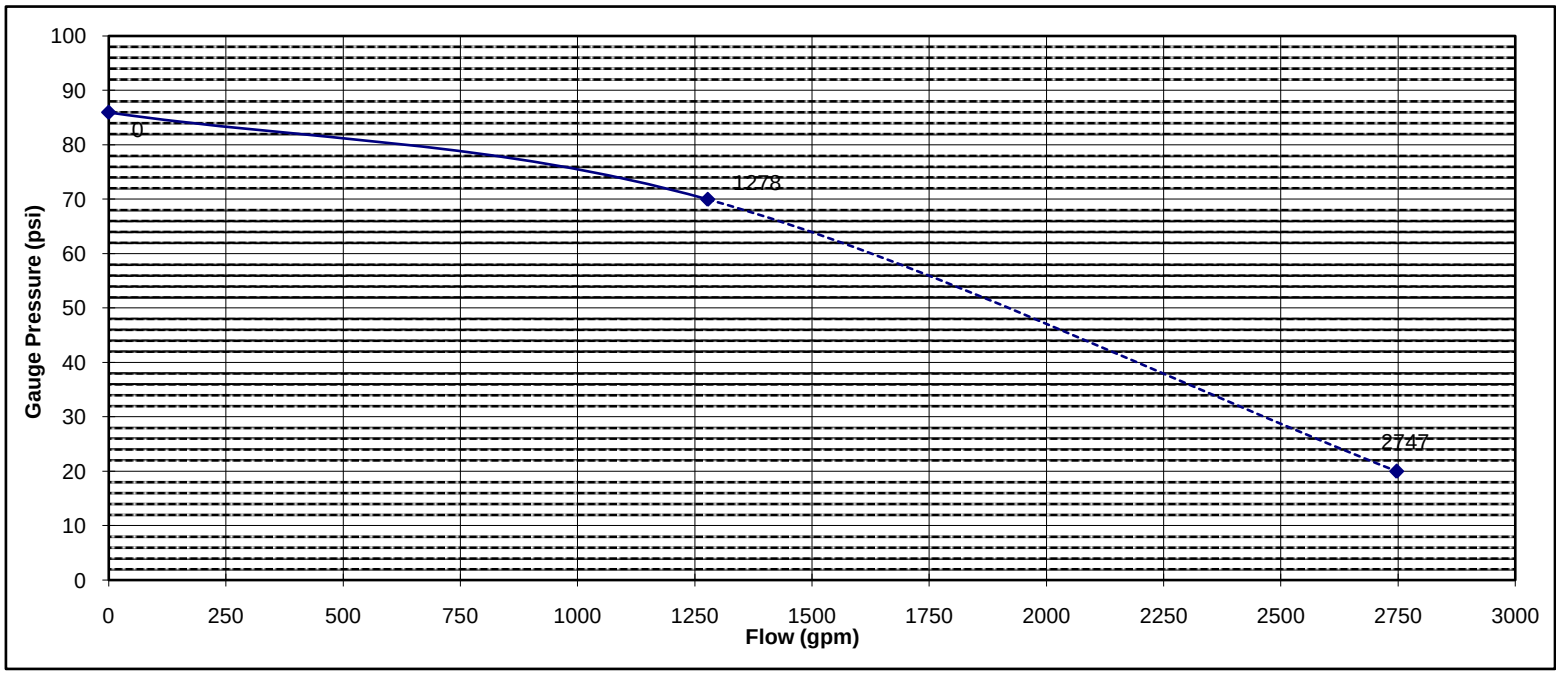
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	86	psi @	0	gpm
Residual pressure of	70	psi @	1277.9	gpm
Available flow @	20	psi --	2746.7	gpm

Flow at 20 psi: 2746.7 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-14 / WTFH3N1WNW100020 / NWC OF ACAPULCO & 137TH

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 72.00

Residual Pressure: 49

Pitot Reading: 47.00

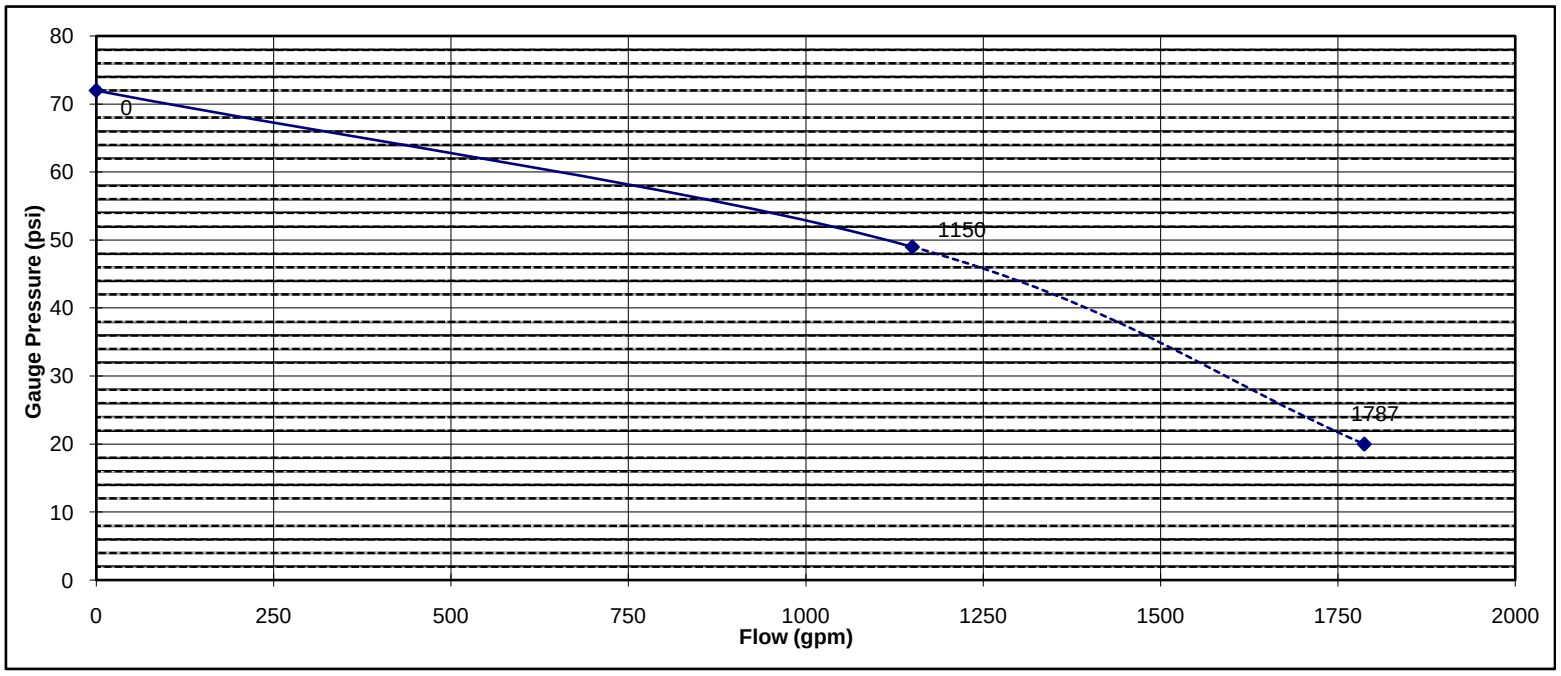
Flow: 1150.3 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	72	psi @	0	gpm
Residual pressure of	49	psi @	1150.3	gpm
Available flow @	20	psi --	1787.0	gpm

Flow at 20 psi: 1787.0 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-14 / WTFH3N1WNW100020 / NWC OF ACAPULCO & 137TH

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 76.00

Residual Pressure: 56

Pitot Reading: 48.00

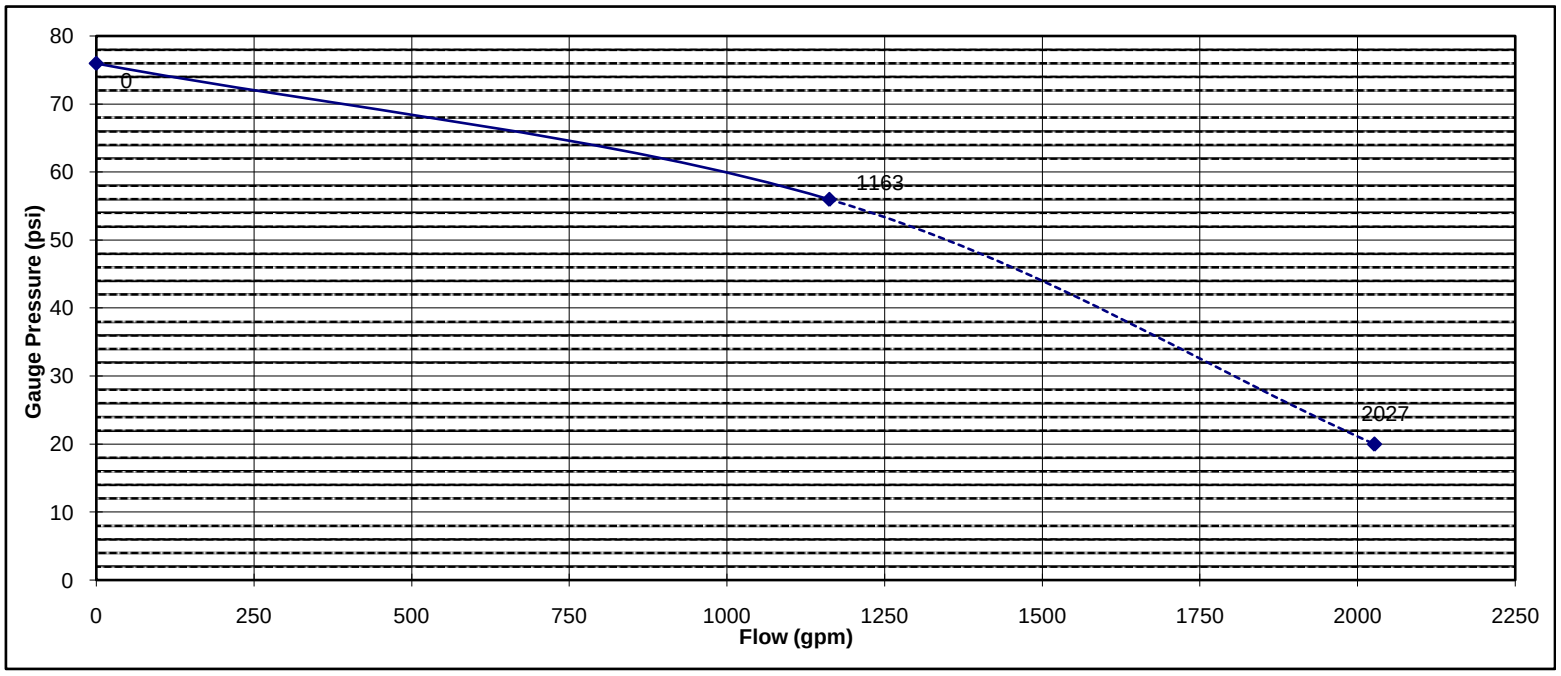
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	76	psi @	0	gpm
Residual pressure of	56	psi @	1162.5	gpm
Available flow @	20	psi --	2027.0	gpm

Flow at 20 psi: 2027.0 gpm



Comments:

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Phoenix, Az. 85008-6945
FF-14 / WTFH3N1WNW100020 / NWC OF ACAPULCO & 137TH

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 75.00

Residual Pressure: 62

Pitot Reading: 50.00

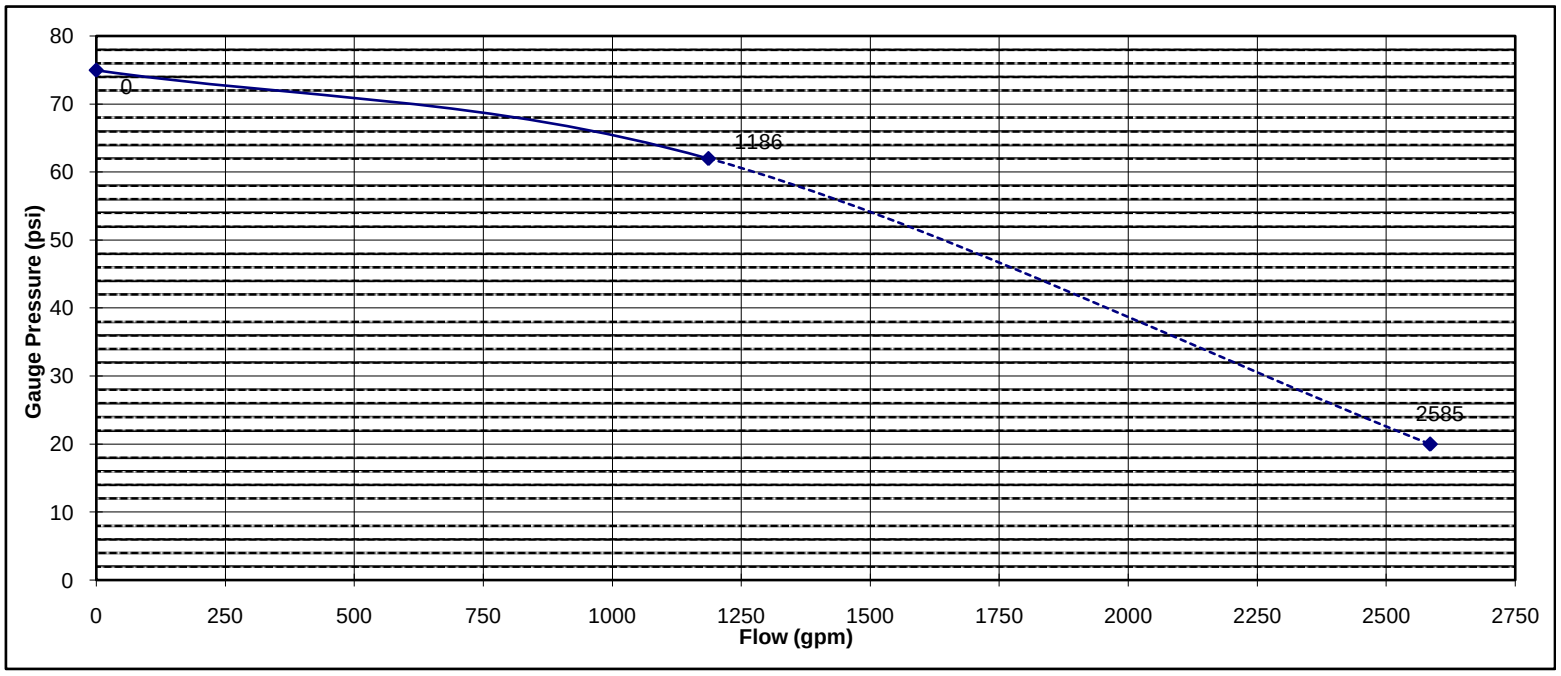
Flow: 1186.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	75	psi @	0	gpm
Residual pressure of	62	psi @	1186.5	gpm
Available flow @	20	psi --	2585.4	gpm

Flow at 20 psi: 2585.4 gpm



Comments:

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FF-15 / WTFH3N1WSE090052 / WADDELL RD & 140TH, NEC

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1
Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 70

Pitot Reading: 62.00

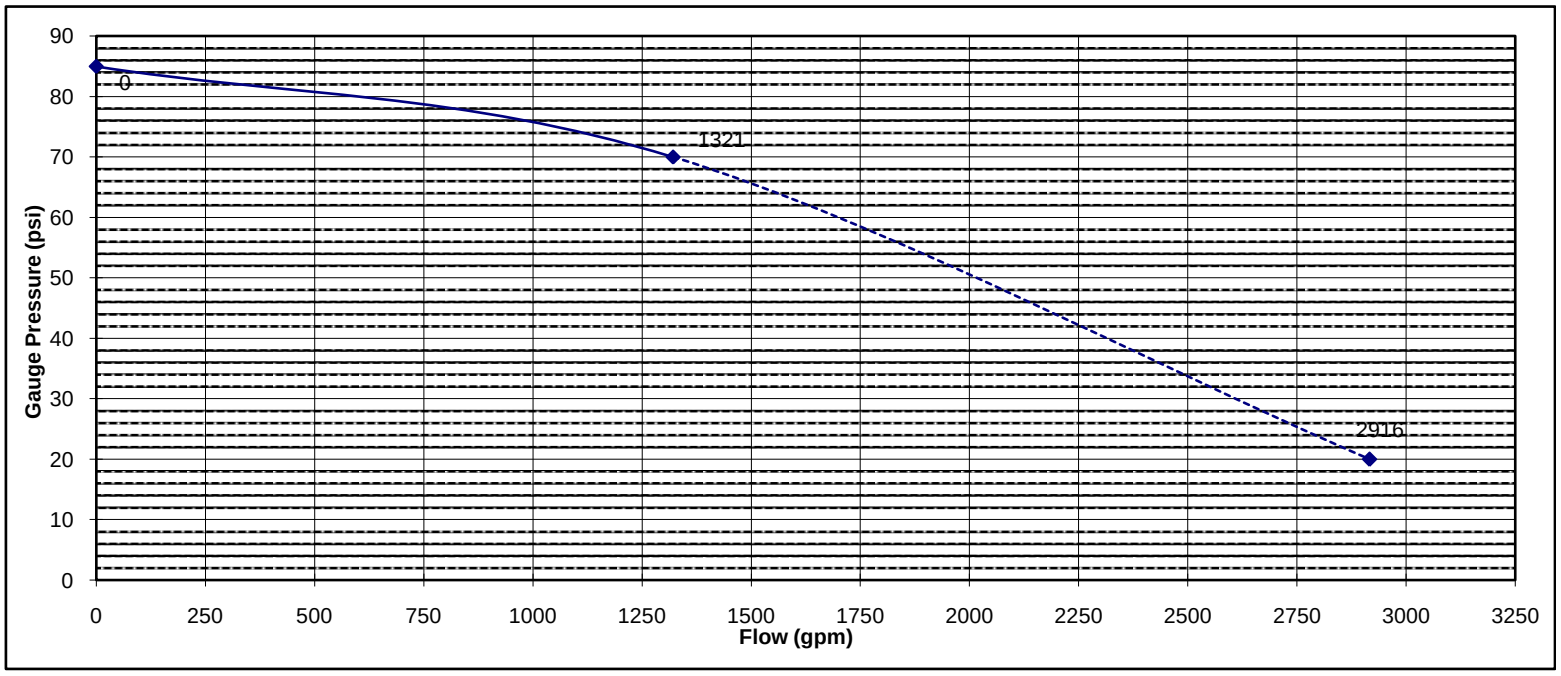
Flow: 1321.2 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	70	psi @	1321.2	gpm
Available flow @	20	psi --	2916.5	gpm

Flow at 20 psi: 2916.5 gpm



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DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 98.00

Residual Pressure: 76

Pitot Reading: 70.00

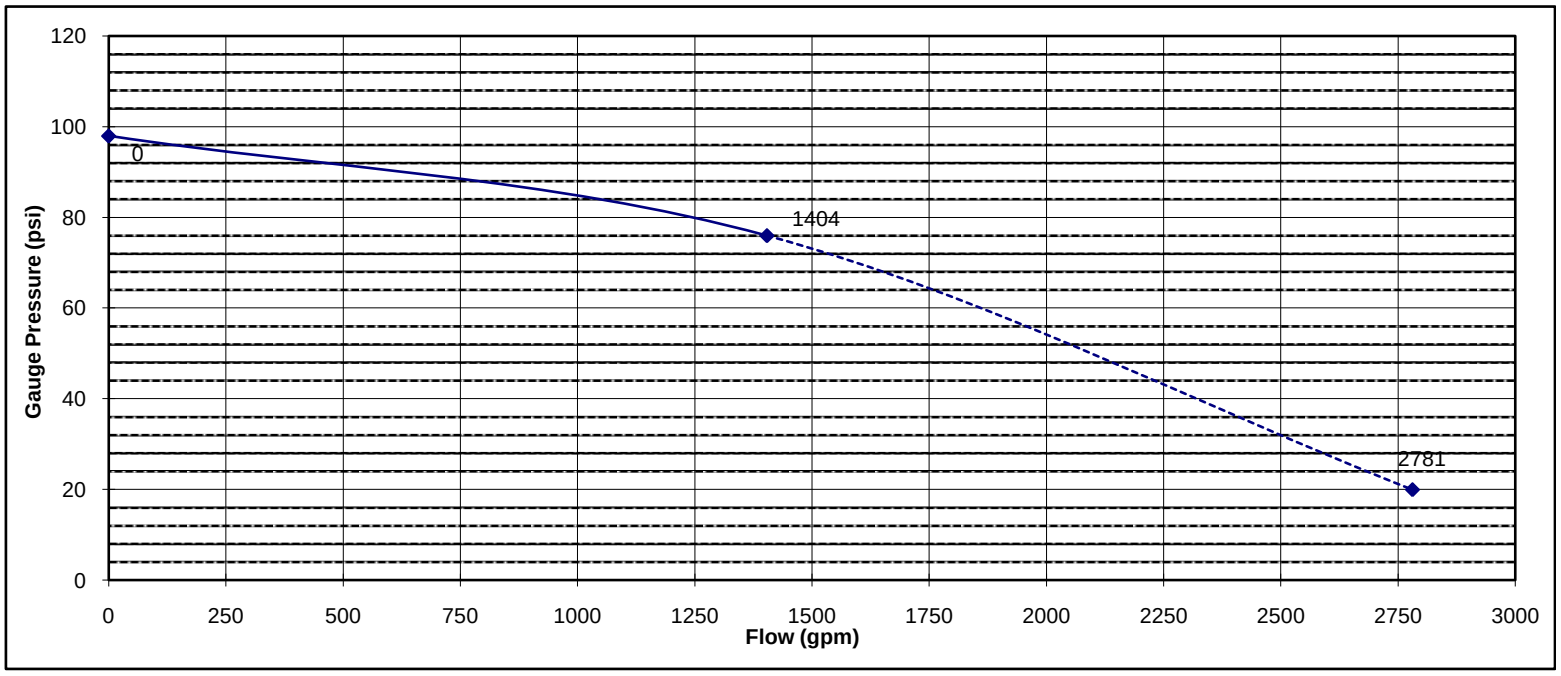
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	98	psi @	0	gpm
Residual pressure of	76	psi @	1403.9	gpm
Available flow @	20	psi --	2780.7	gpm

Flow at 20 psi: 2780.7 gpm



Comments:

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Phoenix, Az. 85008-6945
FF-15 / WTFH3N1WSE090052 / WADDELL RD & 140TH, NEC

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 98.00

Residual Pressure: 79

Pitot Reading: 70.00

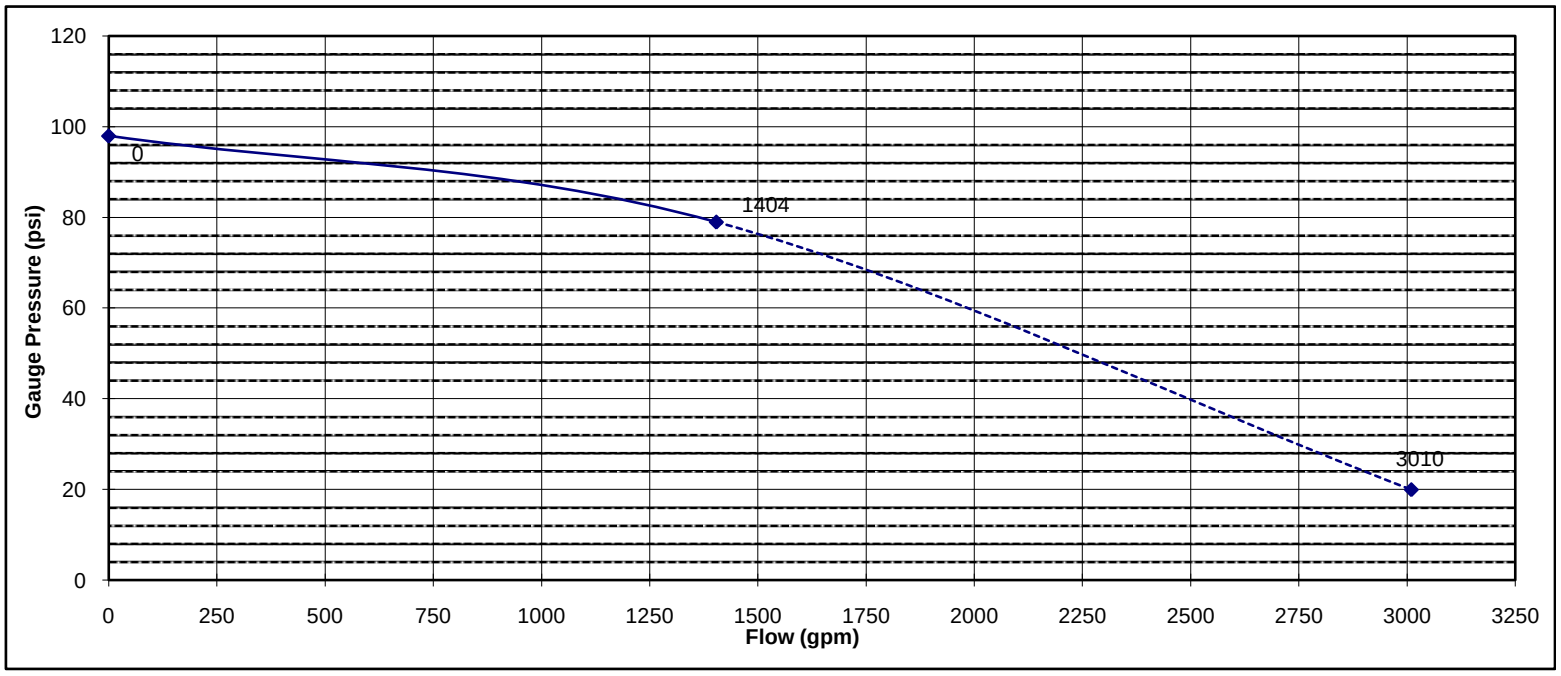
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	98	psi @	0	gpm
Residual pressure of	79	psi @	1403.9	gpm
Available flow @	20	psi --	3009.7	gpm

Flow at 20 psi: 3009.7 gpm



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C. Wastewater System Model Development and Calibration

This appendix contains the technical memorandum summarizing the following tasks in its entirety:

- Task 5.3 – Wastewater Collection System Monitoring
- Task 5.4 – Flow Model

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City of Surprise, Arizona
Water Services Department • 12425 West Bell Road • Surprise, AZ 85374-9002

Integrated Water Master Plan

Wastewater Technical Memorandum:

Task 5.3 – Wastewater Collection System Monitoring
Task 5.4 – Flow Model

November 2008

Report Prepared By:

Malcolm Pirnie, Inc.

4646 East Van Buren Street
Suite 400
Phoenix, AZ 85008

4957-006

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A. Flow Monitoring Test Results

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1. Introduction

1.1. Background

The City of Surprise (City) Water Services Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

The City is expecting to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007). To prepare for this growth and additional growth as the City approaches build-out, the City prepared a *Water Resources Master Plan* and an *Infrastructure Master Plan* in June 2004. The Water Resources Master Plan was developed to ensure that the City's water supplies were adequate to meet the current and projected demands. The Infrastructure Master Plan addressed water, wastewater, reclaimed water, and groundwater recharge infrastructure. The master plans considered a municipal planning area (MPA) of 228 square miles that was broken up into five special planning areas (SPAs): SPA 1 through SPA 5. The master plans, however, did not consider the sixth, 71 square-mile expansion area in the north, SPA 6, that has since been added to the City's MPA.

The existing water resources and infrastructure master plans are in need of updating; they are now four years old, and considerable changes have been experienced in growth and development patterns, as well as the addition of SPA 6 to the City's MPA. In December 2007, the City retained Malcolm Pirnie, Inc., in association with Replenishment Services, LLC and ASU Decision Theater, to update the master plans into an *Integrated Water Master Plan*.

1.2. Project Purpose and Scope

The purpose of the *Integrated Water Master Plan* project is to provide a long-term guidance document for the orderly improvement and growth of the City's water supply portfolio and drinking water, wastewater, reclaimed water, and groundwater recharge infrastructure. Table 1-1 provides a summary of the scope of work technical tasks for each master plan component of the *Integrated Water Master Plan* project.

The purpose of the Water Resources Master Plan component is to identify the projected water demands as the City continues to grow and to develop a water resources strategy that will meet the demands in a cost-effective and sustainable manner. To prepare for the infrastructure master plan updates, the Water Resources Master Plan component also

includes updates to projections of wastewater flows, reclaimed water availability, and reclaimed water demands in an integrated fashion. Finally, the Water Resources Master Plan component includes a review and evaluation of water reuse options and reuse program alternatives as a critical element of the City's water resource portfolio.

The purpose of the Recharge Master Plan component is to support the Water Resources Master Plan by evaluating options and program alternatives to recharge reclaimed water supplies, and to develop a comprehensive plan and infrastructure improvements that allows the City to recharge reclaimed water in a legal, cost-effective, and sustainable manner.

The purpose of the Water Infrastructure, Wastewater, and Reclaimed Water Master Plan components is to enhance the existing plans where reasonable and to provide the City with comprehensive master plans that allow the City to manage its infrastructures in an effective and efficient manner and to provide for infrastructure expansions.

Table 1-1.
Integrated Water Master Plan Technical Scope of Work Tasks

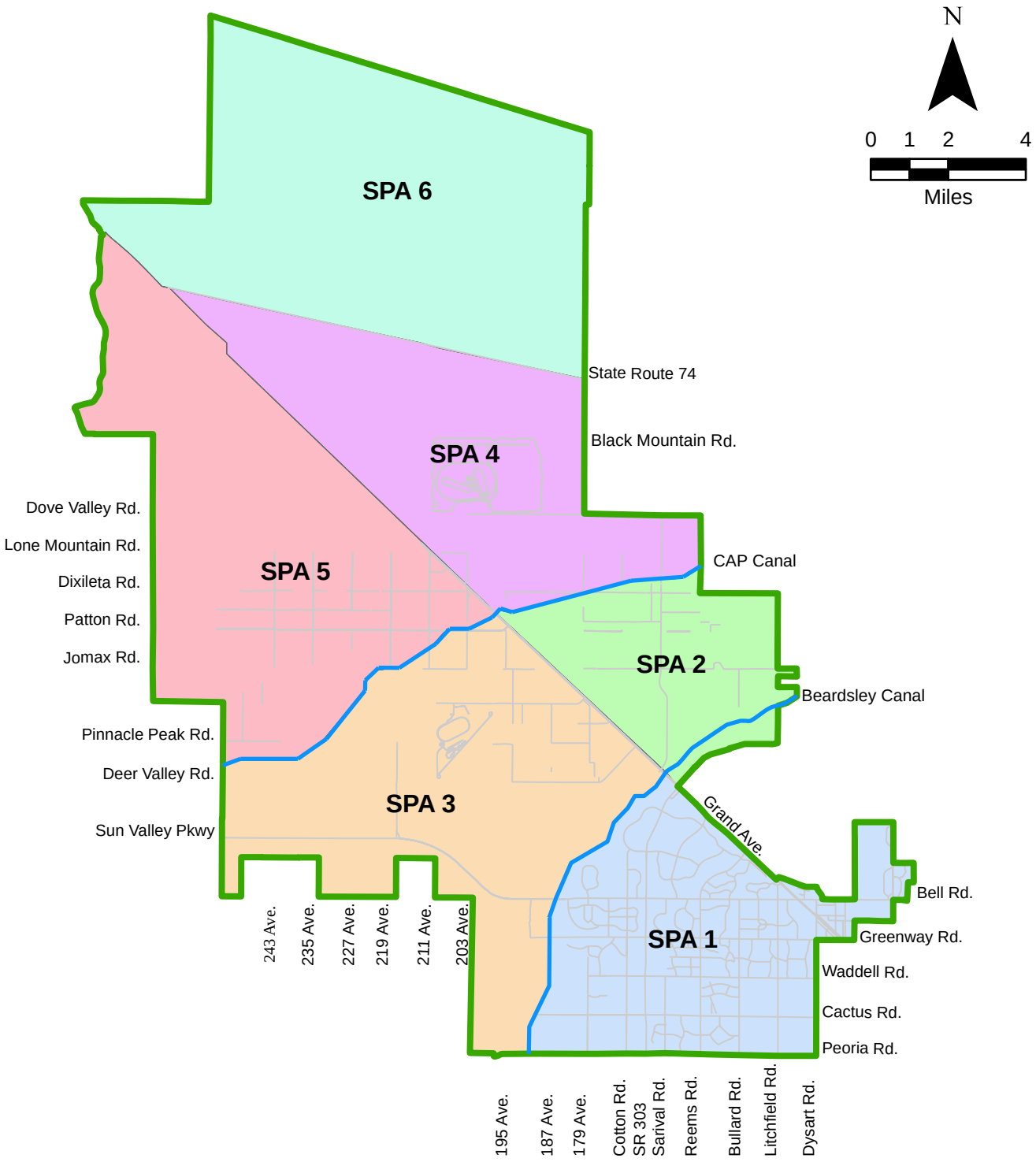
Water Resources Master Plan	**Drinking Water Infrastructure Master Plan**
2.1 Review of Regulations and Guidelines	4.1 Review of Regulations and Guidelines
2.2 Review of Background Information	4.2 Review of Background Information
2.3 Supplies	4.3 Fire Flow Testing
2.4 CAGRD Replenishment Obligations	4.4 Flow Model
2.5 Demand and Flow Factors	4.5 Evaluation of the Existing System
2.6 Demand Module	4.6 Improvements to the Existing System
2.7 Additional Water Supplies	4.7 Drinking Water Infrastructure Master Plan Report
2.8 Reclaimed Water Management	**Wastewater Master Plan**
2.9 Dual Water System Evaluation	5.1 Review of Regulations and Guidelines
2.10 Water Resource Model	5.2 Review of Background Information
2.11 Water Resource Scenarios	5.3 Wastewater Collection System Monitoring
2.12 Water Resource Management	5.4 Flow Model
2.13 Assured Water Supply Management	5.5 Evaluation of the Existing System
2.14 Water Resources Master Plan Report	5.6 Improvements to the Existing System
	5.7 Wastewater Master Plan Report
Recharge Master Plan	**Reclaimed Water Master Plan**
3.1 Regulations and Background Information	6.1 Review of Background Information
3.2 Recharge Methods and Evaluation	6.2 Flow Model
3.3 Recharge Improvements	6.3 Evaluation of the Existing System
3.4 Build-out of the Recharge System	6.4 Improvements to the Existing System
3.5 Recharge Master Plan Report	6.5 Reclaimed Water Master Plan Report

1.3. Purpose of Technical Memorandum

The purpose of this technical memorandum is to summarize the work conducted in Wastewater Master Plan Tasks 5.3 (Wastewater Collection System Monitoring) and 5.4 (Flow Model). The technical memorandum includes descriptions of how the wastewater collection system model was developed, the collection system monitoring that was conducted, and the process used to calibrate the model using the collection system monitoring results. In future tasks, the calibrated model will be used to evaluate the existing system and future scenarios to determine necessary wastewater infrastructure improvements.

1.4. Study Area

The study area for this project, illustrated on Figure 1-1, includes all of the City's MPA. The MPA has been divided into six SPAs to maintain consistency with the City's previous master plan efforts and for convenience of wastewater and reclaimed water planning; i.e., the SPAs comprise logical drainage areas for existing, planned, and potential water reclamation facilities.



Legend

- Streets
- Canals
- Municipal Planning Area
- Special Planning Areas

MALCOLM PIRNIE

4646 E. Van Buren St.,
Suite 400
Phoenix, AZ 85008

CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Study Area

November 2008 | **Figure 1-1**

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2. Model Development

A computerized hydraulic model was developed to simulate the response of the City's wastewater collection and conveyance system to wastewater flow generation scenarios. The model was used to identify the adequacy of the system to accommodate existing and projected wastewater flows within the existing service area and to identify future system improvements as the service area develops. This section describes the development of the City's existing wastewater collection system model.

2.1. Data Sources

The primary sources of information for the current modeling effort were the most current geographical information system (GIS) shapefiles provided by the City and the existing collection system model last updated in 2004. Supplemental information for the model was collected during field visits conducted in May 2008 and through interviews with City staff. Collection system spatial loadings were obtained from the Water Resource Demand Module (Demand Module) developed as a part of *Water Resources Master Plan.*

2.2. Model Description

As indicated in the previous master planning efforts, collection system flows within the City's wastewater planning areas were divided into SPAs. Because a majority of existing developments lie in SPA 1, the existing system model updated was limited to SPA 1. The City did not have an existing wastewater model for new developments within the other area that is partially developed, SPA 2. Models for SPA 2 and other the remaining SPAs will be developed and evaluation as part of subsequent tasks in the Wastewater Master Plan.

The City's existing collection system was modeled using SewerCAD®, version 5.6. SewerCAD® is a commercially available program for the design and analysis of gravity flow and pressure flow through pipe networks and pumping stations. The gravity network is calculated using a built-in numerical model, which utilizes both the direct step and standard step, gradually varied flow methods. Gravity and pressure flow components can also be modeled, with the systems in parallel or in series as they exist in the field. Pressure flow elements can be controlled based on system hydraulics, with pumps turned on or off based on changes in flows and pressures.

SewerCAD® can run both steady state and extended period analyses. Steady state analyses model a single instant in time and are generally used to model a network under

peak loading conditions (maximum or minimum) and average loading conditions. Extended period analyses model a network over a specified duration of time and are generally used to model hydrograph loading, wet well capacities, and automated pump behavior. For the purposes of this master planning effort, the City's wastewater collection/conveyance system was modeled using steady state analyses.

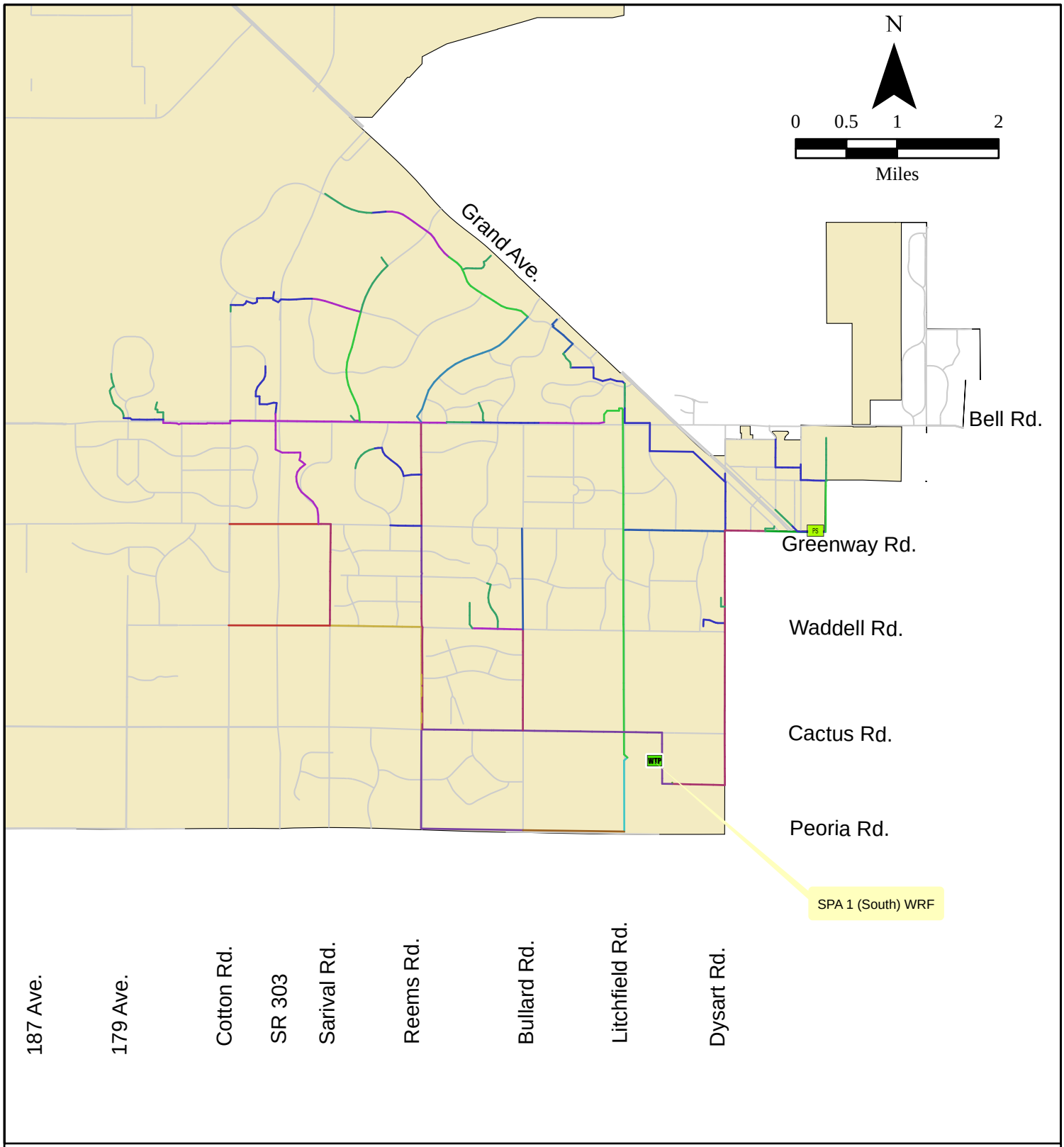
The City's existing system consists of nearly 3 million feet of pipe (gravity and force mains), roughly 11,250 manholes, and 7 pump stations. Because not all pipelines are necessary to adequately model the collection system, a skeletonized network of pipes was represented in the existing model provided by the City. Skeletonization is typically performed using standard modeling procedures to remove pipes that do not change or affect the hydraulics of the system. Starting with the existing model provided by the City, a similar methodology was used to update the model to existing (2008) conditions (Figure 2-1). A comparison of the modeled system versus the entire collection system (as measured from the City's GIS database) is shown in Table 2-1. The percentage of the existing wastewater infrastructure shown in Table 2-1 that is being modeled is typical for master planning.

Table 2-1.
Modeled and System Attribute Summary

System Attribute	Modeled	System Total	Percent of System Modeled
Manholes	553	11,250	4.9%
Gravity Sewers (feet)	202,000	2,903,299	7.0%
Force Mains (feet)	2,619	60,385	4.3%
Pump Stations	2	7	28.6%

2.3. Flow Allocation

Once the physical structures of the model were developed (pipe, manholes, pump stations, etc.), wastewater loadings were imported into the model. The system loadings were located spatially using the Demand Module. The Demand Module utilizes City land use categories, service areas, dwelling unit densities, and water demand factors (gallons per day per acre or per dwelling unit) to project water demands and wastewater flows. The Demand Module assumes that 100 percent of indoor water consumption is returned to the City via the wastewater collection system (wastewater loading). These demands and flows are spatially allocated throughout the City and can be isolated by water service provider, or in this case, wastewater service provider. The flows used in the model calibration were limited to SPA 1 and the City's wastewater service area.



Legend

- Streets
- City of Surprise Wastewater Service Area
- Lift Stations
- Water Reclaimation Facility
- Force Main

Gravity Pipe

- 6 inch
- 8 inch
- 10 inch
- 12 inch
- 15 inch
- 18 inch
- 21 inch
- 24 inch
- 27 inch
- 30 inch
- 42 inch
- 48 inch
- 54 inch

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4646 E. Van Buren St.,
Suite 400
Phoenix, AZ 85008

CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Modeled Collection System (Skeletonized)

November 2008 | **Figure 2-1**

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3. Model Calibration

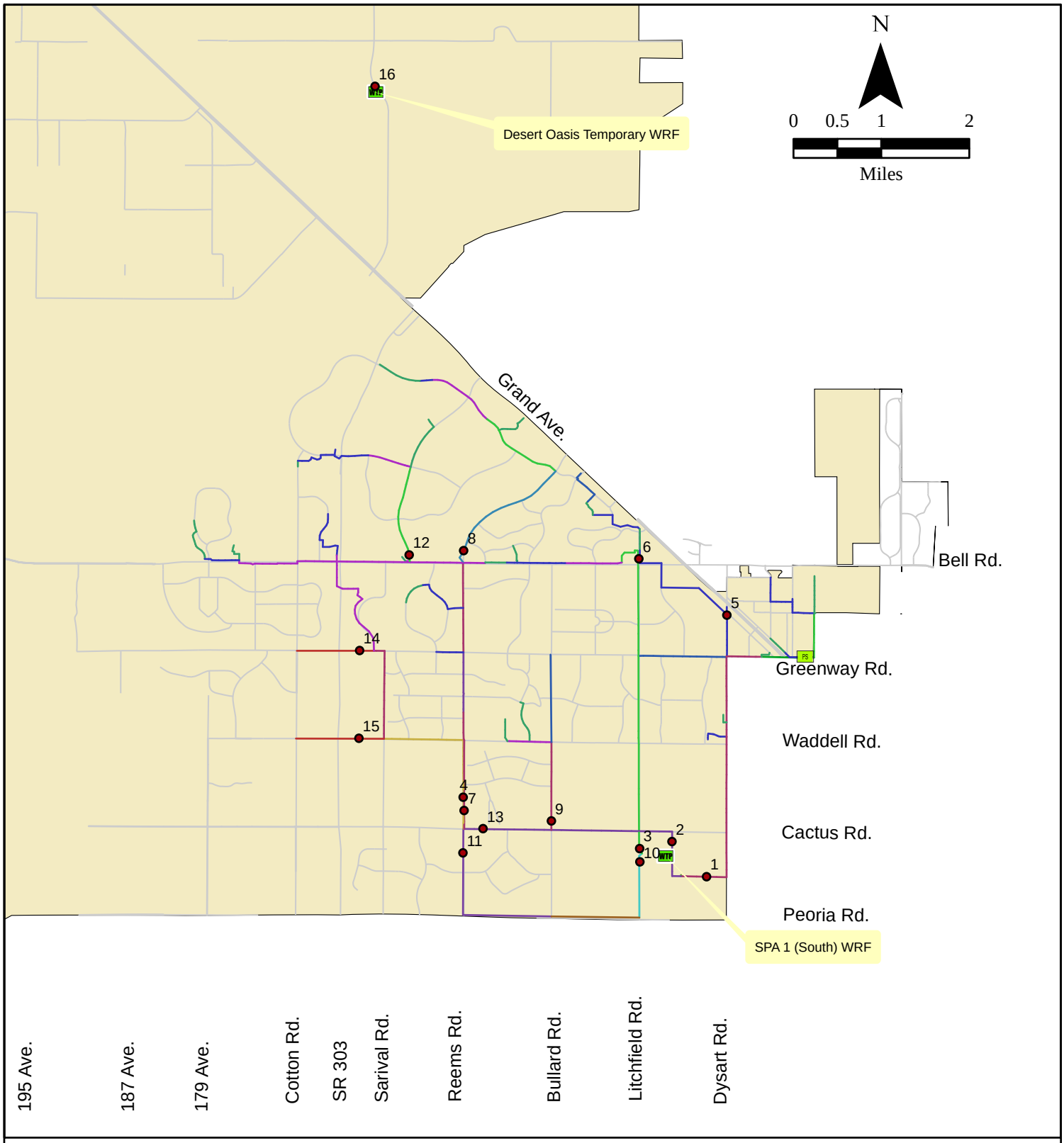
This section describes how the City's existing wastewater collection system was calibrated. Model calibration is necessary before conducting a system analysis to ensure that the model setup represents the actual system with sufficient accuracy. The level of calibration depends on the intended use of the model. The model developed for this project will be a steady-state model with primary use as a master planning tool. Flow and depth data gathered from the collection system monitoring performed in June 2008 were used to calibrate the model.

3.1. Collection System Monitoring

Collection system flow monitoring was conducted to determine the flow, depth, and velocity at key locations throughout the City's collection system (Figure 3-1). The parameters were recorded in 15 minute intervals for a two week period starting on June 12, 2008 and ending on June 25, 2008. Half way through the testing, meter calibration was verified. With the exception of flow meter #5 which captures commercial area flows, the remaining flow meters collected data from residential areas as defined in the City's General Plan. Flow meter #16 was located in SPA 2 to capture data that may be used for future evaluations.

The average, maximum, and minimum values for the flow, depth, and velocity for each flow meter is presented in Table 3-1. The typical hydrograph pattern observed during the testing indicates elevated flows during the weekends, characteristic of bedroom communities where people commute to nearby cities during the work week (Figure 3-2). The maximum hour weekend flow conditions observed during the testing were assessed in the model. The complete set of flow monitoring data is presented in Appendix A.

During the data collection process, it was noted that flow meter #10 was heavily influenced by a nearby pump station, which may have caused some excessive peak flows associated with the pump station's operation. It should also be noted that the meter located in the commercial area (#5) had a different flow pattern than the rest of the meter locations. Its hydrograph exhibited a single peak during business hours as opposed to the diurnal peak normally associated with residential areas. The average flow from flow meter #2 (receiving water from metered basin #9 and #13), was lower than the sum of the flows from flow meters #9 and #13. Review of the flow meter data did not reveal any explanation for this discrepancy and as a result, the data from flow meters #9 and #13 were used instead.



Legend

- Streets
- City of Surprise Wastewater Service Area
- Flow Monitoring Locations
- Lift Stations
- Water Reclaimation Facility
- Force Main

Gravity Pipe

- 6 inch
- 8 inch
- 10 inch
- 12 inch
- 15 inch
- 18 inch
- 21 inch
- 24 inch
- 27 inch
- 30 inch
- 42 inch
- 48 inch
- 54 inch

MALCOLM PIRNIE

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Suite 400
Phoenix, AZ 85008

CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Flow Monitoring Locations

November 2008

Figure 3-1

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Table 3-1.
Flow Meter Summary

Meter ID	Flow (mgd)			Depth (in)			Velocity (ft/s)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
1	1.13	1.90	0.45	6.71	8.46	4.42	2.37	3.04	1.67
2	2.09	4.13	0.63	4.45	6.76	2.26	6.83	7.92	5.75
3	0.97	1.74	0.31	4.81	6.54	2.74	2.84	3.47	1.93
4	1.39	2.28	0.55	4.41	5.41	3.69	4.96	6.29	2.57
5	0.14	0.29	0.05	2.52	3.69	1.47	1.72	2.30	1.23
6	0.39	0.64	0.15	4.00	5.10	2.65	1.71	2.15	1.11
7	1.41	2.91	0.56	4.47	6.70	2.89	5.23	6.46	3.95
8	0.20	0.60	0.06	2.70	4.66	1.54	1.64	2.36	1.02
9	0.54	1.27	0.15	4.35	6.87	2.38	2.05	2.64	1.38
10	1.43	4.93	0.44	12.90	37.59	5.14	1.07	1.86	0.17
11	1.11	2.00	0.47	3.79	5.27	2.72	5.03	6.04	3.54
12	0.25	0.73	0.05	1.94	3.24	1.25	3.46	5.30	1.34
13	1.80	3.62	0.57	5.30	7.57	3.78	4.59	5.81	2.39
14	0.49	0.87	0.14	5.73	7.46	3.72	1.50	2.09	0.69
15	0.30	0.62	0.06	4.13	6.81	1.88	1.45	2.12	0.88
16	0.11	0.21	0.03	1.60	2.12	1.09	1.78	2.51	0.90

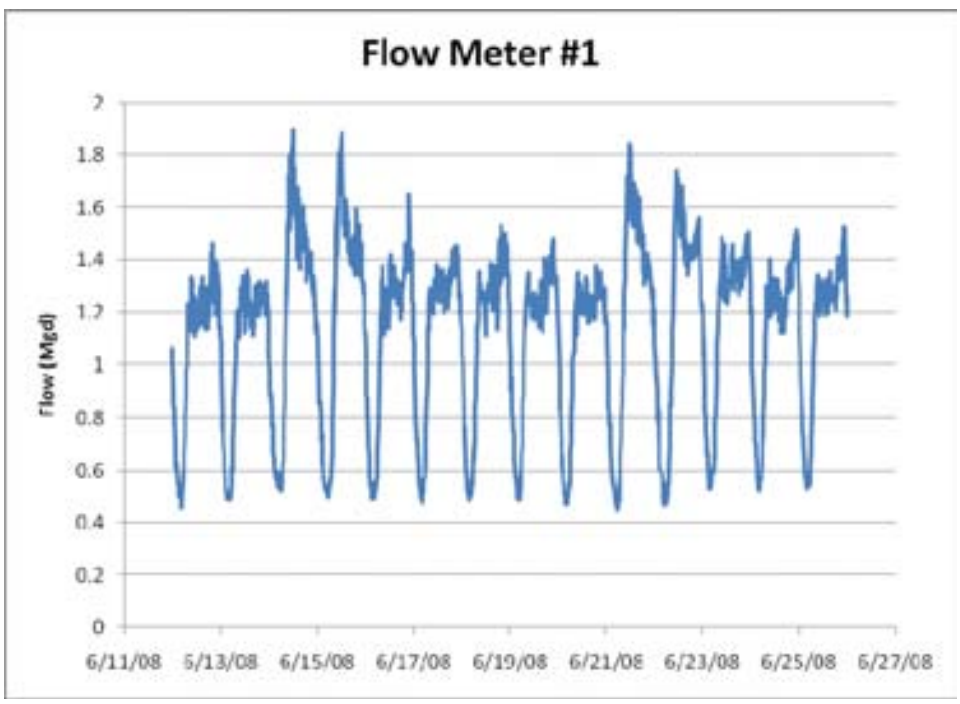

Figure 3-2: Example Hydrograph from Collection System Monitoring

3.2. Model Calibration

In order to obtain an accurate representation of the collection system, the model results were reviewed against the metered values and City staff operational knowledge. Model parameters listed below were adjusted to meet reasonable calibration goals, as well as the City's understanding of the system.

- Average wastewater loads quantity
- Spatial location of wastewater loads
- Peaking factors
- Pipe roughness
- Collection system configuration
- Pipe constrictions/obstructions

Table 3-2 summarizes the peaking factors used for each of the flow meter basins. The peaking factors used were based on the flow meter results for each basin with two exceptions. Flow meter basins #2 and #10 were based on an area weighted average of the remaining basin's peaking factors. These two basins were impacted by a flow imbalance or were influenced by a downstream pumping station, which made direct use of the meter results to determine the peaking factor difficult. As there were no precipitation events during the monitoring program, the values listed in Table 3-2 could be viewed as dry weather peaking factors experienced during the monitoring program.

Table 3-2.
Flow Meter Peaking Factors

Meter ID	Peaking Factor
1	1.66
2	2.05
3	2.02
4	1.14
5	2.03
6	1.64
7	1.92
8	2.94
9	2.34
10	2.05
12	2.95
14	1.78
15	2.09

3.2.1. Calibration Guidelines

The ranges listed below were used as guidelines during the calibration process. In the event that these ranges could not be achieved, possible explanations for the variance were explored.

- The average modeled flow is ± 10 percent of the metered average flow
- The peak hour modeled flow is ± 10 percent of the metered peak hour flow
- The peak hour modeled flow depth is ± 4 inches of the metered peak hour flow depth

3.2.2. Model Results vs. Meter Records

The average flow during the monitoring period influent to the treatment plant was determined by analyzing the data from flow meters #1, #2, #3, and #10 to yield an average flow rate of 5.62 mgd. The average annual flow rate as determined from the Demand Module was 5.86 mgd. Tables 3-3, 3-4 and 3-5 show the comparison of the model results for average flow, peak hour flow, and depth at peak hour conditions along with the relative percentage difference and whether or not the calibration goal was met. A composite summary of the calibration goals is presented in Table 3-6.

Table 3-3.
Calibration Comparison for Average Flow Conditions

Flow Meter	Meter Flow Rate (mgd)	Model Flow Rate (mgd)	Percent Difference (%)	Calibration Goal Met?
1	1.13	1.12	-0.7%	Yes
2	2.09	2.22	6.0%	Yes
3	0.97	0.97	-0.3%	Yes
4	1.39	1.48	6.4%	Yes
5	0.14	0.13	-4.1%	Yes
6	0.39	0.37	-5.9%	Yes
7	1.41	1.33	-5.9%	Yes
8	0.20	0.20	-3.7%	Yes
9	0.54	0.54	-0.6%	Yes
10	1.43	1.54	8.0%	Yes
11	1.11	1.18	6.6%	Yes
12	0.25	0.25	1.3%	Yes
13	1.80	1.62	-9.9%	Yes
14	0.49	0.49	0.3%	Yes
15	0.30	0.30	0.7%	Yes

Table 3-4.
Calibration Comparison for Peak Flow Conditions

Flow Meter	Meter Flow Rate (mgd)	Model Flow Rate (mgd)	Percent Difference (%)	Calibration Goal Met?
1	1.90	1.91	0.8%	Yes
2	4.13	4.84	17.1%	No
3	1.74	1.82	4.5%	Yes
4	2.28	2.28	0.3%	Yes
5	0.29	0.27	-5.2%	Yes
6	0.64	0.65	1.1%	Yes
7	2.91	3.01	3.3%	Yes
8	0.60	0.58	-2.5%	Yes
9	1.27	1.26	-0.8%	Yes
10	4.93	2.56	-48%	No
11	2.00	1.83	8.9%	Yes
12	0.73	0.74	1.4%	Yes
13	3.62	3.47	-4.4%	Yes
14	0.87	0.87	0.3%	Yes
15	0.62	0.63	0.6%	Yes

Table 3-5.
Calibration Comparison for Depth at Peak Flow Conditions

Flow Meter	Meter Depth at Peak Hour (in)	Model Depth at Peak Hour (in)	Difference (in)	Calibration Goal Met?
1	8.46	9.36	-0.9	Yes
2	6.76	12.60	-6.20	No
3	6.54	8.04	-1.50	Yes
4	5.41	9.00	-3.59	Yes
5	3.69	3.36	0.33	Yes
6	5.10	5.04	0.05	Yes
7	6.70	9.12	-2.42	Yes
8	4.66	7.68	-3.02	Yes
9	6.87	7.92	-1.06	Yes
10	37.59	8.40	29.19	No
11	5.27	6.60	-1.33	Yes
12	3.24	6.36	-3.13	Yes
13	7.57	10.80	-3.23	Yes
14	7.46	7.32	0.14	Yes
15	6.81	9.36	-2.55	Yes

Table 3-6.
Summary of Calibration Results

Flow Meter	Average Flow Rate	Peak Hour Flow Rate	Depth at Peak Hour	Calibrated?
1	Yes	Yes	Yes	Yes
2	Yes	No	No	Partially
3	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes
6	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes
8	Yes	Yes	Yes	Yes
9	Yes	Yes	Yes	Yes
10	Yes	No	No	Partially
11	Yes	Yes	Yes	Yes
12	Yes	Yes	Yes	Yes
13	Yes	Yes	Yes	Yes
14	Yes	Yes	Yes	Yes
15	Yes	Yes	Yes	Yes

For average flow conditions, the calibration goals were met at all the flow meter locations. The relative percentage differences in flows were within the accepted range. Therefore, the model was successfully calibrated for the average flow conditions.

For peak hour flow conditions, flow meters #2 and #10 did not meet the calibration goal. For flow meter # 2, the sum of the flows recorded at the two upstream flow meters (#9 and #13) was higher than the reading at meter #2. This is most likely due to an incorrect understanding of the piping configuration upstream of meter #2. For this reason, peak hour calibration at this meter was not possible. Flow meter #10 exhibited flow spikes that were difficult to match in a steady-state model. These spikes were likely due to the downstream pump station. For this reason, the peak hour calibration goal could not be met at this location either.

For depth at peak hour flow conditions, flow meters #2 and #10 did not meet the calibration goals. Since flow meters #2 and # 10 did not meet the peak hour calibration goals, the peak hour flow depth calibration goal, likewise, could not be met.

Even though the other flow meters met the calibration goals, some flow meters (#4, #12, #13, #14 and #15) raised concerns because they were located within smaller diameter sewers. As the diameter of the collection system pipe decreases, a 3-inch difference in the metered versus modeled flow depths becomes a greater percentage of the pipe's

diameter. To minimize the difference between the model and metered depths, the pipe roughness was adjusted in the vicinity of the flow meter basins.

3.3. Calibration Results

Based on the comparison of the metered versus modeled results for three calibration goals, the City's model was considered calibrated for the existing conditions. The accuracy of the model was considered sufficient to perform system-wide evaluations for master planning purposes, including responses to stress conditions such as peak hour flow during dry and wet weather conditions.

A. Flow Monitoring Test Results

CITY OF SURPRISE, AZ MASTER PLAN

PREPARED FOR: MALCOLM PIRNIE, INC. – TIMOTHY FRANCIS, P.E., BCEE

PREPARED BY: INFRASTRUCTURE ENGINEERING CORP. – CYNTHIA JORDAN-KASPER

DATE: JULY 16, 2008

UPTIME: 100%

USEABLE DATA: 100%

1.0 Project Summary

The purpose of this report is to present the results of a comprehensive wastewater flow monitoring project conducted by Infrastructure Engineering Corporation (IEC) for Malcolm Pirnie, Inc. The flow monitoring project was carried out to establish the capacity sewage flows at sixteen (16) locations in the City of Surprise sanitary sewer system. The objective of the project was to provide information to Malcolm Pirnie, Inc. for the preparation of a Wastewater Master Plan for the City of Surprise and its environs.

The flow survey was carried out from 06/09/08 through 06/27/08. The data contained in this report is for the period of 06/12/08 beginning at 00:00 AM through 06/25/08 ending at 23:45 PM. The result of those efforts is described in this report.

2.0 Project Scope and Location Summary

2.1 Project Scope

The scope of this study involved using temporary flow monitors to quantify wastewater flow at the designated locations (Table 1.1). Specifically, the study included the following key components.

- Investigate the proposed flow-monitoring sites for adequate hydraulic conditions and traffic control requirements
- Flow monitor installations
- Flow monitor confirmations and data collections
- Flow data analysis

2.2 Location Summary

Table 1.1 – Flow meters, their identification numbers, location, and metering periods are summarized.

Table 1.1

Meter ID	Site #	Meter Type	Pipe Size (in)	Installation Date	Removal Date
SSMH3N1WSE220001	Site 01	D/V	24	10-Jun-08	27-Jun-08
SSMHN1WNW220012	Site 02	D/V	30	09-Jun-08	27-Jun-08
SSMH3N1WNW220001	Site 03	D/V	30	09-Jun-08	26-Jun-08
Alternate Location	Site 04	D/V	27	11-Jun-08	27-Jun-08
SSMH3N1WSW020046	Site 05	D/V	12	10-Jun-08	27-Jun-08
SSMH4N1WSW330113	Site 06	D/V	24	09-Jun-08	26-Jun-08
SSMH3N1WSW170111	Site 07	D/V	24	09-Jun-08	26-Jun-08
SSMH4N1WSW320090	Site 08	D/V	21	09-Jun-08	26-Jun-08
SSMH3N1WSW160002	Site 09	D/V	24	09-Jun-08	26-Jun-08
SSMH3N1WNW220005	Site 10	D/V	48	10-Jun-08	27-Jun-08
SSMH3N1WNE190089	Site 11	D/V	26	09-Jun-08	26-Jun-08
SSMH4N1WSW310016	Site 12	D/V	18	09-Jun-08	26-Jun-08
SSMH3N1WSW170115	Site 13	D/V	30	11-Jun-08	27-Jun-08
SSMH3N2WSE010107	Site 14	D/V	18	10-Jun-08	26-Jun-08
SSMH3N2WSE120003	Site 15	D/V	18	10-Jun-08	26-Jun-08
SSMH4N2WSE010020	Site 16	D/V	24	09-Jun-08	26-Jun-08

Table 1.2 – The following Flow Monitoring Summary Table contains a summary of important flow data and a numerical and narrative description of each meter location. Additional site detail is contained in enclosed site sheets.

CITY OF SURPRISE FLOW MONITORING STUDY

Table 1.2 - Flow Monitoring Summary

Site #	Location	Pipe Diam. (in)	Avg. Depth (in)	Peak Depth (in)	d/D Max. Peak Depth / Diam.	d/D Min. Min Depth/ Diam.	Avg. Vel. (fps)	Peak Vel. (fps)	Avg Daily Flow (mgd or gpm)	Peak Flow (mgd or gpm)	Peaking Factor Peak Flow / Avg Flow
01	Outside WRF near Cactus and Dysart	24.00	6.71	8.46	35.3%	18.4%	2.37	3.04	1.13	1.90	1.68
02	Inside WRF off 136th and Cactus	30.00	4.45	6.76	22.5%	7.5%	6.83	7.92	2.09	4.13	1.98
03	Litchfield Line - North	30.00	4.81	6.54	21.8%	9.1%	2.84	3.47	0.97	1.74	1.80
04	Reems Road S of Waddell Road	27.00	4.41	5.41	20.0%	13.7%	4.96	6.29	1.39	2.28	1.64
05	16011 N Dysart Road	12.00	2.52	3.69	30.8%	12.3%	1.72	2.30	0.14	0.29	2.03
06	Litchfield Road N of Bell Road	24.00	4.00	5.10	21.2%	11.1%	1.71	2.15	0.39	0.64	1.64
07	Reems Road S of W Larkspur Drive	24.00	4.47	6.70	27.9%	12.0%	5.23	6.46	1.41	2.91	2.07
08	Reems Road at Brookside Lane	21.00	2.70	4.66	22.2%	7.3%	1.64	2.36	0.20	0.60	2.94

Table 1.2 - Flow Monitoring Summary Continued

Site Number	Location	Pipe Diam. (in)	Avg. Depth (in)	Peak Depth (in)	d/D Max. Peak Depth / Diam.	d/D Min. Min Depth/ Diam.	Avg. Vel. (fps)	Peak Vel. (fps)	Avg Daily Flow (mgd or gpm)	Peak Flow (mgd or gpm)	Peaking Factor Peak Flow / Avg Flow
09	Bullard Avenue and Charter Oaks	24.00	4.35	6.87	28.6%	9.92%	2.05	2.64	0.54	1.27	2.34
10	Litchfield Lane - South	48.00	12.90	37.59	78.3%	10.7%	1.07	1.86	1.43	4.93	3.45
11	Reems Road S of Sunnyside Drive	26.00	3.79	5.27	20.3%	10.4%	5.03	6.04	1.11	2.00	1.81
12	Sunrise Blvd N of Bell Road	18.00	1.94	3.24	18.0%	6.9%	3.46	5.30	0.25	0.73	2.95
13	W Cactus W of 153rd Avenue	30.00	5.30	7.57	25.2%	12.6%	4.59	5.81	1.80	3.62	2.01
14	Greenway Road E of Hwy 303	18.00	5.73	7.46	41.4%	20.7%	1.50	2.09	0.49	0.87	1.78
15	Waddell Road ¼ mile from Hwy 303	18.00	4.13	6.81	37.8%	10.4%	1.45	2.12	0.30	0.62	2.09
16	163rd Avenue S of Desert Oasis Blvd	24.00	1.60	2.12	8.8%	4.5%	1.78	2.51	0.11	0.21	1.94

3.0 Site Verification

IEC Field Application Specialists performed flow meter site visits three times following initial installation to confirm satisfactory equipment operation and to collect depth, velocity and flow measurements. To verify meter operation, IEC conducts *point velocity and depth measurements* which is the collection of depth and velocity measurements at specific points across the channel cross section. Meter verifications are independent of meter equipment measurements. Manual depths of flow (DOF) measurements are performed using a ruled tape. Velocity measurements are taken using a handheld point-velocity measurement probe. Depth measurement is used for direct comparison or to verify an offset value if the sensor is not mounted on the invert of the pipe. The velocity measurements are used as a guide to verify proper operation of the velocity sensor. Handheld velocity measurements cannot be directly compared to meter measurements due to spatial and temporal differences between the two measurements.

Every installed flow meter on this project met or exceeded engineering performance specifications. High quality flow data was collected at each location.

4.0 Equipment and Principles of Operation

4.1 Equipment

Open channel flow for this project was measured with temporary flow meters at sixteen (16) locations. The flow meters used by IEC use various depth measurement and velocity measurement technologies. Each of the technologies will provide data of high quality when properly applied to specific environmental, hydraulic and physical conditions. The sensors were mounted on an expandable aluminum ring installed in the sewer pipe, normally upstream from the manhole invert. The signal from the sensors was transmitted to the monitor through a communications cable.

IEC carries a variety of flow monitoring products for all pipe capacities and types and are not bound by a specific manufacturer. In an open channel, temporary flow monitoring project, IEC primarily utilizes the **ADFM® Pro20 Velocity Profiler** and the **2150 Area Velocity Module (AV)**. These flow meters meet equipment criteria for depth and velocity measurements, five minute sampling and data storage. The actual flow meter used at each location and installation method will be determined based on an evaluation of site conditions including but not limited to pipe size, expected minimum depth, expected maximum depth, expected minimum velocity, silt levels, water quality, presence of debris and surcharge evidence.
For the City of Surprise project, two meter types were used, the ADFM™ Pro20 and the Isco 2150 Area Velocity (AV). The flow meters were programmed to record the measured flow depth and velocity at 5-minute intervals.

ADFM® Pro20 Velocity Profiler

The ADFM® Pro20 (ADFM) is particularly well suited for use in pipes larger than 24 inches in diameter that have minimum depths of flow of eight inches delivering flow rate data within 2% of actual value, in flow depths up to 20 feet. The ADFM uses a combination level/velocity transducer featuring an upward-looking ultrasonic level sensor and advanced pulse Doppler technology to accurately measure velocities at multiple points throughout the wetted cross-section. Pulse Doppler technology gives a very accurate velocity measurement, and therefore a more accurate flow rate measurement than traditional continuous wave Doppler flow meters. This includes environments with very slow or fast velocities, as well as during backup and reversed flow conditions.

The ADFM is capable of measuring flows when flows are periodically too shallow to measure velocities. Since the flow pattern and measured velocity distribution are dependent upon each other, the ADFM's advanced flow algorithms automatically adapt to changing hydraulic conditions within the pipe.

2150 Area Velocity Module (AV)

The 2150 Flow Module uses continuous wave Doppler technology to measure mean velocity. IEC typically uses the 2150 area velocity flow meters for pipe sizes 30" and less use continuous wave Doppler technology to measure mean velocity. The sensor transmits a continuous ultrasonic wave and measures the frequency shift of returned echoes reflected by air bubbles or particles in the flow. The 500 KHz Doppler is ideal for applications such as sewer flow monitoring, I&I Studies, combined sewer overflow (CSO) monitoring, and storm water runoff monitoring.

4.2 Principles of Operation

ADFM® Pro20 Velocity Profiler

Four (4) piezoelectric ceramics in the sensor emit short pulses along narrow acoustic beams pointing in different directions to measure velocity. A fifth ceramic mounted in the center of the sensor assembly, and aimed vertically, is used to measure the depth. Each acoustic beam measures velocity at multiple points, or "bins", within the water column. The measured velocity data within each bin are very precise – to within 0.01 ft/s. The measurements are then used to determine the flow pattern over the entire flow cross-section. Since the flow pattern and measured velocity distribution are dependent on each other, the Pro20's advanced flow algorithms automatically adapt to changing hydraulic conditions. This removes the need for in-situ calibration and insures accurate flow rate measurement over a host of different measurement environments and hydraulic conditions.

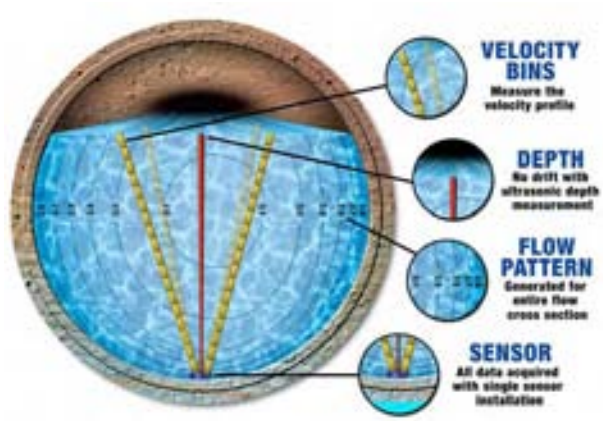

Image Courtesy of Teledyne Isco

2150 Area Velocity Module (AV)

The area velocity method is one method commonly used for automatically measuring open channel flow. A Doppler flow meter (area-velocity meter) operates by emitting into the flow ultrasonic waves of known frequency and duration from a transmitter located in the channel invert. Suspended particles and air bubbles in the flow reflect the emitted waves. The sensor receives and detects the deflected frequencies, and processes them to determine the average velocity. The area velocity method calculates flow rate by multiplying the area of the flow by its average velocity. This is often referred to as the *continuity equation*, **Q = A * V.** The main advantage of the area velocity method is that it can be used to measure flow under a wide range of conditions such as open channel, surcharged, full pipe, submerged and reverse flow. You don't have to estimate the slope and roughness of the channel, and silt correction allows you to compensate for debris that accumulates on the bottom of the channel.

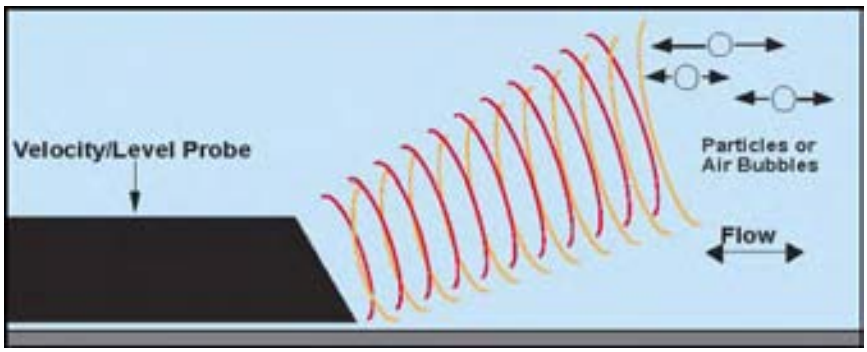

Image Courtesy of Teledyne Isco

5.0 Data Presentation

This section of the report provides a detailed description of the flow meter station information and flow data provided for each meter location. Flow meter station information and flow meter data graphs and tabular data are provided for the each meter location at the end of this report.

5.1 Field Investigation Reports

The Field Investigation Report consists of the Temporary Flow Monitoring (TFM) Site Information Form. The TFM Site Information Form provides an illustration of the physical location of each flow monitoring station. Pertinent information relative to site access, safety, instrumentation, additional notes, and hydraulic conditions are listed. Manhole Condition and Site Calibration documents are kept on file for **reference only**.

5.2 Site Summary Sheet

The Site Summary Sheet is provided for a quick overview of the flow monitoring results at each site. It contains the average, minimum, and maximum values for depth of flow, average velocity, and flow rate over the duration of the monitoring period and a flow data hydrograph.

5.3 Hydrograph (Times Series) Data Presentation

A graphical time series presentation of flow Depth (inches), Average Velocity (feet/second), and Flow Rate (mgd) is provided for each site. Graphs are created using 15-minute averages of the measured data. The stacked axis allows easy visual identification of system performance.

5.4 Scattergraphs

Scattergraphs, or X-Y plots of observed average velocities and flow rates versus observed depths, are provided for each site. These plots provide a graphical representation of hydraulic conditions at the sites. These graphs are particularly useful for showing a site's hydraulic reaction to conditions such as backwater and surcharge.

For this report, there are two different types of scattergraphs, the Flow Rate vs. Depth and the Average Velocity vs. Depth. The Flow Rate vs. Depth scattergraph is different from the Average Velocity vs. Depth scattergraph. Average velocity, by definition, is the flow rate Q divided by the area A. In a circular pipe, area is not a linear function of the depth, so therefore the two scattergraphs have different shapes.

5.5 Tabular Data Presentation

Tabular presentations of Flow Rate (mgd), Average Velocity (ft/s) and Depth (inches) are provided as a function of time of day and date. The flow monitors recorded data at all monitoring locations at 5-minute intervals. The tabular information in this report provides hourly averages of these 5-minute recordings. For example, all flow rate, or discharge measurements recorded from 00:00 through 00:59 for a given day are reported as an hourly average on row one (1) of the tabular report.

Hourly averages of the measured data are provided for each day of monitoring as well as the average, hourly minimum and maximum and instantaneous minimum and maximum values.

At the bottom of each day's column of hourly average data are summary statistics for that day, as follows:

- The *"Mean"* is the average of all instantaneous readings recorded during that day.
- The *"Maximum Hourly Mean"* is the maximum hourly average shown in the hours 0 through 24.
- The *"Minimum Hourly Mean"* is the minimum hourly average shown in the hours 0 through 24.
- The *"Instantaneous Maximum"* is the greatest single reading data value obtained during the day.
- The *"Instantaneous Minimum"* is the smallest single reading data value obtained during the day.

5.6 Electronic Data Presentation

Final data reports are produced in electronic format allowing a complete data report, including all data plots and photographs. Flow rate, depth and average velocity data in 15-minute increments are transmitted electronically to the client.

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 01
Address: Outside WRF at N Dysart Road
MH ID# SSMH3N1WSE220001

Date: 06/10/08
GPS: 33.352687N -112.203570W

Overview

Street Level

Meter Details

Meter Type 2150
Serial # 204M01443
Sensor Serial # 204K00796
Telemetry None
Sample Rate 5 min

Down Manhole

Pipe Details and Manhole Condition

Pipe Size (in) Vert. 24" Horiz. 24"
Laterals 0
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Hydraulics:
Moderate to fast flow conditions.

Comments:
All site conditions confirmed safe to enter. Good monitoring location.

Photos
MH #SSMH3N1WSE220001
Site #01

Site ID

Down Manhole

24” Influent

24” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

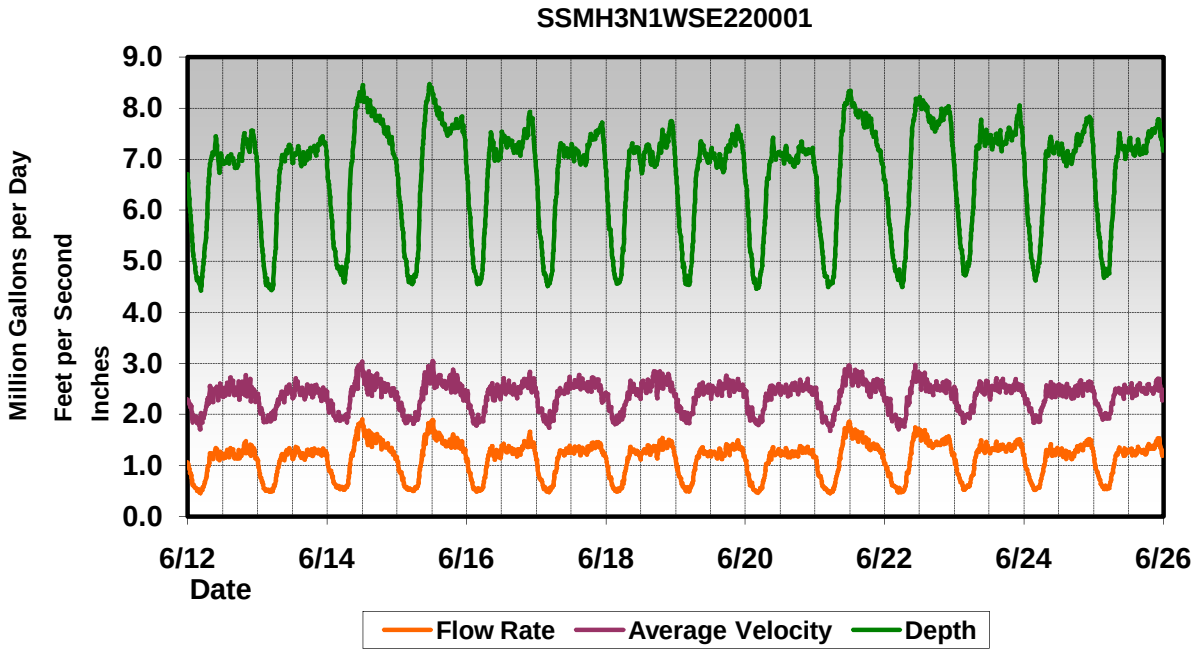
Site	**SSMH3N1WSE220001**
Address	**Outside WRF near Cactus and Dysart**
Diameter	**24** Inches
GPS	**33.352687N -112.203570W**

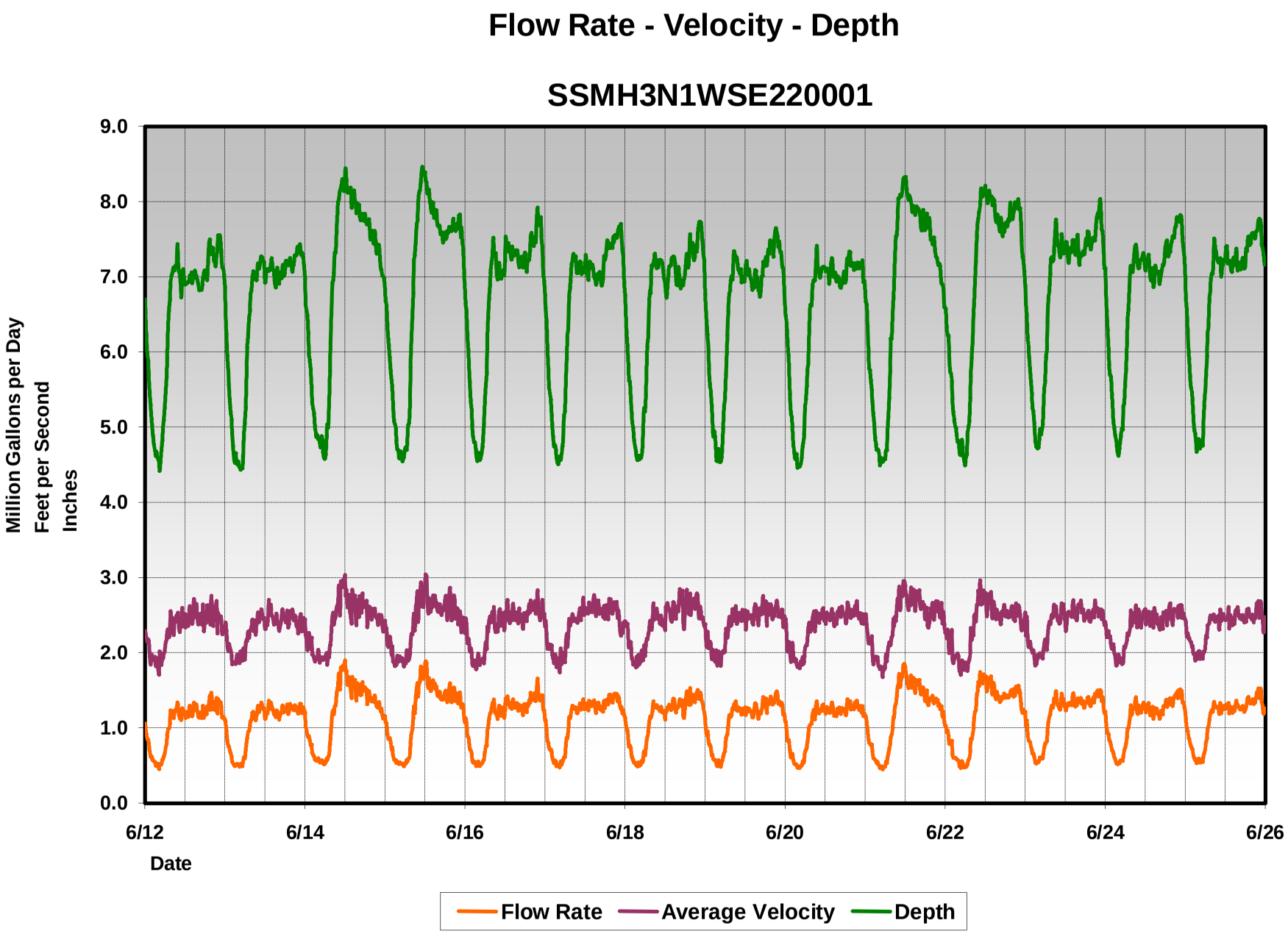
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	6.71
Maximum	8.46
Minimum	4.42
Max d/D	35.3%

Flow velocity	
	Feet per Second
Average	2.37
Maximum	3.04
Minimum	1.67

Flow Rate	
	Million Gallons per Day
Average	1.13
Maximum	1.90
Minimum	0.45
Peak Factor	1.68



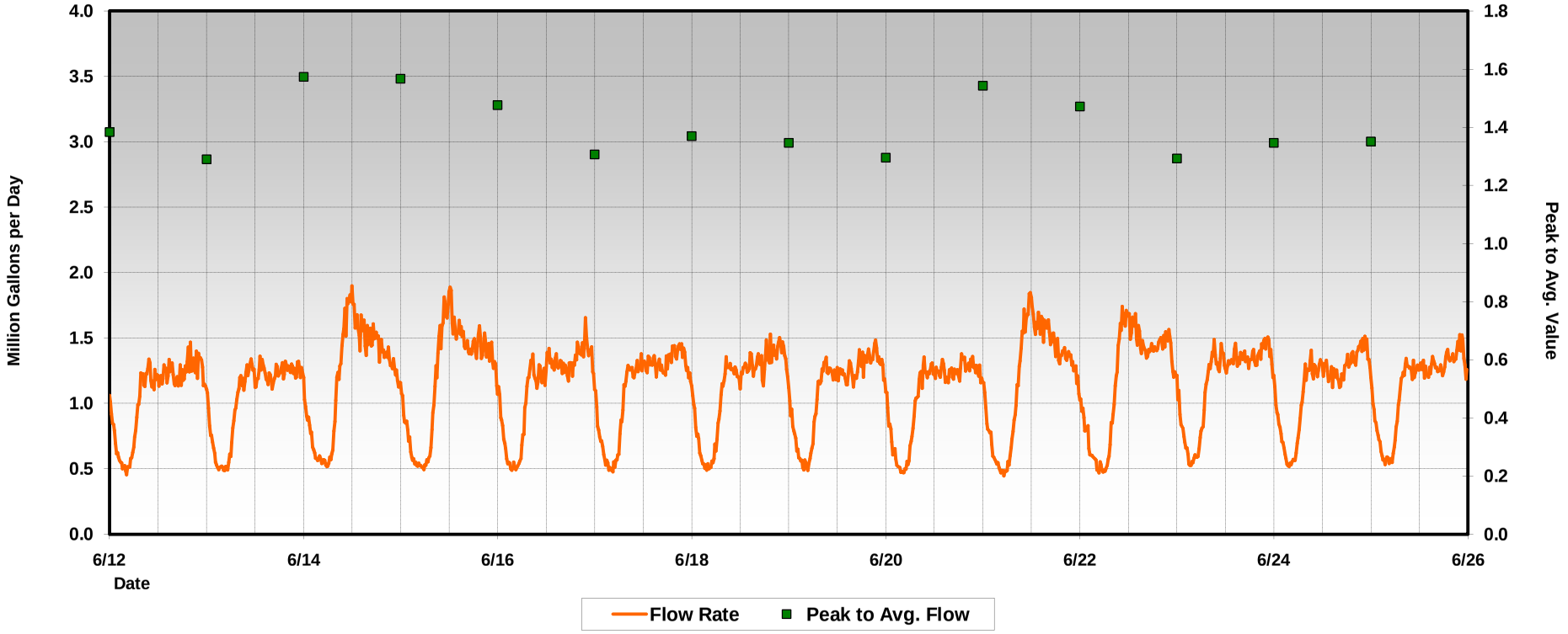

Flow Rate - Velocity - Depth
SSMH3N1WSE220001
Million Gallons per Day
Feet per Second
Inches
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

Peak to Average Flow Rate

Site ID SSMH3N1WSE220001

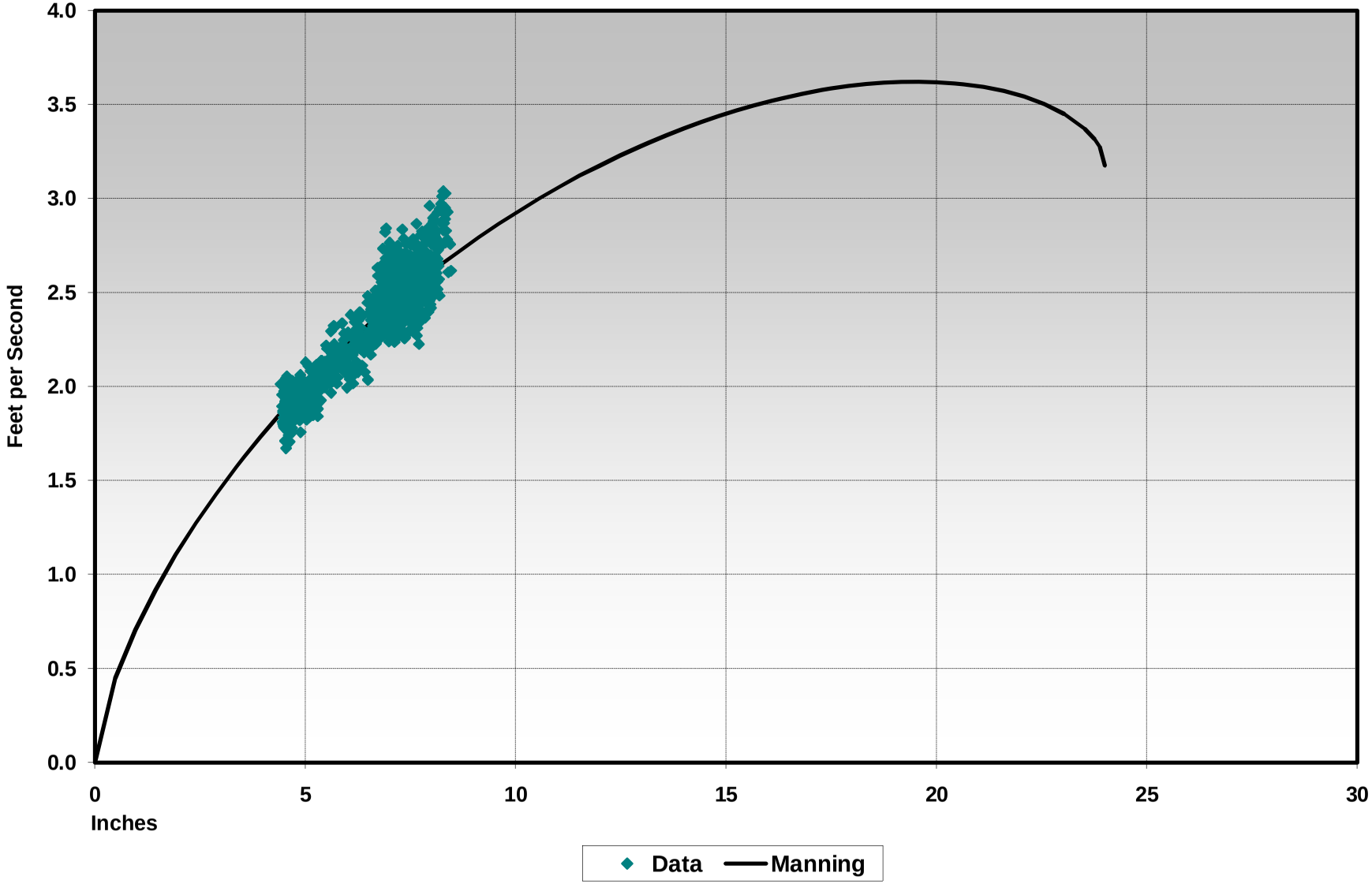
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.38	1.29	1.57	1.57	1.48	1.31	1.37	1.35	1.30	1.54	1.47	1.29	1.35	1.35



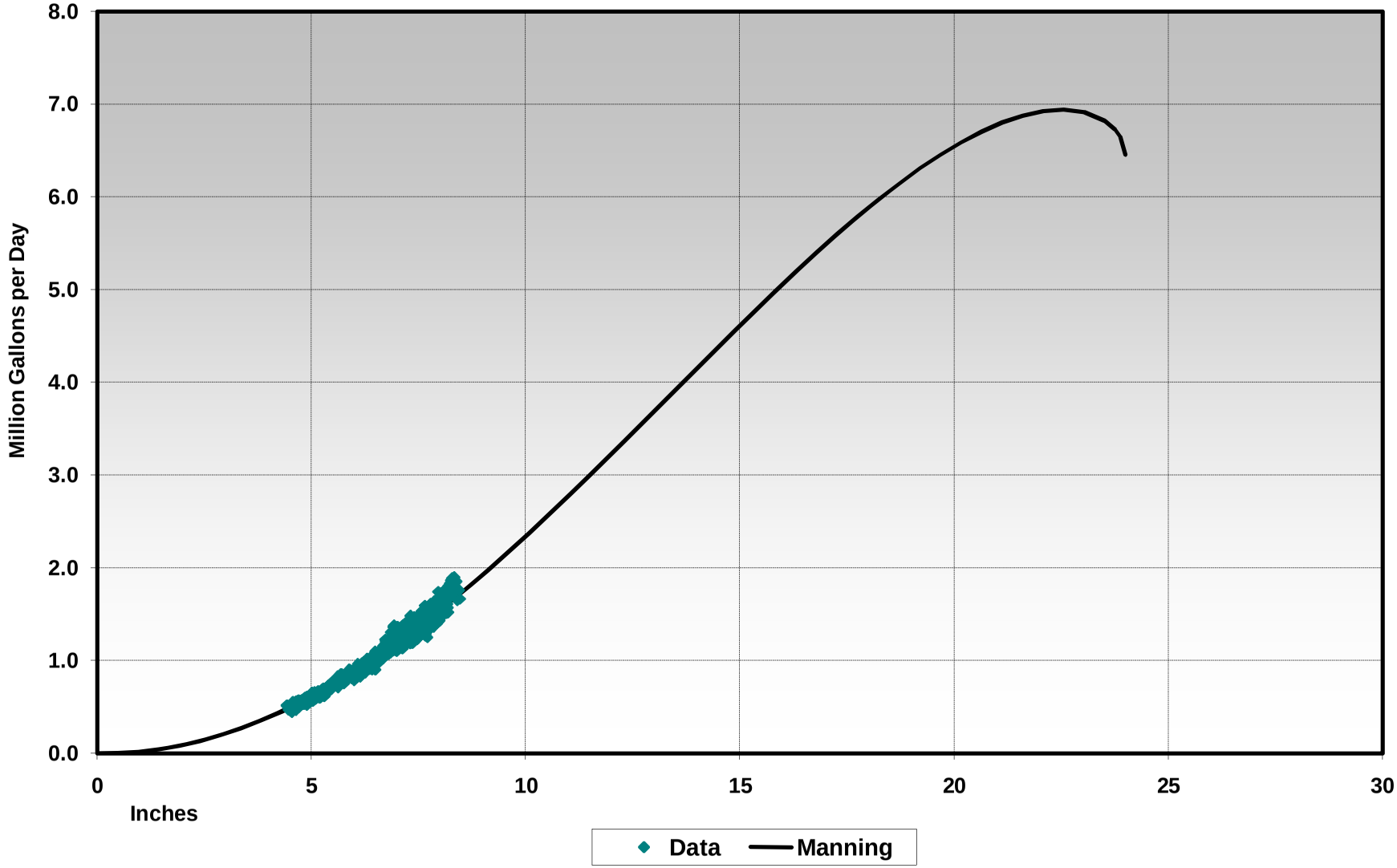
Velocity vs. Depth Scattergraph

SSMH3N1WSE220001



Flow Rate vs. Depth Scattergraph

SSMH3N1WSE220001



Flow Rate - Tabular Output

Site ID SSMH3N1WSE220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.96	1.00	1.03	1.05	1.04	1.00	1.04	1.00	0.99	1.09	0.99	1.06	1.06	1.07
1:00	0.74	0.72	0.84	0.84	0.78	0.74	0.76	0.78	0.74	0.80	0.82	0.81	0.83	0.82
2:00	0.58	0.55	0.68	0.67	0.58	0.59	0.58	0.61	0.59	0.66	0.67	0.66	0.67	0.66
3:00	0.52	0.51	0.57	0.56	0.51	0.53	0.51	0.53	0.50	0.55	0.59	0.54	0.54	0.56
4:00	0.49	0.50	0.56	0.53	0.52	0.50	0.51	0.53	0.48	0.49	0.50	0.58	0.55	0.57
5:00	0.58	0.54	0.55	0.51	0.55	0.56	0.59	0.60	0.54	0.47	0.51	0.64	0.61	0.60
6:00	0.77	0.74	0.56	0.55	0.79	0.78	0.77	0.84	0.74	0.54	0.50	0.84	0.85	0.85
7:00	1.07	1.01	0.73	0.66	1.13	1.10	1.07	1.13	1.00	0.76	0.68	1.16	1.15	1.13
8:00	1.18	1.17	1.16	1.08	1.32	1.27	1.26	1.25	1.18	1.04	0.97	1.32	1.24	1.27
9:00	1.26	1.17	1.39	1.42	1.17	1.23	1.28	1.28	1.25	1.40	1.35	1.38	1.29	1.28
10:00	1.20	1.27	1.65	1.61	1.23	1.27	1.26	1.25	1.23	1.61	1.63	1.29	1.26	1.24
11:00	1.19	1.29	1.79	1.71	1.20	1.29	1.21	1.21	1.27	1.76	1.66	1.38	1.30	1.26
12:00	1.19	1.16	1.75	1.80	1.35	1.30	1.21	1.24	1.23	1.70	1.60	1.28	1.27	1.28
13:00	1.22	1.30	1.59	1.56	1.31	1.31	1.28	1.23	1.23	1.60	1.64	1.32	1.24	1.26
14:00	1.24	1.24	1.55	1.56	1.31	1.33	1.32	1.18	1.26	1.62	1.52	1.38	1.22	1.23
15:00	1.26	1.19	1.51	1.52	1.30	1.28	1.26	1.28	1.20	1.58	1.43	1.33	1.22	1.32
16:00	1.17	1.16	1.48	1.43	1.27	1.28	1.33	1.18	1.23	1.55	1.38	1.37	1.16	1.26
17:00	1.18	1.25	1.52	1.40	1.24	1.26	1.24	1.32	1.25	1.50	1.42	1.32	1.25	1.25
18:00	1.23	1.26	1.47	1.43	1.29	1.34	1.37	1.31	1.26	1.41	1.42	1.35	1.32	1.32
19:00	1.31	1.26	1.44	1.51	1.37	1.40	1.37	1.36	1.32	1.36	1.44	1.33	1.35	1.36
20:00	1.33	1.26	1.37	1.43	1.40	1.39	1.41	1.34	1.27	1.37	1.48	1.37	1.35	1.35
21:00	1.27	1.27	1.34	1.44	1.49	1.42	1.44	1.44	1.31	1.37	1.49	1.46	1.44	1.41
22:00	1.35	1.26	1.27	1.39	1.42	1.34	1.44	1.32	1.26	1.28	1.47	1.47	1.46	1.49
23:00	1.17	1.24	1.18	1.26	1.32	1.22	1.29	1.25	1.21	1.18	1.22	1.32	1.36	1.27
Average	1.06	1.05	1.21	1.21	1.12	1.11	1.12	1.10	1.06	1.20	1.18	1.17	1.12	1.13
Median	1.18	1.19	1.33	1.38	1.24	1.25	1.25	1.22	1.21	1.33	1.40	1.30	1.24	1.25
Max Hr. Mean	1.35	1.30	1.79	1.80	1.49	1.42	1.44	1.44	1.32	1.76	1.66	1.47	1.46	1.49
Min Hr. Mean	0.49	0.50	0.55	0.51	0.51	0.50	0.51	0.53	0.48	0.47	0.50	0.54	0.54	0.56
Inst. Max	1.47	1.36	1.90	1.89	1.65	1.46	1.53	1.48	1.38	1.85	1.74	1.51	1.51	1.53
Inst. Min	0.45	0.49	0.52	0.49	0.49	0.48	0.49	0.49	0.47	0.45	0.47	0.53	0.52	0.53

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSE220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.22	2.28	2.22	2.30	2.31	2.27	2.38	2.24	2.28	2.40	2.26	2.36	2.30	2.33
1:00	2.04	2.06	2.14	2.13	2.11	2.09	2.12	2.11	2.05	2.13	2.11	2.10	2.20	2.17
2:00	1.93	1.89	2.02	1.95	1.90	1.96	1.89	1.96	1.99	2.00	2.00	2.00	2.06	2.03
3:00	1.89	1.90	1.91	1.88	1.83	1.91	1.86	1.91	1.87	1.94	1.96	1.88	1.87	1.94
4:00	1.86	1.92	1.95	1.91	1.90	1.87	1.89	1.93	1.83	1.81	1.80	1.97	1.93	1.98
5:00	1.93	1.99	1.92	1.88	1.89	1.92	1.99	2.01	1.88	1.76	1.83	2.00	1.92	1.98
6:00	2.15	2.09	1.93	1.92	2.14	2.08	2.11	2.20	2.11	1.92	1.81	2.12	2.15	2.21
7:00	2.33	2.27	2.04	1.98	2.40	2.35	2.34	2.40	2.33	2.11	2.03	2.38	2.36	2.43
8:00	2.36	2.38	2.42	2.35	2.51	2.45	2.47	2.47	2.46	2.31	2.28	2.54	2.44	2.48
9:00	2.46	2.38	2.54	2.60	2.31	2.43	2.49	2.49	2.46	2.56	2.55	2.51	2.45	2.45
10:00	2.40	2.48	2.75	2.66	2.47	2.50	2.46	2.51	2.46	2.69	2.78	2.45	2.47	2.44
11:00	2.45	2.50	2.91	2.71	2.42	2.59	2.41	2.48	2.52	2.86	2.75	2.59	2.51	2.49
12:00	2.46	2.34	2.81	2.91	2.55	2.56	2.55	2.46	2.46	2.77	2.66	2.40	2.50	2.45
13:00	2.49	2.59	2.62	2.61	2.48	2.59	2.54	2.48	2.49	2.69	2.73	2.52	2.45	2.47
14:00	2.53	2.46	2.61	2.68	2.52	2.64	2.55	2.45	2.50	2.77	2.56	2.57	2.47	2.41
15:00	2.54	2.44	2.57	2.65	2.48	2.62	2.55	2.58	2.43	2.71	2.50	2.50	2.44	2.57
16:00	2.44	2.35	2.56	2.58	2.48	2.59	2.72	2.51	2.53	2.70	2.46	2.65	2.37	2.48
17:00	2.42	2.50	2.65	2.57	2.41	2.55	2.56	2.63	2.55	2.65	2.56	2.52	2.45	2.46
18:00	2.49	2.48	2.59	2.61	2.50	2.53	2.68	2.55	2.50	2.49	2.52	2.50	2.46	2.50
19:00	2.47	2.45	2.58	2.73	2.60	2.63	2.61	2.55	2.55	2.45	2.50	2.46	2.56	2.52
20:00	2.53	2.49	2.51	2.55	2.59	2.58	2.68	2.52	2.51	2.54	2.57	2.53	2.49	2.45
21:00	2.46	2.43	2.50	2.58	2.66	2.59	2.70	2.62	2.59	2.65	2.53	2.61	2.55	2.55
22:00	2.49	2.38	2.43	2.46	2.52	2.40	2.56	2.49	2.49	2.55	2.52	2.53	2.55	2.62
23:00	2.31	2.40	2.38	2.37	2.56	2.35	2.42	2.49	2.43	2.49	2.36	2.45	2.52	2.42
Average	2.32	2.31	2.40	2.40	2.36	2.38	2.40	2.38	2.34	2.41	2.36	2.38	2.35	2.37
Median	2.38	2.38	2.47	2.51	2.43	2.46	2.45	2.47	2.45	2.53	2.47	2.47	2.42	2.45
Max Hr. Mean	2.54	2.59	2.91	2.91	2.66	2.64	2.72	2.63	2.59	2.86	2.78	2.65	2.56	2.62
Min Hr. Mean	1.86	1.89	1.91	1.88	1.83	1.87	1.86	1.91	1.83	1.76	1.80	1.88	1.87	1.94
Inst. Max	2.76	2.70	3.03	3.04	2.83	2.77	2.84	2.75	2.69	2.95	2.96	2.70	2.66	2.69
Inst. Min	1.71	1.85	1.84	1.82	1.78	1.74	1.81	1.83	1.79	1.67	1.71	1.83	1.83	1.90

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSE220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	6.35	6.40	6.67	6.62	6.55	6.45	6.41	6.51	6.39	6.61	6.43	6.56	6.70	6.63
1:00	5.58	5.47	5.98	5.98	5.71	5.54	5.61	5.71	5.59	5.79	5.92	5.85	5.80	5.78
2:00	4.95	4.84	5.33	5.39	4.98	4.95	5.01	5.06	4.90	5.27	5.33	5.25	5.21	5.23
3:00	4.65	4.56	4.92	4.89	4.67	4.65	4.65	4.66	4.56	4.76	4.92	4.76	4.78	4.79
4:00	4.51	4.48	4.81	4.66	4.60	4.56	4.60	4.61	4.49	4.59	4.69	4.86	4.76	4.78
5:00	4.90	4.59	4.74	4.59	4.82	4.84	4.90	4.92	4.76	4.57	4.68	5.17	5.14	4.97
6:00	5.58	5.53	4.79	4.73	5.70	5.73	5.65	5.82	5.48	4.72	4.66	6.00	5.97	5.83
7:00	6.62	6.50	5.54	5.30	6.78	6.72	6.63	6.77	6.35	5.61	5.29	6.95	6.91	6.72
8:00	7.08	6.98	6.86	6.65	7.34	7.24	7.17	7.14	6.85	6.56	6.31	7.26	7.15	7.21
9:00	7.20	7.01	7.53	7.54	7.15	7.16	7.21	7.24	7.15	7.53	7.35	7.57	7.33	7.30
10:00	7.06	7.18	8.09	8.12	7.06	7.14	7.19	7.08	7.05	8.06	7.94	7.34	7.17	7.16
11:00	6.93	7.24	8.22	8.39	7.03	7.08	7.11	6.96	7.12	8.22	8.12	7.40	7.26	7.16
12:00	6.91	7.01	8.30	8.26	7.37	7.15	6.83	7.11	7.09	8.22	8.09	7.40	7.17	7.31
13:00	6.97	7.10	8.16	8.07	7.37	7.13	7.12	7.04	7.04	8.04	8.09	7.29	7.12	7.17
14:00	6.99	7.14	8.02	7.91	7.30	7.10	7.26	6.87	7.13	7.91	8.02	7.45	6.99	7.17
15:00	7.01	6.96	7.95	7.81	7.33	6.95	6.99	7.03	7.00	7.89	7.80	7.40	7.08	7.23
16:00	6.85	6.99	7.85	7.65	7.19	7.04	6.98	6.79	6.92	7.83	7.69	7.26	6.99	7.16
17:00	6.94	7.07	7.79	7.52	7.22	7.02	6.93	7.09	6.98	7.74	7.62	7.31	7.15	7.18
18:00	7.01	7.16	7.75	7.56	7.23	7.36	7.19	7.20	7.09	7.74	7.69	7.48	7.42	7.34
19:00	7.36	7.20	7.65	7.63	7.33	7.42	7.32	7.40	7.24	7.64	7.85	7.48	7.35	7.46
20:00	7.33	7.14	7.53	7.67	7.47	7.45	7.33	7.39	7.15	7.48	7.83	7.48	7.52	7.57
21:00	7.24	7.32	7.45	7.66	7.67	7.55	7.39	7.58	7.15	7.27	7.96	7.70	7.72	7.60
22:00	7.51	7.36	7.31	7.70	7.74	7.66	7.71	7.39	7.15	7.11	7.89	7.89	7.79	7.74
23:00	7.15	7.25	7.02	7.39	7.23	7.26	7.41	7.08	7.05	6.81	7.26	7.44	7.47	7.32
Average	6.53	6.52	6.93	6.90	6.70	6.63	6.61	6.60	6.49	6.83	6.89	6.86	6.75	6.74
Median	6.95	7.05	7.43	7.58	7.18	7.06	7.03	6.99	6.98	7.32	7.66	7.31	7.12	7.17
Max Hr. Mean	7.51	7.36	8.30	8.39	7.74	7.66	7.71	7.58	7.24	8.22	8.12	7.89	7.79	7.74
Min Hr. Mean	4.51	4.48	4.74	4.59	4.60	4.56	4.60	4.61	4.49	4.57	4.66	4.76	4.76	4.78
Inst. Max	7.55	7.44	8.45	8.46	7.92	7.70	7.74	7.65	7.42	8.33	8.21	8.04	7.82	7.78
Inst. Min	4.42	4.44	4.58	4.55	4.55	4.51	4.56	4.54	4.46	4.49	4.50	4.72	4.62	4.67

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 02**	**Date:**	**6/9/08**
Address:	**Inside WRF off 136th near Cactus Road**	**GPS:**	**33.353672N -112.210970W**
MH ID#	**SSMHN1WNW220012**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**204L00133**
Sensor Serial #	**205K01554**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**30"**	**Horiz.**	**30"**
Laterals	**2**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole

Hydraulics:
Fast flow conditions at time of installation.

Comments:
Lots of TP in flow.

Photos
MH #SSMHN1WNW220012
Site #02

Site ID

Down Manhole

30” Influent

30” Effluent

6” Drop In (Dry)

6” Drop In (Wet)

Photos
MH #SSMHN1WNW220012
Site #02

Manhole Cover Top

Manhole Cover Bottom

Location Summary

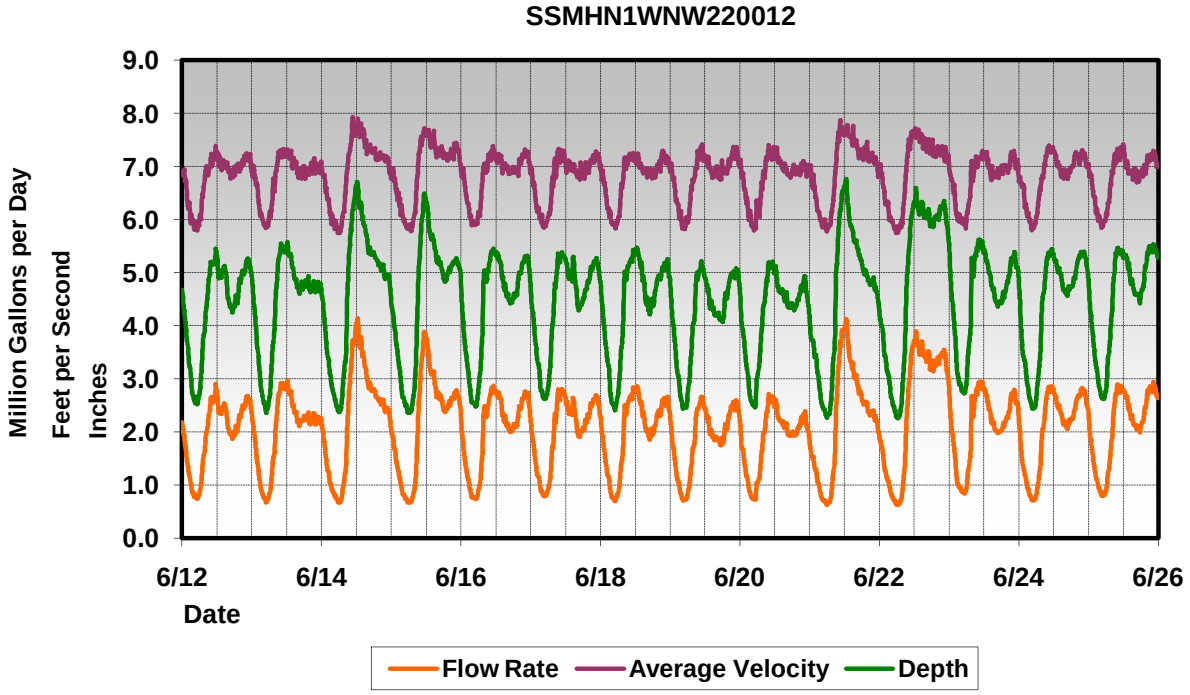
Site	**SSMHN1WNW220012**
Address	**Inside WRF off 136th and Cactus**
Diameter	**30** Inches
GPS	**33.353672N -112.210970W**

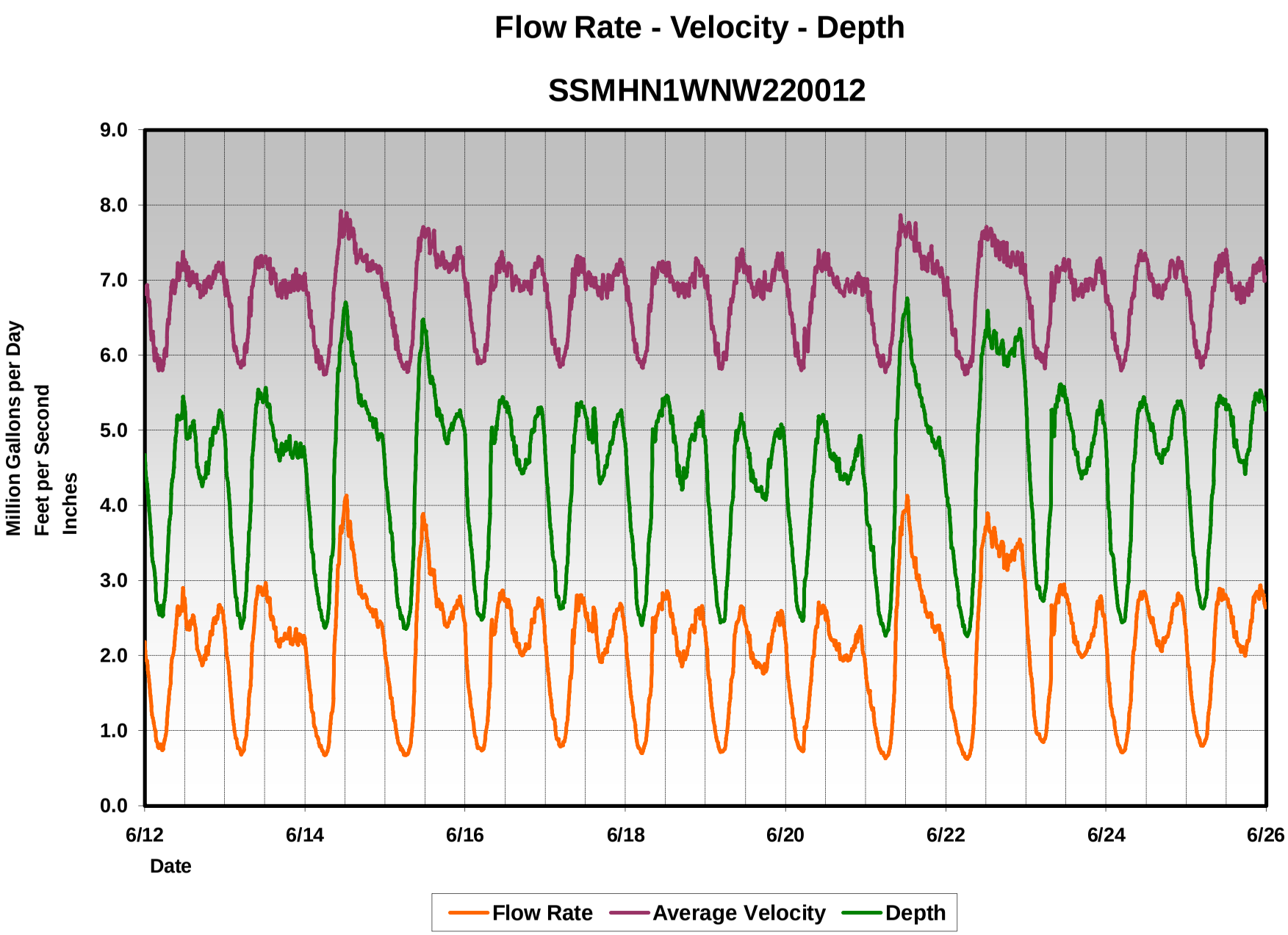
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.45
Maximum	6.76
Minimum	2.26
Max d/D	22.5%

Flow velocity	
	Feet per Second
Average	6.83
Maximum	7.92
Minimum	5.75

Flow Rate	
	Million Gallons per Day
Average	2.09
Maximum	4.13
Minimum	0.63
Peak Factor	1.98



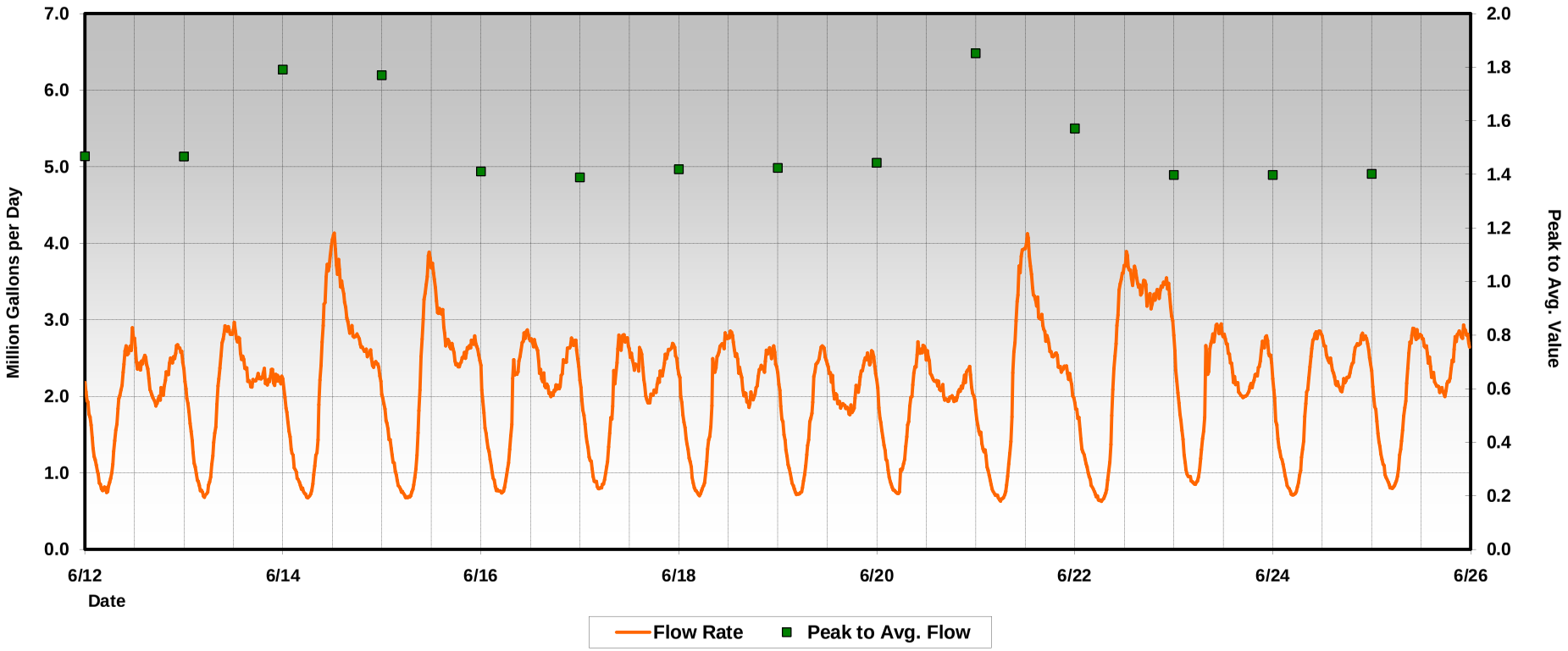

Flow Rate - Velocity - Depth
SSMHN1WNW220012
Million Gallons per Day
Feet per Second
Inches
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

Peak to Average Flow Rate

Site ID SSMHN1WNW220012

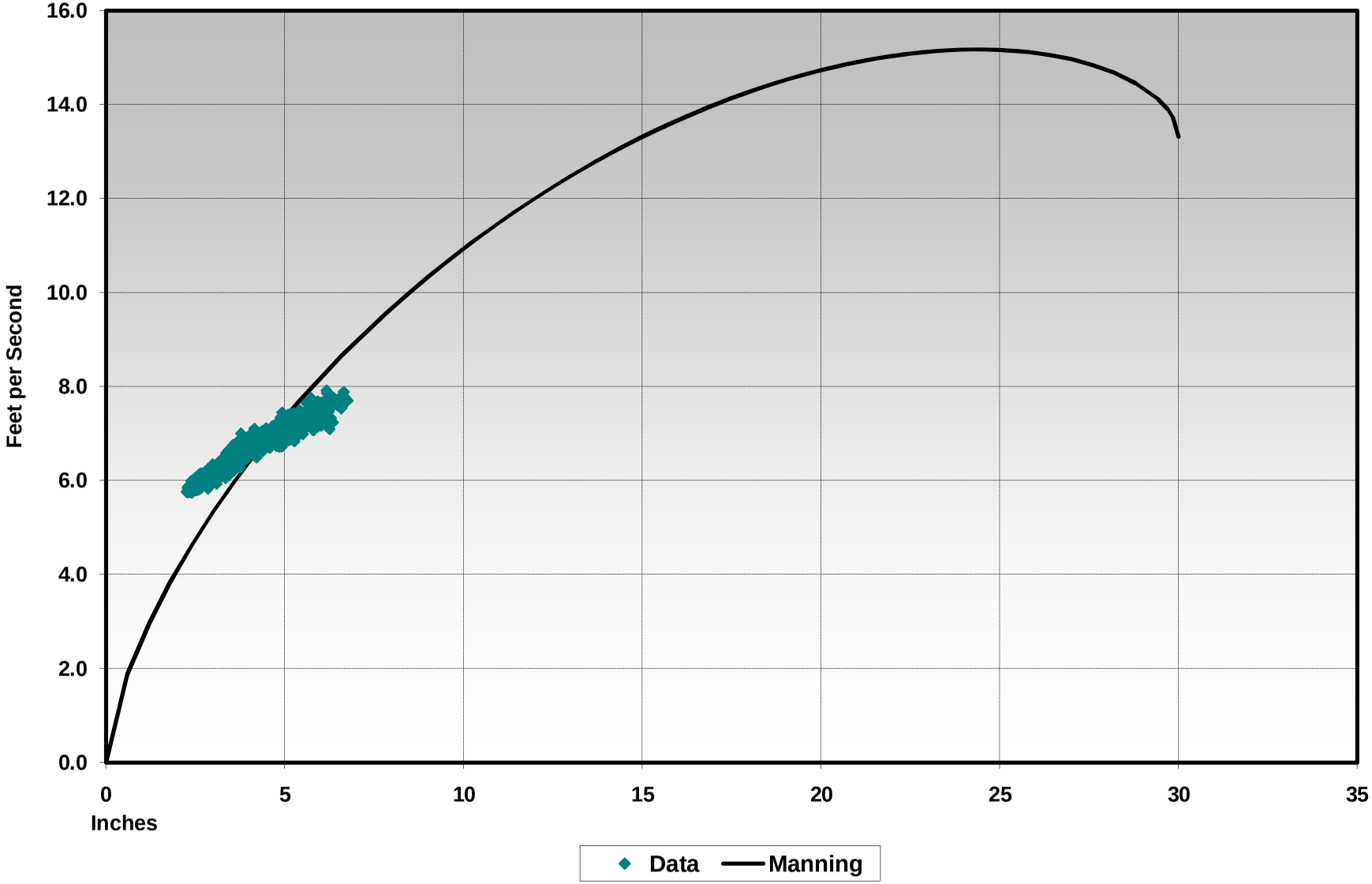
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.47	1.47	1.79	1.77	1.41	1.39	1.42	1.42	1.44	1.85	1.57	1.40	1.40	1.40



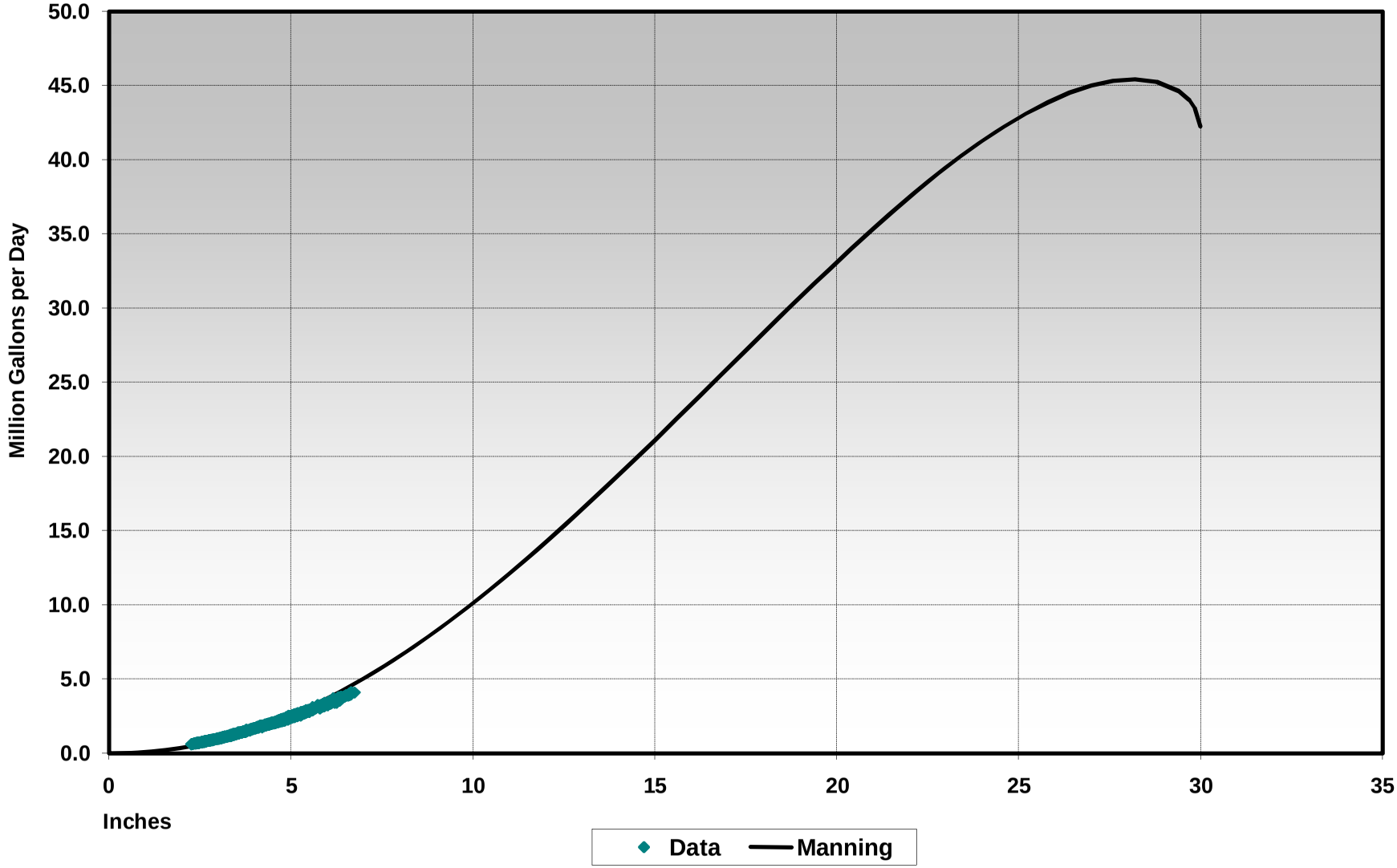
Velocity vs. Depth Scattergraph

SSMHN1WNW220012



Flow Rate vs. Depth Scattergraph

SSMHN1WNW220012



Flow Rate - Tabular Output

Site ID SSMHN1WNW220012

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.02	2.16	2.04	1.93	2.05	2.03	2.11	2.10	1.97	1.67	1.82	2.48	1.99	2.07
1:00	1.64	1.72	1.62	1.59	1.46	1.57	1.61	1.57	1.51	1.43	1.51	1.85	1.42	1.61
2:00	1.20	1.22	1.21	1.28	1.14	1.21	1.26	1.17	1.17	1.22	1.20	1.34	1.13	1.22
3:00	0.93	0.90	0.97	1.01	0.86	0.94	0.92	0.90	0.87	0.94	0.99	0.98	0.88	0.98
4:00	0.79	0.75	0.83	0.80	0.77	0.82	0.75	0.74	0.76	0.74	0.80	0.90	0.75	0.83
5:00	0.78	0.72	0.72	0.72	0.76	0.83	0.75	0.74	0.81	0.68	0.69	0.87	0.73	0.83
6:00	0.98	0.95	0.69	0.68	1.01	1.03	0.96	0.94	1.10	0.66	0.64	1.12	0.92	1.03
7:00	1.47	1.43	0.92	0.77	1.66	1.57	1.46	1.42	1.53	0.81	0.72	1.84	1.41	1.51
8:00	1.97	2.16	1.45	1.19	2.34	2.17	2.27	1.92	2.00	1.38	1.11	2.45	2.07	2.08
9:00	2.36	2.70	2.56	2.29	2.48	2.64	2.50	2.41	2.40	2.64	2.18	2.73	2.56	2.69
10:00	2.59	2.89	3.43	3.27	2.75	2.74	2.67	2.59	2.62	3.47	3.02	2.90	2.79	2.83
11:00	2.73	2.83	3.78	3.77	2.82	2.72	2.74	2.57	2.63	3.90	3.55	2.87	2.83	2.81
12:00	2.55	2.86	4.05	3.64	2.71	2.54	2.81	2.35	2.51	4.03	3.78	2.76	2.71	2.74
13:00	2.42	2.70	3.69	3.21	2.66	2.40	2.66	2.12	2.26	3.64	3.63	2.56	2.49	2.57
14:00	2.49	2.46	3.42	3.12	2.34	2.49	2.43	1.97	2.18	3.27	3.59	2.30	2.39	2.36
15:00	2.27	2.28	3.10	2.77	2.19	2.32	2.16	1.89	2.12	3.09	3.47	2.14	2.19	2.20
16:00	2.00	2.16	2.87	2.68	2.09	1.95	1.99	1.87	2.02	2.93	3.41	2.01	2.10	2.10
17:00	1.91	2.21	2.78	2.59	2.03	1.99	1.95	1.81	1.96	2.74	3.35	2.00	2.19	2.05
18:00	2.03	2.25	2.76	2.40	2.11	2.09	2.02	1.86	1.97	2.55	3.25	2.10	2.26	2.16
19:00	2.17	2.27	2.62	2.47	2.20	2.27	2.27	2.11	1.99	2.55	3.30	2.20	2.45	2.38
20:00	2.38	2.19	2.57	2.57	2.46	2.40	2.37	2.33	2.10	2.37	3.36	2.33	2.66	2.73
21:00	2.48	2.28	2.52	2.66	2.64	2.56	2.55	2.50	2.24	2.37	3.45	2.61	2.75	2.82
22:00	2.63	2.23	2.42	2.71	2.72	2.65	2.58	2.49	2.34	2.30	3.48	2.73	2.76	2.86
23:00	2.56	2.22	2.32	2.57	2.55	2.51	2.51	2.45	2.03	2.09	3.13	2.51	2.55	2.74
Average	1.97	2.02	2.31	2.19	2.03	2.02	2.01	1.87	1.88	2.23	2.48	2.11	2.04	2.09
Median	2.10	2.21	2.51	2.50	2.23	2.21	2.25	1.93	2.01	2.38	3.19	2.23	2.25	2.19
Max Hr. Mean	2.73	2.89	4.05	3.77	2.82	2.74	2.81	2.59	2.63	4.03	3.78	2.90	2.83	2.86
Min Hr. Mean	0.78	0.72	0.69	0.68	0.76	0.82	0.75	0.74	0.76	0.66	0.64	0.87	0.73	0.83
Inst. Max	2.90	2.97	4.13	3.88	2.87	2.80	2.85	2.66	2.71	4.13	3.89	2.95	2.85	2.93
Inst. Min	0.74	0.68	0.67	0.68	0.74	0.79	0.70	0.72	0.73	0.63	0.63	0.85	0.71	0.80

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMHN1WNW220012

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	6.87	6.91	6.91	6.88	6.90	6.85	6.90	6.93	6.95	6.89	6.93	6.87	6.74	6.88
1:00	6.66	6.73	6.65	6.67	6.64	6.56	6.65	6.67	6.67	6.65	6.65	6.64	6.63	6.62
2:00	6.20	6.35	6.32	6.42	6.30	6.20	6.30	6.33	6.34	6.34	6.30	6.24	6.23	6.28
3:00	6.00	6.06	6.05	6.23	6.02	6.00	6.06	6.10	6.07	6.07	6.09	6.01	6.03	6.07
4:00	5.87	5.89	5.93	5.99	5.93	5.92	5.92	5.88	5.87	5.90	5.97	5.98	5.87	5.92
5:00	5.87	5.88	5.85	5.86	5.92	5.93	5.88	5.93	5.99	5.89	5.82	5.91	5.90	5.95
6:00	6.10	6.12	5.79	5.84	6.13	6.11	6.10	6.07	6.10	5.84	5.80	6.13	6.13	6.15
7:00	6.56	6.50	6.06	5.90	6.69	6.56	6.61	6.58	6.52	6.03	5.90	6.65	6.60	6.53
8:00	6.96	6.92	6.65	6.32	6.93	6.88	7.00	6.83	6.87	6.54	6.24	6.84	6.86	6.92
9:00	6.95	7.21	7.15	7.05	7.07	7.23	7.10	7.09	7.17	7.25	7.00	7.08	7.16	7.15
10:00	7.12	7.24	7.63	7.48	7.20	7.23	7.20	7.23	7.24	7.66	7.41	7.13	7.33	7.24
11:00	7.22	7.25	7.62	7.66	7.27	7.18	7.18	7.27	7.26	7.70	7.61	7.20	7.29	7.24
12:00	7.16	7.26	7.80	7.62	7.12	7.00	7.16	7.14	7.24	7.66	7.62	7.22	7.24	7.23
13:00	7.05	7.17	7.68	7.53	7.21	7.02	7.10	7.02	7.12	7.66	7.64	7.10	7.03	7.00
14:00	7.03	7.06	7.64	7.52	6.96	6.99	6.94	6.86	7.00	7.50	7.52	6.89	6.92	6.89
15:00	7.00	6.97	7.34	7.29	6.99	6.93	6.92	6.89	6.99	7.49	7.44	6.83	6.86	6.82
16:00	6.89	6.86	7.34	7.25	6.93	6.86	6.87	6.89	6.88	7.37	7.39	6.90	6.80	6.86
17:00	6.84	6.86	7.27	7.29	6.91	6.92	6.88	6.90	6.82	7.27	7.39	6.85	6.88	6.81
18:00	6.94	6.91	7.27	7.21	6.94	6.88	6.88	6.89	6.96	7.21	7.33	6.95	7.00	6.86
19:00	6.97	6.90	7.16	7.17	6.90	7.00	6.93	6.91	6.90	7.35	7.25	7.01	7.19	6.93
20:00	7.02	6.95	7.19	7.23	7.09	7.02	7.01	7.07	6.93	7.14	7.31	6.93	7.16	7.11
21:00	7.10	7.04	7.16	7.27	7.19	7.13	7.24	7.26	6.99	7.20	7.26	7.18	7.18	7.17
22:00	7.16	6.94	7.15	7.34	7.25	7.17	7.16	7.22	7.00	7.09	7.23	7.18	7.21	7.22
23:00	7.12	6.97	6.96	7.20	7.11	7.14	7.10	7.16	6.94	6.94	7.17	7.03	7.05	7.09
Average	6.78	6.79	6.94	6.93	6.82	6.78	6.79	6.80	6.78	6.94	6.93	6.78	6.80	6.79
Median	6.95	6.91	7.15	7.20	6.95	6.92	6.94	6.91	6.92	7.14	7.22	6.91	6.93	6.88
Max Hr. Mean	7.22	7.26	7.80	7.66	7.27	7.23	7.24	7.27	7.26	7.70	7.64	7.22	7.33	7.24
Min Hr. Mean	5.87	5.88	5.79	5.84	5.92	5.92	5.88	5.88	5.87	5.84	5.80	5.91	5.87	5.92
Inst. Max	7.38	7.32	7.92	7.71	7.37	7.32	7.29	7.41	7.40	7.86	7.71	7.29	7.39	7.40
Inst. Min	5.80	5.84	5.75	5.78	5.89	5.84	5.84	5.82	5.80	5.78	5.75	5.83	5.80	5.84

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMHN1WNW220012

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.46	4.64	4.46	4.31	4.48	4.47	4.58	4.55	4.34	3.90	4.13	5.13	4.46	4.52
1:00	3.95	4.04	3.90	3.85	3.65	3.86	3.90	3.83	3.72	3.59	3.73	4.29	3.58	3.89
2:00	3.34	3.32	3.32	3.41	3.19	3.36	3.41	3.24	3.22	3.33	3.31	3.58	3.20	3.35
3:00	2.88	2.80	2.95	2.95	2.71	2.90	2.83	2.78	2.73	2.86	2.96	2.98	2.75	2.95
4:00	2.60	2.50	2.67	2.59	2.54	2.67	2.50	2.50	2.54	2.50	2.60	2.81	2.51	2.69
5:00	2.60	2.44	2.46	2.46	2.53	2.68	2.51	2.47	2.61	2.36	2.39	2.77	2.47	2.67
6:00	2.94	2.86	2.41	2.37	3.00	3.05	2.90	2.87	3.18	2.31	2.28	3.20	2.81	3.03
7:00	3.69	3.65	2.83	2.55	3.94	3.86	3.65	3.60	3.81	2.61	2.44	4.23	3.57	3.76
8:00	4.34	4.63	3.61	3.25	4.89	4.67	4.75	4.31	4.43	3.52	3.14	5.10	4.53	4.52
9:00	4.92	5.26	5.09	4.75	5.02	5.17	5.04	4.92	4.88	5.16	4.62	5.38	5.10	5.28
10:00	5.16	5.49	5.97	5.86	5.34	5.31	5.23	5.10	5.14	6.01	5.57	5.58	5.33	5.42
11:00	5.30	5.41	6.41	6.37	5.39	5.30	5.34	5.05	5.14	6.50	6.14	5.51	5.40	5.39
12:00	5.08	5.45	6.62	6.24	5.32	5.15	5.44	4.82	4.99	6.67	6.41	5.34	5.26	5.30
13:00	4.95	5.28	6.26	5.76	5.22	4.94	5.26	4.54	4.69	6.21	6.21	5.13	5.06	5.20
14:00	5.07	5.01	5.96	5.65	4.87	5.09	5.01	4.38	4.64	5.85	6.23	4.85	4.97	4.95
15:00	4.77	4.80	5.73	5.32	4.65	4.87	4.64	4.24	4.55	5.63	6.14	4.65	4.71	4.75
16:00	4.42	4.68	5.43	5.22	4.54	4.35	4.41	4.21	4.45	5.49	6.09	4.43	4.60	4.59
17:00	4.31	4.76	5.34	5.07	4.45	4.39	4.34	4.13	4.38	5.29	6.01	4.44	4.70	4.53
18:00	4.44	4.78	5.32	4.86	4.56	4.56	4.46	4.20	4.35	5.06	5.92	4.54	4.76	4.66
19:00	4.63	4.81	5.18	4.97	4.71	4.76	4.80	4.58	4.40	4.99	6.04	4.65	4.93	4.96
20:00	4.91	4.67	5.10	5.07	4.99	4.94	4.90	4.82	4.54	4.84	6.07	4.88	5.24	5.35
21:00	5.01	4.77	5.04	5.19	5.19	5.12	5.04	4.97	4.72	4.82	6.22	5.16	5.34	5.44
22:00	5.20	4.73	4.92	5.22	5.27	5.22	5.13	4.96	4.86	4.77	6.27	5.32	5.36	5.47
23:00	5.12	4.70	4.84	5.09	5.11	5.04	5.06	4.94	4.44	4.53	5.86	5.10	5.15	5.38
Average	4.34	4.39	4.66	4.52	4.40	4.41	4.38	4.17	4.20	4.53	4.87	4.54	4.41	4.50
Median	4.54	4.72	5.02	5.02	4.73	4.72	4.78	4.32	4.45	4.84	5.88	4.77	4.74	4.74
Max Hr. Mean	5.30	5.49	6.62	6.37	5.39	5.31	5.44	5.10	5.14	6.67	6.41	5.58	5.40	5.47
Min Hr. Mean	2.60	2.44	2.41	2.37	2.53	2.67	2.50	2.47	2.54	2.31	2.28	2.77	2.47	2.67
Inst. Max	5.44	5.56	6.70	6.48	5.45	5.38	5.46	5.22	5.21	6.76	6.59	5.61	5.44	5.53
Inst. Min	2.53	2.36	2.37	2.36	2.48	2.63	2.41	2.44	2.47	2.26	2.26	2.73	2.44	2.63

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 03
Address: Litchfield Line - North (at Laurel)
MH ID# SSMH3N1WNW220001

Date: 06/09/08
GPS: 33.353329N -112.213314W

Overview

Street Level

Meter Details

Meter Type	2150
Serial #	204K00870
Sensor Serial #	204M01676
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	30"	Horiz.	30"
Laterals	0			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole

Hydraulics:
Moderate to fast flow conditions.

Comments:
Elbow configuration

Photos
MH #SSMH3N1WNW220001
Site #03

Site ID (Night Photo)

Down Manhole

30” Influent

30” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

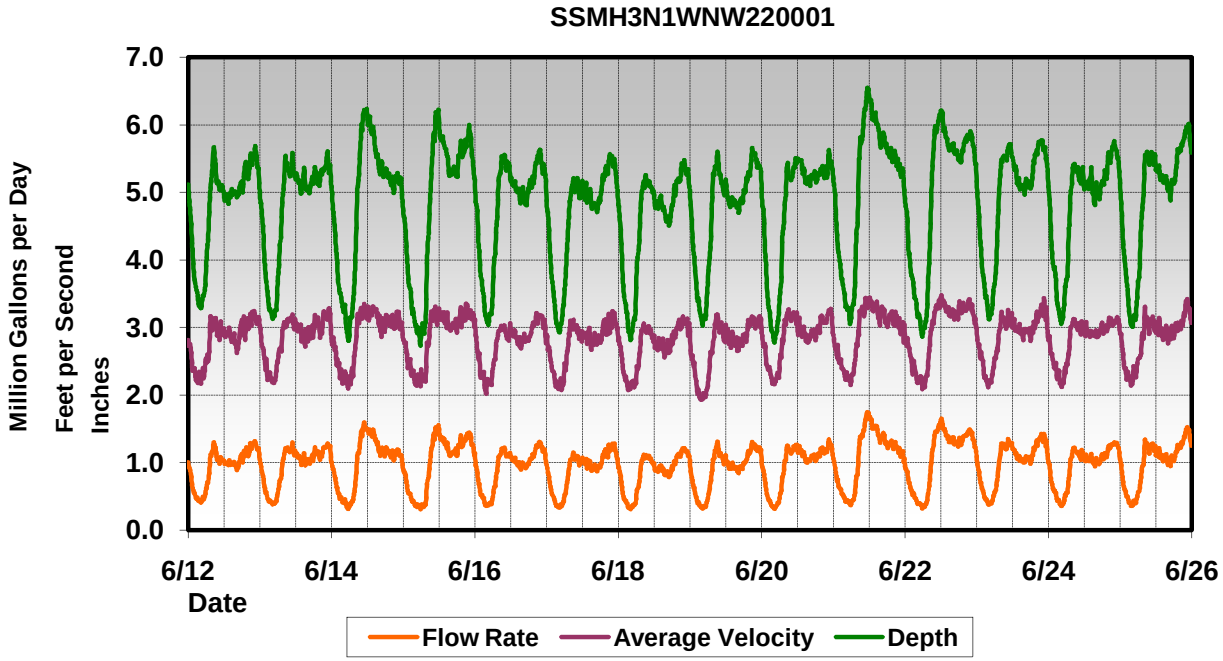
Site	**SSMH3N1WNW220001**
Address	**Litchfield Line - North**
Diameter	**30** Inches
GPS	**33.353329N -112.213314W**

Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.81
Maximum	6.54
Minimum	2.74
Max d/D	21.8%

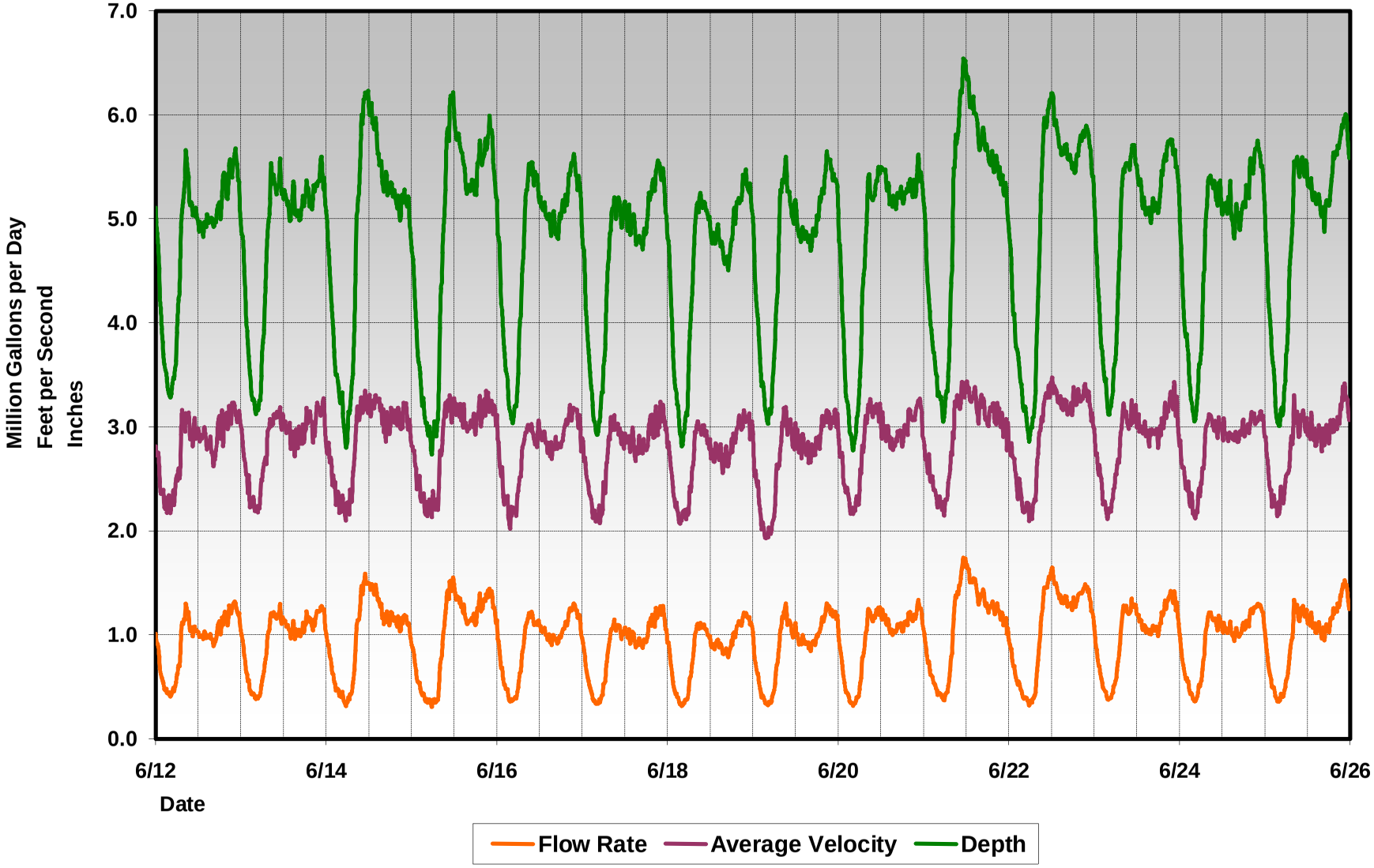
Flow velocity	
	Feet per Second
Average	2.84
Maximum	3.47
Minimum	1.93

Flow Rate	
	Million Gallons per Day
Average	0.97
Maximum	1.74
Minimum	0.31
Peak Factor	1.80



Flow Rate - Velocity - Depth

SSMH3N1WNW220001

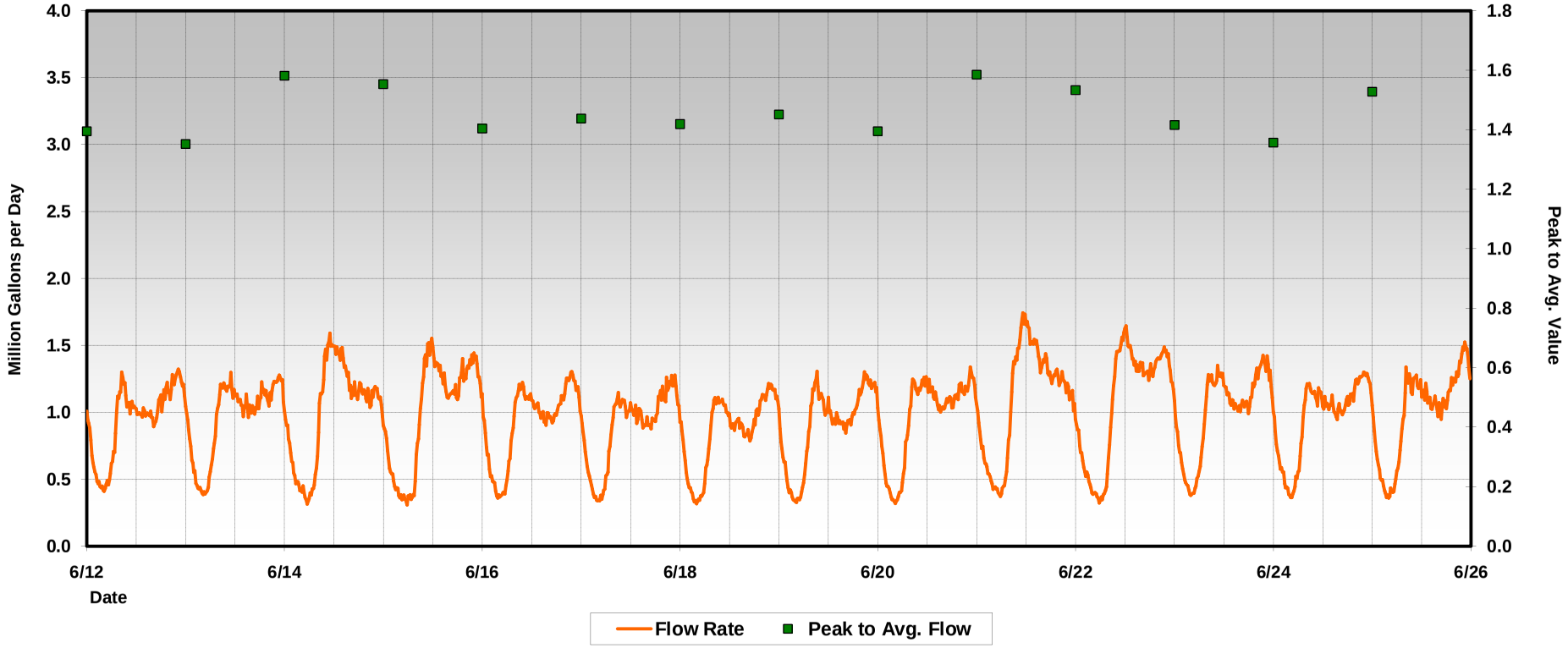


Peak to Average Flow Rate

Site ID SSMH3N1WNW220001

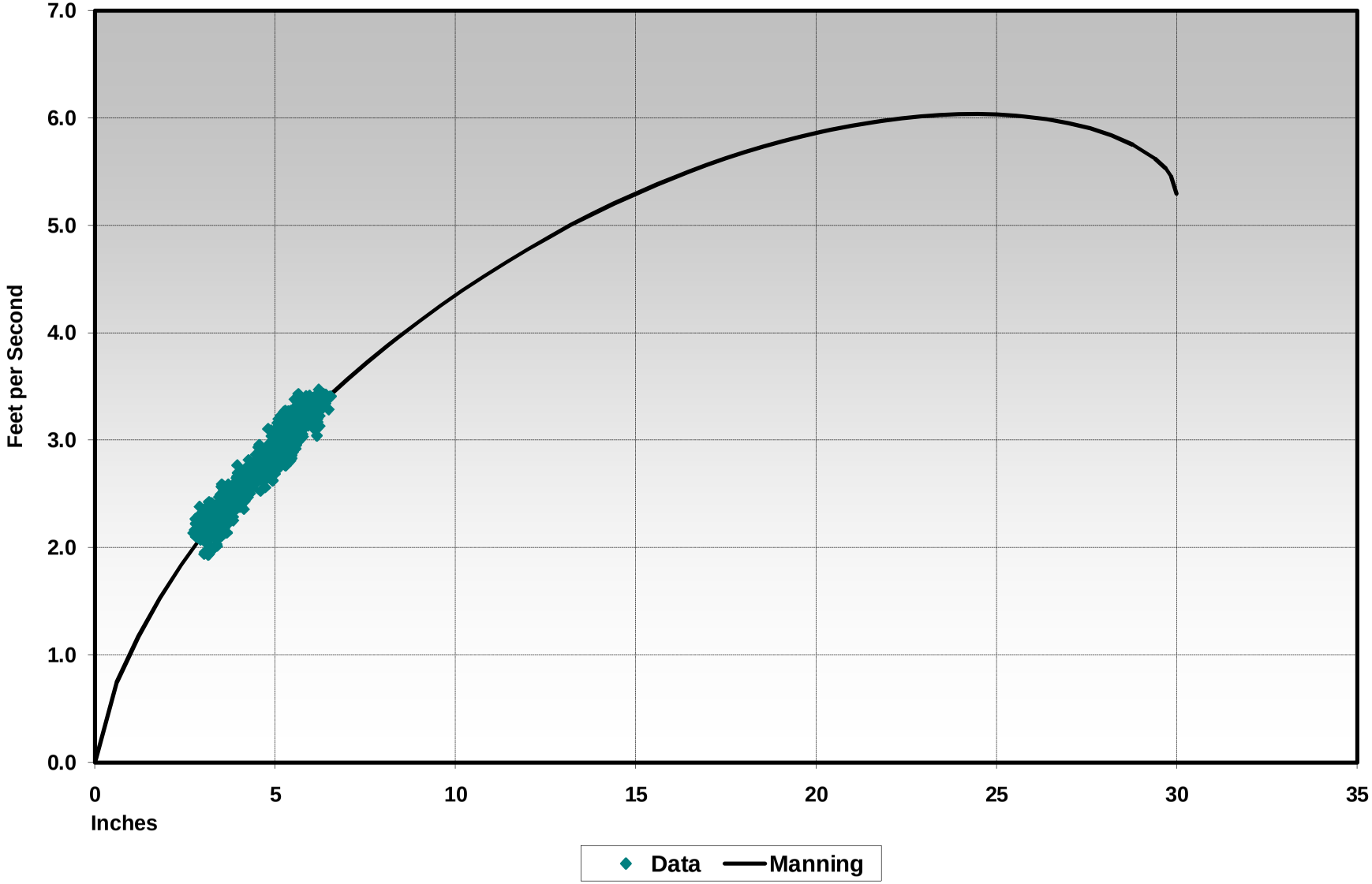
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.39	1.35	1.58	1.55	1.40	1.44	1.42	1.45	1.39	1.59	1.53	1.42	1.36	1.53



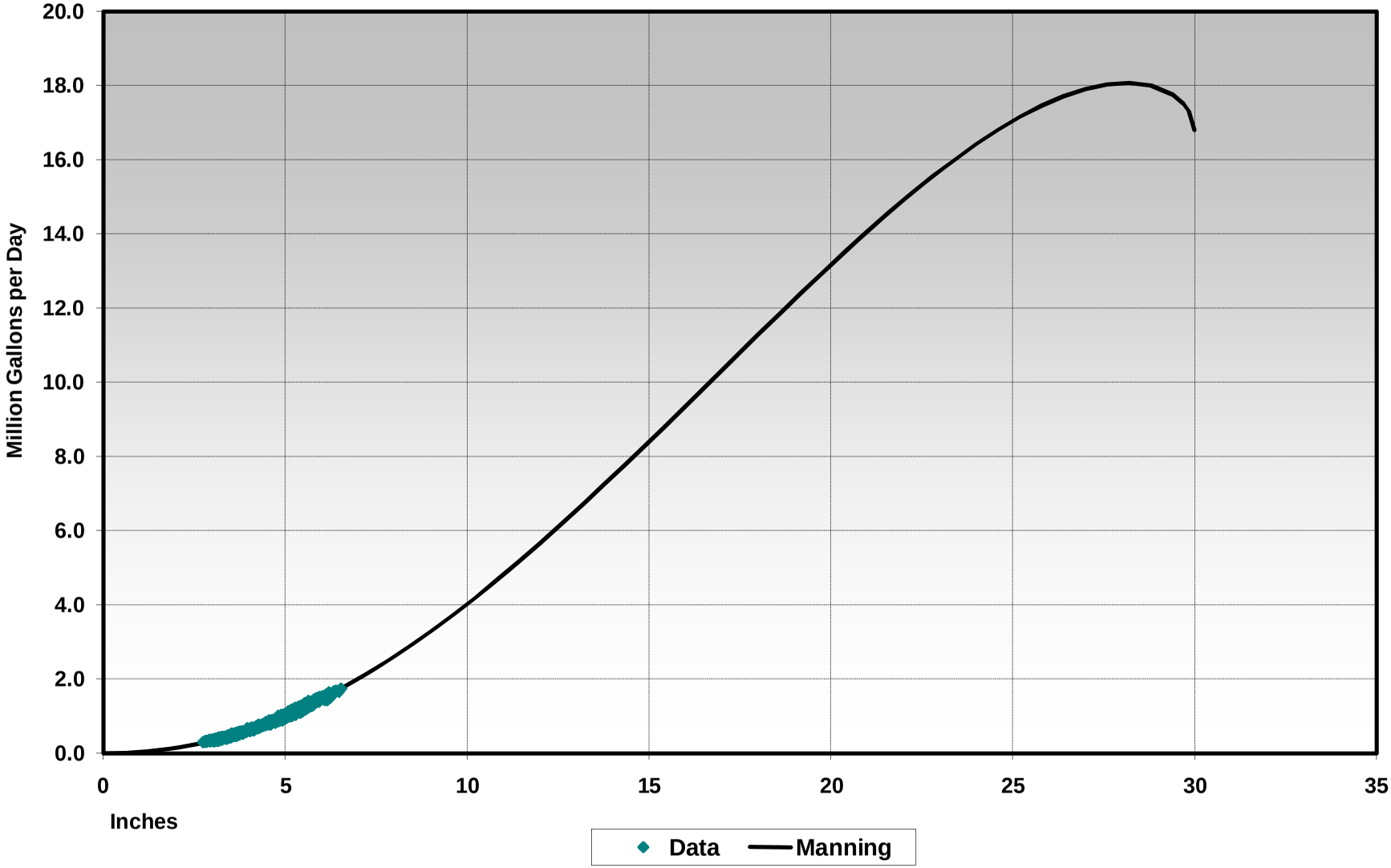
Velocity vs. Depth Scattergraph

SSMH3N1WNW220001



Flow Rate vs. Depth Scattergraph

SSMH3N1WNW220001



Flow Rate - Tabular Output

Site ID SSMH3N1WNW220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.94	0.96	0.94	0.86	0.97	0.88	0.88	0.85	0.92	0.96	0.90	0.95	0.90	0.91
1:00	0.67	0.70	0.72	0.63	0.67	0.62	0.60	0.62	0.65	0.73	0.70	0.69	0.65	0.63
2:00	0.51	0.51	0.54	0.50	0.50	0.47	0.44	0.44	0.45	0.59	0.55	0.52	0.54	0.49
3:00	0.45	0.43	0.46	0.42	0.40	0.37	0.36	0.36	0.36	0.50	0.48	0.43	0.42	0.39
4:00	0.43	0.39	0.42	0.36	0.38	0.35	0.34	0.34	0.33	0.43	0.40	0.39	0.37	0.40
5:00	0.50	0.44	0.34	0.35	0.41	0.40	0.38	0.39	0.40	0.40	0.36	0.48	0.47	0.44
6:00	0.66	0.63	0.39	0.37	0.59	0.58	0.58	0.58	0.60	0.43	0.36	0.64	0.64	0.62
7:00	1.02	0.90	0.50	0.40	0.87	0.86	0.86	0.88	0.89	0.63	0.45	0.96	0.98	0.90
8:00	1.22	1.15	0.93	0.79	1.12	1.06	1.07	1.16	1.18	1.07	0.82	1.24	1.20	1.23
9:00	1.15	1.19	1.24	1.15	1.20	1.08	1.09	1.21	1.17	1.39	1.24	1.23	1.15	1.20
10:00	1.05	1.19	1.47	1.42	1.13	1.08	1.07	1.12	1.19	1.53	1.46	1.27	1.10	1.26
11:00	1.05	1.19	1.52	1.50	1.12	1.00	1.01	1.00	1.23	1.71	1.55	1.28	1.15	1.20
12:00	1.00	1.12	1.48	1.40	1.06	1.02	0.92	1.02	1.19	1.65	1.58	1.18	1.06	1.13
13:00	0.99	1.07	1.44	1.35	1.04	0.98	0.90	0.93	1.14	1.52	1.46	1.10	1.05	1.13
14:00	0.99	1.05	1.39	1.27	0.99	1.00	0.93	0.95	1.08	1.52	1.36	1.07	1.06	1.05
15:00	0.98	1.01	1.26	1.14	0.94	0.90	0.86	0.91	1.03	1.36	1.34	1.03	0.98	1.07
16:00	0.93	1.02	1.15	1.14	0.97	0.92	0.84	0.90	1.06	1.39	1.32	1.05	1.02	1.01
17:00	1.04	1.05	1.15	1.15	0.96	0.93	0.83	0.94	1.10	1.32	1.29	1.06	1.04	1.07
18:00	1.10	1.14	1.19	1.18	1.03	1.00	0.97	1.01	1.07	1.25	1.30	1.06	1.09	1.11
19:00	1.16	1.14	1.14	1.30	1.10	1.14	1.04	1.11	1.14	1.29	1.36	1.22	1.13	1.22
20:00	1.18	1.09	1.10	1.31	1.21	1.14	1.12	1.22	1.18	1.24	1.41	1.31	1.23	1.26
21:00	1.25	1.21	1.12	1.39	1.27	1.20	1.17	1.25	1.17	1.21	1.46	1.39	1.27	1.37
22:00	1.30	1.25	1.16	1.40	1.23	1.24	1.19	1.20	1.28	1.16	1.42	1.36	1.29	1.49
23:00	1.19	1.20	1.06	1.21	1.12	1.11	1.12	1.19	1.21	1.10	1.23	1.21	1.21	1.36
Average	0.95	0.96	1.01	1.00	0.93	0.89	0.86	0.90	0.96	1.10	1.07	1.01	0.96	1.00
Median	1.01	1.05	1.13	1.15	1.00	0.97	0.92	0.96	1.10	1.23	1.29	1.09	1.05	1.09
Max Hr. Mean	1.30	1.25	1.52	1.50	1.27	1.24	1.19	1.25	1.28	1.71	1.58	1.39	1.29	1.49
Min Hr. Mean	0.43	0.39	0.34	0.35	0.38	0.35	0.34	0.34	0.33	0.40	0.36	0.39	0.37	0.39
Inst. Max	1.32	1.30	1.59	1.55	1.30	1.28	1.22	1.31	1.34	1.74	1.65	1.42	1.30	1.52
Inst. Min	0.41	0.39	0.32	0.31	0.36	0.34	0.32	0.33	0.32	0.37	0.32	0.38	0.36	0.36

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WNW220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.76	2.90	2.81	2.79	2.87	2.78	2.78	2.68	2.81	2.78	2.79	2.82	2.74	2.80
1:00	2.46	2.60	2.61	2.52	2.52	2.52	2.47	2.41	2.59	2.62	2.68	2.58	2.54	2.46
2:00	2.30	2.35	2.42	2.41	2.30	2.31	2.25	2.11	2.38	2.47	2.45	2.35	2.40	2.27
3:00	2.27	2.28	2.31	2.29	2.15	2.14	2.11	1.97	2.24	2.35	2.37	2.20	2.28	2.23
4:00	2.23	2.20	2.29	2.20	2.21	2.15	2.15	1.98	2.20	2.27	2.19	2.19	2.16	2.28
5:00	2.37	2.33	2.18	2.22	2.23	2.15	2.17	2.04	2.30	2.23	2.22	2.36	2.30	2.35
6:00	2.53	2.60	2.27	2.27	2.47	2.48	2.35	2.36	2.59	2.29	2.18	2.60	2.53	2.55
7:00	2.94	2.82	2.43	2.30	2.81	2.80	2.74	2.66	2.91	2.58	2.33	2.86	2.91	2.80
8:00	3.07	3.04	2.96	2.78	2.98	3.03	3.00	3.02	3.14	2.95	2.83	3.14	3.10	3.11
9:00	3.03	3.09	3.14	3.12	3.00	3.02	2.97	3.08	3.17	3.23	3.09	3.05	3.02	3.01
10:00	2.92	3.12	3.21	3.24	2.90	2.97	2.97	3.03	3.18	3.28	3.29	3.10	2.99	3.12
11:00	2.97	3.09	3.21	3.19	2.91	2.87	2.87	2.85	3.14	3.38	3.35	3.11	3.03	3.03
12:00	2.92	3.01	3.21	3.20	2.92	2.90	2.77	2.92	3.00	3.37	3.41	3.03	2.96	2.96
13:00	2.93	3.00	3.24	3.16	2.92	2.84	2.75	2.80	2.93	3.26	3.32	2.97	2.91	3.00
14:00	2.86	2.88	3.27	3.10	2.82	2.88	2.77	2.85	2.90	3.32	3.24	2.98	2.92	2.88
15:00	2.83	2.82	3.17	3.00	2.77	2.74	2.68	2.75	2.82	3.13	3.22	2.90	2.91	2.93
16:00	2.69	2.90	3.03	3.02	2.83	2.82	2.72	2.77	2.88	3.26	3.19	2.95	2.89	2.88
17:00	2.93	2.90	3.04	3.03	2.82	2.81	2.69	2.79	2.94	3.12	3.17	2.95	2.97	2.95
18:00	3.04	3.04	3.13	3.05	2.87	2.85	2.86	2.85	2.92	3.08	3.28	2.91	2.98	2.98
19:00	2.99	3.12	3.09	3.17	3.03	3.06	2.93	3.00	3.01	3.20	3.28	3.06	2.98	3.01
20:00	3.09	2.95	3.08	3.17	3.13	2.98	3.05	3.10	3.12	3.09	3.28	3.16	3.10	3.03
21:00	3.13	3.16	3.08	3.27	3.14	2.98	3.06	3.08	3.09	3.09	3.35	3.27	3.07	3.17
22:00	3.17	3.14	3.18	3.21	3.15	3.15	3.08	3.05	3.22	3.03	3.29	3.27	3.09	3.34
23:00	3.10	3.17	2.99	3.13	2.96	3.02	3.03	3.11	3.13	2.97	3.09	3.09	3.09	3.19
Average	2.81	2.85	2.89	2.87	2.78	2.76	2.72	2.72	2.86	2.93	2.95	2.87	2.83	2.85
Median	2.90	2.97	3.04	3.02	2.85	2.86	2.79	2.81	2.93	3.06	3.17	2.97	2.94	2.93
Max Hr. Mean	3.17	3.17	3.27	3.27	3.15	3.15	3.08	3.11	3.22	3.38	3.41	3.27	3.10	3.34
Min Hr. Mean	2.23	2.20	2.18	2.20	2.15	2.14	2.11	1.97	2.20	2.23	2.18	2.19	2.16	2.23
Inst. Max	3.24	3.28	3.35	3.35	3.21	3.24	3.16	3.19	3.27	3.44	3.47	3.43	3.15	3.42
Inst. Min	2.17	2.18	2.10	2.14	2.03	2.08	2.07	1.93	2.17	2.15	2.10	2.12	2.12	2.14

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WNW220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.92	4.84	4.87	4.60	4.89	4.68	4.67	4.69	4.78	4.98	4.74	4.89	4.78	4.77
1:00	4.21	4.19	4.28	3.95	4.15	3.96	3.89	4.03	3.96	4.31	4.09	4.19	4.03	4.06
2:00	3.67	3.61	3.68	3.52	3.63	3.47	3.34	3.49	3.29	3.86	3.72	3.67	3.71	3.58
3:00	3.41	3.28	3.41	3.20	3.27	3.08	3.03	3.24	2.97	3.58	3.44	3.36	3.25	3.11
4:00	3.33	3.17	3.23	2.99	3.07	2.97	2.88	3.10	2.83	3.30	3.18	3.16	3.10	3.10
5:00	3.53	3.29	2.89	2.87	3.23	3.23	3.14	3.30	3.09	3.16	2.96	3.44	3.46	3.28
6:00	4.12	3.91	3.08	2.95	3.84	3.79	3.91	3.93	3.73	3.28	3.00	3.93	4.00	3.91
7:00	4.96	4.70	3.48	3.11	4.61	4.59	4.63	4.83	4.56	3.89	3.33	4.88	4.88	4.72
8:00	5.47	5.28	4.63	4.34	5.27	5.03	5.09	5.34	5.27	5.12	4.40	5.46	5.39	5.47
9:00	5.30	5.38	5.44	5.20	5.50	5.10	5.18	5.43	5.21	5.79	5.51	5.53	5.34	5.51
10:00	5.10	5.31	6.06	5.87	5.42	5.16	5.13	5.20	5.28	6.15	5.92	5.61	5.20	5.56
11:00	5.06	5.36	6.20	6.18	5.36	5.00	5.04	5.04	5.43	6.49	6.10	5.62	5.30	5.48
12:00	4.94	5.23	6.08	5.87	5.15	5.05	4.84	5.02	5.48	6.35	6.12	5.40	5.09	5.33
13:00	4.90	5.10	5.91	5.76	5.10	4.95	4.81	4.83	5.40	6.11	5.89	5.23	5.14	5.28
14:00	4.99	5.16	5.76	5.59	5.03	5.00	4.86	4.87	5.24	6.06	5.70	5.11	5.15	5.18
15:00	4.99	5.11	5.49	5.33	4.93	4.80	4.72	4.83	5.18	5.83	5.66	5.08	4.90	5.17
16:00	4.97	5.02	5.33	5.29	4.94	4.79	4.60	4.78	5.19	5.78	5.63	5.10	5.04	5.03
17:00	5.08	5.15	5.29	5.32	4.92	4.83	4.61	4.88	5.26	5.72	5.56	5.12	5.03	5.15
18:00	5.13	5.28	5.31	5.40	5.10	5.04	4.92	5.06	5.19	5.58	5.48	5.18	5.19	5.24
19:00	5.41	5.20	5.22	5.61	5.15	5.26	5.08	5.23	5.29	5.56	5.64	5.51	5.31	5.57
20:00	5.32	5.22	5.11	5.64	5.39	5.35	5.18	5.45	5.32	5.53	5.79	5.66	5.49	5.67
21:00	5.49	5.34	5.17	5.75	5.57	5.52	5.35	5.58	5.29	5.43	5.85	5.74	5.65	5.82
22:00	5.60	5.50	5.19	5.87	5.41	5.44	5.36	5.44	5.48	5.33	5.80	5.67	5.67	5.95
23:00	5.35	5.31	5.06	5.40	5.29	5.17	5.22	5.35	5.38	5.21	5.50	5.43	5.44	5.77
Average	4.80	4.79	4.84	4.82	4.76	4.64	4.56	4.71	4.75	5.10	4.96	4.91	4.81	4.90
Median	5.00	5.13	5.19	5.29	5.06	4.90	4.80	4.90	5.21	5.50	5.58	5.16	5.12	5.20
Max Hr. Mean	5.60	5.50	6.20	6.18	5.57	5.52	5.36	5.58	5.48	6.49	6.12	5.74	5.67	5.95
Min Hr. Mean	3.33	3.17	2.89	2.87	3.07	2.97	2.88	3.10	2.83	3.16	2.96	3.16	3.10	3.10
Inst. Max	5.68	5.60	6.23	6.22	5.63	5.56	5.48	5.65	5.62	6.54	6.21	5.77	5.75	6.01
Inst. Min	3.29	3.13	2.81	2.74	3.04	2.93	2.82	3.03	2.78	3.06	2.86	3.12	3.06	3.01

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 04**	**Date:**	**06/11/08**
Address:	**N Reems Road S of Waddell Road**	**GPS:**	**33.363319N -112.233798W**
MH ID#	**Alternate Location**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**204M01456**
Sensor Serial #	**204M01442**
Telemetry	**None**
Sample Rate	**5 min**

Down Manhole

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert. 27" Horiz. 27"**
Laterals	**0**
Pipe Material	**PVC**
Surcharge Evidence	**No**
Height Above Crown (in)	**0**
Infiltration	**No**
Silt	**No**
Debris	**Yes - toilet paper**
Grease	**No**
Pests	**No**

Hydraulics:
Fast flow conditions.

Comments:
Original site buried by road construction. No install possible.
Alternate site installation.

Photos
MH # ALTERNATE LOCATION
Site #04

Site ID

Down Manhole

27” Influent

27” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

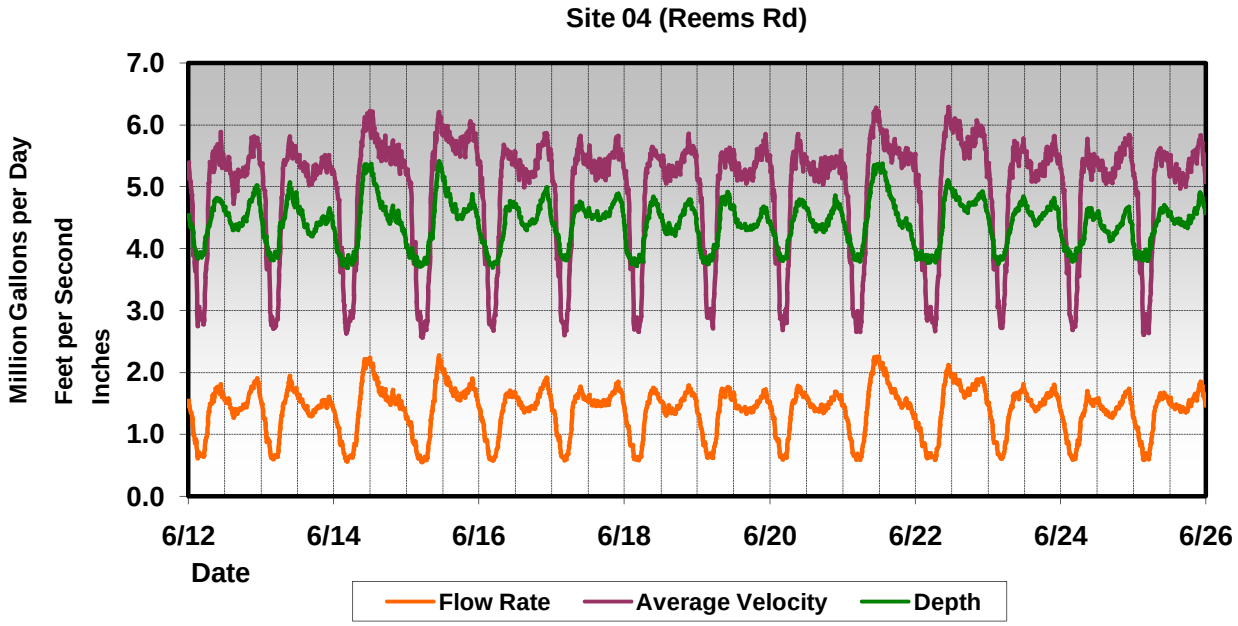
Site	**Site 04 (Reems Rd)**	
Address	**Reems Rd S of Waddell**	
Diameter	**27**	Inches
GPS	**33.363319N -112.233798W**	

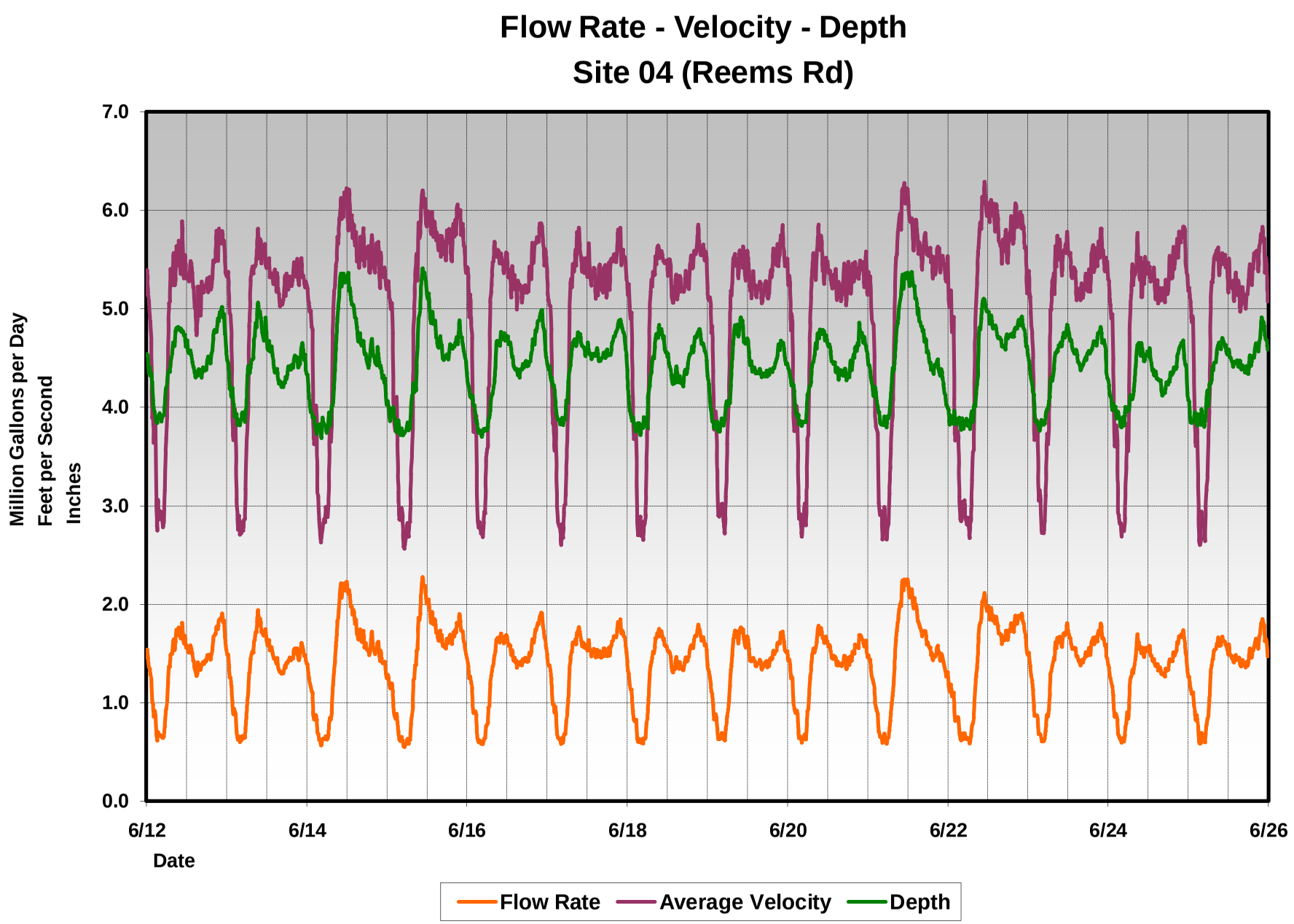
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.41
Maximum	5.41
Minimum	3.69
Max d/D	20.0%

Flow velocity	
	Feet per Second
Average	4.96
Maximum	6.29
Minimum	2.57

Flow Rate	
	Million Gallons per Day
Average	1.39
Maximum	2.28
Minimum	0.55
Peak Factor	1.64



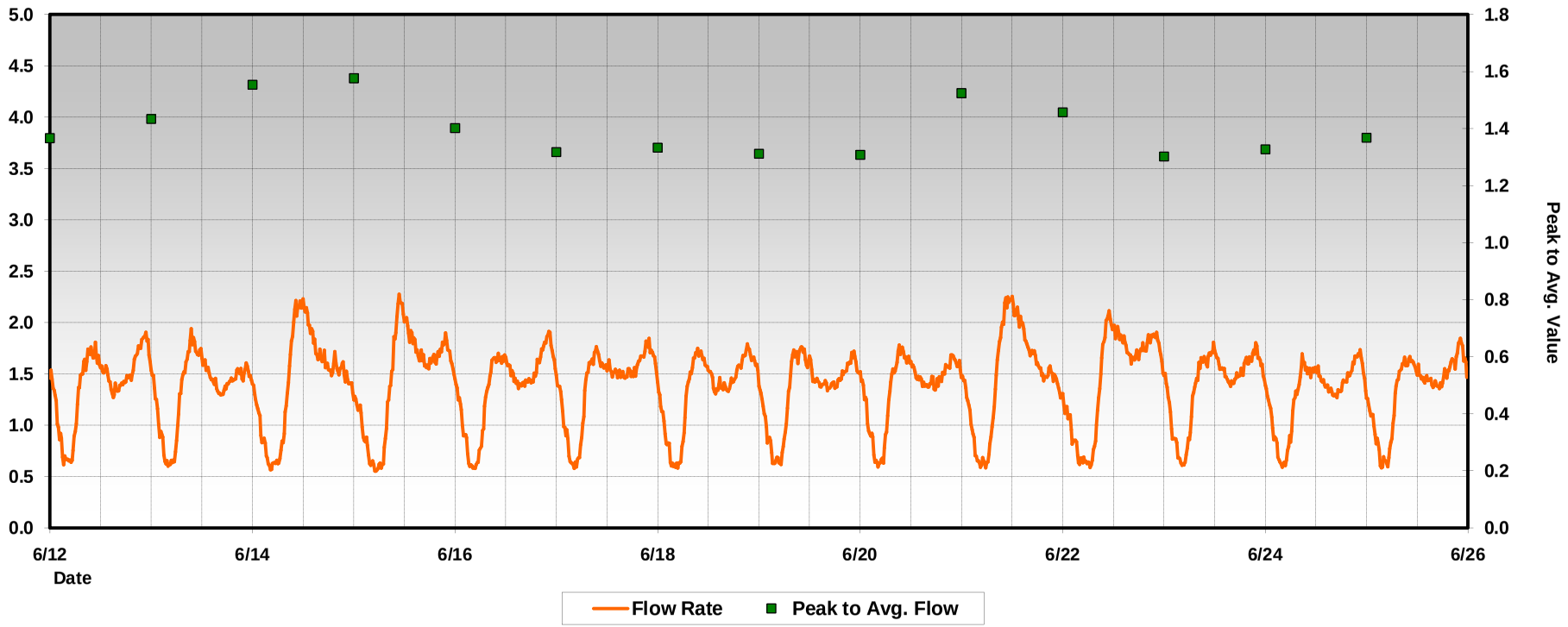

Flow Rate - Velocity - Depth
Site 04 (Reems Rd)
Million Gallons per Day
Feet per Second
Inches
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

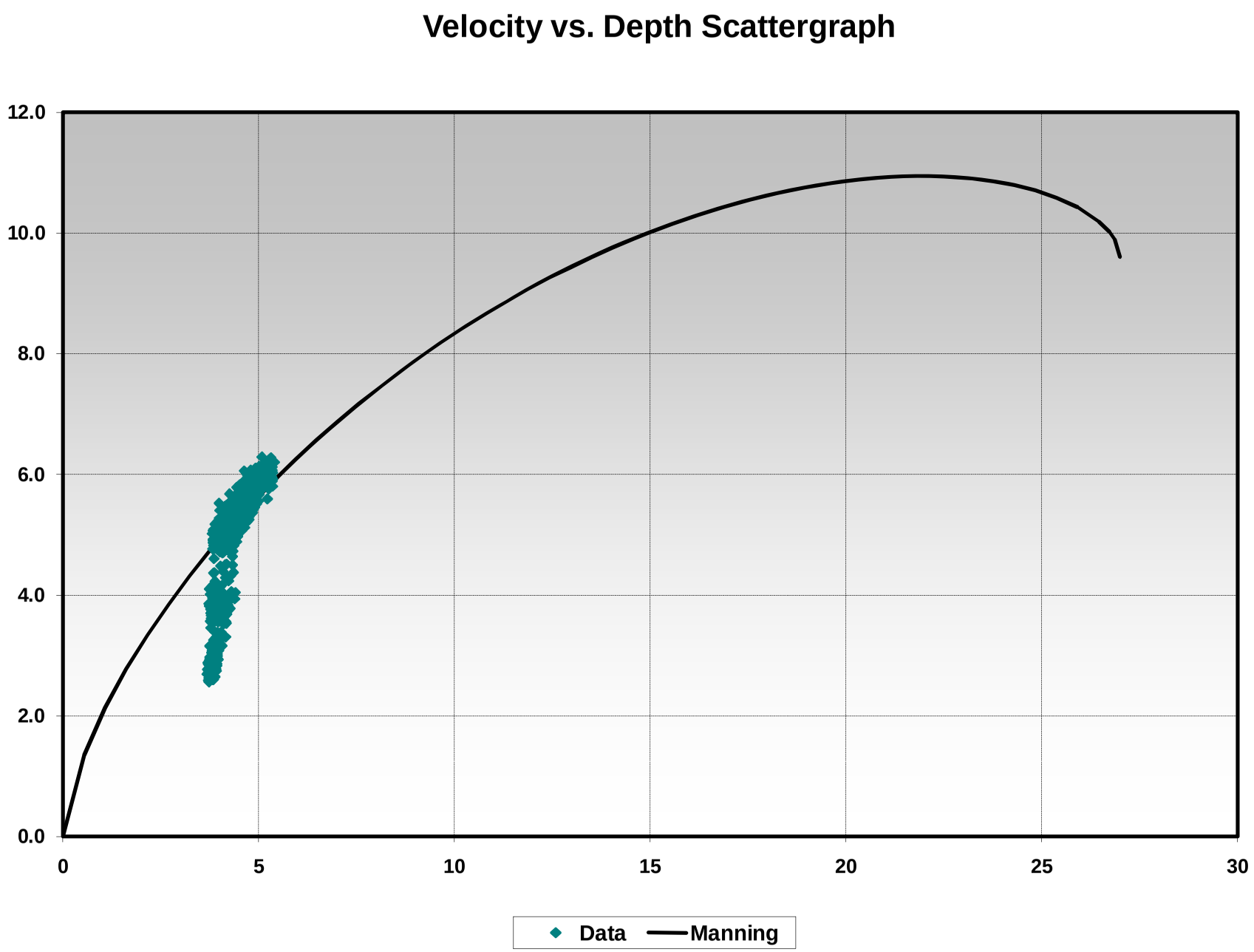
Peak to Average Flow Rate

Site ID Site 04 (Reems Rd)

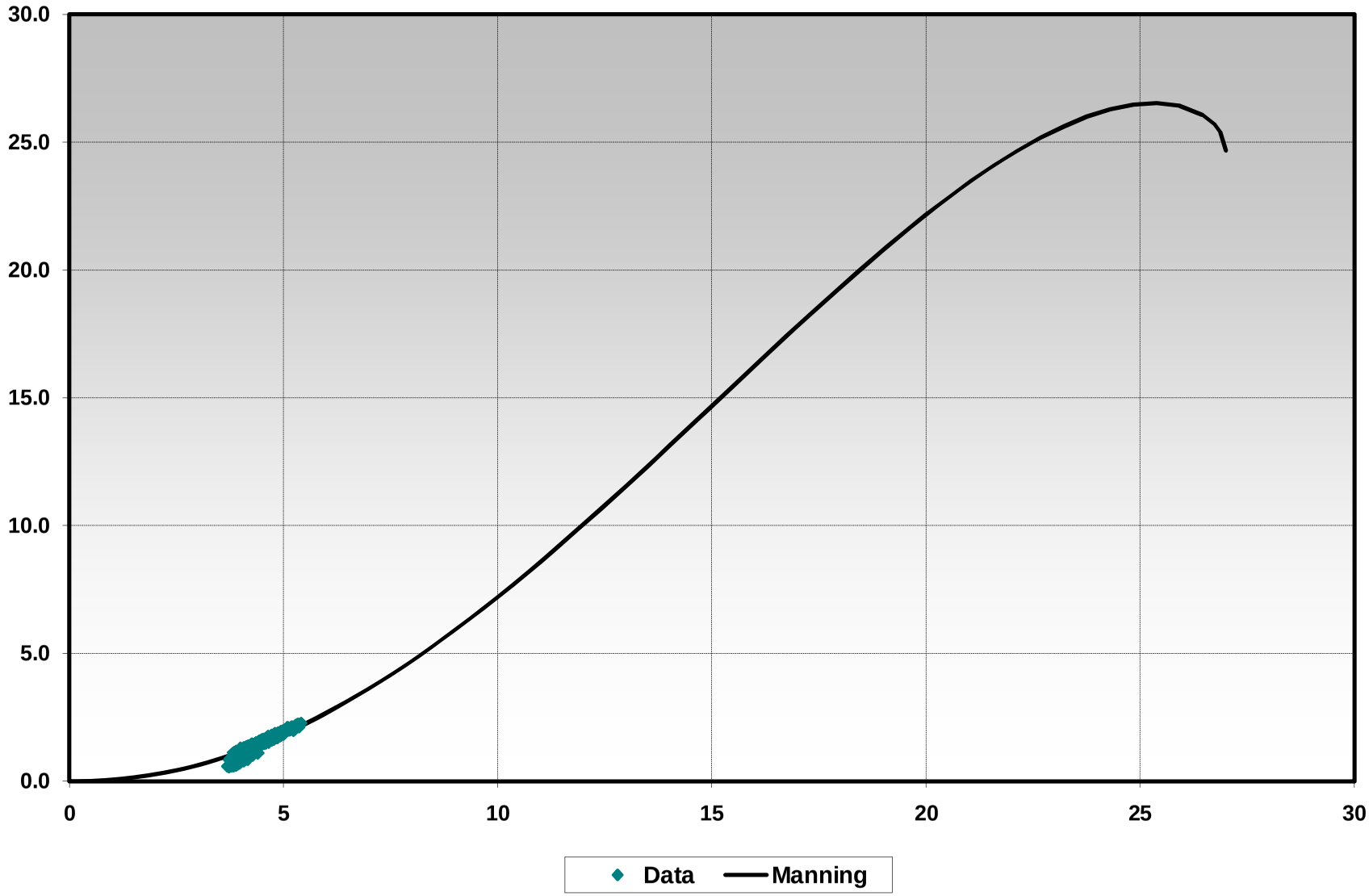
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.37	1.43	1.55	1.58	1.40	1.32	1.33	1.31	1.31	1.52	1.46	1.30	1.33	1.37




Velocity vs. Depth Scattergraph
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
25
30
Data
Manning

Flow Rate vs. Depth Scattergraph



Flow Rate - Tabular Output

Site ID Site 04 (Reems Rd)

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.45	1.47	1.33	1.25	1.36	1.41	1.30	1.32	1.44	1.45	1.20	1.44	1.32	1.21
1:00	1.22	1.17	1.14	1.15	1.15	1.17	1.05	1.09	1.20	1.27	1.11	1.15	1.10	1.07
2:00	0.91	0.90	0.86	0.89	0.90	0.93	0.82	0.85	0.92	1.01	0.87	0.87	0.86	0.86
3:00	0.67	0.66	0.71	0.76	0.64	0.65	0.62	0.65	0.72	0.73	0.76	0.72	0.65	0.64
4:00	0.66	0.62	0.59	0.63	0.59	0.61	0.61	0.67	0.62	0.62	0.65	0.62	0.61	0.66
5:00	0.74	0.67	0.64	0.56	0.66	0.71	0.68	0.69	0.69	0.64	0.65	0.75	0.78	0.72
6:00	1.13	1.07	0.67	0.61	0.87	1.08	1.03	0.99	1.05	0.71	0.62	1.04	1.04	1.07
7:00	1.46	1.44	0.93	0.81	1.29	1.52	1.44	1.45	1.45	1.03	0.77	1.39	1.31	1.45
8:00	1.60	1.62	1.37	1.31	1.51	1.61	1.59	1.69	1.55	1.55	1.19	1.57	1.53	1.57
9:00	1.72	1.82	1.84	1.69	1.64	1.73	1.71	1.69	1.73	1.91	1.69	1.64	1.58	1.60
10:00	1.70	1.77	2.14	2.10	1.65	1.62	1.69	1.74	1.70	2.14	1.99	1.64	1.51	1.64
11:00	1.64	1.71	2.16	2.16	1.64	1.58	1.60	1.60	1.63	2.22	2.02	1.73	1.55	1.58
12:00	1.54	1.62	2.16	2.01	1.61	1.57	1.52	1.57	1.59	2.14	1.91	1.68	1.53	1.51
13:00	1.54	1.54	1.98	1.88	1.52	1.51	1.36	1.44	1.48	2.07	1.89	1.56	1.44	1.44
14:00	1.38	1.44	1.87	1.80	1.43	1.51	1.39	1.40	1.44	1.99	1.83	1.51	1.38	1.46
15:00	1.33	1.38	1.67	1.67	1.38	1.51	1.37	1.41	1.40	1.80	1.72	1.41	1.34	1.41
16:00	1.36	1.30	1.66	1.66	1.41	1.47	1.35	1.37	1.39	1.71	1.65	1.42	1.29	1.40
17:00	1.41	1.34	1.62	1.57	1.44	1.53	1.41	1.40	1.41	1.67	1.68	1.48	1.32	1.38
18:00	1.46	1.42	1.52	1.64	1.44	1.51	1.47	1.39	1.42	1.58	1.71	1.51	1.40	1.48
19:00	1.49	1.45	1.61	1.64	1.57	1.60	1.57	1.47	1.47	1.47	1.75	1.62	1.46	1.52
20:00	1.68	1.51	1.53	1.71	1.69	1.67	1.67	1.52	1.56	1.50	1.84	1.63	1.54	1.63
21:00	1.78	1.48	1.57	1.82	1.81	1.77	1.75	1.61	1.62	1.51	1.87	1.73	1.65	1.68
22:00	1.87	1.56	1.45	1.75	1.87	1.75	1.66	1.69	1.64	1.46	1.85	1.68	1.69	1.81
23:00	1.74	1.48	1.39	1.57	1.65	1.61	1.58	1.54	1.58	1.31	1.64	1.52	1.47	1.59
Average	1.39	1.35	1.43	1.44	1.36	1.40	1.34	1.34	1.36	1.48	1.45	1.39	1.31	1.35
Median	1.48	1.45	1.53	1.61	1.44	1.52	1.44	1.42	1.46	1.49	1.69	1.49	1.39	1.45
Max Hr. Mean	1.87	1.82	2.16	2.16	1.87	1.77	1.75	1.74	1.73	2.22	2.02	1.73	1.69	1.81
Min Hr. Mean	0.66	0.62	0.59	0.56	0.59	0.61	0.61	0.65	0.62	0.62	0.62	0.62	0.61	0.64
Inst. Max	1.91	1.94	2.23	2.28	1.91	1.85	1.79	1.76	1.78	2.25	2.12	1.81	1.74	1.85
Inst. Min	0.62	0.60	0.57	0.55	0.58	0.58	0.58	0.62	0.59	0.59	0.59	0.61	0.59	0.59

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID Site 04 (Reems Rd)

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.19	5.28	5.15	5.22	5.26	5.15	5.17	5.13	5.33	5.26	5.18	5.21	5.19	5.15
1:00	4.58	4.64	4.89	4.97	4.68	4.50	4.62	4.74	4.63	4.94	4.94	4.50	4.60	4.77
2:00	3.85	3.84	3.83	3.90	3.85	3.75	3.74	3.84	3.86	4.01	3.83	3.82	3.69	3.77
3:00	2.95	2.91	3.24	3.44	2.92	2.87	2.78	2.99	3.18	3.16	3.35	3.25	2.87	2.81
4:00	2.90	2.75	2.71	2.92	2.74	2.72	2.77	2.96	2.79	2.80	2.94	2.76	2.75	2.87
5:00	3.08	2.91	2.88	2.61	3.04	3.07	2.97	2.98	3.02	2.83	2.90	3.25	3.32	3.02
6:00	4.29	4.05	3.01	2.78	3.90	4.16	4.23	4.13	4.14	3.03	2.79	4.21	4.34	4.23
7:00	5.26	5.24	4.01	3.39	5.26	5.31	5.27	5.27	5.34	3.93	3.31	5.23	5.31	5.35
8:00	5.40	5.42	5.19	5.13	5.57	5.46	5.42	5.51	5.38	5.30	4.82	5.49	5.49	5.55
9:00	5.57	5.63	5.70	5.61	5.54	5.73	5.59	5.49	5.69	5.86	5.71	5.60	5.45	5.46
10:00	5.55	5.62	6.01	6.01	5.51	5.49	5.55	5.54	5.56	6.09	6.02	5.49	5.24	5.52
11:00	5.46	5.59	6.06	6.04	5.47	5.47	5.48	5.40	5.42	6.19	6.10	5.65	5.44	5.46
12:00	5.30	5.46	6.05	5.93	5.41	5.43	5.44	5.42	5.41	6.01	5.99	5.56	5.38	5.30
13:00	5.40	5.34	5.89	5.88	5.30	5.31	5.18	5.26	5.28	5.79	6.03	5.36	5.34	5.20
14:00	5.11	5.31	5.78	5.78	5.25	5.28	5.22	5.18	5.25	5.87	5.93	5.26	5.22	5.23
15:00	4.94	5.22	5.49	5.67	5.18	5.32	5.22	5.23	5.24	5.63	5.73	5.14	5.11	5.12
16:00	5.09	5.05	5.60	5.65	5.18	5.21	5.22	5.13	5.19	5.53	5.62	5.18	5.15	5.13
17:00	5.20	5.18	5.62	5.58	5.20	5.35	5.27	5.24	5.26	5.67	5.67	5.25	5.18	5.11
18:00	5.24	5.27	5.52	5.77	5.24	5.27	5.28	5.18	5.31	5.59	5.66	5.25	5.36	5.37
19:00	5.26	5.28	5.54	5.62	5.44	5.49	5.47	5.43	5.29	5.46	5.77	5.54	5.43	5.41
20:00	5.50	5.42	5.47	5.81	5.62	5.51	5.57	5.48	5.40	5.42	5.95	5.51	5.59	5.57
21:00	5.67	5.35	5.56	6.00	5.75	5.67	5.71	5.54	5.37	5.55	5.94	5.65	5.67	5.61
22:00	5.72	5.42	5.37	5.84	5.81	5.62	5.58	5.72	5.45	5.50	5.86	5.62	5.78	5.74
23:00	5.57	5.28	5.34	5.53	5.54	5.46	5.53	5.49	5.37	5.36	5.49	5.46	5.49	5.35
Average	4.92	4.89	5.00	5.04	4.94	4.94	4.93	4.93	4.92	5.03	5.06	4.97	4.93	4.92
Median	5.24	5.29	5.43	5.60	5.31	5.34	5.30	5.25	5.28	5.51	5.66	5.33	5.29	5.27
Max Hr. Mean	5.72	5.63	6.06	6.04	5.81	5.73	5.71	5.72	5.69	6.19	6.10	5.65	5.78	5.74
Min Hr. Mean	2.90	2.75	2.71	2.61	2.74	2.72	2.77	2.96	2.79	2.80	2.79	2.76	2.75	2.81
Inst. Max	5.89	5.81	6.22	6.20	5.87	5.82	5.86	5.85	5.85	6.28	6.29	5.81	5.83	5.83
Inst. Min	2.75	2.71	2.63	2.57	2.68	2.60	2.65	2.73	2.69	2.66	2.67	2.72	2.69	2.60

All Values in Feet per Second

Depth - Tabular Output

Site ID Site 04 (Reems Rd)

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.47	4.46	4.25	4.01	4.25	4.41	4.17	4.23	4.38	4.44	3.93	4.44	4.19	3.98
1:00	4.33	4.17	3.96	3.94	4.11	4.27	3.90	3.91	4.24	4.22	3.85	4.20	4.02	3.86
2:00	3.98	3.98	3.85	3.89	3.96	4.11	3.79	3.82	4.02	4.15	3.87	3.89	3.95	3.88
3:00	3.87	3.87	3.78	3.80	3.79	3.88	3.82	3.78	3.89	3.94	3.87	3.81	3.89	3.87
4:00	3.89	3.88	3.79	3.74	3.73	3.84	3.78	3.85	3.84	3.82	3.82	3.84	3.84	3.90
5:00	4.01	3.92	3.82	3.74	3.78	3.93	3.86	3.94	3.89	3.85	3.86	3.92	3.96	4.00
6:00	4.29	4.27	3.83	3.80	3.83	4.23	4.07	4.03	4.17	3.94	3.81	4.10	4.03	4.18
7:00	4.46	4.43	3.93	4.01	4.08	4.55	4.41	4.42	4.38	4.28	3.93	4.32	4.11	4.38
8:00	4.67	4.69	4.30	4.20	4.37	4.65	4.64	4.78	4.58	4.62	4.10	4.54	4.46	4.51
9:00	4.80	4.94	4.95	4.72	4.66	4.72	4.76	4.79	4.75	4.97	4.65	4.62	4.60	4.62
10:00	4.78	4.88	5.30	5.23	4.70	4.66	4.75	4.87	4.76	5.24	5.03	4.68	4.56	4.67
11:00	4.71	4.77	5.31	5.32	4.71	4.57	4.61	4.66	4.72	5.33	5.03	4.76	4.53	4.58
12:00	4.61	4.66	5.30	5.12	4.67	4.58	4.48	4.59	4.63	5.30	4.91	4.73	4.53	4.54
13:00	4.53	4.57	5.10	4.92	4.57	4.52	4.30	4.41	4.48	5.31	4.85	4.61	4.38	4.45
14:00	4.37	4.40	4.96	4.82	4.39	4.54	4.32	4.37	4.41	5.12	4.79	4.56	4.32	4.47
15:00	4.36	4.32	4.74	4.64	4.34	4.52	4.29	4.36	4.33	4.92	4.70	4.43	4.27	4.43
16:00	4.34	4.24	4.67	4.62	4.40	4.49	4.24	4.33	4.35	4.80	4.63	4.42	4.15	4.40
17:00	4.39	4.25	4.58	4.50	4.44	4.54	4.34	4.34	4.35	4.65	4.66	4.50	4.21	4.38
18:00	4.47	4.36	4.44	4.52	4.43	4.55	4.47	4.35	4.35	4.50	4.72	4.56	4.28	4.43
19:00	4.51	4.41	4.60	4.61	4.57	4.61	4.57	4.37	4.46	4.37	4.73	4.62	4.36	4.50
20:00	4.75	4.47	4.48	4.64	4.71	4.74	4.69	4.45	4.57	4.44	4.80	4.66	4.42	4.63
21:00	4.85	4.46	4.51	4.74	4.86	4.83	4.77	4.59	4.73	4.39	4.87	4.77	4.60	4.69
22:00	4.99	4.56	4.37	4.70	4.93	4.83	4.67	4.65	4.71	4.32	4.86	4.69	4.62	4.87
23:00	4.83	4.50	4.25	4.52	4.67	4.65	4.55	4.49	4.64	4.08	4.68	4.47	4.35	4.67
Average	4.47	4.39	4.46	4.45	4.37	4.47	4.34	4.35	4.40	4.54	4.46	4.42	4.28	4.37
Median	4.48	4.41	4.45	4.54	4.42	4.54	4.38	4.37	4.44	4.43	4.70	4.54	4.28	4.46
Max Hr. Mean	4.99	4.94	5.31	5.32	4.93	4.83	4.77	4.87	4.76	5.33	5.03	4.77	4.62	4.87
Min Hr. Mean	3.87	3.87	3.78	3.74	3.73	3.84	3.78	3.78	3.84	3.82	3.81	3.81	3.84	3.86
Inst. Max	5.02	5.06	5.36	5.41	4.99	4.89	4.84	4.91	4.85	5.37	5.10	4.84	4.68	4.91
Inst. Min	3.84	3.82	3.69	3.72	3.70	3.82	3.72	3.75	3.81	3.80	3.77	3.76	3.80	3.80

All Values in Inches

FLOW SERVICES GROUP

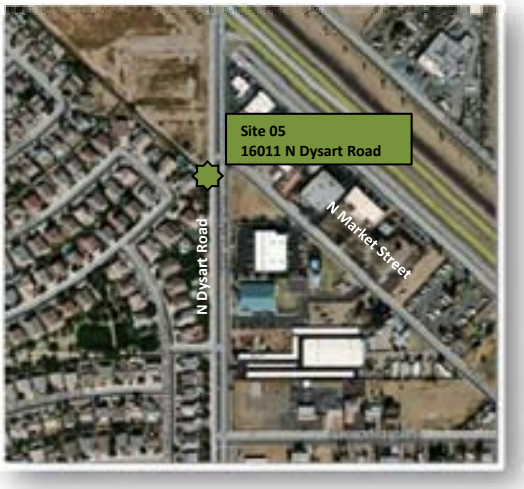
Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 05
Address: 16011 N Dysart Road
MH ID# SSMH3N1WSW020046

Date: 06/10/08
GPS: 33.374960N -112.203199W

Overview



Street Level

Meter Details

Meter Type 2150
Serial # 201D01151
Sensor Serial # 205E00560
Telemetry None
Sample Rate 5 min

Pipe Details and Manhole Condition

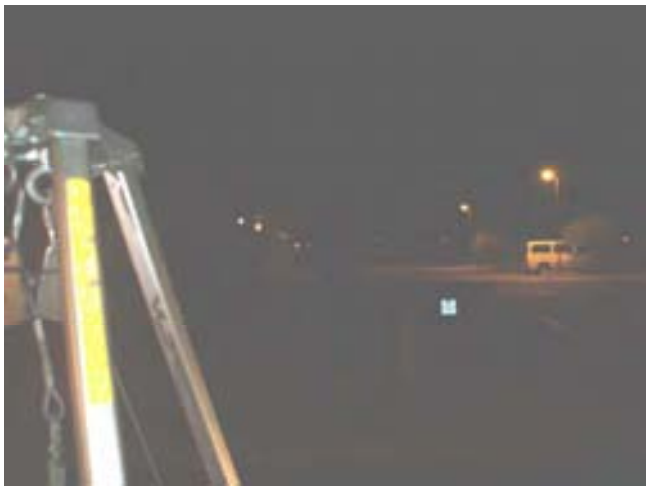
Pipe Size (in) Vert. 12" Horiz. 12"
Laterals 1
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Down Manhole

Hydraulics:
Low flow conditions.

Comments:
Swirling prevents effluent readings.

Photos
MH #SSMH3N1WSW020046
Site #05


Site ID (Night Photo)

Down Manhole

12” Influent

12” Effluent

6” Drop In (Dry)

MANHOLE COVER TOP

Photos
MH #SSMH3N1WSW020046
Site #05

Manhole Cover Bottom

Location Summary

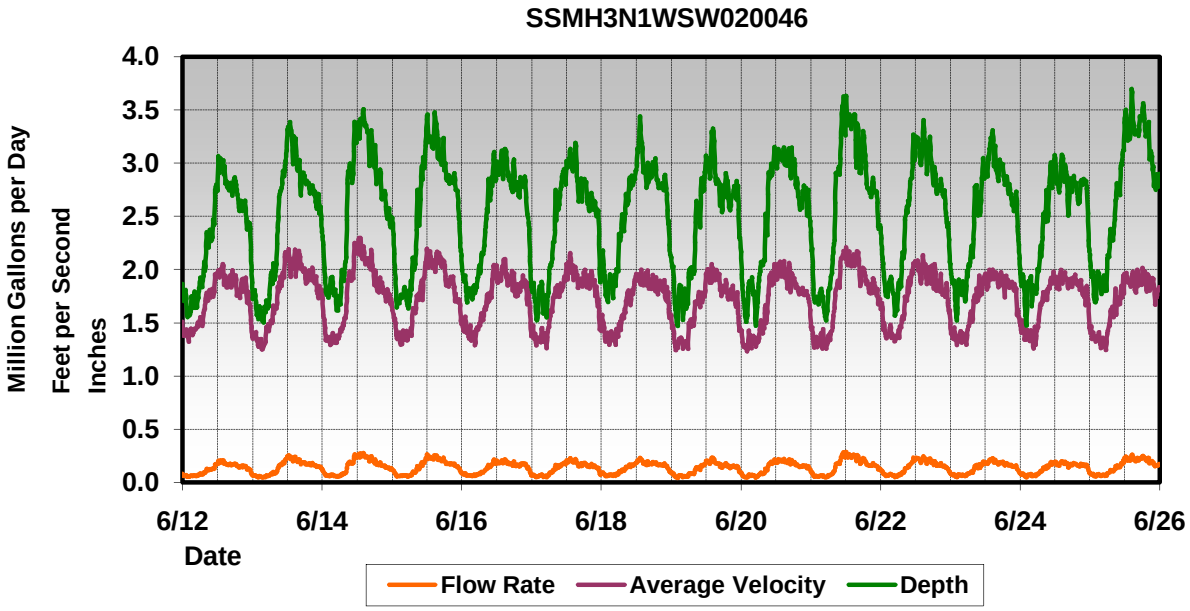
Site	**SSMH3N1WSW020046**	
Address	**16011 N Dysart Road**	
Diameter	**12**	Inches
GPS	**33.374960N**	**-112.203199W**

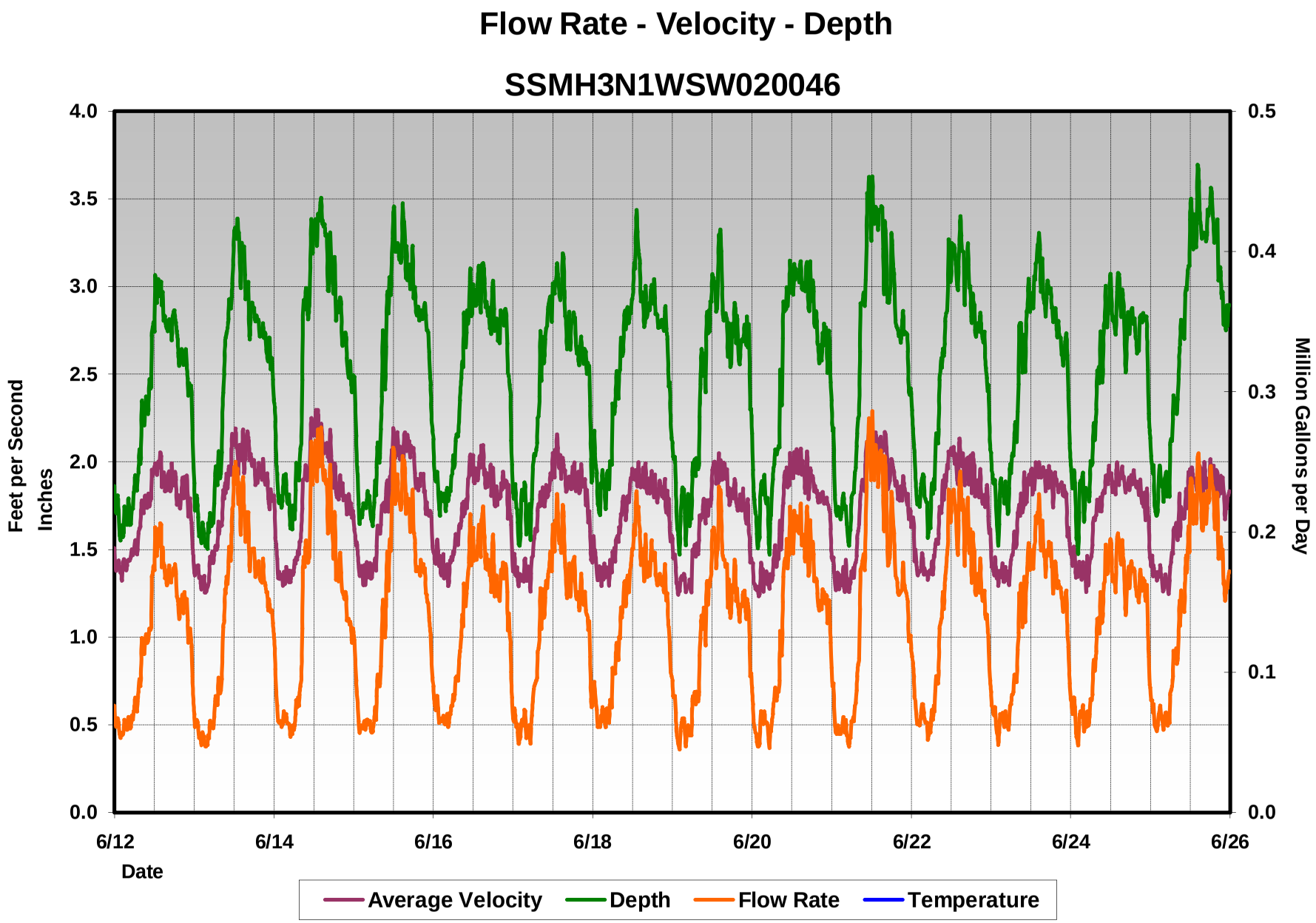
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	2.52
Maximum	3.69
Minimum	1.47
Max d/D	30.8%

Flow velocity	
	Feet per Second
Average	1.72
Maximum	2.30
Minimum	1.23

Flow Rate	
	Million Gallons per Day
Average	0.14
Maximum	0.29
Minimum	0.05
Peak Factor	2.03



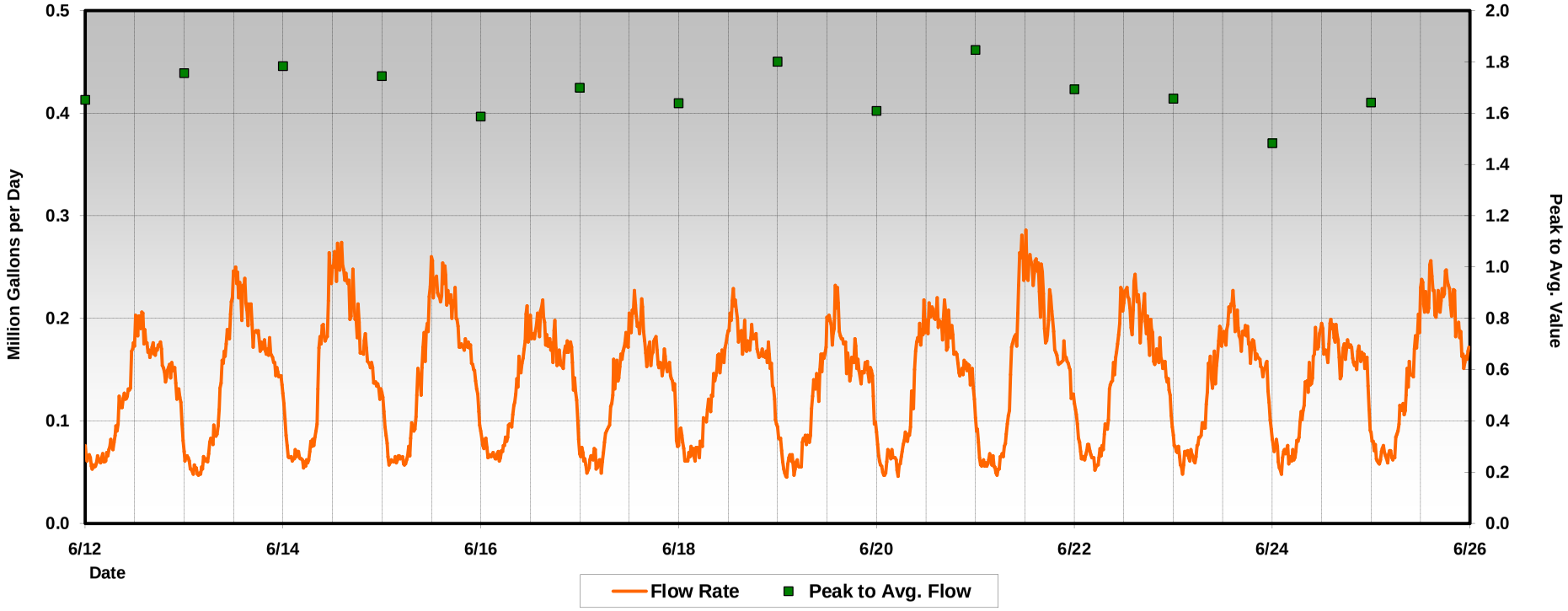

Flow Rate - Velocity - Depth
SSMH3N1WSW020046
Feet per Second
Inches
Million Gallons per Day
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.5
0.4
0.3
0.2
0.1
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate
Temperature

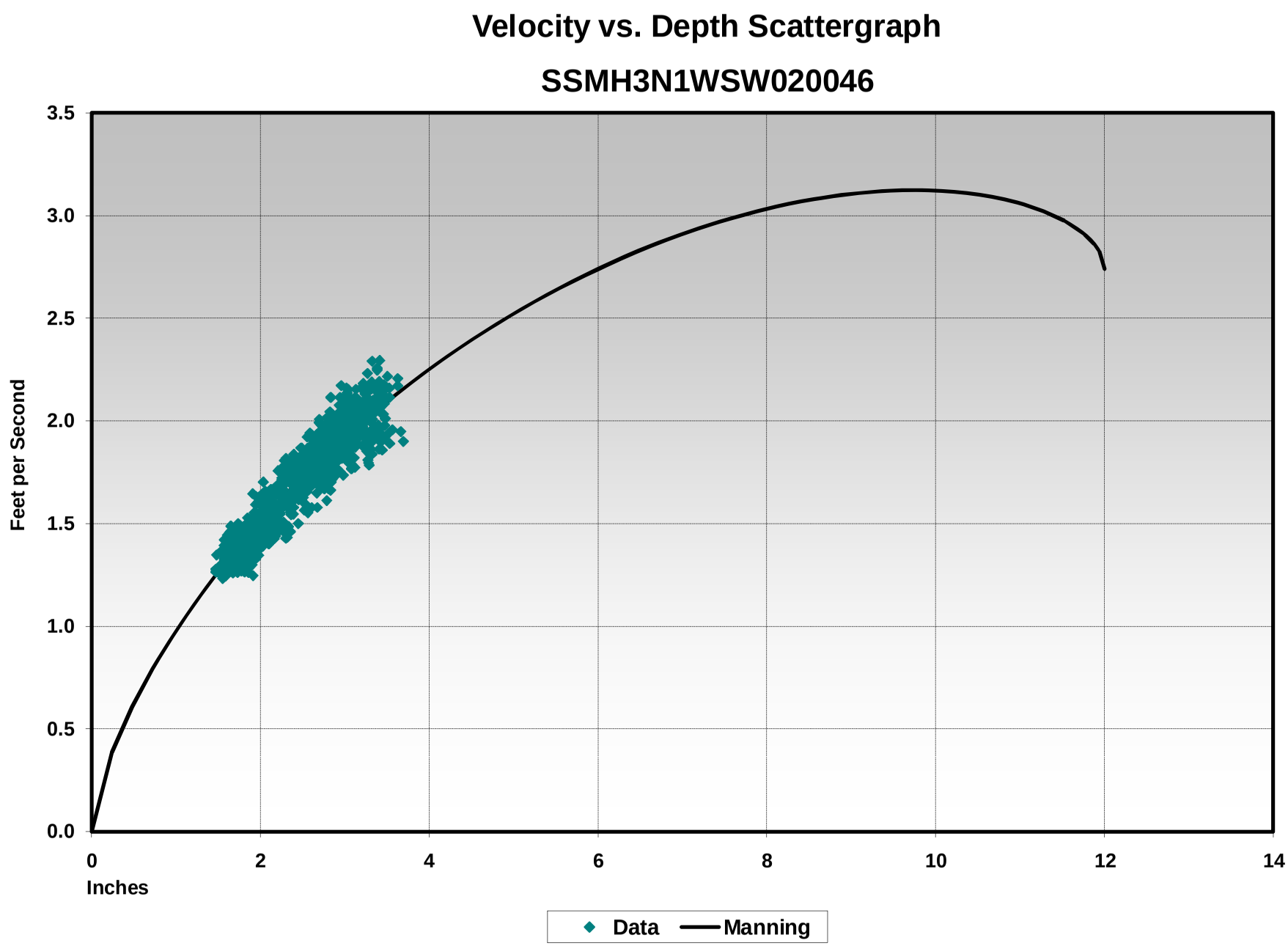
Peak to Average Flow Rate

Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

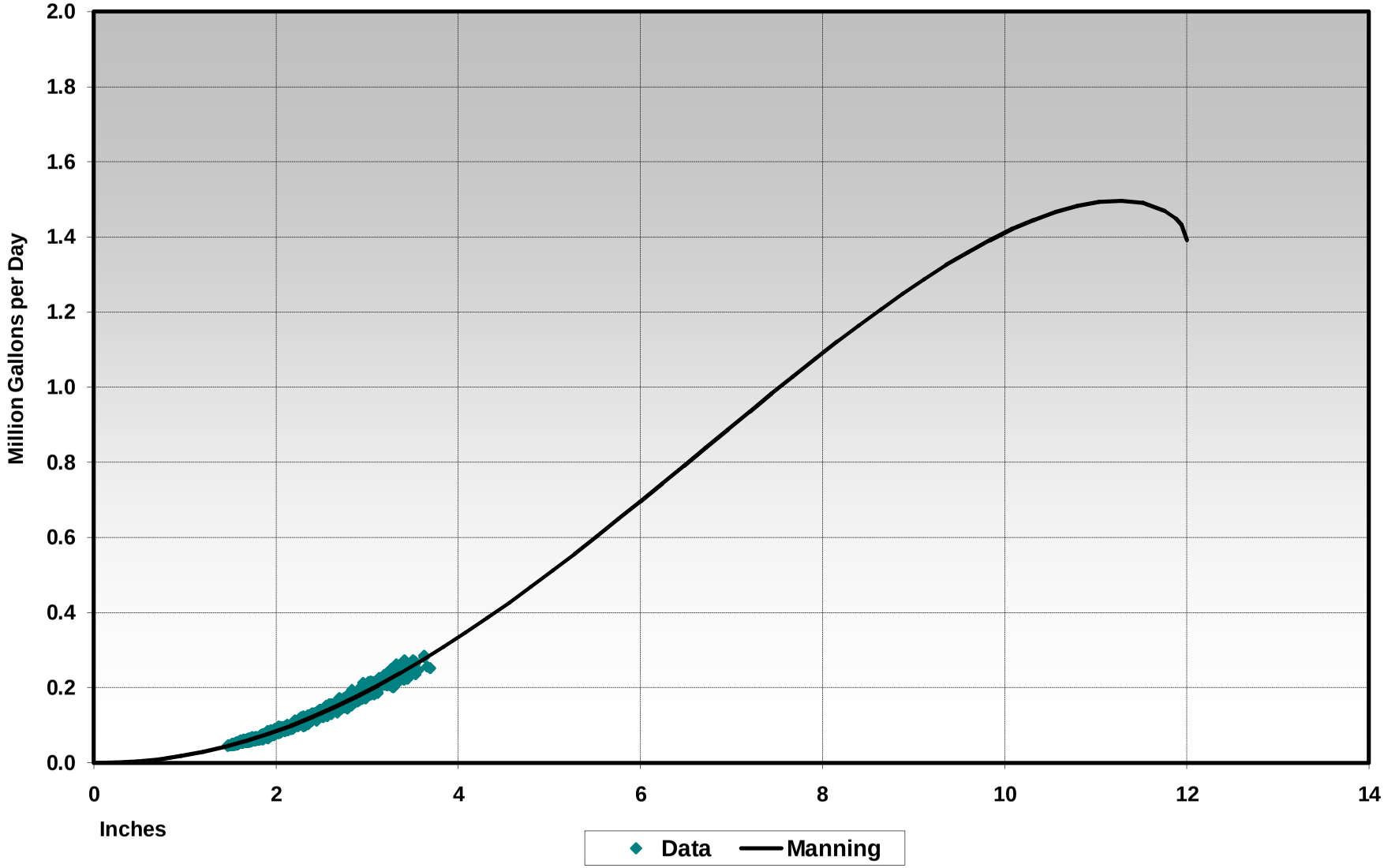
Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.65	1.76	1.78	1.75	1.59	1.70	1.64	1.80	1.61	1.85	1.69	1.66	1.48	1.64




Velocity vs. Depth Scattergraph
SSMH3N1WSW020046
Feet per Second
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
Inches
Data
Manning

Flow Rate vs. Depth Scattergraph

SSMH3N1WSW020046



Flow Rate - Tabular Output

Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.07	0.07	0.11	0.11	0.08	0.07	0.09	0.09	0.07	0.09	0.11	0.08	0.08	0.08
1:00	0.06	0.06	0.07	0.07	0.08	0.06	0.07	0.06	0.05	0.06	0.07	0.07	0.07	0.07
2:00	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.07
3:00	0.06	0.05	0.07	0.06	0.07	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.07	0.07
4:00	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.06	0.06	0.06	0.06	0.07	0.06	0.07
5:00	0.07	0.06	0.06	0.06	0.07	0.06	0.07	0.06	0.05	0.05	0.06	0.07	0.07	0.06
6:00	0.08	0.08	0.07	0.07	0.09	0.09	0.10	0.08	0.07	0.07	0.07	0.08	0.09	0.09
7:00	0.09	0.09	0.08	0.09	0.10	0.11	0.11	0.08	0.08	0.08	0.09	0.10	0.11	0.11
8:00	0.11	0.11	0.12	0.12	0.13	0.14	0.13	0.12	0.11	0.13	0.11	0.14	0.14	0.12
9:00	0.12	0.16	0.19	0.14	0.15	0.15	0.16	0.14	0.15	0.18	0.14	0.14	0.14	0.15
10:00	0.13	0.18	0.18	0.18	0.17	0.17	0.16	0.15	0.18	0.22	0.17	0.16	0.17	0.16
11:00	0.16	0.21	0.24	0.21	0.20	0.18	0.17	0.17	0.19	0.26	0.21	0.18	0.18	0.19
12:00	0.19	0.24	0.26	0.24	0.19	0.20	0.19	0.20	0.20	0.25	0.22	0.18	0.18	0.23
13:00	0.20	0.23	0.25	0.23	0.19	0.21	0.22	0.19	0.21	0.26	0.21	0.20	0.17	0.21
14:00	0.19	0.22	0.26	0.23	0.20	0.19	0.19	0.22	0.21	0.25	0.22	0.22	0.19	0.24
15:00	0.17	0.21	0.24	0.24	0.20	0.20	0.18	0.18	0.20	0.23	0.22	0.20	0.18	0.21
16:00	0.17	0.20	0.22	0.22	0.18	0.16	0.18	0.17	0.20	0.23	0.20	0.18	0.16	0.22
17:00	0.17	0.19	0.22	0.21	0.17	0.17	0.18	0.15	0.18	0.18	0.20	0.19	0.17	0.22
18:00	0.17	0.18	0.19	0.19	0.17	0.18	0.18	0.16	0.18	0.21	0.18	0.17	0.17	0.24
19:00	0.15	0.17	0.17	0.17	0.16	0.16	0.17	0.16	0.16	0.17	0.16	0.18	0.17	0.22
20:00	0.15	0.17	0.17	0.17	0.16	0.16	0.17	0.14	0.15	0.16	0.17	0.16	0.16	0.21
21:00	0.15	0.16	0.15	0.17	0.17	0.15	0.17	0.15	0.15	0.16	0.16	0.15	0.17	0.19
22:00	0.13	0.15	0.14	0.15	0.15	0.14	0.15	0.15	0.15	0.16	0.15	0.15	0.16	0.16
23:00	0.10	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.14	0.13	0.11	0.11	0.12	0.17
Average	0.12	0.14	0.15	0.15	0.14	0.13	0.14	0.13	0.14	0.15	0.14	0.14	0.13	0.16
Median	0.13	0.16	0.16	0.16	0.15	0.15	0.16	0.14	0.15	0.16	0.15	0.15	0.16	0.17
Max Hr. Mean	0.20	0.24	0.26	0.24	0.20	0.21	0.22	0.22	0.21	0.26	0.22	0.22	0.19	0.24
Min Hr. Mean	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Inst. Max	0.21	0.25	0.27	0.26	0.22	0.23	0.23	0.23	0.22	0.29	0.24	0.23	0.20	0.26
Inst. Min	0.05	0.05	0.05	0.06	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.42	1.37	1.66	1.60	1.46	1.40	1.50	1.48	1.37	1.44	1.64	1.42	1.46	1.42
1:00	1.40	1.37	1.37	1.45	1.50	1.34	1.37	1.31	1.27	1.31	1.43	1.38	1.43	1.37
2:00	1.39	1.30	1.33	1.37	1.40	1.35	1.36	1.30	1.29	1.32	1.37	1.35	1.38	1.35
3:00	1.41	1.28	1.35	1.34	1.38	1.39	1.37	1.34	1.34	1.33	1.42	1.36	1.38	1.34
4:00	1.44	1.34	1.35	1.36	1.35	1.36	1.37	1.28	1.35	1.34	1.37	1.35	1.33	1.31
5:00	1.48	1.45	1.35	1.37	1.44	1.36	1.38	1.29	1.32	1.29	1.36	1.34	1.39	1.30
6:00	1.51	1.50	1.42	1.41	1.52	1.55	1.47	1.50	1.39	1.36	1.40	1.47	1.52	1.45
7:00	1.59	1.60	1.49	1.60	1.57	1.67	1.56	1.50	1.45	1.47	1.52	1.54	1.68	1.62
8:00	1.73	1.70	1.70	1.68	1.67	1.77	1.66	1.65	1.55	1.70	1.65	1.72	1.76	1.65
9:00	1.77	1.86	1.94	1.77	1.73	1.79	1.79	1.73	1.76	1.88	1.79	1.76	1.79	1.67
10:00	1.78	1.92	1.93	1.83	1.84	1.83	1.74	1.72	1.92	2.02	1.91	1.83	1.86	1.74
11:00	1.91	2.07	2.16	1.99	2.01	1.89	1.86	1.78	1.94	2.14	2.03	1.90	1.92	1.80
12:00	1.97	2.13	2.23	2.12	1.94	2.01	1.93	1.98	1.97	2.11	2.07	1.90	1.87	1.95
13:00	2.00	2.04	2.17	2.11	1.92	2.07	1.93	1.93	2.01	2.14	1.99	1.93	1.87	1.89
14:00	1.94	2.09	2.16	2.05	2.03	1.98	1.90	1.98	1.99	2.08	2.01	1.95	1.93	1.92
15:00	1.87	2.03	2.08	2.10	1.96	1.97	1.93	1.96	1.96	2.07	2.00	1.94	1.93	1.87
16:00	1.90	2.11	2.05	2.11	1.90	1.87	1.89	1.90	1.95	2.10	1.96	1.91	1.87	1.91
17:00	1.90	2.00	2.05	2.06	1.90	1.87	1.86	1.80	1.89	1.89	1.95	1.89	1.86	1.88
18:00	1.87	1.94	1.91	1.97	1.82	1.94	1.88	1.84	1.88	1.98	1.96	1.86	1.90	1.95
19:00	1.77	1.94	1.81	1.88	1.80	1.88	1.82	1.78	1.83	1.88	1.85	1.92	1.89	1.91
20:00	1.84	1.94	1.87	1.90	1.83	1.89	1.84	1.76	1.79	1.81	1.87	1.85	1.85	1.90
21:00	1.87	1.89	1.79	1.82	1.89	1.87	1.84	1.77	1.80	1.85	1.79	1.85	1.82	1.88
22:00	1.75	1.81	1.76	1.72	1.82	1.75	1.75	1.70	1.77	1.80	1.80	1.83	1.75	1.78
23:00	1.58	1.80	1.72	1.65	1.64	1.56	1.64	1.51	1.70	1.74	1.67	1.57	1.67	1.79
Average	1.71	1.77	1.78	1.76	1.72	1.72	1.69	1.66	1.69	1.75	1.74	1.70	1.71	1.69
Median	1.78	1.87	1.81	1.77	1.77	1.83	1.77	1.72	1.77	1.84	1.80	1.81	1.81	1.79
Max Hr. Mean	2.00	2.13	2.23	2.12	2.03	2.07	1.93	1.98	2.01	2.14	2.07	1.95	1.93	1.95
Min Hr. Mean	1.39	1.28	1.33	1.34	1.35	1.34	1.36	1.28	1.27	1.29	1.36	1.34	1.33	1.30
Inst. Max	2.05	2.19	2.30	2.19	2.10	2.16	2.00	2.05	2.08	2.21	2.13	2.00	2.00	2.01
Inst. Min	1.32	1.25	1.29	1.30	1.29	1.26	1.29	1.24	1.23	1.26	1.33	1.29	1.26	1.25

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.77	1.79	2.23	2.36	1.98	1.84	2.06	2.05	1.94	2.19	2.24	1.95	1.91	2.02
1:00	1.67	1.65	1.83	1.83	1.87	1.66	1.86	1.71	1.62	1.73	1.90	1.80	1.78	1.79
2:00	1.61	1.59	1.79	1.71	1.78	1.68	1.79	1.61	1.69	1.70	1.78	1.66	1.65	1.82
3:00	1.70	1.55	1.89	1.75	1.78	1.84	1.88	1.79	1.87	1.77	1.91	1.85	1.91	1.89
4:00	1.70	1.62	1.77	1.80	1.82	1.63	1.88	1.69	1.79	1.69	1.78	1.84	1.77	1.88
5:00	1.73	1.66	1.67	1.68	1.88	1.70	1.96	1.67	1.60	1.58	1.61	1.81	1.81	1.83
6:00	1.86	1.91	1.80	1.79	2.03	2.02	2.31	1.98	1.92	1.82	1.84	2.01	2.02	2.15
7:00	1.98	1.96	1.94	2.03	2.17	2.17	2.42	1.97	2.06	2.04	2.04	2.15	2.22	2.35
8:00	2.24	2.16	2.37	2.34	2.45	2.55	2.59	2.33	2.28	2.51	2.32	2.57	2.51	2.44
9:00	2.30	2.66	2.94	2.56	2.70	2.65	2.74	2.58	2.70	2.93	2.60	2.63	2.57	2.73
10:00	2.36	2.86	2.88	2.93	2.81	2.83	2.81	2.67	2.91	3.17	2.80	2.69	2.85	2.84
11:00	2.68	2.99	3.23	3.11	2.95	2.87	2.85	2.86	3.02	3.48	3.14	2.94	2.87	3.07
12:00	2.91	3.31	3.33	3.33	2.94	3.00	3.04	3.04	3.03	3.42	3.20	2.92	2.92	3.39
13:00	3.01	3.29	3.35	3.21	3.02	3.07	3.30	2.93	3.06	3.43	3.13	3.09	2.78	3.29
14:00	2.92	3.17	3.43	3.25	2.99	2.95	3.04	3.27	3.09	3.41	3.18	3.25	3.04	3.54
15:00	2.80	3.06	3.32	3.27	3.03	3.03	2.87	2.87	3.00	3.27	3.22	3.04	2.91	3.32
16:00	2.78	2.88	3.12	3.11	2.87	2.73	2.89	2.77	3.08	3.19	3.03	2.89	2.66	3.29
17:00	2.78	2.88	3.13	3.10	2.81	2.77	2.94	2.67	2.97	2.96	3.09	2.99	2.79	3.40
18:00	2.81	2.83	2.98	2.94	2.86	2.82	2.95	2.79	2.93	3.18	2.87	2.89	2.84	3.50
19:00	2.62	2.78	2.87	2.84	2.76	2.63	2.82	2.77	2.78	2.83	2.78	2.83	2.75	3.30
20:00	2.61	2.75	2.79	2.83	2.80	2.65	2.79	2.61	2.63	2.72	2.79	2.74	2.68	3.21
21:00	2.61	2.70	2.71	2.87	2.84	2.62	2.80	2.72	2.69	2.77	2.73	2.62	2.83	3.02
22:00	2.43	2.65	2.52	2.72	2.63	2.56	2.72	2.72	2.66	2.73	2.59	2.67	2.82	2.80
23:00	2.25	2.54	2.48	2.34	2.23	2.19	2.31	2.49	2.60	2.46	2.30	2.34	2.43	2.86
Average	2.34	2.47	2.60	2.57	2.50	2.44	2.57	2.44	2.50	2.62	2.54	2.51	2.47	2.74
Median	2.42	2.71	2.74	2.78	2.72	2.63	2.77	2.62	2.68	2.75	2.68	2.69	2.70	2.88
Max Hr. Mean	3.01	3.31	3.43	3.33	3.03	3.07	3.30	3.27	3.09	3.48	3.22	3.25	3.04	3.54
Min Hr. Mean	1.61	1.55	1.67	1.68	1.78	1.63	1.79	1.61	1.60	1.58	1.61	1.66	1.65	1.79
Inst. Max	3.06	3.39	3.50	3.47	3.13	3.19	3.44	3.33	3.15	3.63	3.40	3.31	3.08	3.69
Inst. Min	1.55	1.51	1.62	1.64	1.69	1.52	1.70	1.47	1.47	1.52	1.57	1.52	1.48	1.69

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 06
Address: Litchfield N off Bell Road
MH ID# SSMH4N1WSW330113

Date: 06/09/08
GPS: 33.374960N -112.203199W

Overview

Street Level

Meter Details

Meter Type 2150
Serial # 204L00480
Sensor Serial # 205J00125
Telemetry None
Sample Rate 5 min

Pipe Details and Manhole Condition

Pipe Size (in) Vert. 24" Horiz. 24"
Laterals 1
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris Yes - paper
Grease No
Pests Yes - roaches

Down Manhole

Hydraulics:
Low to moderate flow conditions

Comments:
Debris in bench area at time of installation

Photos
MH #SSMH4N1WSW330113
Site #06

Site ID

Down Manhole

24” Influent

24” Effluent

18” Lateral

Manhole Cover Top

Photos
MH #SSMH4N1WSW330113
Site #06

Manhole Cover Bottom

Location Summary

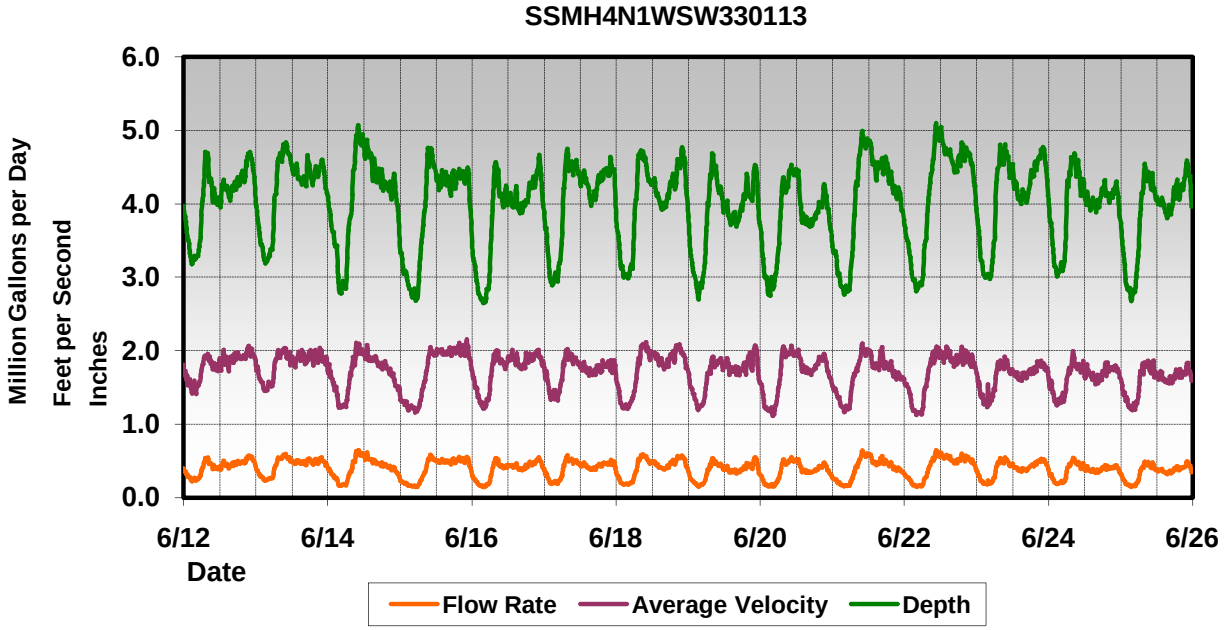
Site	**SSMH4N1WSW330113**	
Address	**Litchfield N of Bell Road**	
Diameter	**24**	Inches
GPS	**33.374960N**	**-112.203199W**

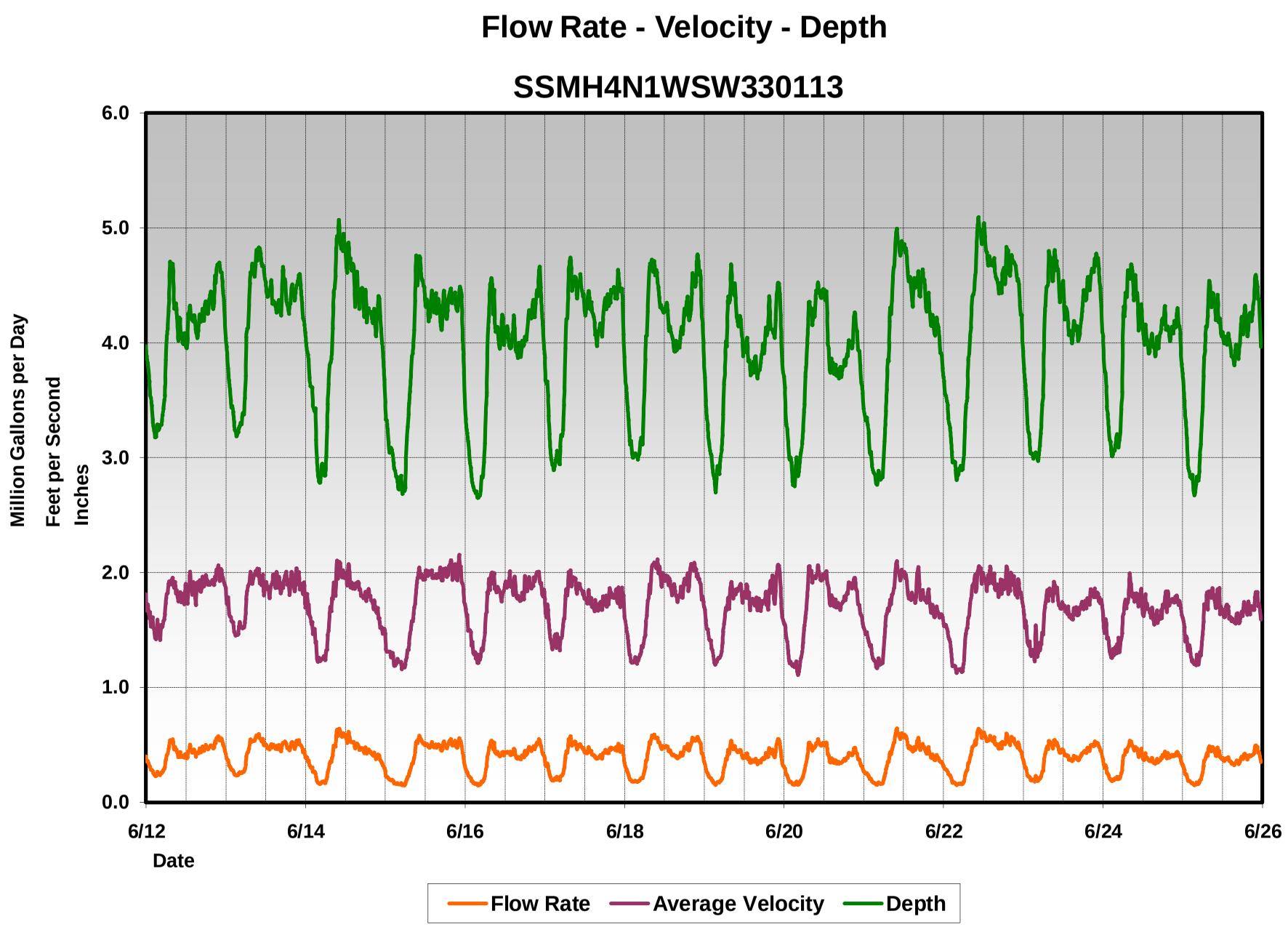
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.00
Maximum	5.10
Minimum	2.65
Max d/D	21.2%

Flow velocity	
	Feet per Second
Average	1.71
Maximum	2.15
Minimum	1.11

Flow Rate	
	Million Gallons per Day
Average	0.39
Maximum	0.64
Minimum	0.15
Peak Factor	1.64



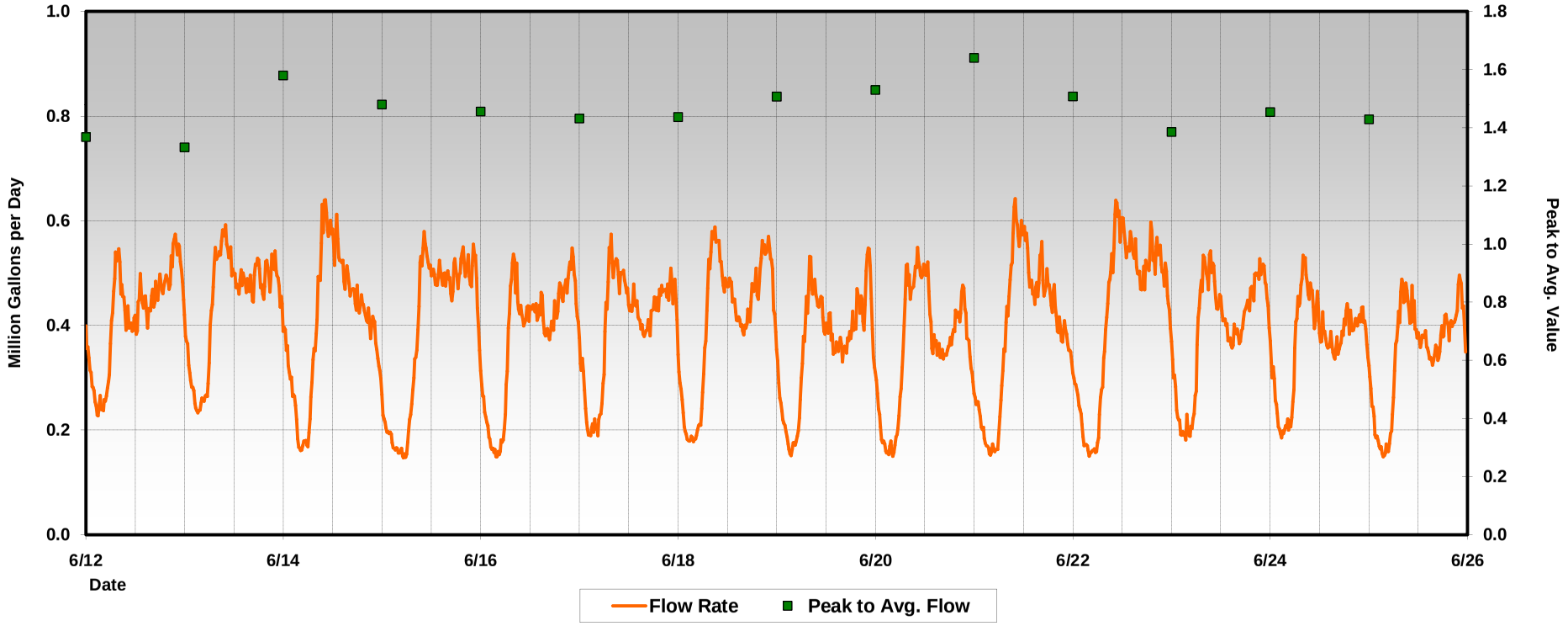

Flow Rate - Velocity - Depth
SSMH4N1WSW330113
Million Gallons per Day
Feet per Second
Inches
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

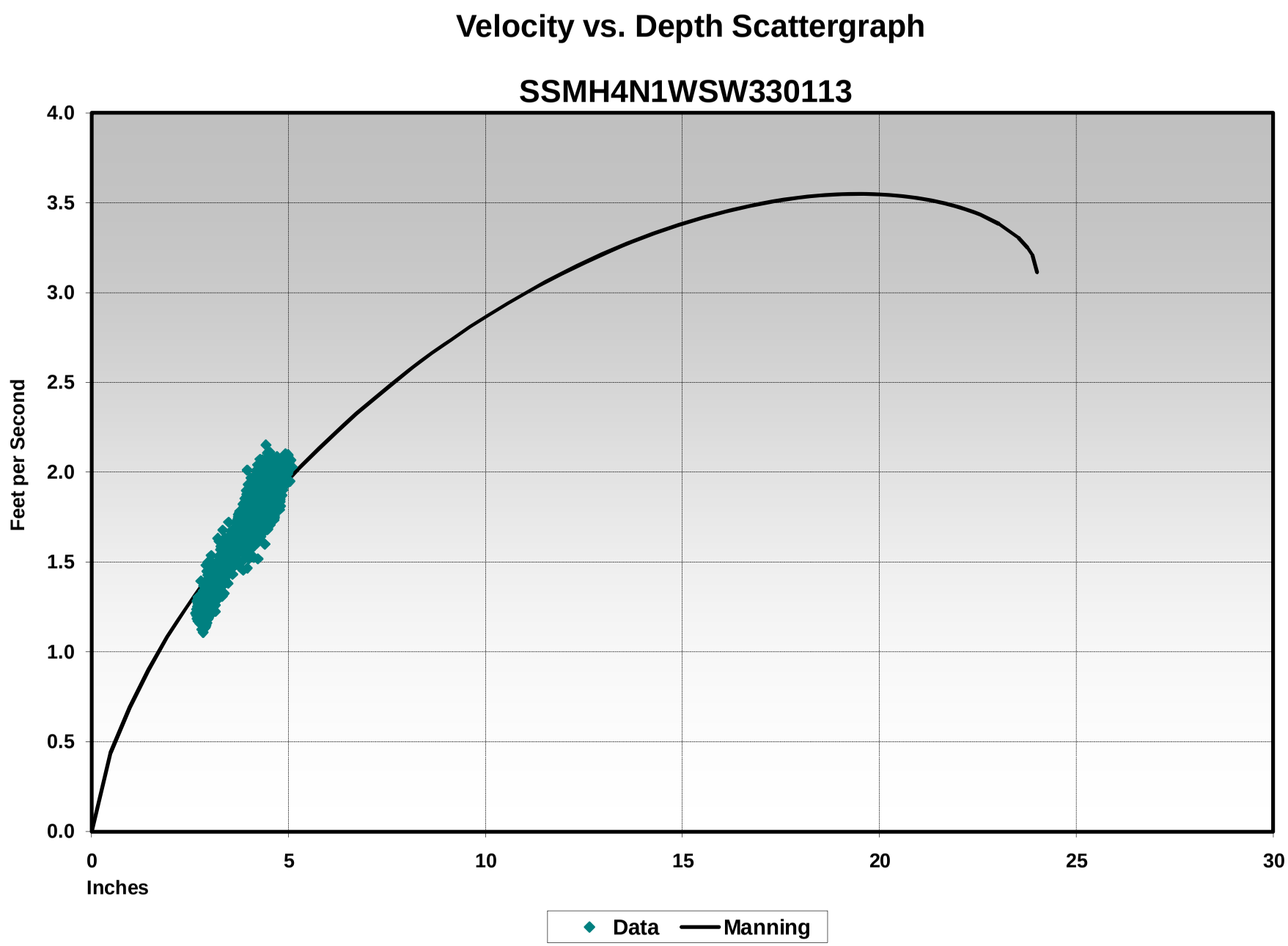
Peak to Average Flow Rate

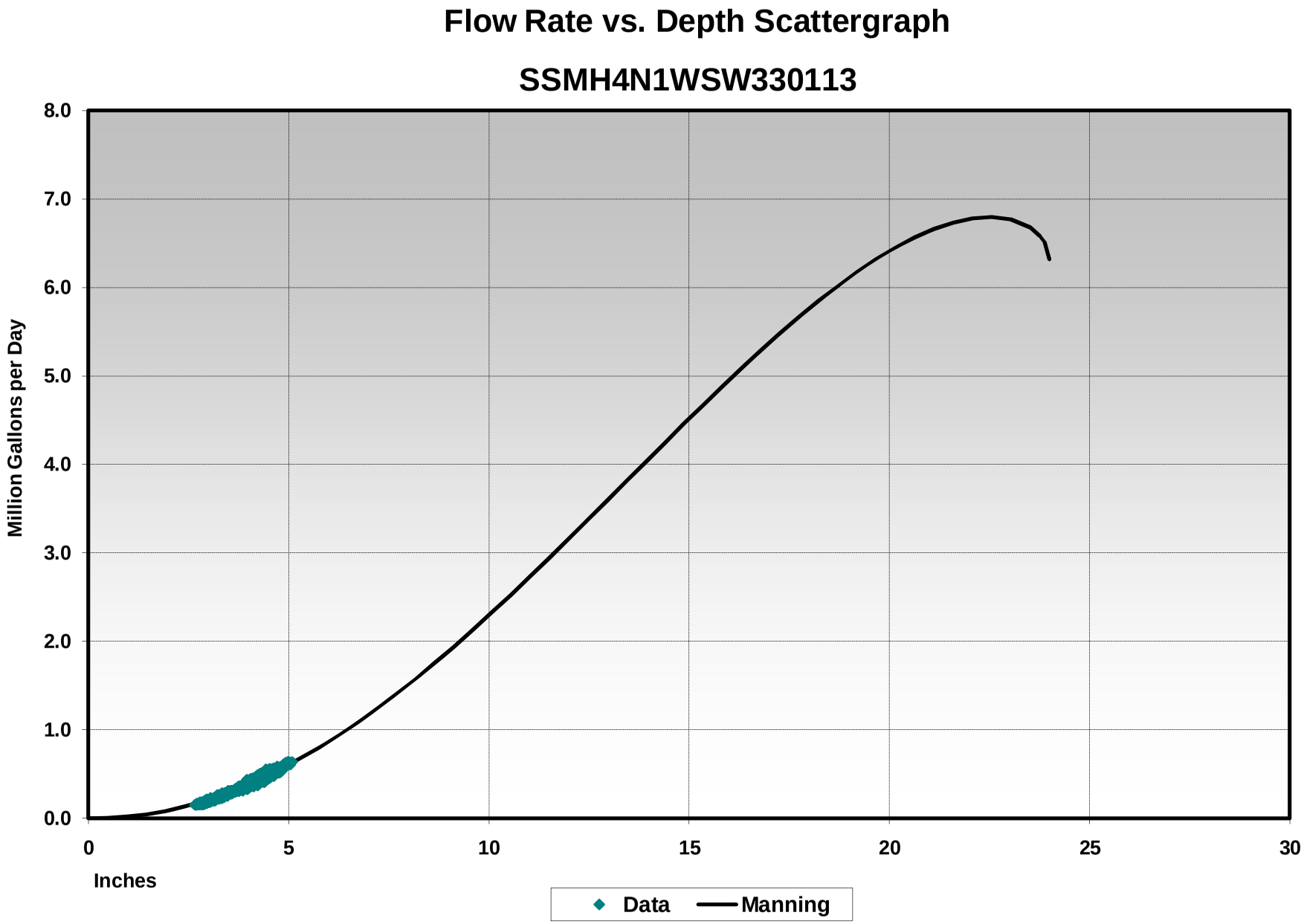
Site ID SSMH4N1WSW330113

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.37	1.33	1.58	1.48	1.46	1.43	1.44	1.51	1.53	1.64	1.51	1.39	1.45	1.44




Velocity vs. Depth Scattergraph
SSMH4N1WSW330113
Feet per Second
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH4N1WSW330113
Million Gallons per Day
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH4N1WSW330113

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.36	0.38	0.38	0.23	0.28	0.34	0.31	0.31	0.28	0.26	0.30	0.33	0.33	0.29
1:00	0.30	0.30	0.32	0.20	0.22	0.26	0.22	0.23	0.20	0.23	0.26	0.24	0.26	0.21
2:00	0.25	0.26	0.27	0.18	0.17	0.19	0.18	0.19	0.17	0.19	0.20	0.20	0.20	0.18
3:00	0.24	0.24	0.20	0.16	0.16	0.21	0.18	0.16	0.17	0.16	0.17	0.20	0.20	0.16
4:00	0.25	0.26	0.16	0.16	0.16	0.20	0.19	0.18	0.16	0.16	0.16	0.20	0.21	0.16
5:00	0.29	0.27	0.18	0.15	0.19	0.25	0.22	0.22	0.20	0.16	0.16	0.23	0.24	0.20
6:00	0.42	0.40	0.21	0.19	0.31	0.39	0.33	0.34	0.30	0.24	0.21	0.37	0.41	0.33
7:00	0.52	0.52	0.33	0.26	0.48	0.54	0.48	0.44	0.47	0.36	0.31	0.49	0.46	0.42
8:00	0.50	0.54	0.45	0.36	0.51	0.51	0.56	0.50	0.47	0.45	0.43	0.51	0.52	0.46
9:00	0.43	0.57	0.56	0.50	0.43	0.50	0.57	0.47	0.49	0.56	0.51	0.51	0.47	0.46
10:00	0.41	0.56	0.62	0.56	0.41	0.50	0.53	0.44	0.52	0.60	0.61	0.49	0.44	0.42
11:00	0.40	0.52	0.58	0.52	0.42	0.47	0.48	0.41	0.50	0.57	0.60	0.44	0.44	0.40
12:00	0.41	0.49	0.55	0.50	0.44	0.43	0.48	0.40	0.51	0.58	0.59	0.43	0.39	0.37
13:00	0.46	0.48	0.56	0.48	0.43	0.45	0.46	0.38	0.41	0.50	0.54	0.40	0.38	0.38
14:00	0.44	0.49	0.51	0.50	0.43	0.42	0.42	0.36	0.37	0.46	0.56	0.37	0.37	0.35
15:00	0.42	0.47	0.50	0.49	0.41	0.39	0.40	0.36	0.35	0.47	0.53	0.38	0.35	0.33
16:00	0.45	0.47	0.47	0.49	0.38	0.39	0.40	0.35	0.34	0.53	0.48	0.38	0.36	0.35
17:00	0.47	0.51	0.45	0.49	0.40	0.41	0.43	0.37	0.35	0.48	0.50	0.41	0.37	0.37
18:00	0.48	0.50	0.44	0.49	0.43	0.44	0.47	0.40	0.37	0.46	0.52	0.44	0.42	0.40
19:00	0.49	0.48	0.44	0.53	0.47	0.45	0.48	0.43	0.41	0.45	0.56	0.46	0.41	0.40
20:00	0.49	0.50	0.42	0.51	0.47	0.47	0.53	0.44	0.42	0.40	0.54	0.49	0.40	0.40
21:00	0.55	0.51	0.40	0.50	0.50	0.46	0.54	0.44	0.46	0.38	0.53	0.50	0.41	0.43
22:00	0.55	0.51	0.38	0.53	0.52	0.48	0.54	0.54	0.39	0.39	0.50	0.51	0.42	0.47
23:00	0.49	0.45	0.32	0.42	0.44	0.45	0.44	0.38	0.31	0.35	0.43	0.44	0.38	0.30
Average	0.42	0.44	0.41	0.39	0.38	0.40	0.41	0.36	0.36	0.39	0.42	0.39	0.37	0.34
Median	0.44	0.48	0.42	0.48	0.42	0.43	0.45	0.38	0.36	0.42	0.50	0.41	0.39	0.38
Max Hr. Mean	0.55	0.57	0.62	0.56	0.52	0.54	0.57	0.54	0.52	0.60	0.61	0.51	0.52	0.47
Min Hr. Mean	0.24	0.24	0.16	0.15	0.16	0.19	0.18	0.16	0.16	0.16	0.16	0.20	0.20	0.16
Inst. Max	0.57	0.59	0.64	0.58	0.55	0.57	0.59	0.55	0.55	0.64	0.64	0.54	0.53	0.50
Inst. Min	0.23	0.23	0.16	0.15	0.15	0.19	0.18	0.15	0.15	0.15	0.15	0.18	0.19	0.15

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N1WSW330113

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.72	1.77	1.73	1.36	1.66	1.69	1.55	1.62	1.51	1.49	1.54	1.61	1.56	1.53
1:00	1.59	1.61	1.63	1.30	1.49	1.54	1.34	1.45	1.29	1.42	1.47	1.42	1.45	1.38
2:00	1.52	1.52	1.51	1.25	1.34	1.36	1.22	1.33	1.20	1.32	1.29	1.32	1.28	1.30
3:00	1.49	1.46	1.32	1.22	1.27	1.43	1.24	1.21	1.20	1.22	1.18	1.34	1.32	1.21
4:00	1.48	1.54	1.24	1.22	1.25	1.39	1.26	1.25	1.14	1.21	1.15	1.33	1.35	1.23
5:00	1.58	1.53	1.26	1.18	1.35	1.50	1.35	1.37	1.30	1.21	1.15	1.39	1.39	1.31
6:00	1.82	1.78	1.34	1.26	1.65	1.76	1.52	1.63	1.58	1.48	1.33	1.63	1.68	1.61
7:00	1.92	1.95	1.62	1.42	1.89	1.96	1.81	1.75	1.95	1.68	1.57	1.81	1.74	1.76
8:00	1.91	1.95	1.84	1.61	1.97	1.92	2.03	1.86	1.96	1.78	1.80	1.83	1.90	1.81
9:00	1.81	2.01	1.95	1.85	1.86	1.89	2.06	1.84	1.96	1.94	1.91	1.85	1.78	1.79
10:00	1.77	1.93	2.06	1.99	1.83	1.88	2.04	1.86	2.01	2.03	1.99	1.79	1.77	1.74
11:00	1.78	1.90	1.98	1.96	1.80	1.83	1.94	1.81	1.95	1.97	1.98	1.71	1.79	1.72
12:00	1.80	1.88	1.96	1.98	1.89	1.76	1.94	1.83	1.98	1.98	1.95	1.69	1.69	1.64
13:00	1.90	1.84	1.96	1.99	1.93	1.78	1.93	1.79	1.85	1.83	1.91	1.66	1.70	1.70
14:00	1.85	1.94	1.88	1.98	1.89	1.72	1.84	1.74	1.76	1.79	1.99	1.61	1.65	1.60
15:00	1.84	1.92	1.90	1.97	1.85	1.71	1.83	1.75	1.73	1.78	1.90	1.65	1.59	1.58
16:00	1.88	1.89	1.85	1.99	1.77	1.69	1.78	1.74	1.71	1.99	1.84	1.65	1.62	1.61
17:00	1.91	1.92	1.79	1.98	1.80	1.73	1.83	1.72	1.72	1.79	1.87	1.71	1.62	1.60
18:00	1.93	1.95	1.79	2.01	1.88	1.75	1.92	1.76	1.78	1.77	1.90	1.72	1.73	1.68
19:00	1.90	1.90	1.80	2.05	1.93	1.79	1.93	1.78	1.86	1.79	1.97	1.75	1.77	1.69
20:00	1.92	1.92	1.73	2.00	1.90	1.80	2.05	1.92	1.89	1.69	1.93	1.80	1.74	1.69
21:00	2.01	1.95	1.67	1.98	1.97	1.80	2.03	1.83	1.92	1.64	1.88	1.81	1.76	1.71
22:00	1.99	1.91	1.56	2.07	1.95	1.78	1.95	2.04	1.75	1.65	1.87	1.79	1.76	1.80
23:00	1.93	1.87	1.50	1.86	1.84	1.82	1.80	1.70	1.61	1.63	1.79	1.75	1.70	1.25
Average	1.80	1.83	1.70	1.73	1.75	1.72	1.76	1.69	1.69	1.67	1.71	1.65	1.64	1.58
Median	1.85	1.89	1.76	1.94	1.83	1.77	1.88	1.75	1.75	1.72	1.84	1.70	1.68	1.65
Max Hr. Mean	2.01	2.01	2.06	2.07	1.97	1.96	2.06	2.04	2.01	2.03	1.99	1.85	1.90	1.81
Min Hr. Mean	1.48	1.46	1.24	1.18	1.25	1.36	1.22	1.21	1.14	1.21	1.15	1.32	1.28	1.21
Inst. Max	2.06	2.04	2.10	2.15	2.01	2.02	2.11	2.07	2.07	2.10	2.06	1.92	1.99	1.87
Inst. Min	1.42	1.45	1.22	1.16	1.22	1.32	1.21	1.20	1.11	1.17	1.13	1.23	1.26	1.19

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N1WSW330113

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.86	3.92	3.98	3.35	3.32	3.72	3.68	3.59	3.51	3.37	3.61	3.75	3.86	3.56
1:00	3.55	3.55	3.70	3.08	3.02	3.30	3.27	3.17	3.10	3.22	3.40	3.32	3.43	3.09
2:00	3.26	3.35	3.47	2.99	2.77	2.93	3.05	2.96	2.89	2.98	3.11	3.06	3.10	2.84
3:00	3.24	3.21	3.11	2.84	2.69	2.99	3.02	2.77	2.86	2.84	2.95	3.01	3.07	2.74
4:00	3.28	3.28	2.81	2.76	2.68	3.00	3.04	2.91	2.89	2.82	2.85	3.02	3.14	2.80
5:00	3.46	3.41	2.91	2.72	2.87	3.27	3.21	3.16	3.11	2.82	2.91	3.27	3.34	3.08
6:00	4.07	4.00	3.15	3.03	3.50	3.99	3.89	3.84	3.60	3.21	3.18	4.04	4.24	3.74
7:00	4.59	4.51	3.78	3.53	4.35	4.61	4.53	4.33	4.21	3.87	3.69	4.57	4.51	4.22
8:00	4.48	4.62	4.24	3.97	4.44	4.53	4.66	4.56	4.23	4.37	4.22	4.67	4.61	4.41
9:00	4.21	4.75	4.79	4.57	4.14	4.52	4.64	4.39	4.32	4.78	4.52	4.66	4.49	4.38
10:00	4.14	4.78	4.94	4.70	4.01	4.53	4.43	4.19	4.47	4.89	4.99	4.63	4.32	4.25
11:00	4.03	4.63	4.86	4.52	4.15	4.44	4.29	4.04	4.42	4.82	4.94	4.43	4.25	4.14
12:00	4.05	4.45	4.73	4.36	4.09	4.29	4.31	3.97	4.42	4.82	4.94	4.35	4.08	4.05
13:00	4.25	4.48	4.74	4.24	3.99	4.38	4.17	3.88	3.99	4.61	4.74	4.20	4.01	4.03
14:00	4.21	4.35	4.61	4.36	4.10	4.28	4.04	3.77	3.81	4.44	4.69	4.06	3.99	3.96
15:00	4.08	4.29	4.47	4.36	3.97	4.07	3.95	3.82	3.76	4.52	4.65	4.13	3.95	3.85
16:00	4.21	4.31	4.37	4.27	3.92	4.12	3.99	3.74	3.73	4.53	4.50	4.08	3.98	3.94
17:00	4.28	4.55	4.37	4.30	3.98	4.16	4.12	3.91	3.76	4.52	4.51	4.17	4.11	4.07
18:00	4.29	4.38	4.31	4.27	4.06	4.35	4.29	4.02	3.83	4.47	4.61	4.41	4.25	4.19
19:00	4.41	4.35	4.27	4.43	4.25	4.36	4.29	4.25	3.95	4.35	4.75	4.49	4.12	4.15
20:00	4.40	4.44	4.23	4.38	4.31	4.46	4.46	4.11	3.98	4.20	4.68	4.57	4.08	4.22
21:00	4.63	4.49	4.19	4.33	4.36	4.42	4.56	4.18	4.21	4.12	4.69	4.66	4.13	4.38
22:00	4.65	4.53	4.29	4.43	4.54	4.55	4.68	4.49	3.97	4.14	4.55	4.72	4.21	4.50
23:00	4.39	4.23	3.87	4.02	4.18	4.34	4.24	3.97	3.66	3.87	4.22	4.36	3.99	3.13
Average	4.08	4.20	4.09	3.91	3.82	4.07	4.03	3.83	3.78	4.02	4.16	4.11	3.97	3.82
Median	4.20	4.36	4.25	4.25	4.03	4.30	4.16	3.91	3.82	4.25	4.52	4.29	4.08	4.04
Max Hr. Mean	4.65	4.78	4.94	4.70	4.54	4.61	4.68	4.56	4.47	4.89	4.99	4.72	4.61	4.50
Min Hr. Mean	3.24	3.21	2.81	2.72	2.68	2.93	3.02	2.77	2.86	2.82	2.85	3.01	3.07	2.74
Inst. Max	4.70	4.83	5.07	4.75	4.66	4.74	4.77	4.68	4.53	4.99	5.10	4.81	4.68	4.59
Inst. Min	3.18	3.19	2.78	2.68	2.65	2.89	2.99	2.70	2.75	2.77	2.81	2.97	3.01	2.67

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 07
Address: N Reems Road S of W Larkspur Drive
MH ID# SSMH3N1WSW170111

Date: 6/9/2008
GPS: 33.355312N -112.233708W

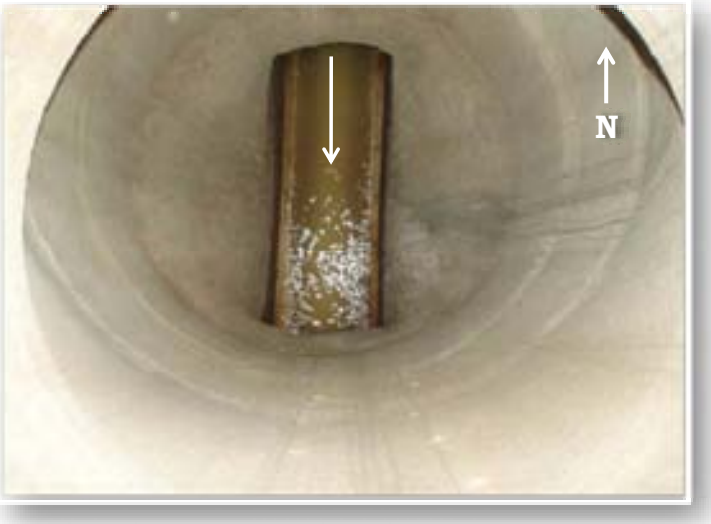
Overview

Street Level

Meter Details

Meter Type 215000
Serial # 20500083
Sensor Serial # Temp Tag 5
Telemetry None
Sample Rate 5 min

Down Manhole



Pipe Details and Manhole Condition

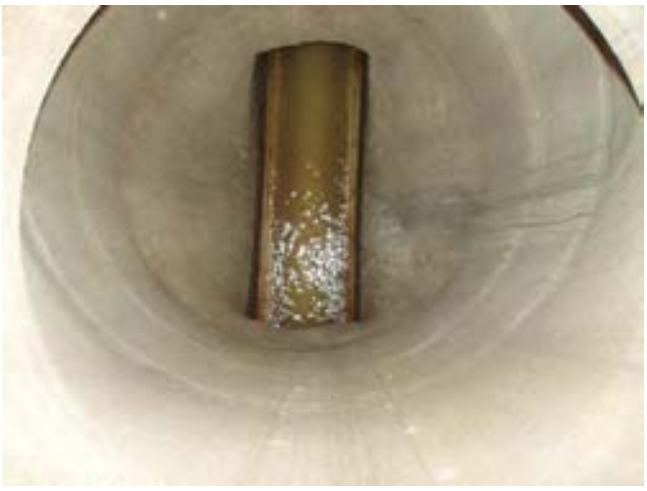
Pipe Size (in) Vert. 24" Horiz. 24"
Laterals 0
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Hydraulics:
Moderate to fast flow conditions at installation

Comments:
Good monitoring site

Photos
MH #SSMH3N1WSW170111
Site #07

Site ID


Down Manhole

24” Influent

24” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

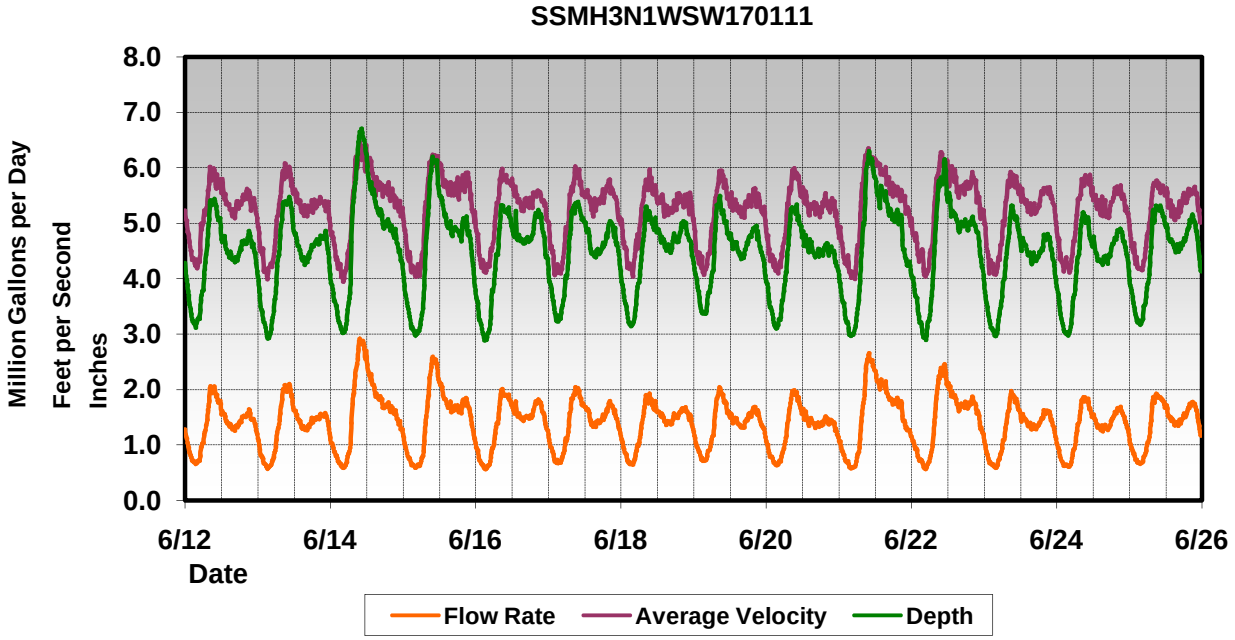
Site	**SSMH3N1WSW170111**	
Address	**Reems Rd S of W Larkspur Drive**	
Diameter	**24**	Inches
GPS	**33.355312N -112.233708W**	

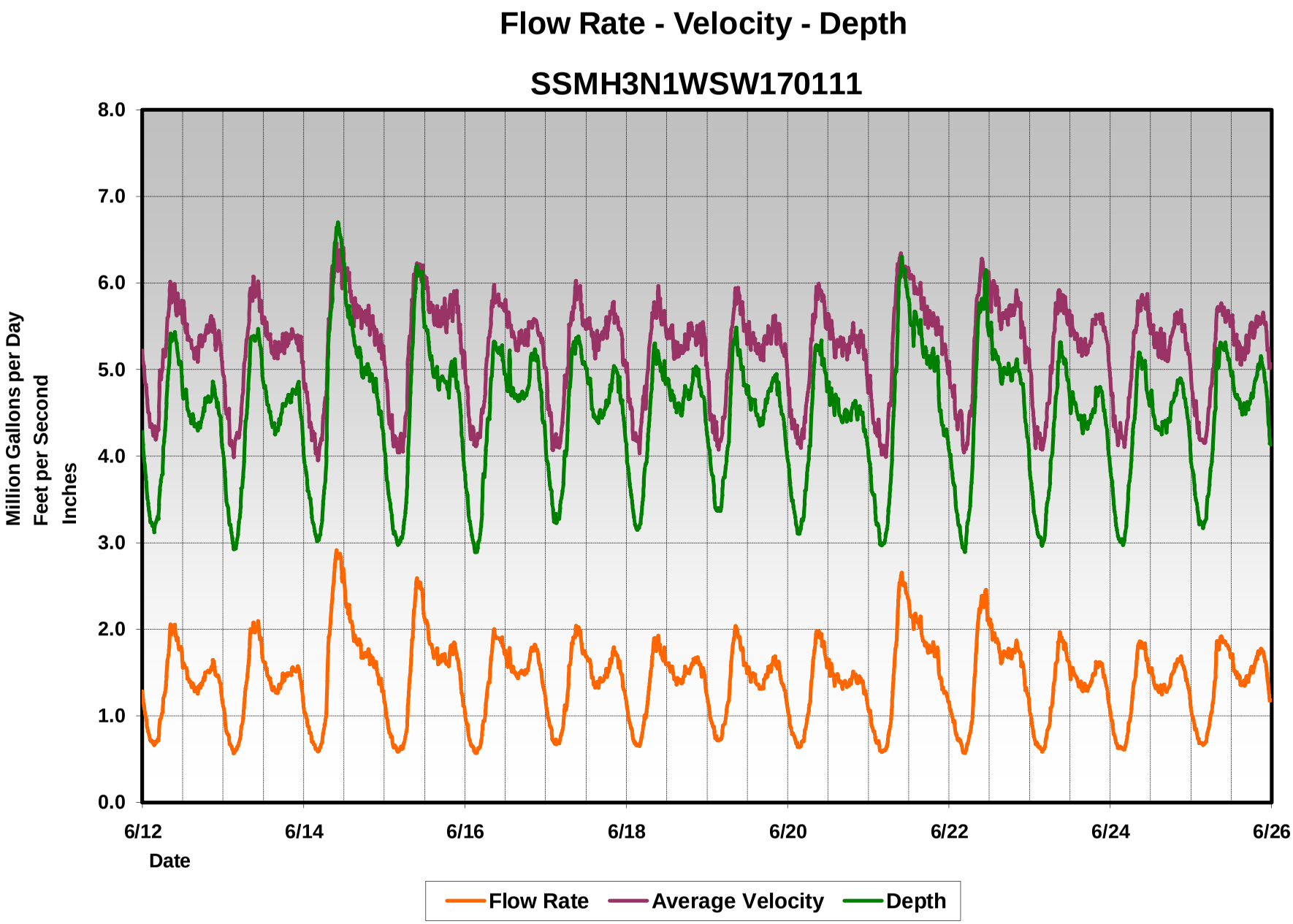
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.47
Maximum	6.70
Minimum	2.89
Max d/D	27.9%

Flow velocity	
	Feet per Second
Average	5.23
Maximum	6.46
Minimum	3.95

Flow Rate	
	Million Gallons per Day
Average	1.41
Maximum	2.91
Minimum	0.56
Peak Factor	2.07



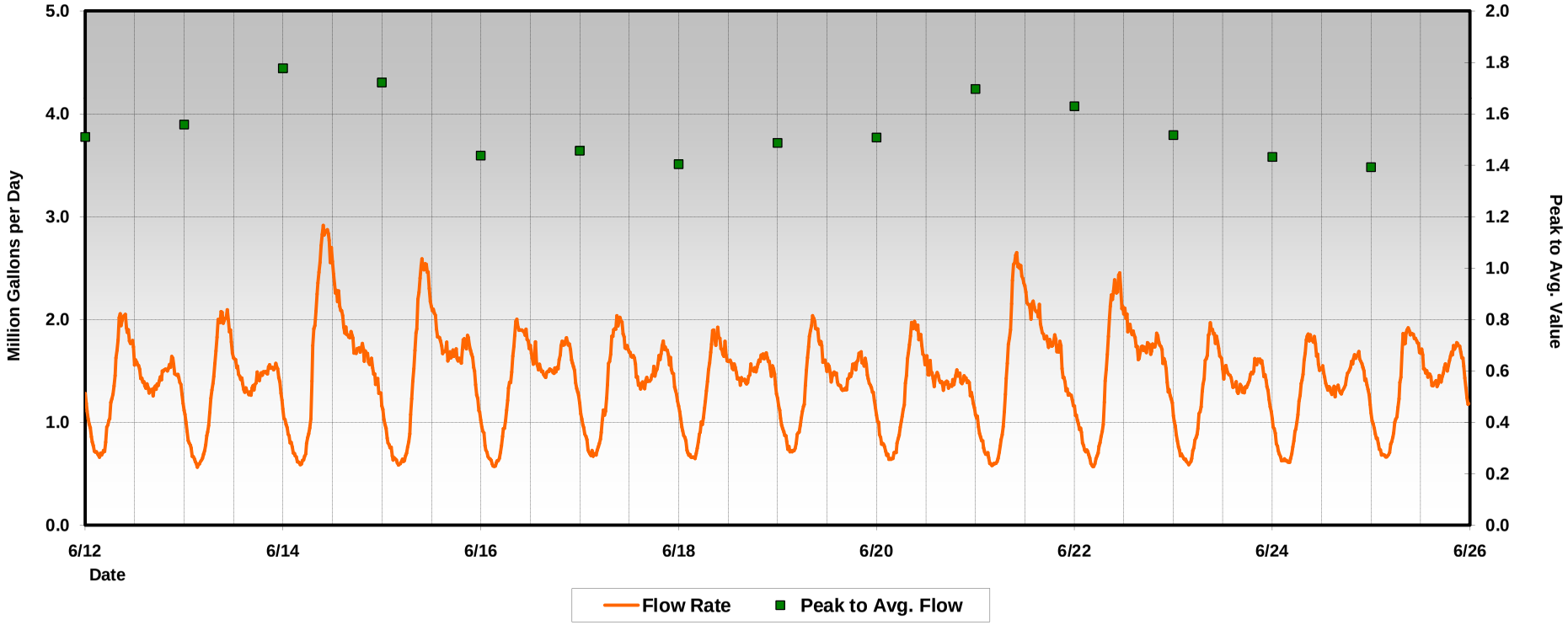

Flow Rate - Velocity - Depth
SSMH3N1WSW170111
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

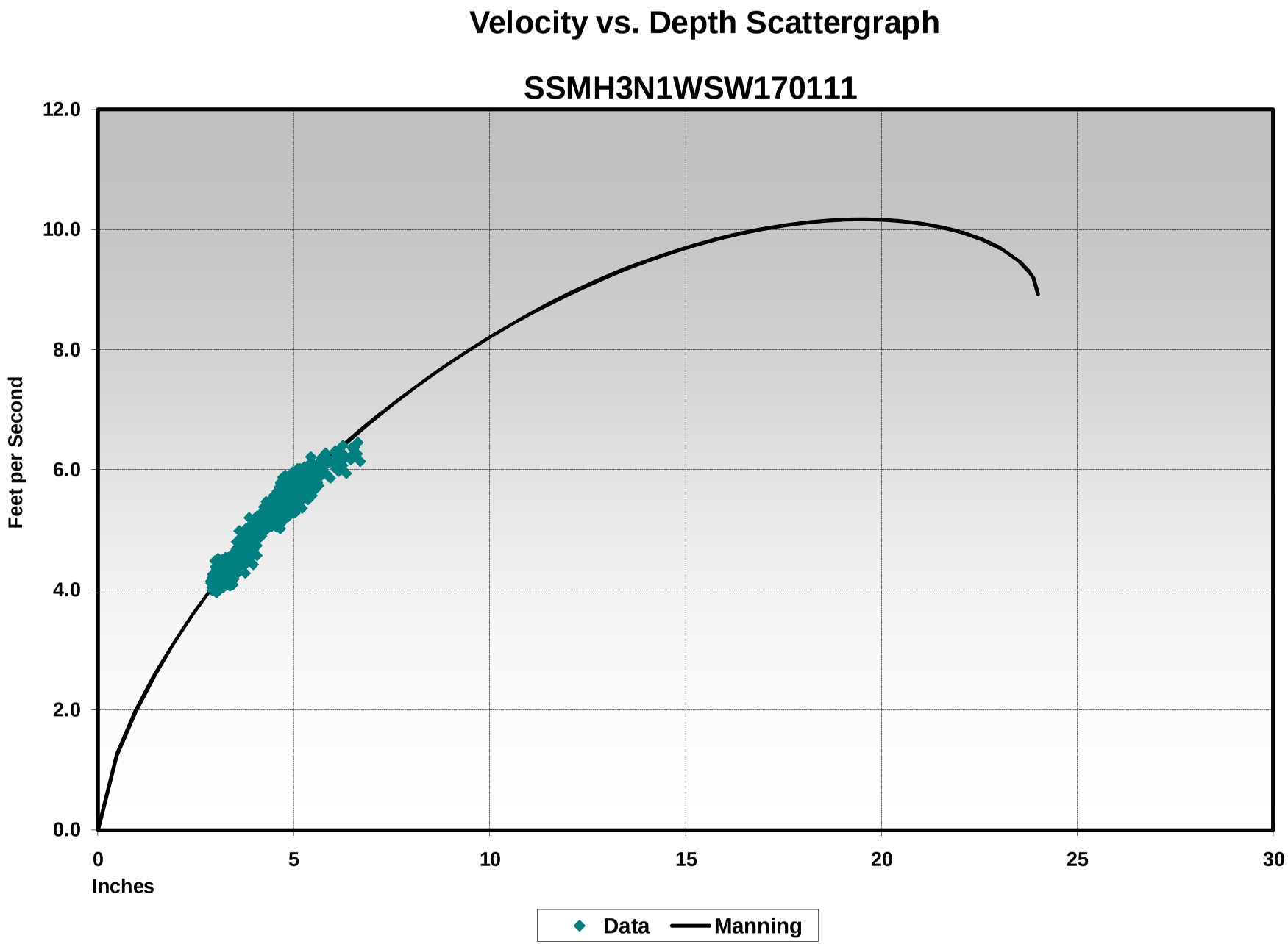
Peak to Average Flow Rate

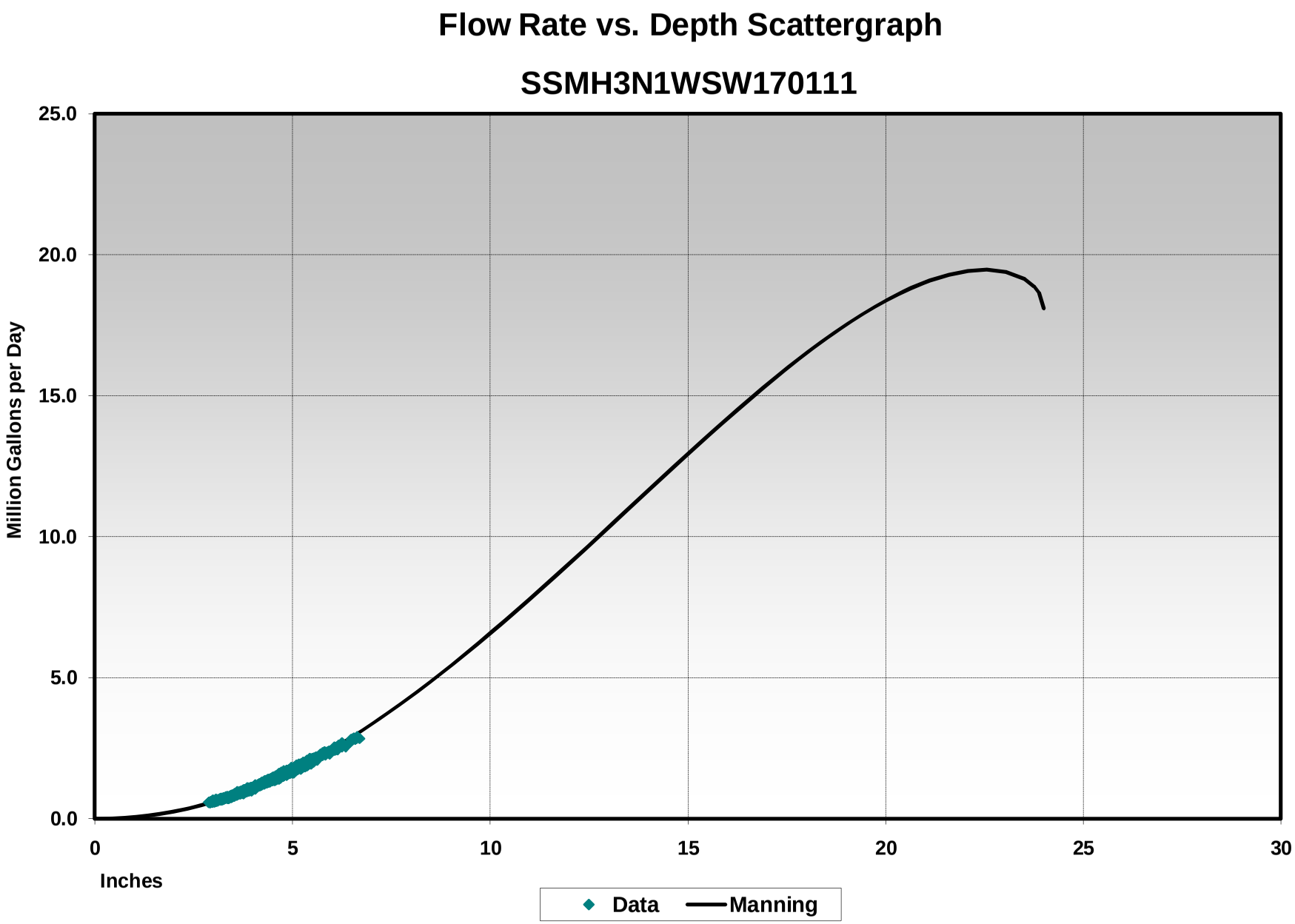
Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.51	1.56	1.78	1.72	1.44	1.46	1.40	1.49	1.51	1.70	1.63	1.52	1.43	1.39




Velocity vs. Depth Scattergraph
SSMH3N1WSW170111
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Feet per Second
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WSW170111
Million Gallons per Day
25.0
20.0
15.0
10.0
5.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.15	1.03	1.04	1.07	0.95	1.07	1.06	1.14	0.99	1.03	1.08	0.98	0.96	1.01
1:00	0.90	0.79	0.88	0.84	0.72	0.88	0.87	0.92	0.81	0.85	0.94	0.75	0.74	0.84
2:00	0.73	0.65	0.74	0.70	0.63	0.70	0.70	0.80	0.71	0.71	0.75	0.66	0.64	0.71
3:00	0.68	0.59	0.64	0.64	0.58	0.70	0.66	0.72	0.64	0.64	0.70	0.61	0.63	0.67
4:00	0.71	0.65	0.60	0.60	0.65	0.74	0.73	0.79	0.69	0.59	0.58	0.65	0.64	0.71
5:00	0.94	0.82	0.70	0.64	0.88	0.97	0.94	0.95	0.87	0.64	0.66	0.83	0.86	0.89
6:00	1.18	1.15	0.93	0.79	1.17	1.19	1.17	1.20	1.09	0.86	0.84	1.07	1.14	1.11
7:00	1.53	1.52	1.75	1.31	1.48	1.67	1.54	1.68	1.53	1.34	1.27	1.42	1.46	1.59
8:00	1.95	1.95	2.29	1.92	1.89	1.89	1.84	1.97	1.87	1.91	1.91	1.74	1.79	1.82
9:00	2.03	2.03	2.75	2.44	1.90	1.99	1.84	1.93	1.93	2.52	2.27	1.91	1.81	1.88
10:00	1.87	2.03	2.85	2.51	1.88	1.91	1.72	1.77	1.86	2.55	2.33	1.81	1.76	1.84
11:00	1.77	1.81	2.71	2.35	1.81	1.72	1.67	1.58	1.66	2.43	2.25	1.65	1.56	1.75
12:00	1.58	1.60	2.40	2.09	1.65	1.66	1.59	1.52	1.55	2.23	2.06	1.51	1.50	1.64
13:00	1.48	1.47	2.22	1.90	1.64	1.57	1.54	1.45	1.50	2.10	1.91	1.48	1.35	1.48
14:00	1.37	1.35	2.03	1.76	1.52	1.38	1.44	1.43	1.43	2.12	1.85	1.38	1.30	1.44
15:00	1.33	1.30	1.87	1.71	1.46	1.36	1.40	1.34	1.41	2.05	1.68	1.33	1.32	1.38
16:00	1.30	1.31	1.84	1.63	1.50	1.41	1.39	1.32	1.36	1.86	1.71	1.33	1.31	1.40
17:00	1.35	1.39	1.71	1.66	1.49	1.43	1.50	1.44	1.37	1.79	1.72	1.32	1.33	1.46
18:00	1.44	1.45	1.71	1.64	1.52	1.50	1.51	1.54	1.37	1.77	1.72	1.41	1.48	1.54
19:00	1.51	1.48	1.70	1.68	1.70	1.63	1.57	1.59	1.46	1.78	1.75	1.52	1.58	1.65
20:00	1.53	1.51	1.65	1.78	1.78	1.75	1.64	1.63	1.43	1.74	1.81	1.59	1.65	1.74
21:00	1.58	1.52	1.57	1.73	1.75	1.66	1.63	1.55	1.43	1.45	1.66	1.58	1.62	1.73
22:00	1.46	1.54	1.43	1.51	1.56	1.53	1.53	1.38	1.36	1.29	1.45	1.42	1.47	1.56
23:00	1.30	1.33	1.32	1.18	1.32	1.28	1.41	1.23	1.22	1.23	1.25	1.20	1.28	1.23
Average	1.36	1.34	1.64	1.50	1.39	1.40	1.37	1.37	1.31	1.56	1.51	1.30	1.30	1.38
Median	1.39	1.42	1.69	1.64	1.51	1.45	1.49	1.43	1.39	1.74	1.69	1.37	1.36	1.46
Max Hr. Mean	2.03	2.03	2.85	2.51	1.90	1.99	1.84	1.97	1.93	2.55	2.33	1.91	1.81	1.88
Min Hr. Mean	0.68	0.59	0.60	0.60	0.58	0.70	0.66	0.72	0.64	0.59	0.58	0.61	0.63	0.67
Inst. Max	2.06	2.10	2.91	2.59	2.00	2.04	1.93	2.04	1.98	2.65	2.45	1.97	1.86	1.92
Inst. Min	0.66	0.56	0.59	0.58	0.57	0.67	0.65	0.71	0.64	0.58	0.57	0.59	0.61	0.66

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.05	4.81	4.83	4.96	4.86	4.82	4.88	4.85	4.71	4.79	4.87	4.87	4.76	4.77
1:00	4.69	4.49	4.57	4.50	4.37	4.48	4.57	4.40	4.41	4.49	4.72	4.33	4.36	4.52
2:00	4.39	4.14	4.30	4.28	4.26	4.13	4.22	4.36	4.32	4.26	4.41	4.28	4.21	4.26
3:00	4.28	4.11	4.13	4.19	4.16	4.19	4.18	4.13	4.16	4.23	4.48	4.16	4.27	4.18
4:00	4.26	4.24	4.05	4.10	4.28	4.18	4.31	4.27	4.22	4.07	4.10	4.23	4.20	4.22
5:00	4.84	4.47	4.24	4.17	4.56	4.64	4.65	4.57	4.52	4.12	4.16	4.54	4.56	4.57
6:00	5.15	5.02	4.61	4.43	4.99	4.93	5.00	5.02	4.86	4.58	4.51	4.96	5.01	4.91
7:00	5.45	5.44	5.38	5.25	5.43	5.56	5.47	5.46	5.47	5.38	5.09	5.51	5.45	5.45
8:00	5.88	5.87	5.99	5.80	5.86	5.73	5.70	5.78	5.75	5.98	5.77	5.79	5.68	5.70
9:00	5.93	5.97	6.27	6.12	5.81	5.92	5.76	5.90	5.90	6.27	6.10	5.82	5.78	5.71
10:00	5.72	5.93	6.25	6.16	5.78	5.83	5.62	5.70	5.85	6.15	6.11	5.76	5.75	5.60
11:00	5.71	5.66	6.23	6.05	5.72	5.53	5.56	5.48	5.54	6.16	5.98	5.60	5.66	5.60
12:00	5.63	5.52	6.10	6.00	5.64	5.53	5.40	5.40	5.50	6.09	5.91	5.51	5.45	5.51
13:00	5.42	5.41	6.05	5.77	5.55	5.48	5.46	5.34	5.43	6.02	5.95	5.40	5.32	5.30
14:00	5.32	5.28	5.79	5.68	5.39	5.27	5.24	5.28	5.23	5.91	5.83	5.30	5.26	5.24
15:00	5.21	5.22	5.67	5.62	5.25	5.29	5.20	5.21	5.32	5.88	5.55	5.25	5.30	5.16
16:00	5.19	5.23	5.67	5.58	5.37	5.39	5.24	5.16	5.29	5.72	5.64	5.27	5.23	5.23
17:00	5.34	5.27	5.61	5.60	5.32	5.42	5.29	5.34	5.21	5.60	5.63	5.25	5.19	5.37
18:00	5.37	5.32	5.61	5.61	5.35	5.49	5.37	5.41	5.30	5.63	5.70	5.41	5.42	5.45
19:00	5.46	5.34	5.56	5.72	5.53	5.64	5.48	5.44	5.41	5.58	5.70	5.57	5.60	5.52
20:00	5.52	5.42	5.54	5.74	5.54	5.68	5.37	5.45	5.34	5.51	5.83	5.61	5.58	5.56
21:00	5.46	5.38	5.42	5.78	5.51	5.55	5.44	5.49	5.32	5.43	5.61	5.58	5.53	5.60
22:00	5.38	5.32	5.31	5.48	5.38	5.42	5.40	5.23	5.28	5.24	5.32	5.44	5.37	5.43
23:00	5.22	5.23	5.24	5.16	5.17	5.08	5.30	5.17	5.06	5.09	5.22	5.18	5.16	5.08
Average	5.24	5.17	5.35	5.32	5.21	5.22	5.17	5.16	5.14	5.34	5.34	5.19	5.17	5.16
Median	5.34	5.32	5.54	5.58	5.38	5.43	5.33	5.30	5.30	5.53	5.61	5.35	5.32	5.31
Max Hr. Mean	5.93	5.97	6.27	6.16	5.86	5.92	5.76	5.90	5.90	6.27	6.11	5.82	5.78	5.71
Min Hr. Mean	4.26	4.11	4.05	4.10	4.16	4.13	4.18	4.13	4.16	4.07	4.10	4.16	4.20	4.18
Inst. Max	6.01	6.07	6.46	6.23	5.98	6.02	5.97	5.94	5.99	6.34	6.28	5.92	5.87	5.77
Inst. Min	4.19	3.99	3.95	4.04	4.11	4.07	4.04	4.07	4.10	3.99	4.04	4.08	4.11	4.15

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.07	3.88	3.92	3.92	3.64	3.99	3.94	4.16	3.84	3.92	3.99	3.72	3.73	3.86
1:00	3.61	3.40	3.61	3.55	3.25	3.68	3.58	3.84	3.49	3.57	3.70	3.35	3.33	3.54
2:00	3.27	3.14	3.35	3.25	3.02	3.33	3.27	3.49	3.26	3.28	3.34	3.12	3.08	3.28
3:00	3.18	2.95	3.13	3.07	2.90	3.27	3.16	3.38	3.12	3.06	3.11	3.01	3.01	3.20
4:00	3.27	3.09	3.04	3.00	3.08	3.42	3.30	3.51	3.25	2.99	2.93	3.09	3.09	3.31
5:00	3.63	3.50	3.24	3.10	3.62	3.82	3.75	3.83	3.61	3.13	3.15	3.49	3.56	3.65
6:00	4.08	4.08	3.74	3.43	4.15	4.24	4.15	4.20	4.02	3.55	3.53	3.91	4.05	4.05
7:00	4.71	4.69	5.19	4.31	4.59	4.92	4.71	5.02	4.69	4.32	4.31	4.43	4.56	4.82
8:00	5.29	5.29	5.83	5.27	5.17	5.26	5.19	5.39	5.21	5.13	5.27	4.94	5.10	5.16
9:00	5.40	5.37	6.46	6.02	5.25	5.34	5.14	5.23	5.24	6.06	5.74	5.24	5.08	5.26
10:00	5.24	5.40	6.62	6.12	5.21	5.25	5.00	5.05	5.14	6.19	5.83	5.10	4.99	5.24
11:00	5.04	5.15	6.41	5.91	5.10	5.06	4.93	4.80	4.91	5.96	5.77	4.87	4.65	5.08
12:00	4.70	4.80	5.96	5.47	4.84	4.93	4.87	4.72	4.71	5.65	5.47	4.62	4.63	4.90
13:00	4.61	4.59	5.66	5.26	4.88	4.77	4.70	4.60	4.65	5.49	5.18	4.62	4.38	4.70
14:00	4.43	4.42	5.50	5.04	4.72	4.47	4.63	4.58	4.62	5.58	5.13	4.46	4.32	4.62
15:00	4.40	4.32	5.27	4.98	4.68	4.41	4.57	4.41	4.53	5.48	4.94	4.39	4.33	4.55
16:00	4.35	4.35	5.21	4.84	4.68	4.48	4.52	4.41	4.42	5.22	4.97	4.37	4.34	4.55
17:00	4.38	4.49	4.99	4.89	4.71	4.51	4.73	4.58	4.49	5.16	4.99	4.37	4.41	4.60
18:00	4.56	4.59	4.98	4.84	4.74	4.61	4.71	4.74	4.45	5.08	4.94	4.46	4.60	4.72
19:00	4.65	4.67	4.99	4.84	5.01	4.79	4.78	4.84	4.57	5.15	5.00	4.61	4.72	4.90
20:00	4.67	4.68	4.90	5.04	5.16	5.01	5.00	4.91	4.55	5.10	5.05	4.74	4.87	5.08
21:00	4.78	4.74	4.81	4.92	5.13	4.90	4.93	4.72	4.55	4.53	4.87	4.73	4.84	5.04
22:00	4.59	4.80	4.57	4.63	4.81	4.71	4.73	4.49	4.42	4.30	4.60	4.46	4.61	4.77
23:00	4.33	4.39	4.36	4.07	4.39	4.37	4.52	4.20	4.22	4.23	4.21	4.11	4.31	4.24
Average	4.38	4.37	4.82	4.57	4.45	4.48	4.45	4.46	4.33	4.67	4.58	4.26	4.27	4.46
Median	4.48	4.52	4.95	4.86	4.71	4.56	4.68	4.55	4.48	5.04	4.90	4.45	4.41	4.64
Max Hr. Mean	5.40	5.40	6.62	6.12	5.25	5.34	5.19	5.39	5.24	6.19	5.83	5.24	5.10	5.26
Min Hr. Mean	3.18	2.95	3.04	3.00	2.90	3.27	3.16	3.38	3.12	2.99	2.93	3.01	3.01	3.20
Inst. Max	5.43	5.47	6.70	6.20	5.32	5.38	5.30	5.49	5.34	6.30	6.15	5.31	5.20	5.31
Inst. Min	3.12	2.92	3.02	2.97	2.89	3.23	3.15	3.37	3.10	2.97	2.90	2.96	2.98	3.17

All Values in Inches

FLOW SERVICES GROUP

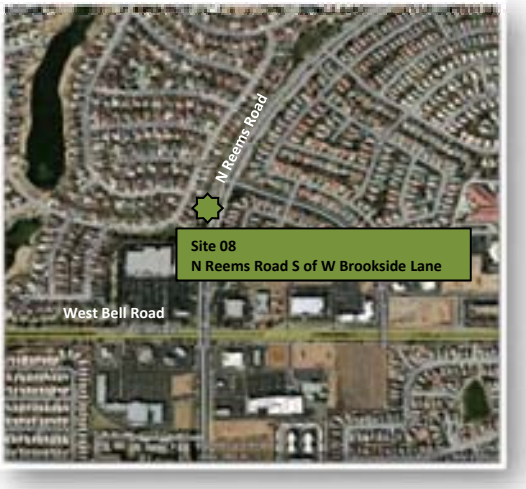
Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 08
Address: N Reems Road S of W Brookside Lane
MH ID# SSMH4N1WSW320090

Date: 6/9/2008
GPS: 33.382881N -112.233747W

Overview

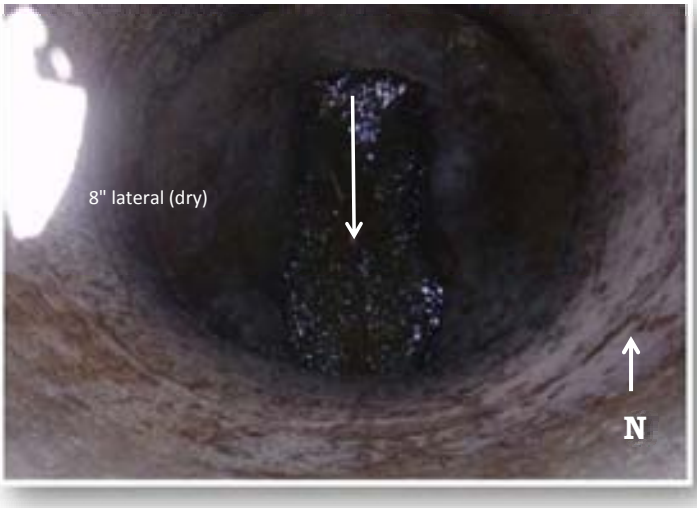


Street Level

Meter Details

Meter Type 2150
Serial # 205F00936
Sensor Serial # 205K01553
Telemetry None
Sample Rate 5 min

Down Manhole



Pipe Details and Manhole Condition

Pipe Size (in) Vert. 21" Horiz. 21"
Laterals 1
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris Yes - towels & TP
Grease No
Pests No

Hydraulics:
Slow to moderate flow conditions

Comments:
Bench area corroded. High H2S levels
Some debris / rock in bench area. Removed debris and rock for installation of equipment

Photos
MH #SSMH4N1WSW320090
Site #08

Site ID

Down Manhole

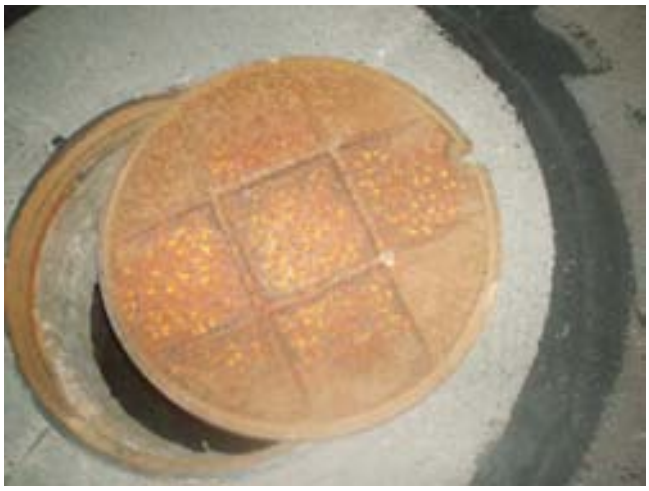
21” Influent

21” Effluent

8” Lateral (Dry)

Manhole Cover Top

Photos
MH #SSMH4N1WSW320090
Site #08



Manhole Cover Bottom

Location Summary

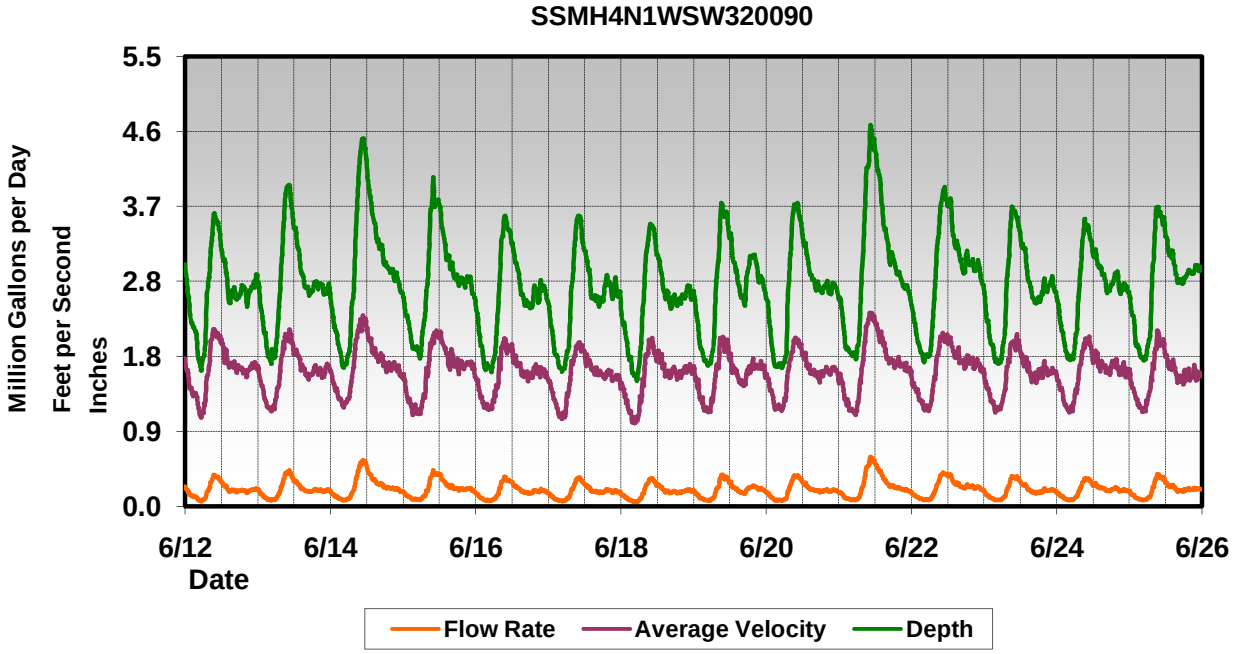
Site	**SSMH4N1WSW320090**	
Address	**Reems Road at Brookside Lane**	
Diameter	**21**	Inches
GPS	**33.382881N -112.233747W**	

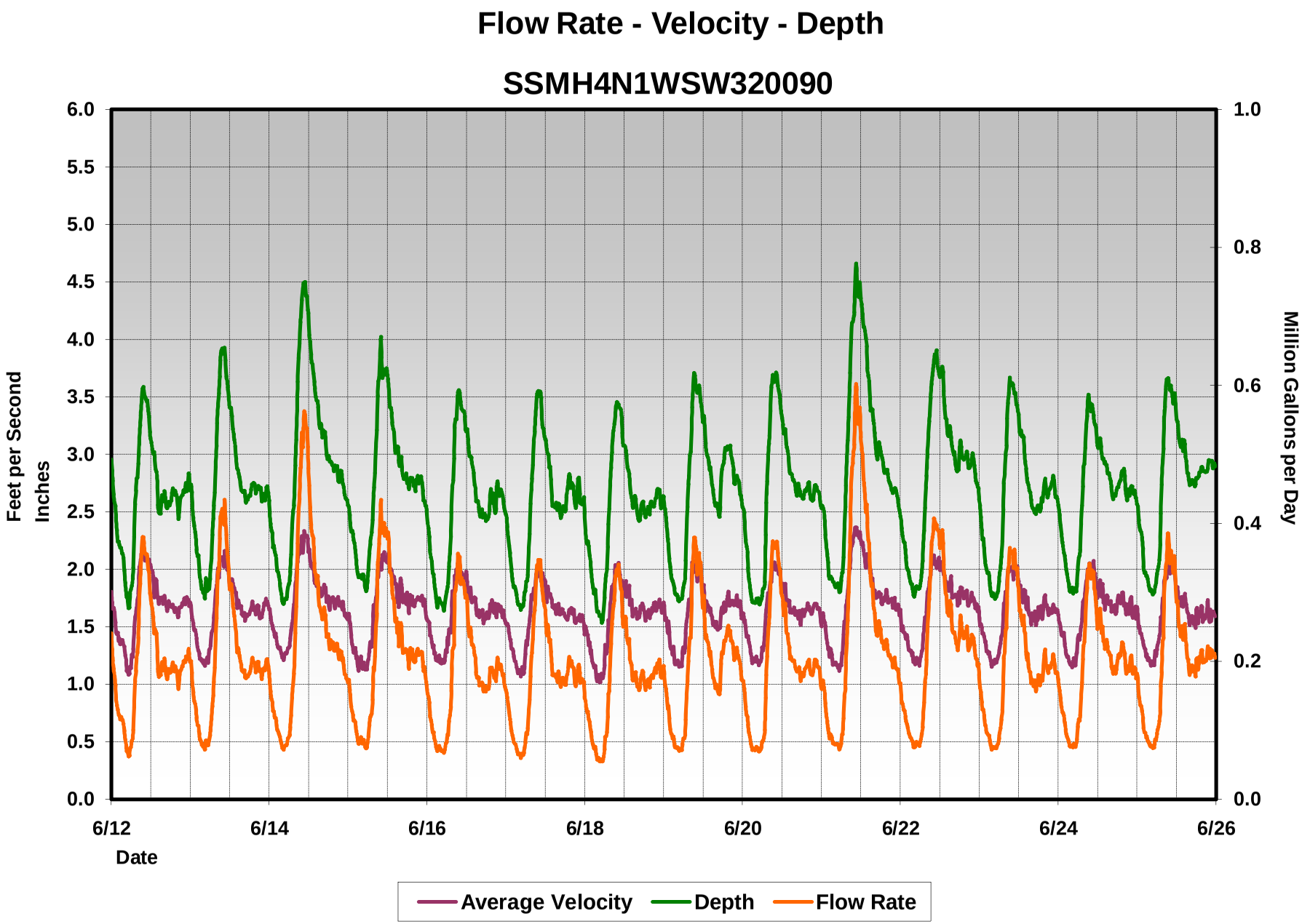
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	2.70
Maximum	4.66
Minimum	1.54
Max d/D	22.2%

Flow velocity	
	Feet per Second
Average	1.64
Maximum	2.36
Minimum	1.02

Flow Rate	
	Million Gallons per Day
Average	0.20
Maximum	0.60
Minimum	0.06
Peak Factor	2.94



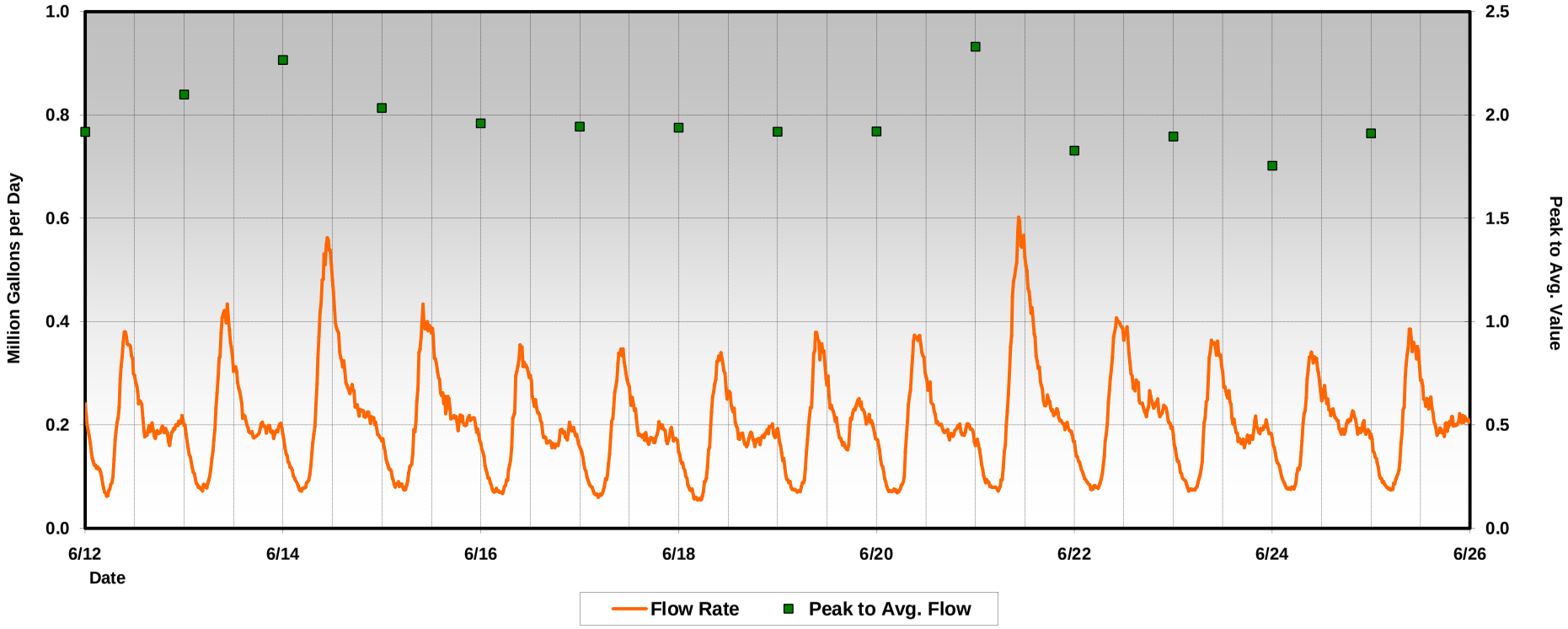

Flow Rate - Velocity - Depth
SSMH4N1WSW320090
Feet per Second
Inches
Million Gallons per Day
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.8
0.6
0.4
0.2
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

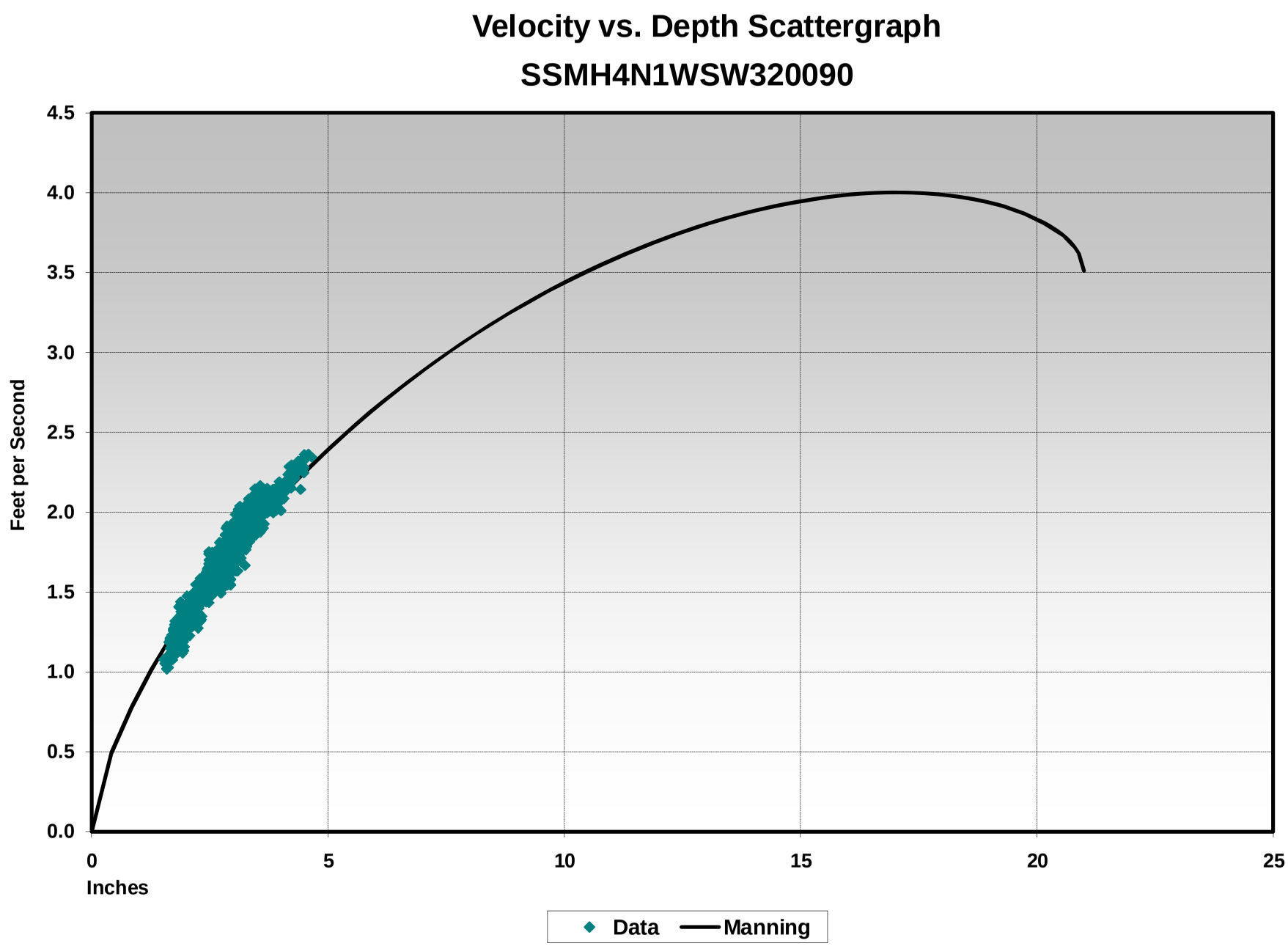
Peak to Average Flow Rate

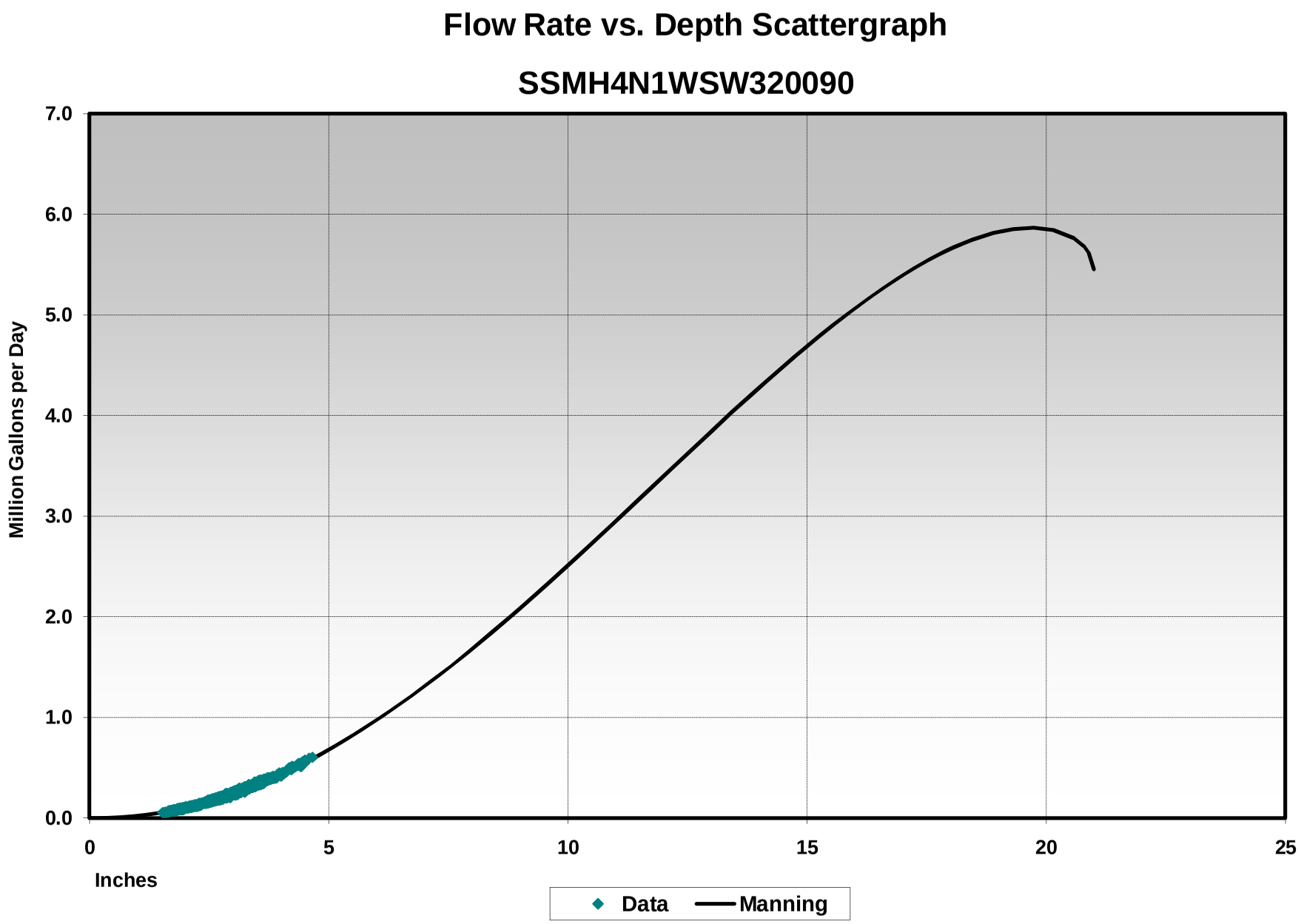
Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.92	2.10	2.27	2.03	1.96	1.94	1.94	1.92	1.92	2.33	1.83	1.89	1.75	1.91




Velocity vs. Depth Scattergraph
SSMH4N1WSW320090
Feet per Second
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH4N1WSW320090
Million Gallons per Day
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.21	0.19	0.16	0.16	0.15	0.15	0.14	0.17	0.16	0.17	0.15	0.16	0.16	0.16
1:00	0.16	0.14	0.13	0.12	0.11	0.11	0.11	0.13	0.12	0.13	0.12	0.12	0.13	0.13
2:00	0.12	0.11	0.11	0.10	0.09	0.09	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.10
3:00	0.11	0.08	0.09	0.08	0.07	0.07	0.07	0.08	0.07	0.09	0.09	0.08	0.08	0.08
4:00	0.08	0.08	0.07	0.09	0.07	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08
5:00	0.07	0.08	0.08	0.08	0.07	0.07	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08
6:00	0.09	0.11	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.10	0.09	0.10	0.11	0.10
7:00	0.17	0.19	0.17	0.15	0.16	0.16	0.16	0.18	0.19	0.18	0.15	0.18	0.19	0.18
8:00	0.26	0.30	0.31	0.23	0.26	0.25	0.26	0.27	0.29	0.32	0.25	0.28	0.27	0.29
9:00	0.36	0.41	0.45	0.36	0.34	0.32	0.32	0.37	0.37	0.48	0.35	0.36	0.33	0.37
10:00	0.36	0.41	0.54	0.40	0.32	0.34	0.33	0.35	0.37	0.57	0.40	0.35	0.33	0.35
11:00	0.33	0.36	0.54	0.39	0.31	0.29	0.28	0.32	0.33	0.55	0.39	0.33	0.29	0.33
12:00	0.28	0.31	0.44	0.37	0.27	0.26	0.26	0.27	0.28	0.50	0.38	0.28	0.26	0.27
13:00	0.24	0.27	0.37	0.31	0.24	0.23	0.22	0.23	0.25	0.44	0.33	0.26	0.24	0.25
14:00	0.19	0.22	0.32	0.27	0.21	0.18	0.18	0.20	0.21	0.37	0.28	0.22	0.23	0.24
15:00	0.19	0.20	0.28	0.24	0.18	0.18	0.18	0.17	0.20	0.31	0.27	0.18	0.21	0.21
16:00	0.19	0.18	0.27	0.24	0.17	0.17	0.16	0.16	0.19	0.26	0.24	0.17	0.19	0.19
17:00	0.18	0.18	0.25	0.22	0.16	0.17	0.18	0.18	0.18	0.25	0.22	0.17	0.19	0.18
18:00	0.19	0.19	0.23	0.20	0.16	0.17	0.17	0.22	0.18	0.23	0.25	0.17	0.21	0.20
19:00	0.19	0.20	0.22	0.21	0.19	0.20	0.17	0.24	0.19	0.22	0.24	0.19	0.22	0.21
20:00	0.17	0.19	0.22	0.20	0.18	0.19	0.18	0.24	0.19	0.21	0.23	0.20	0.20	0.20
21:00	0.19	0.18	0.21	0.21	0.19	0.17	0.19	0.21	0.19	0.20	0.23	0.19	0.19	0.21
22:00	0.20	0.19	0.20	0.21	0.19	0.18	0.20	0.21	0.20	0.20	0.23	0.20	0.20	0.21
23:00	0.21	0.20	0.18	0.18	0.17	0.17	0.18	0.19	0.18	0.18	0.20	0.19	0.19	0.21
Average	0.20	0.21	0.25	0.21	0.18	0.18	0.18	0.20	0.19	0.26	0.22	0.19	0.19	0.20
Median	0.19	0.19	0.22	0.21	0.18	0.18	0.18	0.20	0.19	0.22	0.23	0.18	0.20	0.20
Max Hr. Mean	0.36	0.41	0.54	0.40	0.34	0.34	0.33	0.37	0.37	0.57	0.40	0.36	0.33	0.37
Min Hr. Mean	0.07	0.08	0.07	0.08	0.07	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08
Inst. Max	0.38	0.43	0.56	0.43	0.36	0.35	0.34	0.38	0.37	0.60	0.41	0.36	0.34	0.39
Inst. Min	0.06	0.07	0.07	0.07	0.07	0.06	0.06	0.07	0.07	0.07	0.08	0.07	0.08	0.07

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.71	1.64	1.61	1.56	1.55	1.52	1.46	1.63	1.58	1.56	1.53	1.54	1.54	1.57
1:00	1.51	1.48	1.47	1.34	1.38	1.38	1.35	1.49	1.44	1.45	1.43	1.42	1.43	1.41
2:00	1.39	1.32	1.38	1.27	1.27	1.26	1.21	1.30	1.30	1.29	1.35	1.30	1.29	1.30
3:00	1.37	1.21	1.30	1.17	1.22	1.14	1.10	1.23	1.20	1.22	1.28	1.22	1.20	1.23
4:00	1.22	1.18	1.23	1.18	1.20	1.10	1.05	1.18	1.22	1.17	1.19	1.20	1.18	1.18
5:00	1.11	1.23	1.28	1.14	1.23	1.12	1.08	1.19	1.19	1.14	1.19	1.21	1.22	1.22
6:00	1.24	1.39	1.38	1.27	1.38	1.35	1.26	1.34	1.35	1.29	1.26	1.34	1.41	1.36
7:00	1.58	1.63	1.63	1.44	1.56	1.61	1.52	1.64	1.68	1.61	1.51	1.61	1.63	1.58
8:00	1.89	1.92	1.97	1.69	1.84	1.80	1.83	1.84	1.85	1.92	1.78	1.85	1.84	1.85
9:00	2.14	2.09	2.17	2.00	2.00	1.93	1.97	2.04	2.03	2.23	2.00	2.00	1.99	2.07
10:00	2.11	2.10	2.25	2.08	1.95	1.96	1.99	1.99	2.01	2.34	2.07	2.00	2.02	2.02
11:00	2.06	2.01	2.28	2.10	1.93	1.93	1.84	1.93	1.94	2.30	2.06	1.98	1.91	1.97
12:00	1.99	1.89	2.10	2.08	1.85	1.81	1.85	1.74	1.85	2.22	2.02	1.84	1.83	1.80
13:00	1.85	1.84	2.00	1.97	1.76	1.77	1.78	1.69	1.76	2.09	1.95	1.76	1.79	1.72
14:00	1.74	1.73	1.90	1.89	1.75	1.69	1.67	1.62	1.67	2.05	1.85	1.72	1.73	1.73
15:00	1.73	1.66	1.82	1.75	1.63	1.65	1.63	1.52	1.64	1.91	1.87	1.59	1.72	1.63
16:00	1.72	1.59	1.81	1.83	1.61	1.63	1.60	1.50	1.62	1.78	1.77	1.59	1.66	1.55
17:00	1.69	1.60	1.78	1.75	1.58	1.63	1.68	1.57	1.57	1.78	1.76	1.56	1.65	1.54
18:00	1.68	1.65	1.71	1.72	1.60	1.58	1.61	1.67	1.61	1.73	1.80	1.64	1.74	1.61
19:00	1.65	1.67	1.74	1.73	1.67	1.63	1.61	1.75	1.66	1.76	1.77	1.64	1.76	1.64
20:00	1.62	1.66	1.71	1.71	1.66	1.63	1.63	1.71	1.65	1.73	1.74	1.70	1.67	1.57
21:00	1.68	1.59	1.71	1.75	1.64	1.55	1.69	1.71	1.65	1.72	1.74	1.63	1.66	1.63
22:00	1.72	1.67	1.68	1.74	1.65	1.57	1.70	1.71	1.69	1.69	1.71	1.66	1.67	1.59
23:00	1.73	1.72	1.59	1.67	1.59	1.56	1.66	1.65	1.63	1.66	1.67	1.64	1.64	1.61
Average	1.67	1.64	1.73	1.66	1.60	1.58	1.57	1.61	1.62	1.74	1.68	1.61	1.63	1.60
Median	1.69	1.65	1.72	1.72	1.62	1.61	1.63	1.66	1.64	1.74	1.75	1.63	1.68	1.59
Max Hr. Mean	2.14	2.10	2.28	2.10	2.00	1.96	1.99	2.04	2.03	2.34	2.07	2.00	2.02	2.07
Min Hr. Mean	1.11	1.18	1.23	1.14	1.20	1.10	1.05	1.18	1.19	1.14	1.19	1.20	1.18	1.18
Inst. Max	2.17	2.16	2.33	2.15	2.05	2.00	2.06	2.07	2.06	2.36	2.12	2.10	2.07	2.15
Inst. Min	1.09	1.16	1.21	1.12	1.18	1.07	1.02	1.15	1.17	1.12	1.16	1.15	1.15	1.16

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.81	2.66	2.45	2.49	2.39	2.39	2.32	2.54	2.49	2.53	2.38	2.49	2.48	2.48
1:00	2.48	2.35	2.21	2.31	2.08	2.11	2.16	2.23	2.15	2.27	2.18	2.19	2.22	2.28
2:00	2.22	2.10	2.04	2.12	1.86	1.87	1.88	1.95	1.82	1.97	1.98	1.99	2.03	1.98
3:00	2.14	1.87	1.86	1.94	1.71	1.75	1.74	1.82	1.71	1.91	1.87	1.85	1.85	1.89
4:00	1.86	1.81	1.72	1.94	1.71	1.67	1.61	1.75	1.73	1.86	1.80	1.77	1.82	1.80
5:00	1.71	1.84	1.77	1.85	1.69	1.72	1.58	1.75	1.72	1.83	1.84	1.78	1.83	1.83
6:00	1.90	2.08	1.97	2.06	1.89	1.89	1.89	1.93	1.83	1.99	1.95	1.99	2.10	2.01
7:00	2.58	2.64	2.52	2.42	2.41	2.43	2.46	2.61	2.65	2.64	2.44	2.59	2.64	2.59
8:00	3.02	3.32	3.26	2.96	3.07	3.00	3.06	3.16	3.30	3.43	3.06	3.21	3.14	3.33
9:00	3.49	3.83	4.04	3.67	3.47	3.44	3.36	3.64	3.66	4.11	3.53	3.60	3.46	3.64
10:00	3.49	3.88	4.43	3.82	3.44	3.52	3.42	3.58	3.67	4.50	3.81	3.58	3.39	3.56
11:00	3.34	3.60	4.38	3.72	3.33	3.24	3.24	3.45	3.48	4.44	3.78	3.44	3.23	3.48
12:00	3.07	3.39	4.03	3.58	3.15	3.07	3.04	3.24	3.24	4.25	3.73	3.23	3.10	3.24
13:00	2.93	3.15	3.73	3.31	2.97	2.89	2.84	2.98	3.10	4.03	3.50	3.13	3.00	3.10
14:00	2.58	2.88	3.50	3.08	2.79	2.57	2.60	2.82	2.87	3.64	3.21	2.84	2.92	3.05
15:00	2.58	2.73	3.30	2.99	2.58	2.54	2.60	2.62	2.79	3.36	3.16	2.67	2.82	2.85
16:00	2.61	2.67	3.19	2.90	2.49	2.52	2.44	2.53	2.69	3.13	2.99	2.53	2.68	2.75
17:00	2.56	2.61	3.07	2.80	2.47	2.52	2.55	2.66	2.69	3.03	2.86	2.52	2.66	2.75
18:00	2.64	2.68	2.96	2.73	2.44	2.58	2.49	2.97	2.63	2.98	3.05	2.52	2.73	2.80
19:00	2.67	2.74	2.90	2.78	2.61	2.77	2.51	3.05	2.69	2.85	2.97	2.65	2.82	2.87
20:00	2.52	2.70	2.89	2.73	2.57	2.72	2.57	3.03	2.69	2.80	2.97	2.70	2.76	2.86
21:00	2.63	2.68	2.81	2.78	2.67	2.58	2.59	2.82	2.63	2.69	2.91	2.69	2.65	2.88
22:00	2.71	2.62	2.77	2.76	2.67	2.70	2.69	2.79	2.72	2.69	2.92	2.77	2.71	2.94
23:00	2.76	2.68	2.62	2.57	2.57	2.59	2.58	2.66	2.63	2.58	2.73	2.64	2.65	2.90
Average	2.64	2.73	2.93	2.76	2.54	2.55	2.51	2.69	2.65	2.98	2.82	2.64	2.65	2.74
Median	2.64	2.69	2.90	2.77	2.54	2.57	2.55	2.76	2.68	2.86	2.94	2.63	2.71	2.85
Max Hr. Mean	3.49	3.88	4.43	3.82	3.47	3.52	3.42	3.64	3.67	4.50	3.81	3.60	3.46	3.64
Min Hr. Mean	1.71	1.81	1.72	1.85	1.69	1.67	1.58	1.75	1.71	1.83	1.80	1.77	1.82	1.80
Inst. Max	3.59	3.93	4.50	4.02	3.56	3.55	3.45	3.71	3.71	4.66	3.90	3.67	3.52	3.66
Inst. Min	1.66	1.75	1.70	1.81	1.64	1.65	1.54	1.72	1.70	1.80	1.76	1.74	1.79	1.78

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 09
Address: Bullard Avenue at Charter Oaks Road
MH ID# SSMH3N1WSW160002

Date: 6/9/2008
GPS: 33.354711N -112.223552W

Overview

Street Level

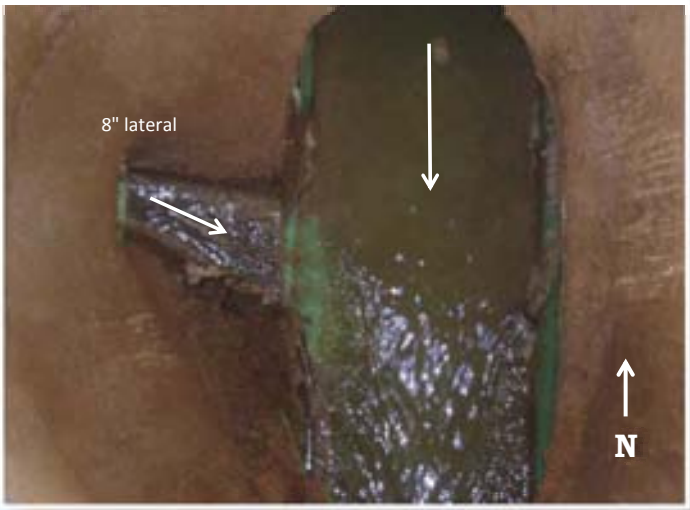
Meter Details

Meter Type	2150
Serial #	202E01460
Sensor Serial #	201C03029
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	24"	Horiz.	24"
Laterals	1			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole



Hydraulics:
Moderate flow conditions

Comments:
Good flow monitoring site

Photos
MH #SSMH3N1WSW160002
Site #09

Site ID

Down Manhole

24” Influent

24” Effluent

8” Lateral

Manhole Cover Top

Photos
MH #SSMH3N1WSW160002
Site #09

Manhole Cover Bottom

Location Summary

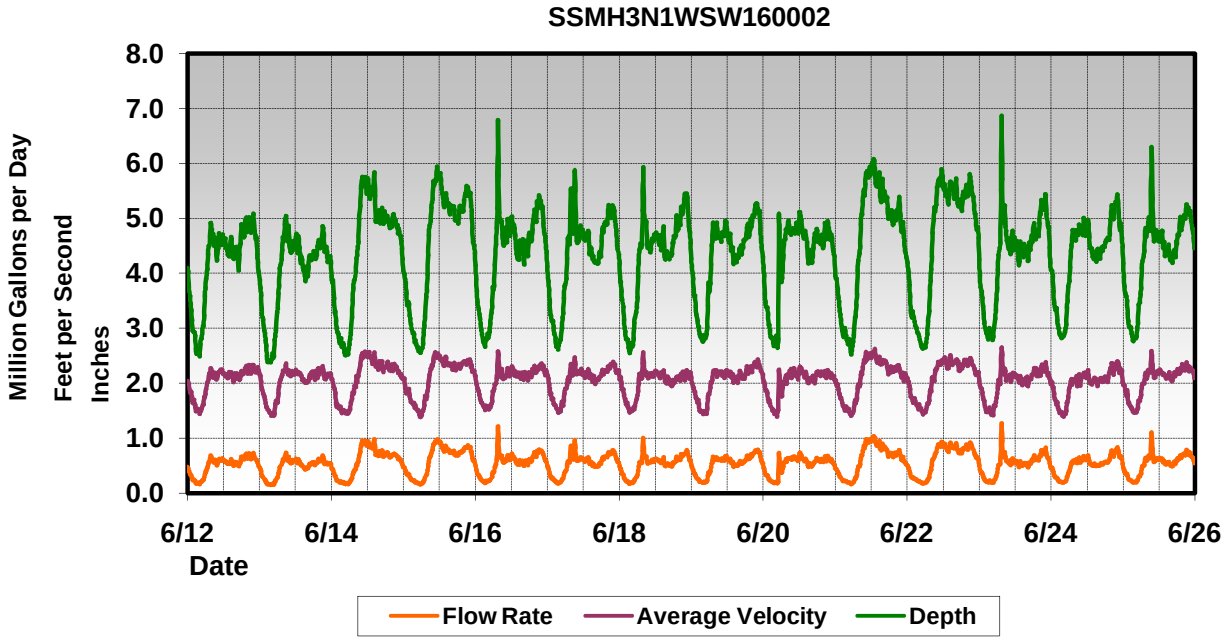
Site	**SSMH3N1WSW160002**
Address	**Bullard Ave and Charter Oaks Rd**
Diameter	**24** Inches
GPS	**33.354711N -112.223552W**

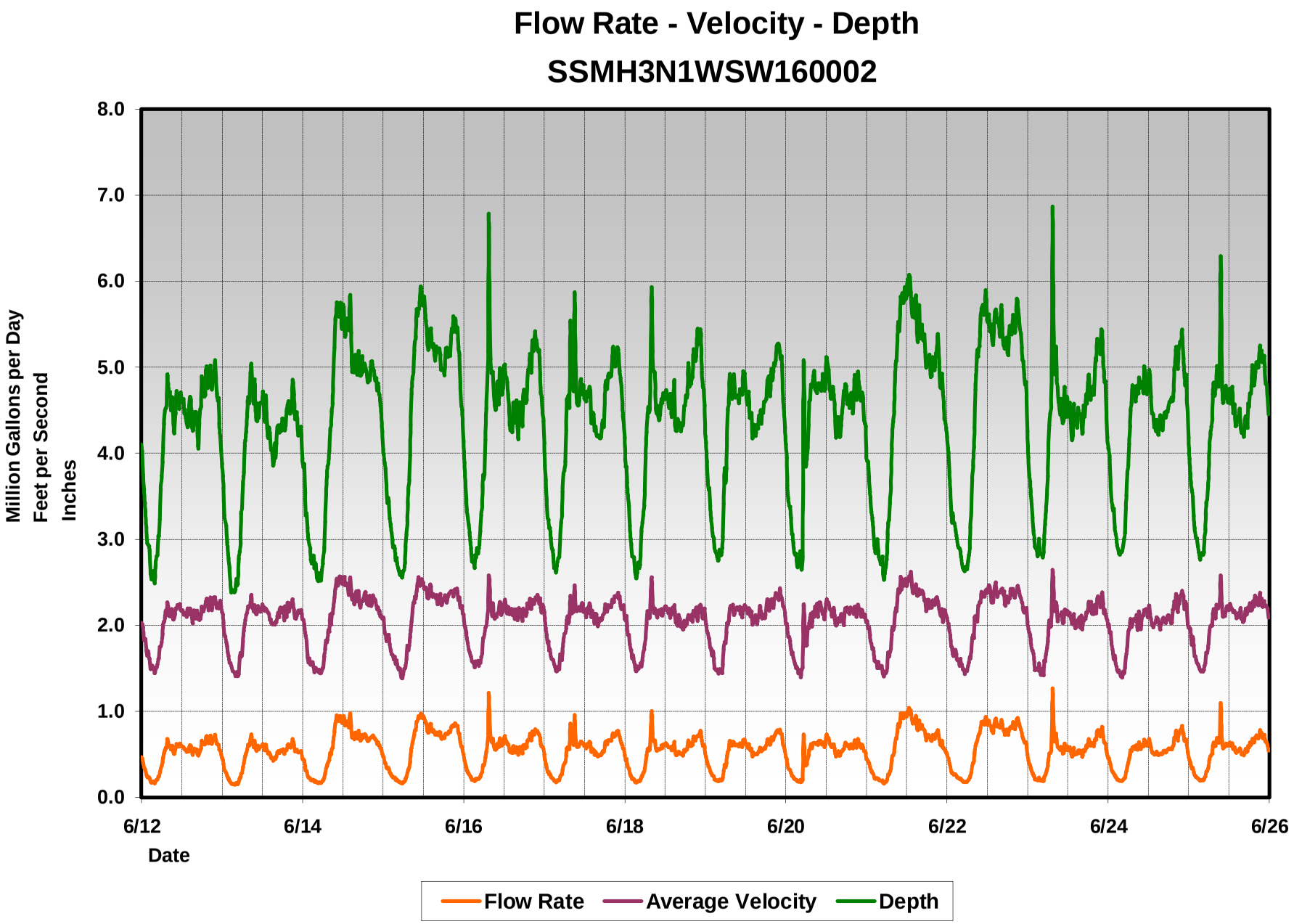
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.35
Maximum	6.87
Minimum	2.38
Max d/D	28.6%

Flow velocity	
	Feet per Second
Average	2.05
Maximum	2.64
Minimum	1.38

Flow Rate	
	Million Gallons per Day
Average	0.54
Maximum	1.27
Minimum	0.15
Peak Factor	2.34



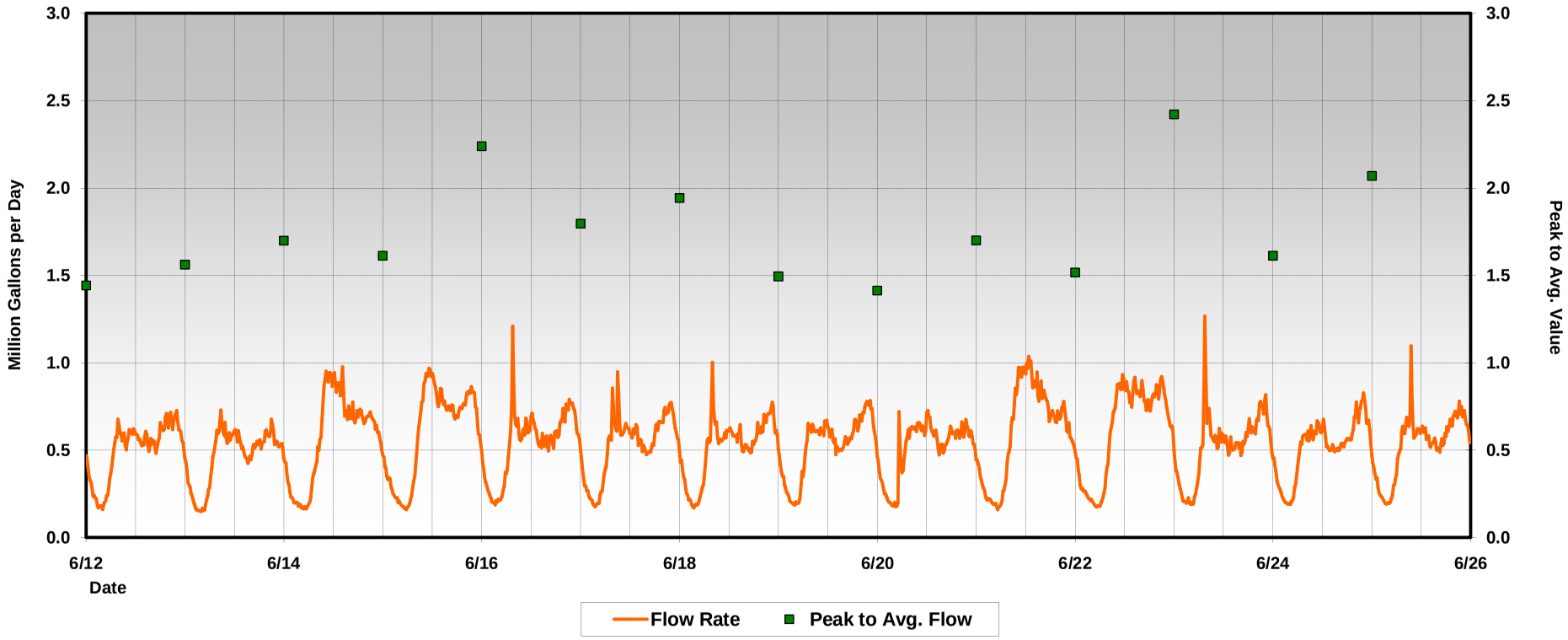

Flow Rate - Velocity - Depth
SSMH3N1WSW160002
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

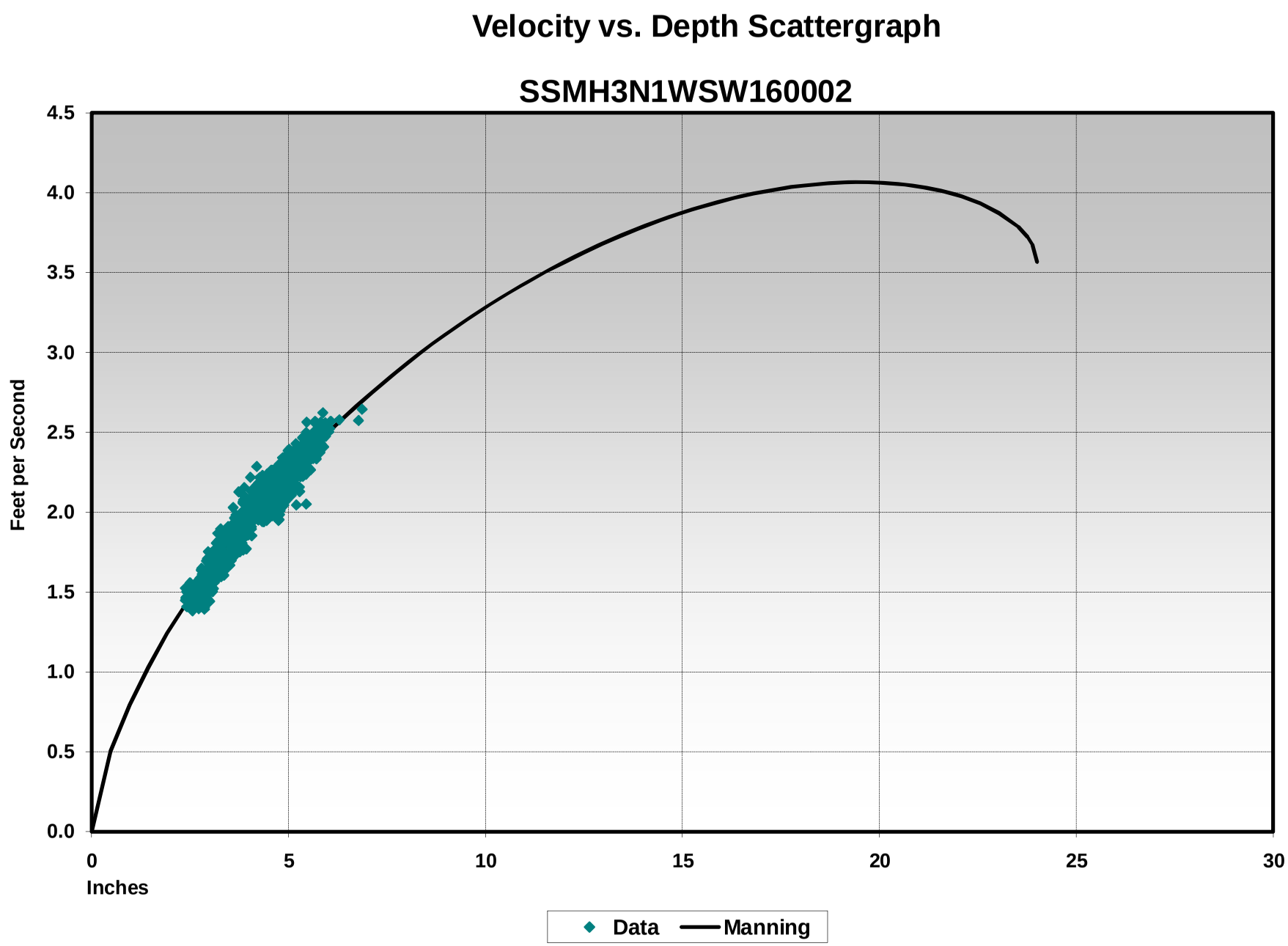
Peak to Average Flow Rate

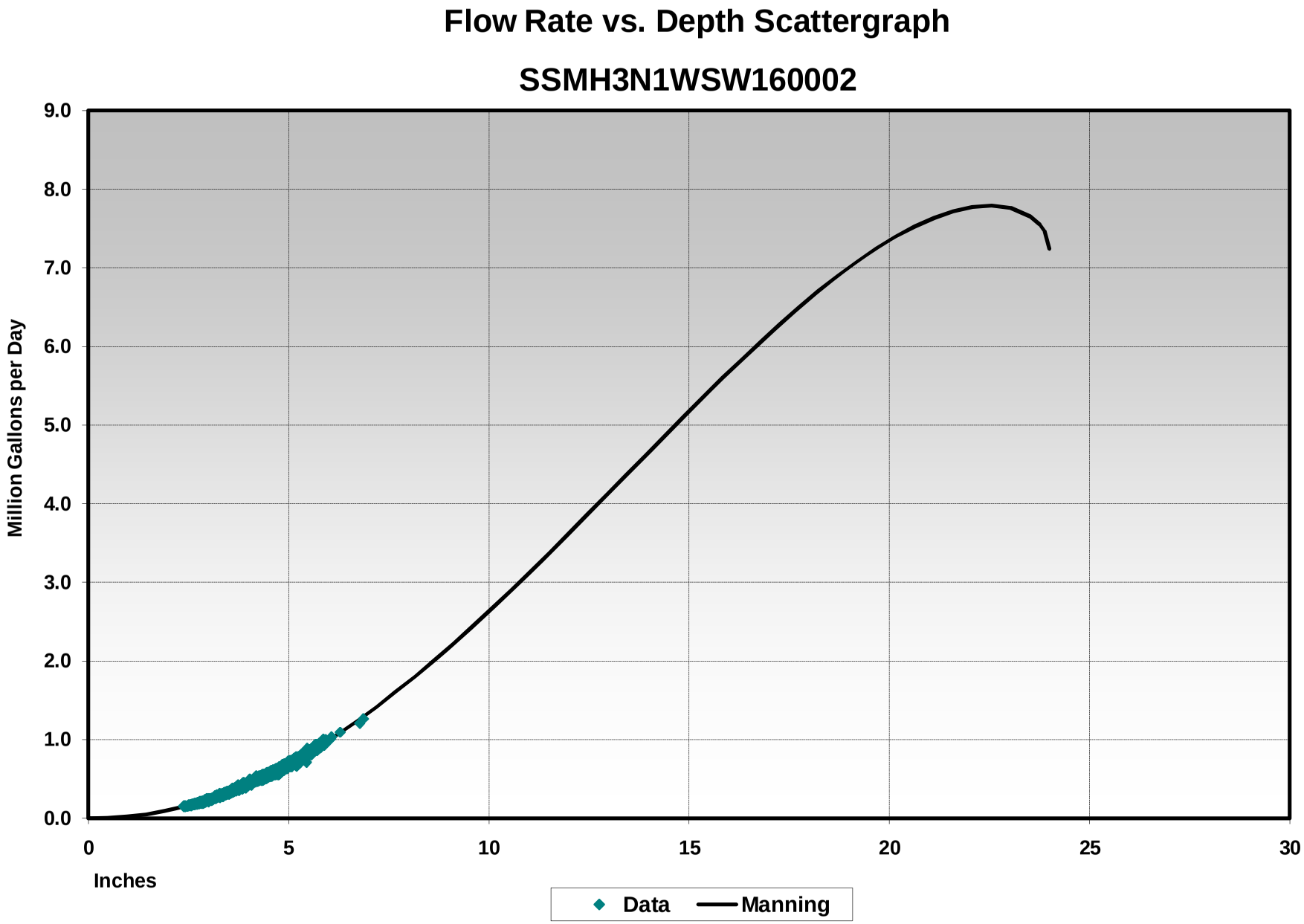
Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.44	1.56	1.70	1.61	2.24	1.80	1.94	1.49	1.41	1.70	1.52	2.42	1.61	2.07




Velocity vs. Depth Scattergraph
SSMH3N1WSW160002
Feet per Second
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WSW160002
Million Gallons per Day
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.42	0.40	0.42	0.43	0.41	0.42	0.44	0.44	0.41	0.43	0.45	0.42	0.42	0.41
1:00	0.29	0.27	0.28	0.34	0.29	0.28	0.30	0.32	0.29	0.32	0.30	0.30	0.30	0.31
2:00	0.22	0.19	0.21	0.26	0.22	0.22	0.22	0.24	0.23	0.24	0.26	0.21	0.23	0.23
3:00	0.18	0.16	0.19	0.22	0.20	0.18	0.18	0.20	0.19	0.22	0.22	0.21	0.20	0.20
4:00	0.19	0.16	0.17	0.19	0.22	0.21	0.19	0.20	0.19	0.19	0.20	0.19	0.20	0.21
5:00	0.27	0.23	0.17	0.17	0.29	0.30	0.27	0.28	0.47	0.17	0.18	0.27	0.29	0.29
6:00	0.43	0.37	0.22	0.19	0.44	0.46	0.45	0.44	0.42	0.23	0.20	0.46	0.48	0.45
7:00	0.59	0.54	0.38	0.30	0.88	0.64	0.61	0.62	0.58	0.39	0.33	0.90	0.57	0.59
8:00	0.60	0.65	0.50	0.53	0.67	0.66	0.77	0.62	0.63	0.58	0.54	0.69	0.58	0.65
9:00	0.55	0.62	0.72	0.74	0.57	0.75	0.58	0.61	0.63	0.78	0.71	0.57	0.59	0.80
10:00	0.59	0.56	0.92	0.91	0.63	0.60	0.56	0.61	0.64	0.93	0.86	0.54	0.62	0.60
11:00	0.61	0.58	0.92	0.94	0.62	0.63	0.60	0.64	0.62	0.95	0.88	0.59	0.62	0.62
12:00	0.58	0.59	0.90	0.90	0.68	0.60	0.61	0.60	0.71	0.98	0.86	0.56	0.62	0.62
13:00	0.55	0.56	0.85	0.78	0.59	0.62	0.58	0.57	0.60	0.95	0.79	0.51	0.51	0.58
14:00	0.58	0.49	0.85	0.81	0.55	0.55	0.60	0.50	0.58	0.89	0.88	0.51	0.51	0.53
15:00	0.53	0.45	0.72	0.75	0.56	0.51	0.51	0.51	0.51	0.84	0.83	0.53	0.50	0.54
16:00	0.54	0.49	0.72	0.74	0.54	0.48	0.52	0.56	0.51	0.82	0.84	0.51	0.52	0.51
17:00	0.53	0.53	0.69	0.71	0.56	0.52	0.51	0.56	0.59	0.74	0.76	0.57	0.54	0.56
18:00	0.63	0.54	0.71	0.71	0.59	0.62	0.56	0.64	0.60	0.71	0.76	0.63	0.56	0.61
19:00	0.67	0.58	0.67	0.75	0.68	0.66	0.62	0.65	0.60	0.68	0.83	0.61	0.62	0.67
20:00	0.67	0.59	0.69	0.80	0.71	0.71	0.66	0.69	0.62	0.70	0.84	0.70	0.71	0.70
21:00	0.67	0.62	0.69	0.84	0.76	0.74	0.69	0.76	0.62	0.73	0.87	0.75	0.76	0.74
22:00	0.65	0.54	0.63	0.79	0.73	0.72	0.75	0.75	0.60	0.61	0.73	0.74	0.75	0.70
23:00	0.55	0.53	0.56	0.59	0.59	0.59	0.61	0.59	0.54	0.55	0.63	0.57	0.62	0.61
Average	0.50	0.47	0.57	0.60	0.54	0.53	0.52	0.52	0.52	0.61	0.61	0.52	0.51	0.53
Median	0.56	0.53	0.67	0.73	0.58	0.57	0.56	0.57	0.58	0.68	0.73	0.54	0.55	0.57
Max Hr. Mean	0.67	0.65	0.92	0.94	0.88	0.75	0.77	0.76	0.71	0.98	0.88	0.90	0.76	0.80
Min Hr. Mean	0.18	0.16	0.17	0.17	0.20	0.18	0.18	0.20	0.19	0.17	0.18	0.19	0.20	0.20
Inst. Max	0.73	0.73	0.98	0.97	1.21	0.95	1.00	0.78	0.73	1.04	0.93	1.27	0.83	1.10
Inst. Min	0.16	0.15	0.16	0.16	0.19	0.18	0.17	0.19	0.18	0.16	0.18	0.19	0.19	0.19

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.96	2.05	2.02	2.00	2.00	2.02	2.05	1.99	1.97	2.01	2.01	1.95	1.96	1.94
1:00	1.76	1.78	1.73	1.87	1.76	1.76	1.82	1.79	1.76	1.80	1.76	1.73	1.70	1.76
2:00	1.60	1.57	1.57	1.70	1.61	1.61	1.64	1.62	1.61	1.63	1.67	1.51	1.55	1.59
3:00	1.51	1.47	1.51	1.61	1.55	1.50	1.50	1.48	1.49	1.55	1.58	1.49	1.44	1.49
4:00	1.50	1.42	1.48	1.53	1.57	1.54	1.52	1.46	1.46	1.50	1.55	1.44	1.43	1.49
5:00	1.68	1.59	1.46	1.42	1.68	1.68	1.63	1.63	1.93	1.43	1.46	1.64	1.64	1.67
6:00	1.94	1.85	1.59	1.49	1.93	1.96	1.95	1.93	1.87	1.57	1.55	1.94	1.99	1.93
7:00	2.16	2.14	1.85	1.71	2.35	2.14	2.17	2.17	2.06	1.82	1.76	2.38	2.03	2.12
8:00	2.14	2.25	2.05	2.00	2.19	2.19	2.30	2.17	2.14	2.07	2.03	2.23	2.04	2.19
9:00	2.13	2.20	2.27	2.29	2.10	2.29	2.14	2.20	2.20	2.31	2.19	2.10	2.05	2.33
10:00	2.19	2.16	2.50	2.49	2.18	2.19	2.16	2.18	2.22	2.48	2.34	2.08	2.12	2.14
11:00	2.22	2.18	2.54	2.49	2.18	2.22	2.17	2.18	2.13	2.50	2.38	2.16	2.15	2.20
12:00	2.15	2.20	2.52	2.44	2.25	2.16	2.20	2.18	2.27	2.51	2.42	2.13	2.14	2.21
13:00	2.14	2.17	2.44	2.34	2.15	2.20	2.14	2.16	2.16	2.51	2.32	2.06	2.00	2.17
14:00	2.17	2.07	2.43	2.40	2.16	2.14	2.18	2.04	2.12	2.42	2.44	2.01	2.06	2.11
15:00	2.12	2.01	2.32	2.34	2.13	2.09	2.04	2.06	2.04	2.37	2.37	2.04	2.00	2.14
16:00	2.11	2.08	2.35	2.29	2.13	2.04	2.07	2.15	2.08	2.39	2.40	2.03	2.06	2.07
17:00	2.10	2.17	2.26	2.30	2.12	2.09	1.99	2.10	2.10	2.28	2.30	2.11	2.06	2.18
18:00	2.19	2.16	2.34	2.31	2.14	2.20	2.03	2.24	2.17	2.24	2.29	2.20	2.07	2.19
19:00	2.28	2.20	2.25	2.33	2.24	2.22	2.09	2.22	2.18	2.25	2.39	2.18	2.17	2.26
20:00	2.25	2.22	2.28	2.39	2.24	2.26	2.12	2.27	2.19	2.27	2.36	2.21	2.25	2.28
21:00	2.26	2.20	2.31	2.39	2.29	2.34	2.12	2.35	2.16	2.26	2.41	2.28	2.31	2.30
22:00	2.26	2.12	2.19	2.36	2.31	2.31	2.21	2.34	2.15	2.12	2.25	2.26	2.32	2.24
23:00	2.23	2.16	2.11	2.19	2.20	2.21	2.15	2.21	2.10	2.14	2.18	2.11	2.19	2.18
Average	2.04	2.02	2.10	2.11	2.06	2.06	2.02	2.05	2.02	2.10	2.10	2.01	1.99	2.05
Median	2.13	2.14	2.23	2.29	2.14	2.15	2.09	2.14	2.10	2.20	2.26	2.08	2.05	2.15
Max Hr. Mean	2.28	2.25	2.54	2.49	2.35	2.34	2.30	2.35	2.27	2.51	2.44	2.38	2.32	2.33
Min Hr. Mean	1.50	1.42	1.46	1.42	1.55	1.50	1.50	1.46	1.46	1.43	1.46	1.44	1.43	1.49
Inst. Max	2.33	2.35	2.57	2.56	2.57	2.46	2.56	2.43	2.30	2.62	2.50	2.64	2.40	2.58
Inst. Min	1.44	1.41	1.44	1.38	1.51	1.47	1.47	1.44	1.40	1.41	1.43	1.42	1.39	1.46

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.87	3.62	3.80	3.93	3.79	3.78	3.88	3.99	3.79	3.87	4.01	3.90	3.93	3.88
1:00	3.21	3.06	3.18	3.49	3.21	3.18	3.26	3.45	3.27	3.40	3.35	3.33	3.39	3.37
2:00	2.84	2.58	2.83	3.12	2.84	2.90	2.83	3.02	2.92	2.96	3.13	2.92	3.03	3.00
3:00	2.59	2.40	2.74	2.87	2.75	2.66	2.60	2.81	2.74	2.90	2.93	2.88	2.85	2.81
4:00	2.70	2.48	2.57	2.70	2.89	2.83	2.73	2.82	2.73	2.75	2.76	2.82	2.91	2.88
5:00	3.22	2.97	2.59	2.59	3.38	3.45	3.24	3.29	4.08	2.61	2.66	3.26	3.43	3.40
6:00	4.01	3.72	2.91	2.73	4.04	4.15	4.04	4.04	4.04	3.01	2.78	4.15	4.19	4.09
7:00	4.63	4.37	3.74	3.38	5.64	4.84	4.67	4.74	4.70	3.83	3.50	5.67	4.72	4.65
8:00	4.68	4.78	4.28	4.47	4.98	4.91	5.26	4.78	4.85	4.70	4.52	5.04	4.72	4.88
9:00	4.46	4.73	5.08	5.20	4.59	5.20	4.62	4.66	4.76	5.33	5.20	4.58	4.79	5.34
10:00	4.55	4.47	5.68	5.66	4.80	4.64	4.46	4.68	4.77	5.78	5.67	4.46	4.83	4.68
11:00	4.61	4.54	5.64	5.81	4.76	4.76	4.65	4.86	4.81	5.83	5.72	4.60	4.81	4.70
12:00	4.58	4.56	5.56	5.71	4.95	4.64	4.68	4.66	5.06	5.94	5.53	4.52	4.82	4.67
13:00	4.39	4.41	5.49	5.30	4.60	4.72	4.61	4.51	4.69	5.79	5.37	4.31	4.42	4.57
14:00	4.53	4.16	5.45	5.36	4.36	4.43	4.63	4.27	4.60	5.70	5.59	4.38	4.31	4.37
15:00	4.33	3.98	5.02	5.19	4.48	4.25	4.32	4.28	4.33	5.53	5.47	4.48	4.35	4.37
16:00	4.39	4.17	5.02	5.19	4.38	4.19	4.32	4.43	4.30	5.42	5.50	4.36	4.36	4.28
17:00	4.36	4.28	4.97	5.02	4.48	4.30	4.39	4.54	4.69	5.22	5.26	4.56	4.47	4.40
18:00	4.77	4.34	4.99	5.03	4.66	4.73	4.64	4.75	4.67	5.10	5.29	4.77	4.59	4.69
19:00	4.85	4.49	4.90	5.18	4.97	4.90	4.86	4.83	4.63	4.97	5.48	4.71	4.74	4.89
20:00	4.91	4.52	4.98	5.33	5.12	5.06	5.05	4.97	4.71	5.04	5.55	5.10	5.10	5.02
21:00	4.87	4.69	4.92	5.51	5.31	5.11	5.23	5.21	4.78	5.21	5.61	5.25	5.25	5.17
22:00	4.81	4.38	4.78	5.31	5.13	5.04	5.35	5.17	4.68	4.79	5.19	5.21	5.18	5.06
23:00	4.30	4.26	4.49	4.57	4.56	4.53	4.75	4.56	4.42	4.41	4.80	4.58	4.70	4.68
Average	4.19	4.00	4.40	4.53	4.36	4.30	4.29	4.30	4.29	4.59	4.62	4.33	4.33	4.33
Median	4.47	4.30	4.88	5.10	4.58	4.57	4.53	4.57	4.63	5.01	5.22	4.47	4.50	4.55
Max Hr. Mean	4.91	4.78	5.68	5.81	5.64	5.20	5.35	5.21	5.06	5.94	5.72	5.67	5.25	5.34
Min Hr. Mean	2.59	2.40	2.57	2.59	2.75	2.66	2.60	2.81	2.73	2.61	2.66	2.82	2.85	2.81
Inst. Max	5.08	5.04	5.84	5.94	6.78	5.84	5.93	5.27	5.12	6.07	5.89	6.87	5.44	6.29
Inst. Min	2.49	2.38	2.51	2.56	2.67	2.61	2.55	2.75	2.65	2.53	2.63	2.79	2.82	2.77

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 10
Address: Litchfield Line - South
MH ID# SSMH3N1WNW220005

Date: 6/10/2008
GPS: 33.352573N -112.213261W

Overview

Street Level

Meter Details

Meter Type 2150
Serial # 206F03429
Sensor Serial # 207M02371
Telemetry None
Sample Rate 5 min

Pipe Details and Manhole Condition

Pipe Size (in) Vert. 48" Horiz. 48"
Laterals 0
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Down Manhole

Hydraulics:
Heavy pump station influence

Comments:
Very slow flow during removal

Photos
MH #SSMH3N1WNW220005
Site #10

Site ID

Down Manhole

48” Influent

48” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

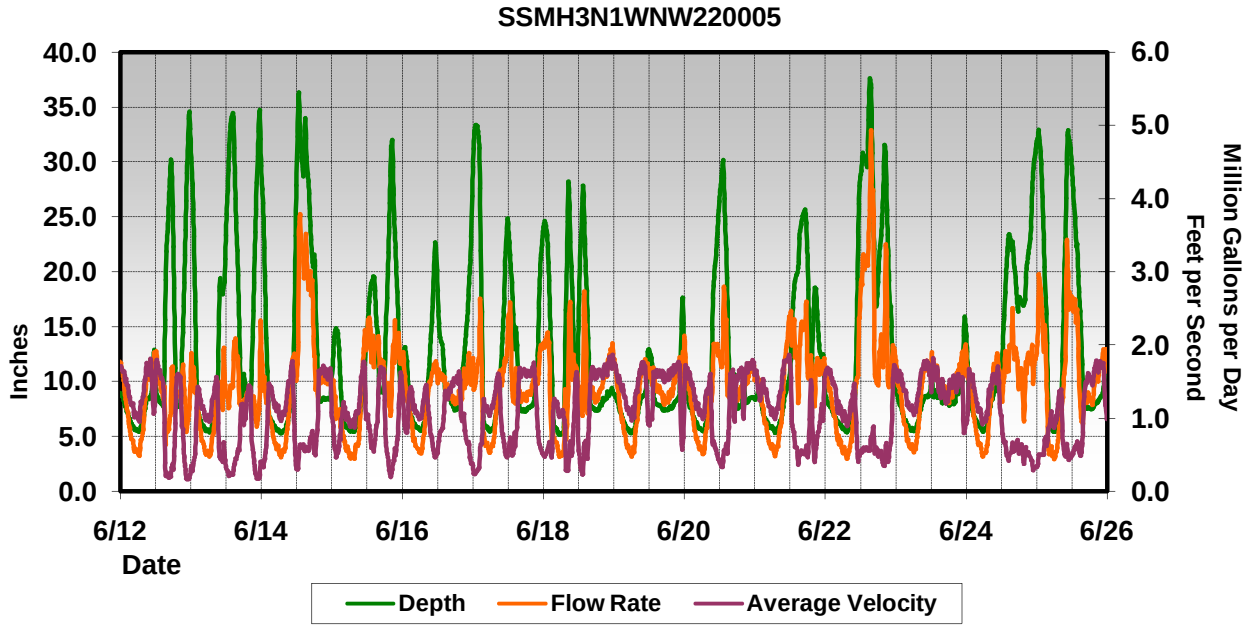
Site	**SSMH3N1WNW220005**	
Address	**Litchfield Line - South**	
Diameter	**48**	Inches
GPS	**33.352573N**	**-112.213261W**

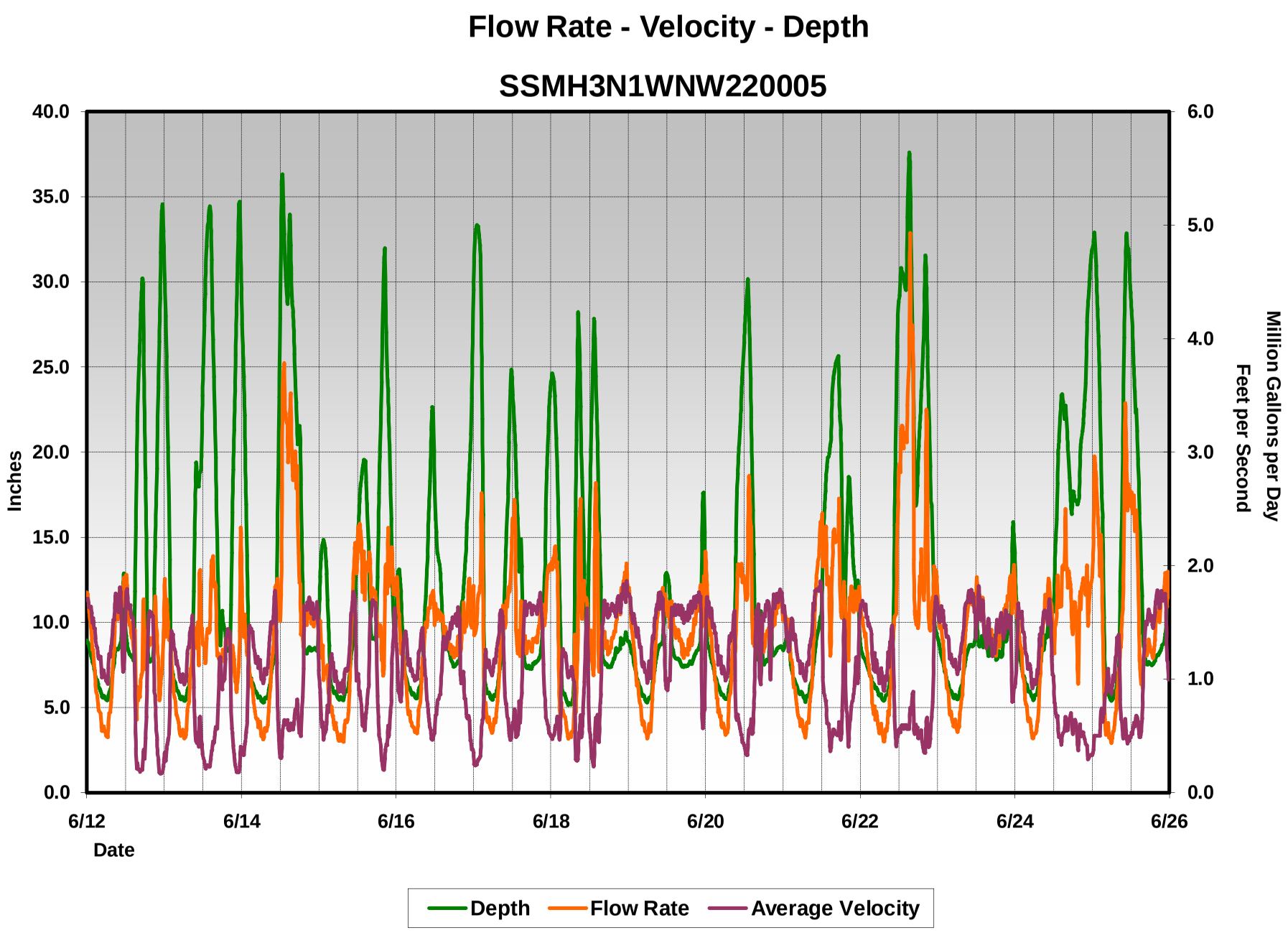
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	12.90
Maximum	37.59
Minimum	5.14
Max d/D	78.3%

Flow velocity	
	Feet per Second
Average	1.07
Maximum	1.86
Minimum	0.17

Flow Rate	
	Million Gallons per Day
Average	1.43
Maximum	4.93
Minimum	0.44
Peak Factor	3.45



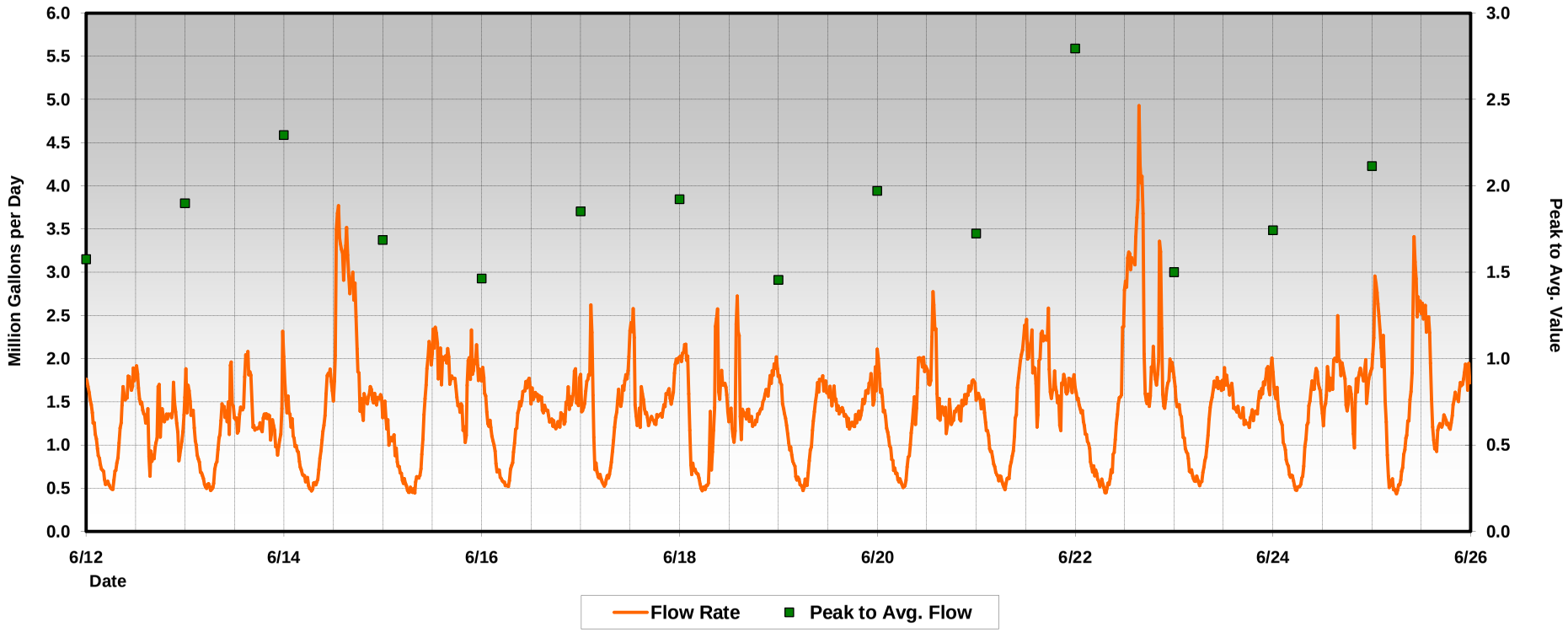

Flow Rate - Velocity - Depth
SSMH3N1WNW220005
Inches
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Million Gallons per Day
Feet per Second
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Depth
Flow Rate
Average Velocity

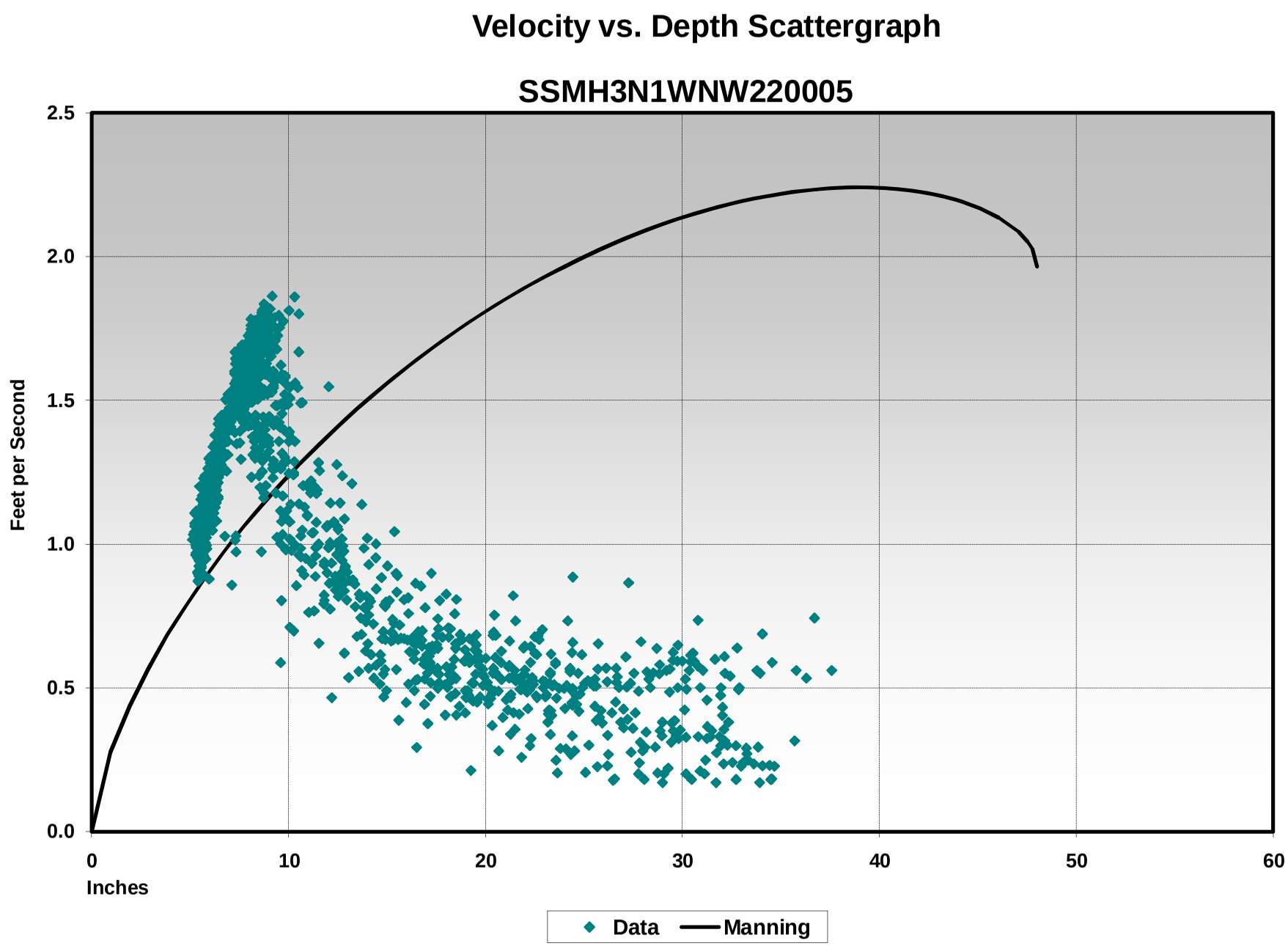
Peak to Average Flow Rate

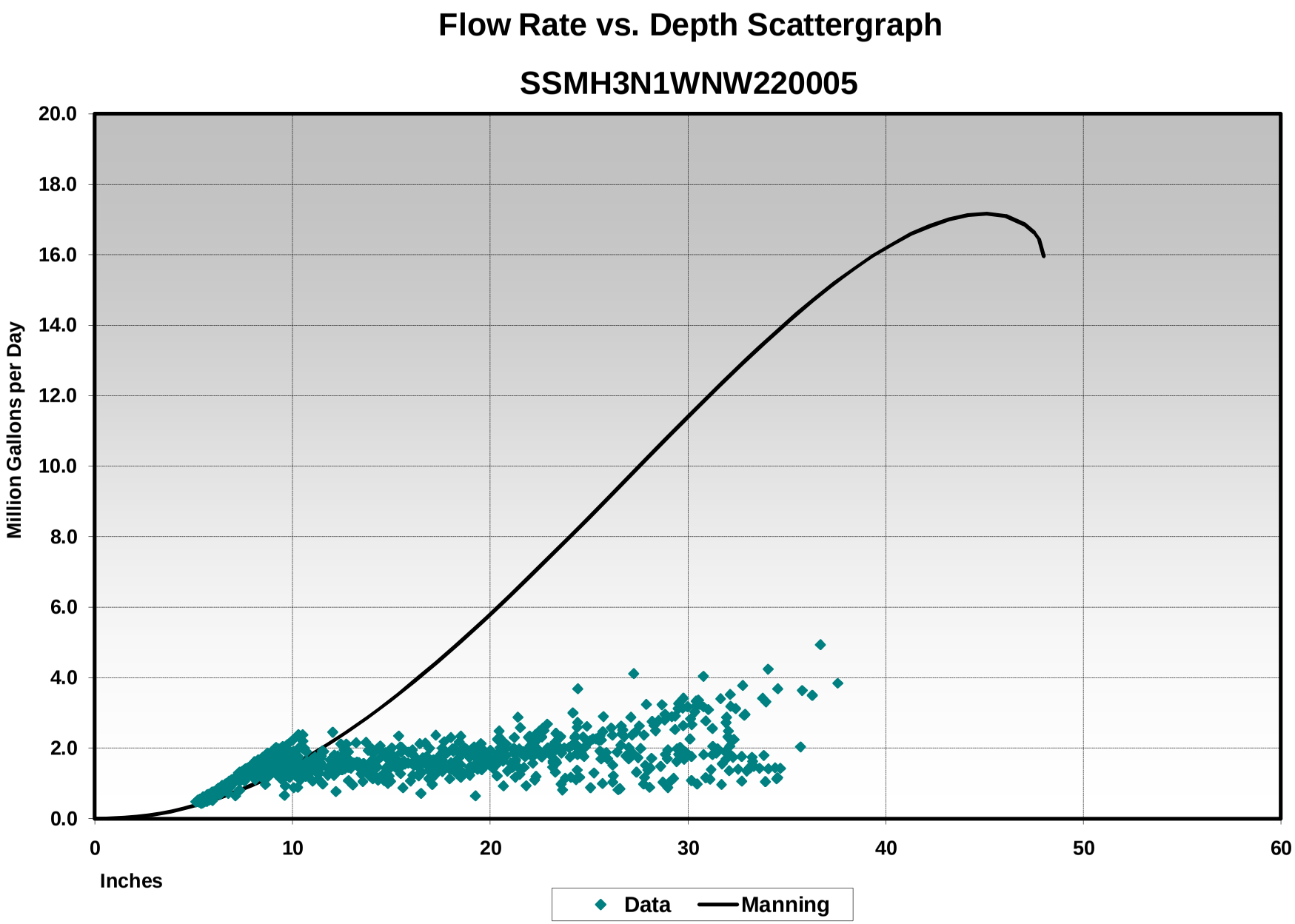
Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.58	1.90	2.29	1.69	1.46	1.85	1.92	1.46	1.97	1.72	2.80	1.50	1.74	2.12




Velocity vs. Depth Scattergraph
SSMH3N1WNW220005
Feet per Second
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WNW220005
Million Gallons per Day
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
10
20
30
40
50
60
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.70	1.63	1.66	1.39	1.76	1.51	2.02	1.76	1.89	1.56	1.59	1.61	1.66	2.29
1:00	1.41	1.47	1.38	1.14	1.36	1.65	2.10	1.39	1.50	1.48	1.42	1.40	1.45	2.69
2:00	1.10	1.16	1.12	1.08	1.16	2.14	1.39	1.08	1.19	1.24	1.19	1.09	1.13	2.16
3:00	0.81	0.80	0.92	0.85	0.85	1.04	0.72	0.87	0.91	0.98	0.96	0.84	0.83	1.41
4:00	0.64	0.62	0.69	0.68	0.67	0.65	0.66	0.66	0.70	0.77	0.71	0.66	0.65	0.57
5:00	0.55	0.53	0.61	0.56	0.57	0.56	0.51	0.55	0.59	0.63	0.64	0.60	0.52	0.51
6:00	0.52	0.50	0.50	0.47	0.54	0.60	0.52	0.53	0.53	0.57	0.56	0.56	0.53	0.50
7:00	0.76	0.72	0.54	0.47	0.80	0.78	0.87	0.74	0.77	0.57	0.48	0.78	0.75	0.73
8:00	1.24	1.11	0.68	0.61	1.19	1.24	1.47	1.20	1.20	0.76	0.61	1.21	1.25	1.11
9:00	1.58	1.42	1.10	0.83	1.47	1.52	2.05	1.61	1.47	1.17	0.89	1.61	1.63	1.57
10:00	1.71	1.32	1.64	1.62	1.65	1.65	1.74	1.77	2.00	1.83	1.41	1.70	1.80	2.99
11:00	1.74	1.70	1.76	2.07	1.71	1.87	1.59	1.67	1.92	2.19	1.97	1.71	1.62	2.61
12:00	1.80	1.27	2.20	2.22	1.56	2.41	1.33	1.61	1.79	2.21	2.92	1.76	1.38	2.55
13:00	1.48	1.35	3.54	2.01	1.57	1.57	1.43	1.56	2.35	2.12	3.16	1.66	1.73	2.45
14:00	1.31	1.67	3.15	1.96	1.52	1.39	2.16	1.44	1.90	1.68	3.19	1.54	1.79	1.75
15:00	0.97	1.92	3.25	2.02	1.41	1.47	1.30	1.41	1.42	1.90	4.16	1.40	2.11	0.98
16:00	0.88	1.44	2.88	1.82	1.32	1.30	1.37	1.31	1.33	2.26	3.47	1.36	1.93	1.22
17:00	1.37	1.19	2.54	1.75	1.25	1.30	1.28	1.25	1.35	2.23	1.55	1.26	1.74	1.28
18:00	1.30	1.20	1.65	1.47	1.23	1.29	1.26	1.26	1.30	1.61	1.70	1.28	1.56	1.25
19:00	1.31	1.34	1.45	1.33	1.32	1.35	1.38	1.33	1.42	1.66	1.86	1.36	1.28	1.31
20:00	1.35	1.26	1.53	1.45	1.37	1.48	1.51	1.44	1.39	1.42	2.60	1.47	1.67	1.56
21:00	1.50	1.20	1.58	1.98	1.53	1.60	1.64	1.59	1.53	1.72	1.70	1.63	1.84	1.64
22:00	1.02	0.96	1.54	1.99	1.72	1.62	1.80	1.74	1.63	1.69	1.66	1.82	1.77	1.81
23:00	1.13	1.48	1.55	1.84	1.57	1.97	1.93	1.63	1.74	1.71	1.93	1.78	1.76	1.80
Average	1.22	1.22	1.64	1.40	1.30	1.42	1.42	1.31	1.41	1.50	1.76	1.34	1.43	1.61
Median	1.29	1.24	1.53	1.48	1.38	1.42	1.41	1.39	1.43	1.60	1.55	1.41	1.59	1.53
Max Hr. Mean	1.80	1.92	3.54	2.22	1.76	2.41	2.16	1.77	2.35	2.26	4.16	1.82	2.11	2.99
Min Hr. Mean	0.52	0.50	0.50	0.47	0.54	0.56	0.51	0.53	0.53	0.57	0.48	0.56	0.52	0.50
Inst. Max	1.92	2.32	3.77	2.37	1.90	2.62	2.73	1.91	2.78	2.59	4.93	2.01	2.50	3.41
Inst. Min	0.49	0.48	0.47	0.45	0.52	0.53	0.47	0.48	0.51	0.48	0.45	0.53	0.48	0.44

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.68	0.32	0.35	0.90	1.14	0.27	0.49	1.73	1.54	1.60	1.64	1.57	1.07	0.39
1:00	1.59	0.54	0.51	0.54	0.85	0.28	0.56	1.55	1.62	1.36	1.64	1.60	1.60	0.50
2:00	1.45	1.34	1.27	0.62	1.30	0.46	0.57	1.44	1.50	1.40	1.51	1.46	1.50	0.55
3:00	1.24	1.23	1.39	0.97	1.28	0.95	1.00	1.35	1.34	1.41	1.38	1.32	1.26	0.69
4:00	1.12	1.10	1.19	1.13	1.13	1.14	1.22	1.17	1.17	1.24	1.13	1.17	1.11	0.93
5:00	1.04	1.01	1.14	1.01	1.03	1.07	1.06	1.08	1.08	1.12	1.10	1.12	0.98	0.96
6:00	1.00	0.98	1.00	0.91	1.03	1.12	1.07	1.04	1.01	1.06	1.03	1.08	0.97	0.96
7:00	1.25	1.21	1.05	0.92	1.29	1.29	0.78	1.24	1.27	1.08	0.94	1.27	1.18	1.20
8:00	1.52	1.46	1.19	1.07	1.32	1.55	0.34	1.51	1.44	1.27	1.09	1.54	1.41	1.18
9:00	1.65	0.87	1.48	1.21	0.92	1.26	0.57	1.67	0.97	1.55	1.29	1.71	1.58	0.56
10:00	1.69	0.46	1.65	1.66	0.62	0.72	0.94	1.73	0.62	1.78	1.08	1.70	1.57	0.55
11:00	1.16	0.56	0.75	1.40	0.49	0.50	1.35	1.18	0.47	1.81	0.48	1.67	1.33	0.46
12:00	1.70	0.28	0.36	0.95	0.67	0.63	0.46	0.95	0.37	1.31	0.55	1.55	0.82	0.52
13:00	1.62	0.23	0.61	0.69	0.84	0.55	0.31	1.37	0.47	0.77	0.58	1.62	0.60	0.63
14:00	1.47	0.28	0.59	0.65	1.19	0.70	0.61	1.60	0.56	0.53	0.58	1.52	0.47	0.58
15:00	0.45	0.45	0.58	0.98	1.28	1.22	0.79	1.63	1.14	0.49	0.64	1.40	0.57	0.62
16:00	0.20	0.62	0.64	1.61	1.40	1.63	1.59	1.59	1.47	0.53	0.76	1.38	0.58	1.35
17:00	0.28	1.10	0.73	1.65	1.50	1.65	1.59	1.56	1.20	0.54	0.56	1.24	0.66	1.56
18:00	0.59	0.98	0.57	0.82	1.53	1.61	1.59	1.57	1.57	0.68	0.50	1.44	0.58	1.53
19:00	1.51	1.34	1.30	0.36	1.55	1.61	1.63	1.60	1.65	1.16	0.44	1.50	0.49	1.55
20:00	1.50	1.23	1.64	0.27	1.02	1.69	1.62	1.65	1.24	0.54	0.50	1.45	0.55	1.73
21:00	0.70	0.46	1.65	0.48	0.86	1.42	1.66	1.70	1.68	0.75	0.45	1.53	0.51	1.71
22:00	0.25	0.21	1.60	0.81	0.66	0.75	1.75	1.60	1.70	1.02	0.78	1.51	0.39	1.73
23:00	0.19	0.25	1.62	1.47	0.42	0.55	1.79	0.68	1.77	1.21	1.63	0.90	0.32	1.22
Average	1.12	0.77	1.04	0.96	1.05	1.03	1.06	1.42	1.20	1.09	0.93	1.43	0.92	0.99
Median	1.28	0.71	1.08	0.96	1.07	1.07	1.05	1.54	1.29	1.13	0.89	1.47	0.92	0.89
Max Hr. Mean	1.70	1.46	1.65	1.66	1.55	1.69	1.79	1.73	1.77	1.81	1.64	1.71	1.60	1.73
Min Hr. Mean	0.19	0.21	0.35	0.27	0.42	0.27	0.31	0.68	0.37	0.49	0.44	0.90	0.32	0.39
Inst. Max	1.81	1.56	1.77	1.77	1.63	1.76	1.86	1.77	1.79	1.86	1.73	1.81	1.70	1.78
Inst. Min	0.17	0.18	0.30	0.20	0.38	0.24	0.23	0.57	0.33	0.37	0.35	0.80	0.29	0.33

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	8.75	28.82	26.94	11.96	11.85	31.60	24.37	8.76	10.18	8.51	8.47	8.82	12.03	32.32
1:00	7.97	18.60	18.15	14.65	12.07	33.16	22.64	8.05	8.21	9.19	7.84	7.93	8.08	30.26
2:00	7.18	7.96	8.20	13.02	8.10	28.23	15.82	7.09	7.40	8.03	7.33	7.08	7.13	23.77
3:00	6.45	6.44	6.48	8.12	6.54	9.95	7.26	6.36	6.62	6.74	6.71	6.33	6.47	14.38
4:00	5.87	5.87	5.97	6.07	6.03	5.90	5.69	5.80	6.07	6.22	6.29	5.87	5.98	6.18
5:00	5.60	5.55	5.62	5.81	5.76	5.59	5.23	5.45	5.70	5.84	5.97	5.64	5.61	5.63
6:00	5.50	5.44	5.37	5.52	5.58	5.64	5.25	5.48	5.51	5.64	5.68	5.53	5.67	5.54
7:00	6.16	6.03	5.47	5.48	6.23	6.14	10.51	6.06	6.13	5.56	5.44	6.18	6.30	6.12
8:00	7.51	7.15	5.89	5.90	8.17	7.44	25.13	7.40	7.62	6.09	5.80	7.31	8.06	8.65
9:00	8.42	13.56	7.02	6.67	12.23	10.19	21.85	8.43	12.88	7.14	6.66	8.30	8.87	18.37
10:00	8.75	18.59	8.63	8.50	17.58	15.67	13.80	8.80	20.07	8.82	11.21	8.65	9.49	30.45
11:00	11.57	19.43	17.47	11.79	21.54	22.69	10.09	11.33	24.04	9.91	24.13	8.83	10.15	31.37
12:00	9.07	26.32	33.04	15.89	15.99	22.95	18.98	12.55	27.70	13.03	29.75	9.66	12.67	27.80
13:00	8.15	32.45	32.36	18.65	13.45	18.27	26.26	9.72	28.75	18.02	30.36	8.83	18.69	23.32
14:00	8.03	33.41	29.95	19.18	10.41	14.19	21.43	8.06	20.58	19.94	31.03	8.77	22.78	18.85
15:00	17.14	25.50	31.35	14.83	9.31	10.29	12.98	7.85	10.67	23.00	36.04	8.83	22.50	12.31
16:00	25.78	15.98	26.32	9.46	8.35	7.42	7.87	7.57	8.23	25.08	26.13	8.58	20.75	8.11
17:00	28.76	9.25	21.40	9.03	7.66	7.36	7.48	7.43	9.60	24.42	17.86	8.86	17.31	7.58
18:00	16.72	10.06	18.85	13.95	7.47	7.43	7.39	7.46	7.60	16.98	20.80	7.99	17.47	7.54
19:00	7.91	8.71	9.75	22.95	7.76	7.67	7.74	7.61	7.83	11.57	25.14	8.11	17.05	7.71
20:00	8.10	9.09	8.27	30.33	10.72	7.91	8.27	7.90	9.55	17.51	29.71	8.81	19.52	8.07
21:00	15.58	17.70	8.43	24.39	13.14	9.55	8.57	8.30	8.13	15.67	22.39	9.09	22.06	8.42
22:00	25.20	26.96	8.43	17.09	17.21	15.30	8.83	9.42	8.45	12.45	15.37	9.86	26.55	8.94
23:00	33.30	33.49	8.42	10.18	22.81	21.74	9.15	16.32	8.56	11.21	9.78	14.25	30.47	11.59
Average	12.23	16.35	14.91	12.89	11.08	13.84	13.02	8.30	11.50	12.36	16.50	8.26	14.24	15.14
Median	8.43	13.88	8.51	11.35	9.64	9.56	9.13	7.85	8.27	10.03	13.75	8.44	12.26	9.75
Max Hr. Mean	33.30	33.49	33.04	30.33	22.81	33.16	26.26	16.32	28.75	25.08	36.04	14.25	30.47	32.32
Min Hr. Mean	5.50	5.44	5.37	5.48	5.58	5.59	5.23	5.45	5.51	5.56	5.44	5.53	5.61	5.54
Inst. Max	34.55	34.69	36.31	31.95	26.88	33.35	28.11	17.62	30.12	25.63	37.59	15.87	31.44	32.91
Inst. Min	5.42	5.39	5.29	5.41	5.53	5.46	5.14	5.31	5.51	5.31	5.39	5.47	5.42	5.40

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 11**	**Date:**	**6/9/2008**
Address:	**N Reems Road S of W Sunnyside Drive**	**GPS:**	**33.352888N -112.233777W**
MH ID#	**SSMH3N1WNE190089**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**204M00191**
Sensor Serial #	**204K01284**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**26"**	**Horiz.**	**26"**
Laterals	**0**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole

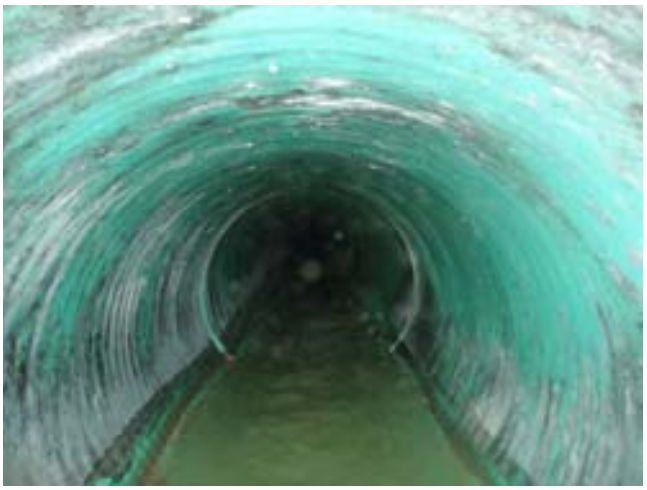
Hydraulics:
Moderate flow conditions. Fairly clear water.

Comments:
Pipe diameter measured at 26". Not 30" diameter as specified.

Photos
MH #SSMH3N1WNE190089
Site #11

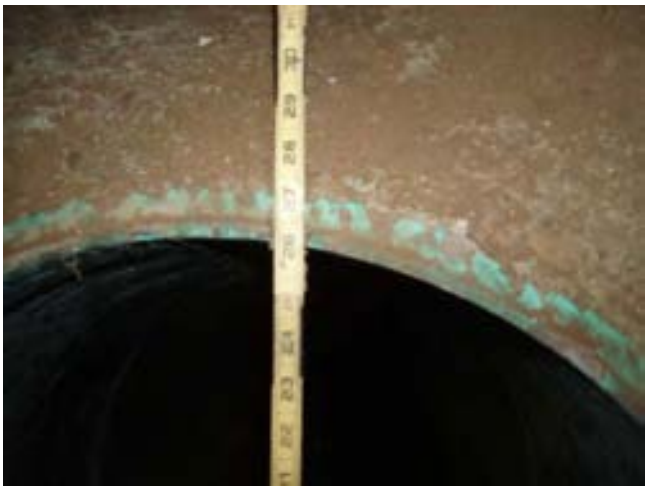
Site ID

Down Manhole


26” Influent

26” Effluent

Manhole Cover Top


Measured 26”

Location Summary

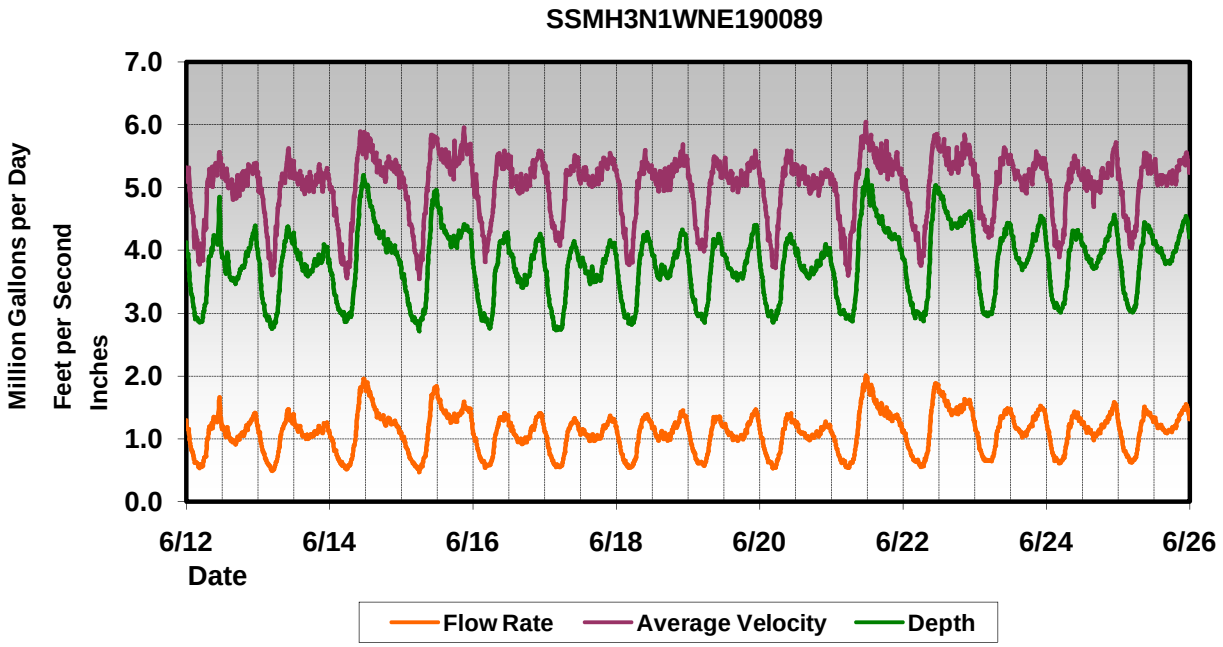
Site	**SSMH3N1WNE190089**
Address	**Reems Rd S of Sunnyside Drive**
Diameter	**26** Inches
GPS	**33.352888N -112.233777W**

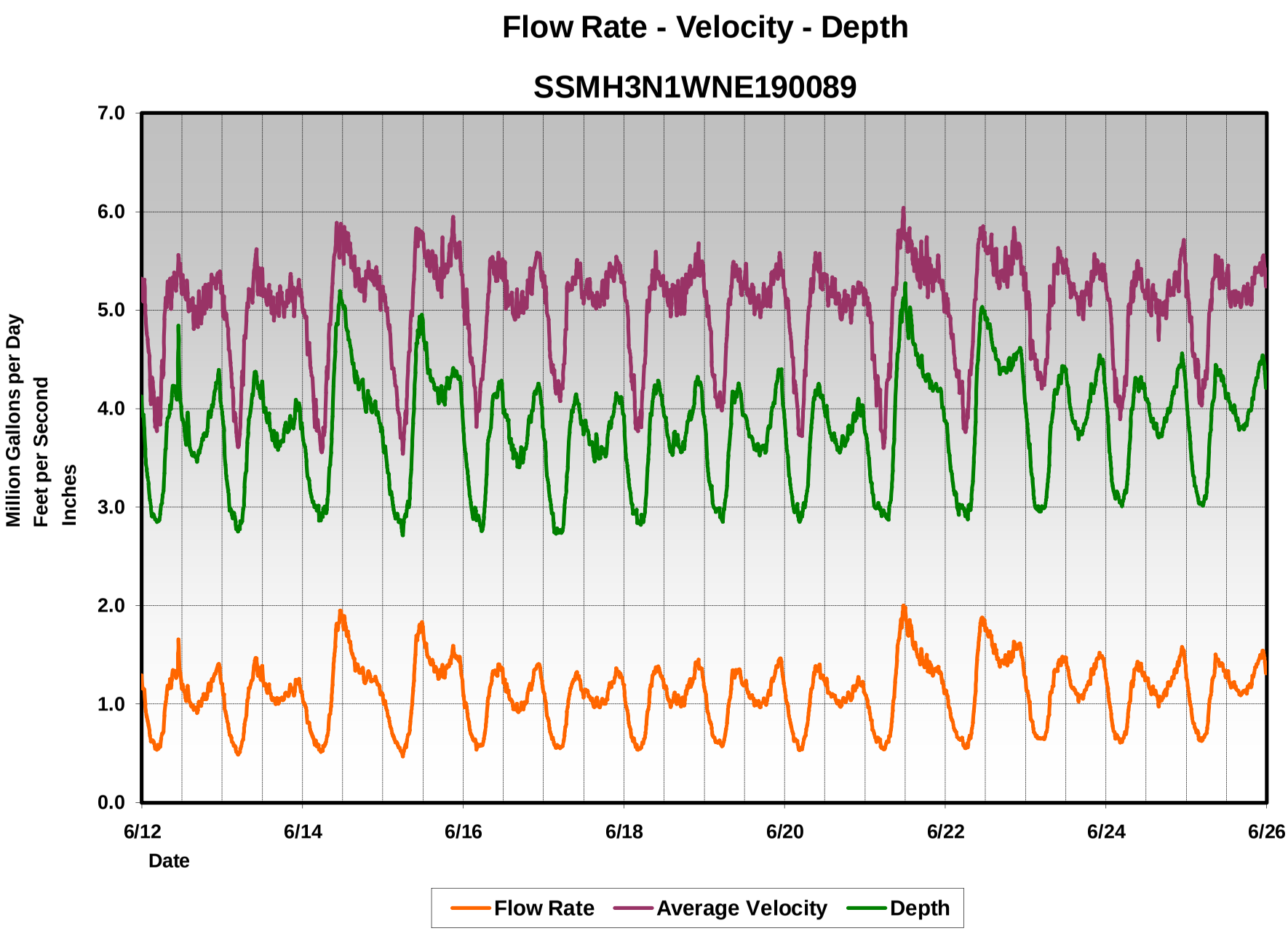
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	3.79
Maximum	5.27
Minimum	2.72
Max d/D	20.3%

Flow velocity	
	Feet per Second
Average	5.03
Maximum	6.04
Minimum	3.54

Flow Rate	
	Million Gallons per Day
Average	1.11
Maximum	2.00
Minimum	0.47
Peak Factor	1.81



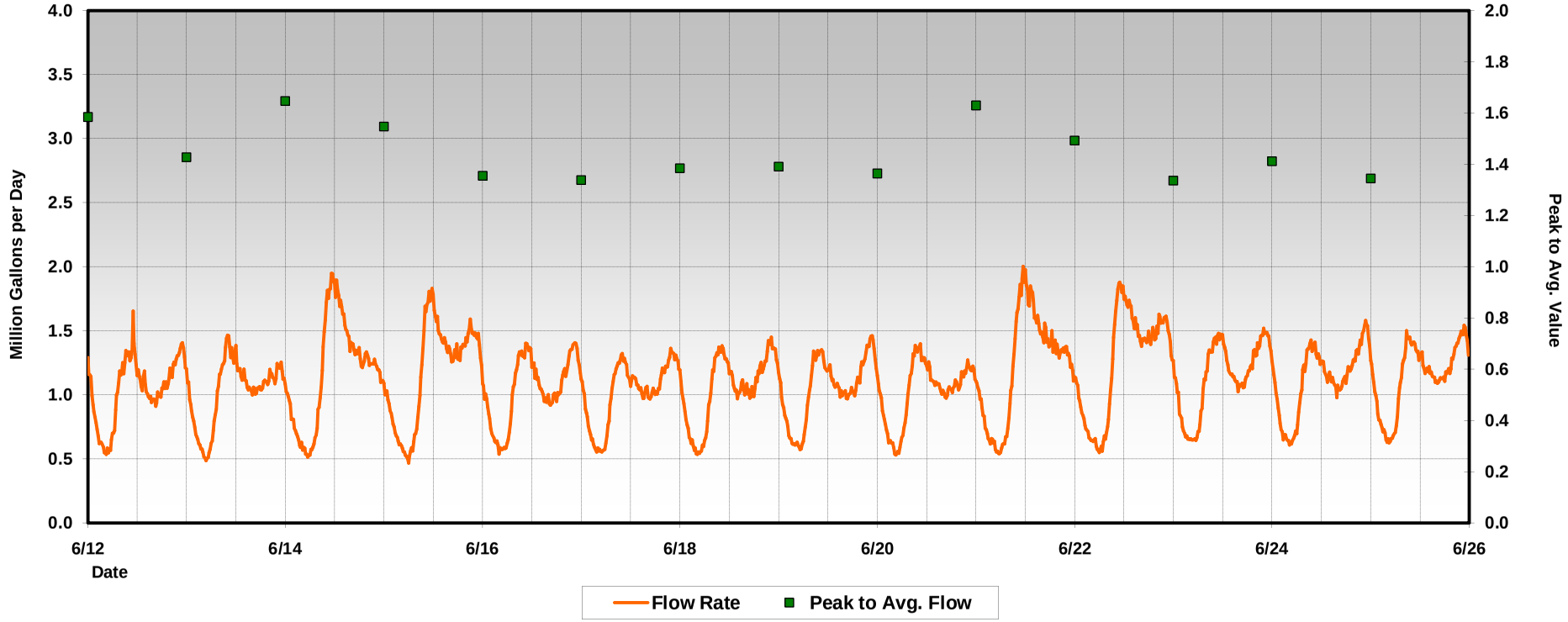

Flow Rate - Velocity - Depth
SSMH3N1WNE190089
Million Gallons per Day
Feet per Second
Inches
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

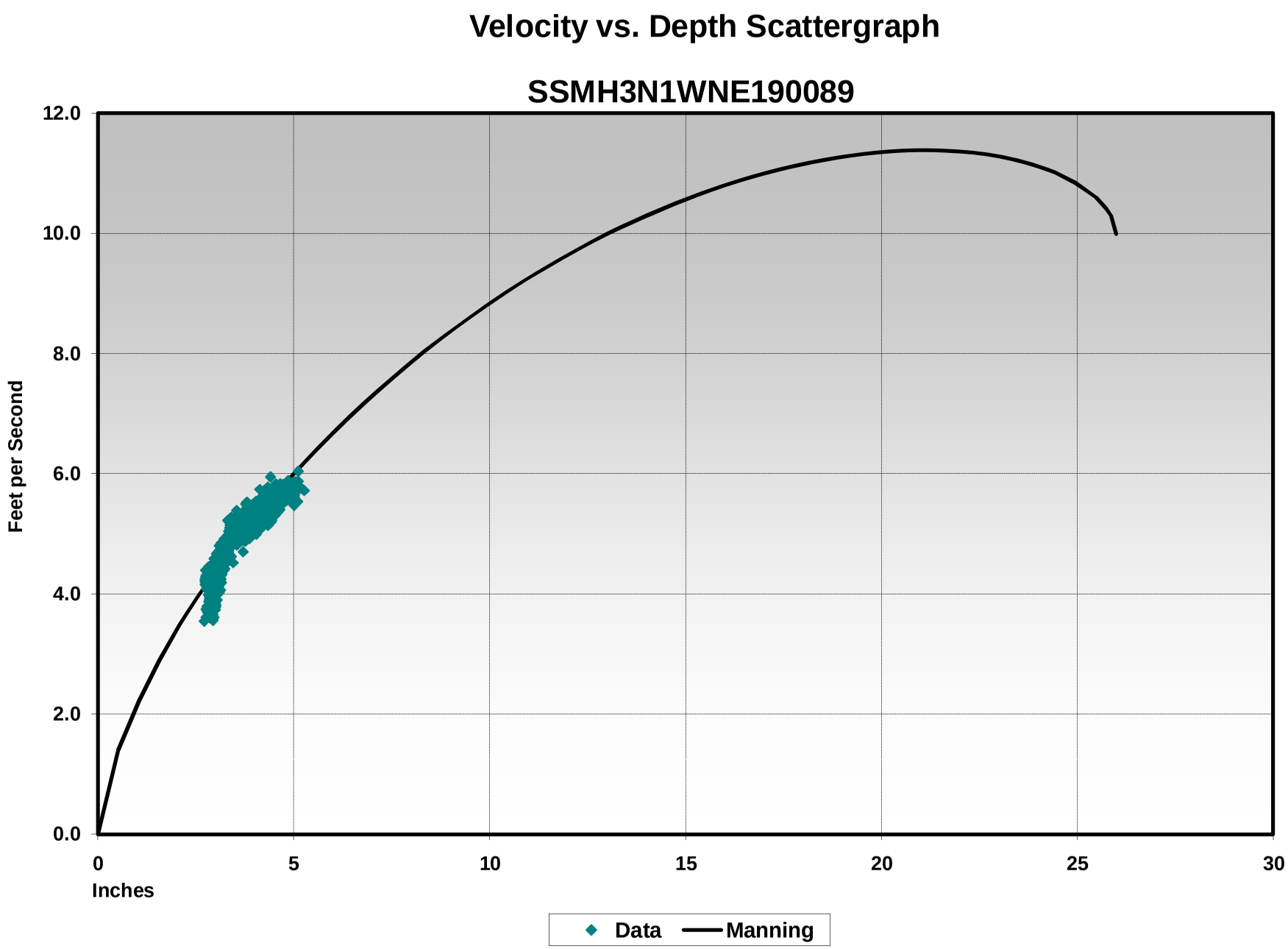
Peak to Average Flow Rate

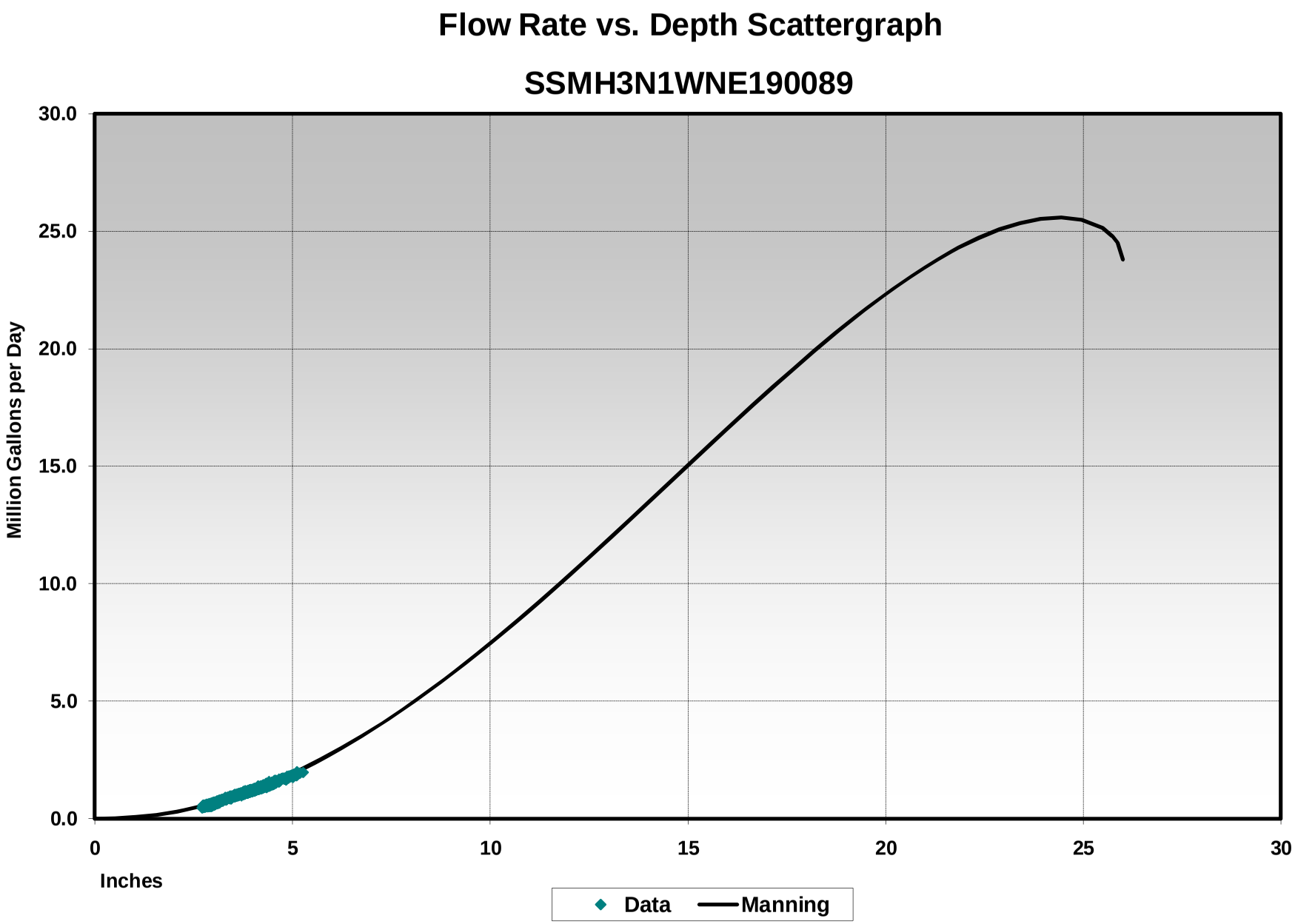
Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.58	1.43	1.65	1.55	1.36	1.34	1.39	1.39	1.36	1.63	1.49	1.34	1.41	1.35




Velocity vs. Depth Scattergraph
SSMH3N1WNE190089
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Feet per Second
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WNE190089
Million Gallons per Day
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.19	1.09	1.03	1.03	1.03	1.07	1.07	1.09	1.07	1.07	1.11	1.16	1.18	1.19
1:00	0.90	0.86	0.88	0.91	0.88	0.83	0.84	0.87	0.88	0.92	0.92	0.93	0.93	0.95
2:00	0.70	0.69	0.74	0.76	0.69	0.68	0.67	0.72	0.70	0.75	0.79	0.75	0.72	0.78
3:00	0.62	0.60	0.63	0.65	0.63	0.58	0.60	0.63	0.63	0.65	0.69	0.67	0.67	0.70
4:00	0.56	0.52	0.59	0.59	0.57	0.57	0.54	0.62	0.55	0.62	0.64	0.65	0.62	0.64
5:00	0.59	0.53	0.53	0.53	0.58	0.57	0.58	0.59	0.58	0.55	0.60	0.65	0.68	0.68
6:00	0.75	0.70	0.57	0.53	0.69	0.72	0.70	0.72	0.72	0.59	0.57	0.77	0.82	0.82
7:00	1.07	0.96	0.68	0.65	1.00	1.01	1.00	1.00	0.96	0.68	0.67	1.05	1.12	1.13
8:00	1.19	1.19	0.96	0.87	1.23	1.19	1.24	1.26	1.22	0.96	0.88	1.26	1.28	1.36
9:00	1.31	1.33	1.41	1.31	1.32	1.27	1.34	1.31	1.34	1.39	1.35	1.36	1.38	1.43
10:00	1.31	1.40	1.78	1.69	1.35	1.28	1.35	1.34	1.35	1.73	1.77	1.44	1.37	1.40
11:00	1.40	1.31	1.90	1.79	1.36	1.16	1.27	1.22	1.27	1.89	1.85	1.46	1.28	1.32
12:00	1.15	1.25	1.84	1.66	1.21	1.12	1.17	1.20	1.23	1.84	1.74	1.39	1.24	1.30
13:00	1.11	1.16	1.72	1.52	1.13	1.10	1.05	1.09	1.11	1.79	1.70	1.22	1.14	1.20
14:00	1.03	1.12	1.58	1.42	1.03	1.04	1.01	1.07	1.09	1.62	1.57	1.15	1.13	1.19
15:00	0.97	1.04	1.44	1.37	0.96	1.00	1.07	1.00	1.04	1.54	1.50	1.09	1.05	1.13
16:00	0.94	1.03	1.39	1.30	0.95	1.00	1.05	1.00	1.00	1.48	1.41	1.08	1.05	1.10
17:00	1.00	1.05	1.33	1.33	0.98	1.02	1.02	1.02	1.04	1.44	1.43	1.09	1.11	1.13
18:00	1.06	1.06	1.27	1.31	1.00	1.02	1.07	1.02	1.05	1.40	1.45	1.19	1.17	1.16
19:00	1.09	1.10	1.29	1.38	1.12	1.13	1.21	1.11	1.08	1.39	1.47	1.28	1.22	1.22
20:00	1.19	1.16	1.27	1.46	1.19	1.20	1.22	1.24	1.12	1.33	1.56	1.35	1.31	1.34
21:00	1.27	1.12	1.25	1.52	1.34	1.29	1.36	1.35	1.18	1.35	1.58	1.44	1.38	1.43
22:00	1.35	1.22	1.21	1.46	1.40	1.32	1.39	1.43	1.23	1.33	1.57	1.49	1.52	1.50
23:00	1.32	1.17	1.12	1.35	1.26	1.26	1.31	1.32	1.18	1.19	1.37	1.41	1.48	1.43
Average	1.04	1.03	1.18	1.18	1.04	1.02	1.05	1.05	1.03	1.23	1.26	1.14	1.12	1.15
Median	1.08	1.10	1.24	1.33	1.05	1.06	1.08	1.07	1.08	1.33	1.43	1.17	1.16	1.18
Max Hr. Mean	1.40	1.40	1.90	1.79	1.40	1.32	1.39	1.43	1.35	1.89	1.85	1.49	1.52	1.50
Min Hr. Mean	0.56	0.52	0.53	0.53	0.57	0.57	0.54	0.59	0.55	0.55	0.57	0.65	0.62	0.64
Inst. Max	1.66	1.47	1.95	1.83	1.41	1.36	1.45	1.46	1.40	2.00	1.88	1.52	1.58	1.54
Inst. Min	0.54	0.49	0.51	0.47	0.54	0.55	0.54	0.57	0.53	0.54	0.55	0.64	0.61	0.63

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.21	5.06	4.99	5.15	5.05	5.22	5.16	5.15	5.12	5.15	5.09	5.18	5.15	5.16
1:00	4.84	4.90	4.77	4.93	4.97	4.88	4.79	4.91	4.89	4.97	4.89	4.84	4.97	4.83
2:00	4.37	4.50	4.47	4.64	4.50	4.45	4.31	4.48	4.47	4.60	4.64	4.57	4.37	4.50
3:00	4.21	4.07	4.05	4.35	4.23	4.28	4.02	4.17	4.17	4.24	4.37	4.38	4.14	4.35
4:00	3.90	3.75	3.89	4.06	3.95	4.22	3.84	4.11	3.81	4.07	4.23	4.31	4.00	4.10
5:00	3.98	3.83	3.65	3.77	4.25	4.19	4.04	4.05	3.87	3.70	3.95	4.29	4.18	4.28
6:00	4.52	4.51	3.76	3.76	4.56	4.63	4.58	4.49	4.51	4.07	3.87	4.61	4.65	4.57
7:00	5.12	4.93	4.35	4.25	5.07	5.23	5.08	5.04	5.04	4.43	4.32	5.07	5.13	5.10
8:00	5.16	5.19	4.96	4.83	5.50	5.26	5.30	5.35	5.29	5.10	4.82	5.29	5.21	5.39
9:00	5.28	5.27	5.47	5.41	5.41	5.30	5.38	5.39	5.49	5.35	5.36	5.47	5.42	5.44
10:00	5.31	5.43	5.73	5.75	5.44	5.42	5.35	5.37	5.40	5.74	5.77	5.53	5.34	5.35
11:00	5.43	5.31	5.72	5.76	5.42	5.26	5.30	5.20	5.31	5.84	5.77	5.43	5.17	5.27
12:00	5.23	5.23	5.69	5.63	5.29	5.16	5.23	5.31	5.33	5.71	5.60	5.42	5.18	5.35
13:00	5.18	5.11	5.73	5.53	5.14	5.25	5.11	5.15	5.16	5.72	5.65	5.21	5.07	5.12
14:00	5.04	5.13	5.54	5.48	5.09	5.13	5.11	5.20	5.21	5.51	5.49	5.20	5.17	5.14
15:00	4.98	5.02	5.43	5.44	4.95	5.08	5.12	5.04	5.13	5.46	5.42	5.09	4.96	5.13
16:00	4.93	5.06	5.37	5.31	5.06	5.11	5.13	5.03	5.06	5.44	5.31	5.09	4.99	5.09
17:00	5.04	5.13	5.22	5.38	5.08	5.21	5.11	5.09	5.01	5.40	5.35	5.03	5.03	5.19
18:00	5.09	5.04	5.22	5.38	5.06	5.22	5.15	5.10	5.12	5.42	5.42	5.23	5.14	5.14
19:00	5.13	5.09	5.39	5.45	5.20	5.32	5.35	5.14	5.04	5.41	5.42	5.22	5.18	5.18
20:00	5.21	5.27	5.36	5.65	5.28	5.40	5.34	5.33	5.08	5.31	5.69	5.39	5.27	5.35
21:00	5.30	5.07	5.30	5.74	5.46	5.40	5.45	5.41	5.18	5.39	5.62	5.44	5.26	5.42
22:00	5.30	5.20	5.34	5.59	5.56	5.46	5.44	5.45	5.23	5.35	5.56	5.41	5.56	5.46
23:00	5.30	5.20	5.17	5.46	5.38	5.34	5.45	5.34	5.17	5.16	5.35	5.37	5.58	5.41
Average	4.96	4.93	5.02	5.11	5.04	5.06	5.01	5.01	4.96	5.11	5.12	5.09	5.01	5.05
Median	5.11	5.08	5.28	5.36	5.14	5.20	5.19	5.15	5.12	5.29	5.36	5.19	5.12	5.17
Max Hr. Mean	5.43	5.43	5.73	5.76	5.56	5.46	5.45	5.45	5.49	5.84	5.77	5.53	5.58	5.46
Min Hr. Mean	3.90	3.75	3.65	3.76	3.95	4.19	3.84	4.05	3.81	3.70	3.87	4.29	4.00	4.10
Inst. Max	5.56	5.61	5.89	5.95	5.58	5.54	5.68	5.58	5.58	6.04	5.85	5.63	5.71	5.55
Inst. Min	3.78	3.61	3.56	3.54	3.82	4.08	3.77	3.98	3.72	3.60	3.76	4.20	3.90	4.03

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.95	3.79	3.68	3.61	3.66	3.66	3.69	3.76	3.72	3.70	3.82	3.88	3.95	3.98
1:00	3.43	3.29	3.40	3.40	3.32	3.23	3.30	3.32	3.34	3.41	3.47	3.50	3.44	3.57
2:00	3.10	3.01	3.17	3.15	3.02	2.99	3.03	3.11	3.06	3.13	3.22	3.14	3.15	3.26
3:00	2.92	2.91	3.03	2.95	2.94	2.77	2.95	2.97	2.98	2.99	3.07	2.99	3.12	3.10
4:00	2.86	2.79	2.99	2.90	2.89	2.75	2.84	2.96	2.88	3.00	2.99	2.97	3.04	3.03
5:00	2.92	2.82	2.89	2.82	2.79	2.76	2.87	2.90	2.96	2.94	2.99	2.99	3.11	3.07
6:00	3.17	3.01	2.97	2.85	2.97	3.02	3.01	3.09	3.08	2.90	2.93	3.17	3.29	3.32
7:00	3.72	3.53	3.04	2.99	3.58	3.53	3.57	3.58	3.49	2.99	3.02	3.68	3.82	3.87
8:00	3.97	3.96	3.52	3.33	3.89	3.92	4.02	4.03	3.97	3.46	3.38	4.06	4.16	4.23
9:00	4.18	4.23	4.28	4.10	4.14	4.08	4.19	4.12	4.14	4.31	4.22	4.18	4.26	4.36
10:00	4.16	4.29	4.89	4.71	4.18	4.04	4.24	4.21	4.21	4.80	4.85	4.32	4.28	4.35
11:00	4.31	4.17	5.13	4.90	4.22	3.86	4.08	4.01	4.09	5.03	4.99	4.41	4.20	4.22
12:00	3.86	4.08	5.03	4.71	3.95	3.81	3.89	3.91	3.97	5.02	4.89	4.29	4.07	4.12
13:00	3.77	3.92	4.78	4.48	3.86	3.73	3.67	3.76	3.79	4.91	4.80	4.01	3.91	4.01
14:00	3.65	3.83	4.60	4.32	3.64	3.64	3.58	3.68	3.71	4.71	4.62	3.87	3.84	3.98
15:00	3.53	3.70	4.38	4.23	3.53	3.58	3.70	3.60	3.64	4.57	4.51	3.77	3.75	3.85
16:00	3.50	3.65	4.30	4.14	3.44	3.55	3.65	3.59	3.58	4.45	4.39	3.75	3.73	3.81
17:00	3.59	3.66	4.26	4.18	3.52	3.56	3.60	3.61	3.68	4.39	4.41	3.82	3.86	3.83
18:00	3.72	3.73	4.13	4.13	3.56	3.55	3.70	3.61	3.66	4.32	4.40	3.94	3.94	3.92
19:00	3.76	3.81	4.08	4.25	3.79	3.76	3.91	3.81	3.79	4.28	4.45	4.16	4.04	4.03
20:00	3.96	3.85	4.04	4.31	3.93	3.87	3.95	4.01	3.85	4.21	4.49	4.20	4.19	4.20
21:00	4.08	3.86	4.04	4.37	4.14	4.06	4.19	4.19	3.94	4.21	4.55	4.38	4.35	4.36
22:00	4.26	4.03	3.94	4.33	4.22	4.10	4.28	4.36	4.02	4.19	4.58	4.50	4.48	4.49
23:00	4.19	3.92	3.82	4.16	4.02	4.04	4.09	4.17	3.96	3.97	4.26	4.35	4.38	4.37
Average	3.69	3.66	3.93	3.89	3.63	3.58	3.67	3.68	3.65	4.00	4.05	3.85	3.85	3.89
Median	3.74	3.78	4.01	4.19	3.67	3.66	3.73	3.72	3.72	4.21	4.39	3.92	3.93	3.98
Max Hr. Mean	4.31	4.29	5.13	4.90	4.22	4.10	4.28	4.36	4.21	5.03	4.99	4.50	4.48	4.49
Min Hr. Mean	2.86	2.79	2.89	2.82	2.79	2.75	2.84	2.90	2.88	2.90	2.93	2.97	3.04	3.03
Inst. Max	4.84	4.37	5.19	4.95	4.28	4.16	4.32	4.40	4.25	5.27	5.03	4.54	4.56	4.54
Inst. Min	2.85	2.75	2.87	2.72	2.76	2.73	2.82	2.85	2.85	2.87	2.88	2.96	3.01	3.02

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 12
Address: N Sunrise Blvd N of Bell Road
MH ID# SSMH4N1WSW310016

Date: 6/9/2008
GPS: 33.382344N -112.241700W

Overview

Street Level

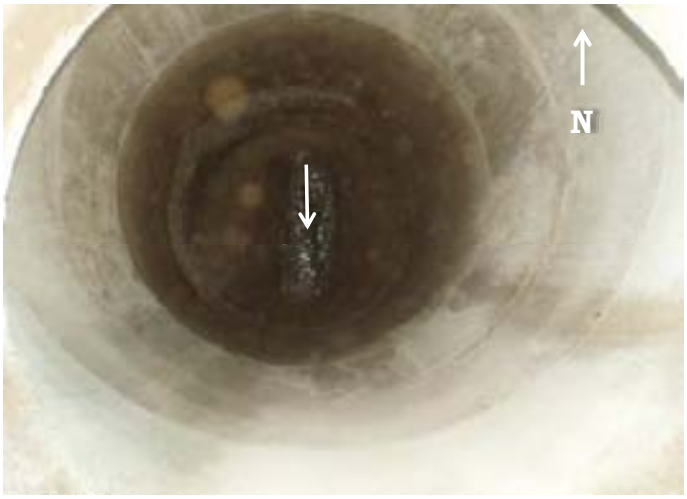
Meter Details

Meter Type	2150
Serial #	203A01267
Sensor Serial #	205E00559
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	18"	Horiz.	18"
Laterals	0			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole



Hydraulics:
Moderate flow conditions

Comments:
Good monitoring site

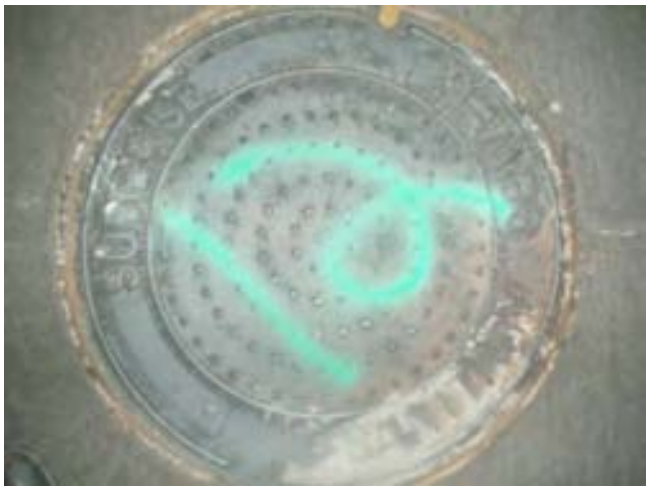
Photos
MH #SSMH4N1WSW310016
Site #12

Site ID

Down Manhole

18” Influent

18” Effluent


Manhole Cover Top

Manhole Cover Bottom

Location Summary

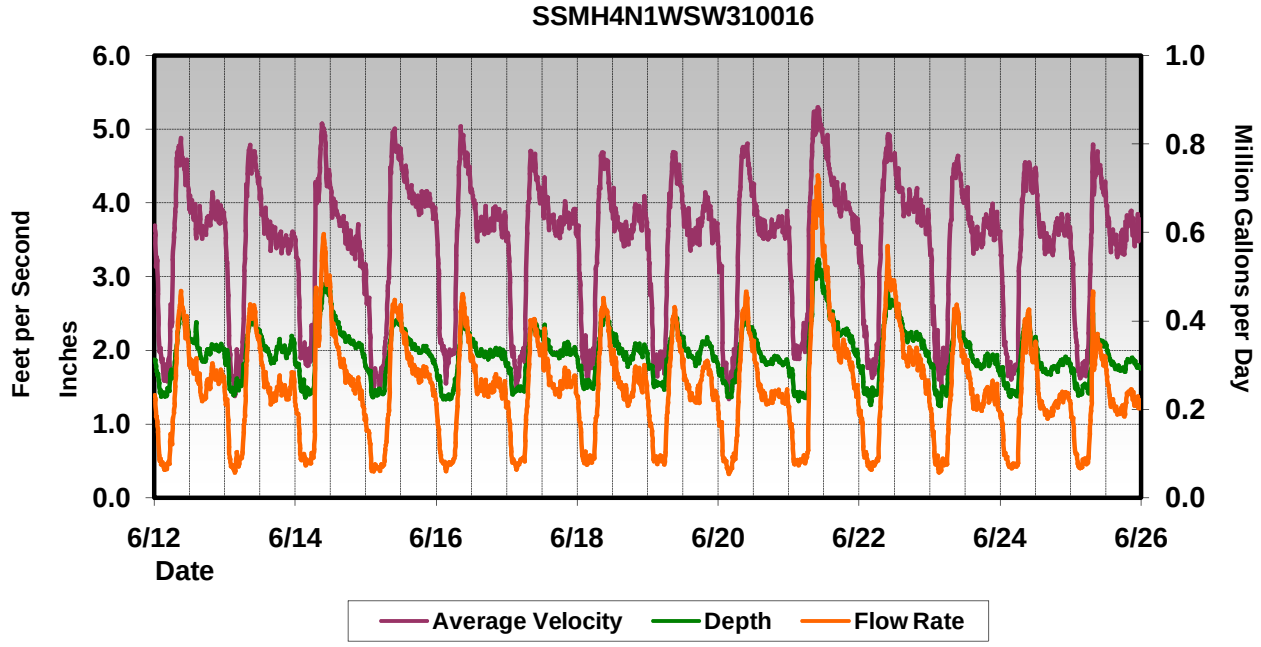
Site	**SSMH4N1WSW310016**	
Address	**Sunrise Blvd N of Bell Road**	
Diameter	**18**	Inches
GPS	**33.382344N**	**-112.241700W**

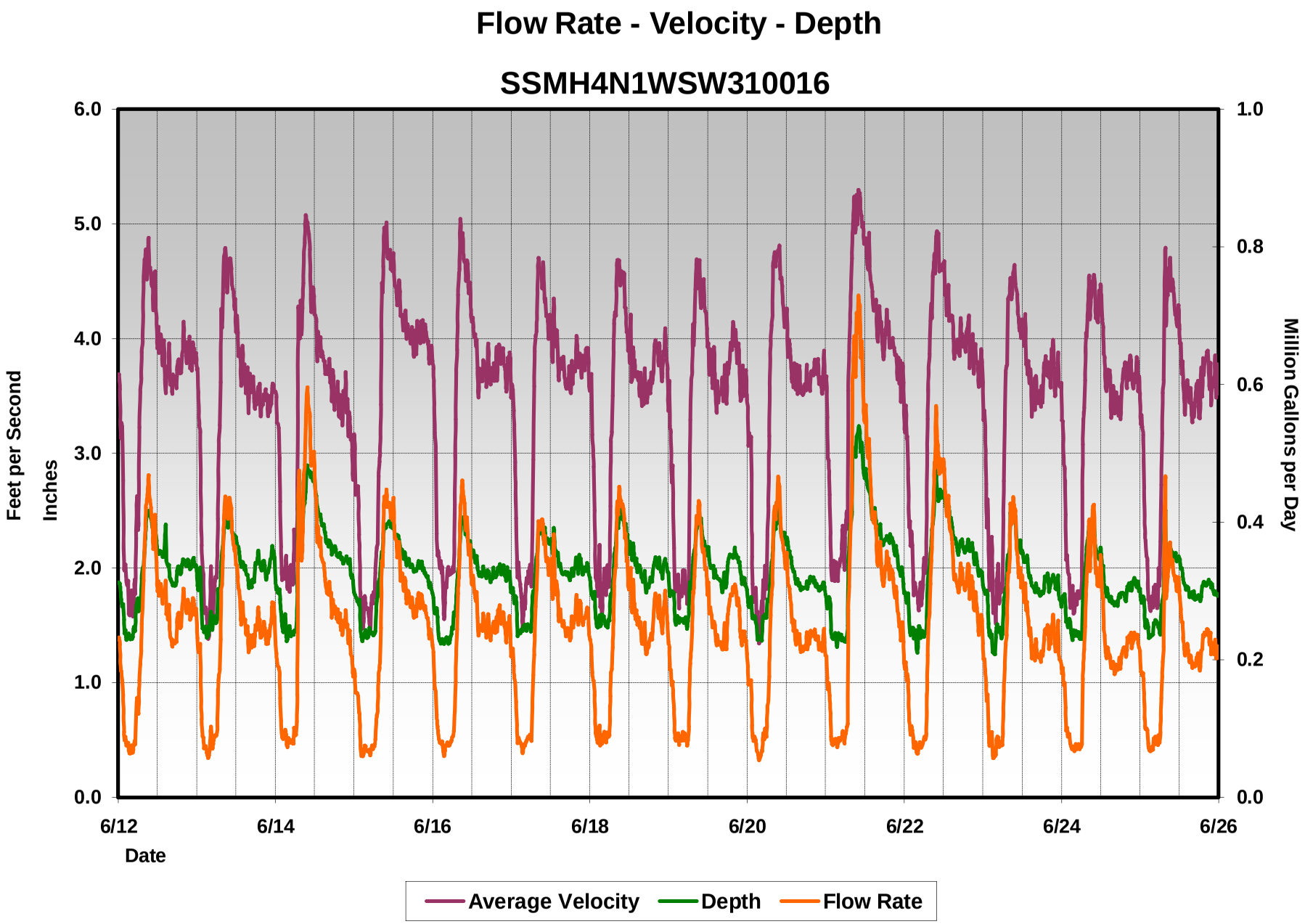
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	1.94
Maximum	3.24
Minimum	1.25
Max d/D	18.0%

Flow velocity	
	Feet per Second
Average	3.46
Maximum	5.30
Minimum	1.34

Flow Rate	
	Million Gallons per Day
Average	0.25
Maximum	0.73
Minimum	0.05
Peak Factor	2.95



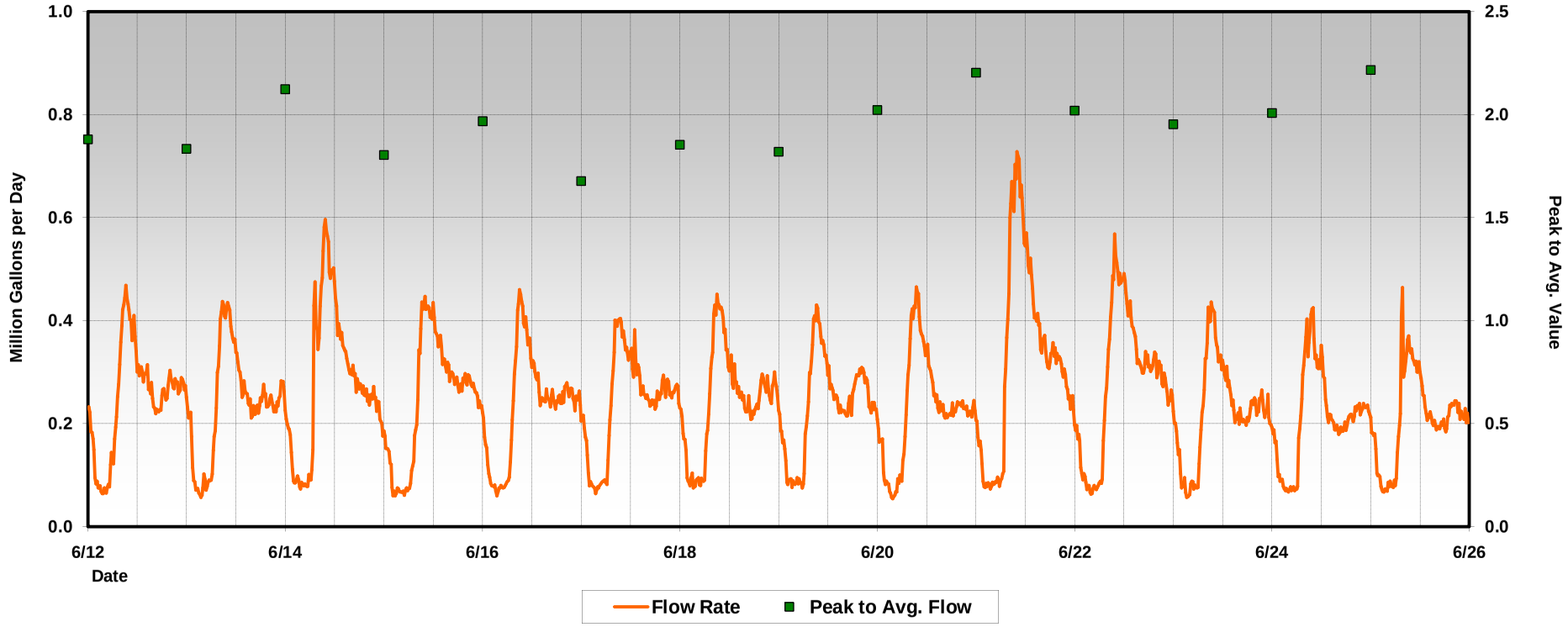

Flow Rate - Velocity - Depth
SSMH4N1WSW310016
Feet per Second
Inches
Million Gallons per Day
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1.0
0.8
0.6
0.4
0.2
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

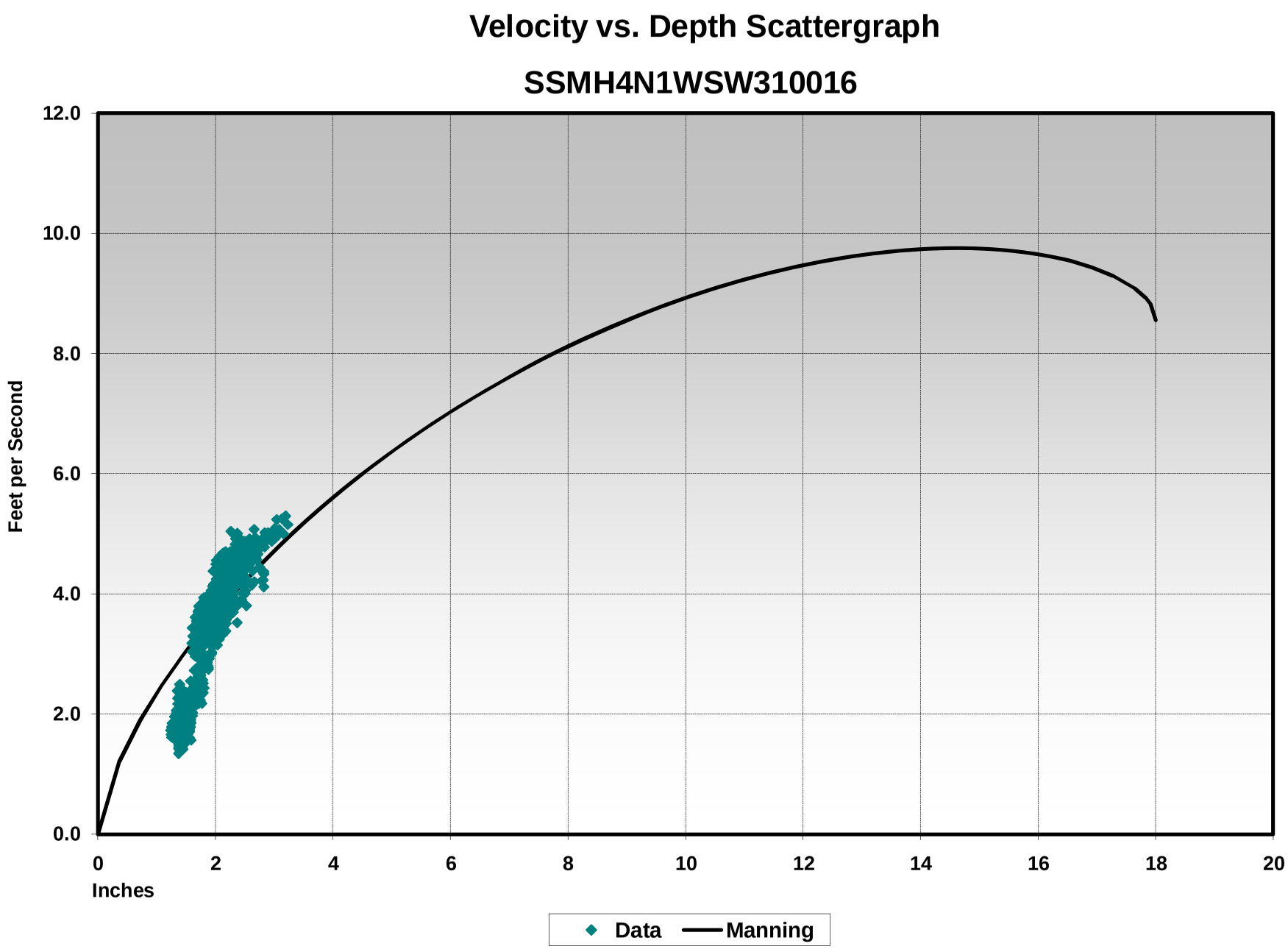
Peak to Average Flow Rate

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

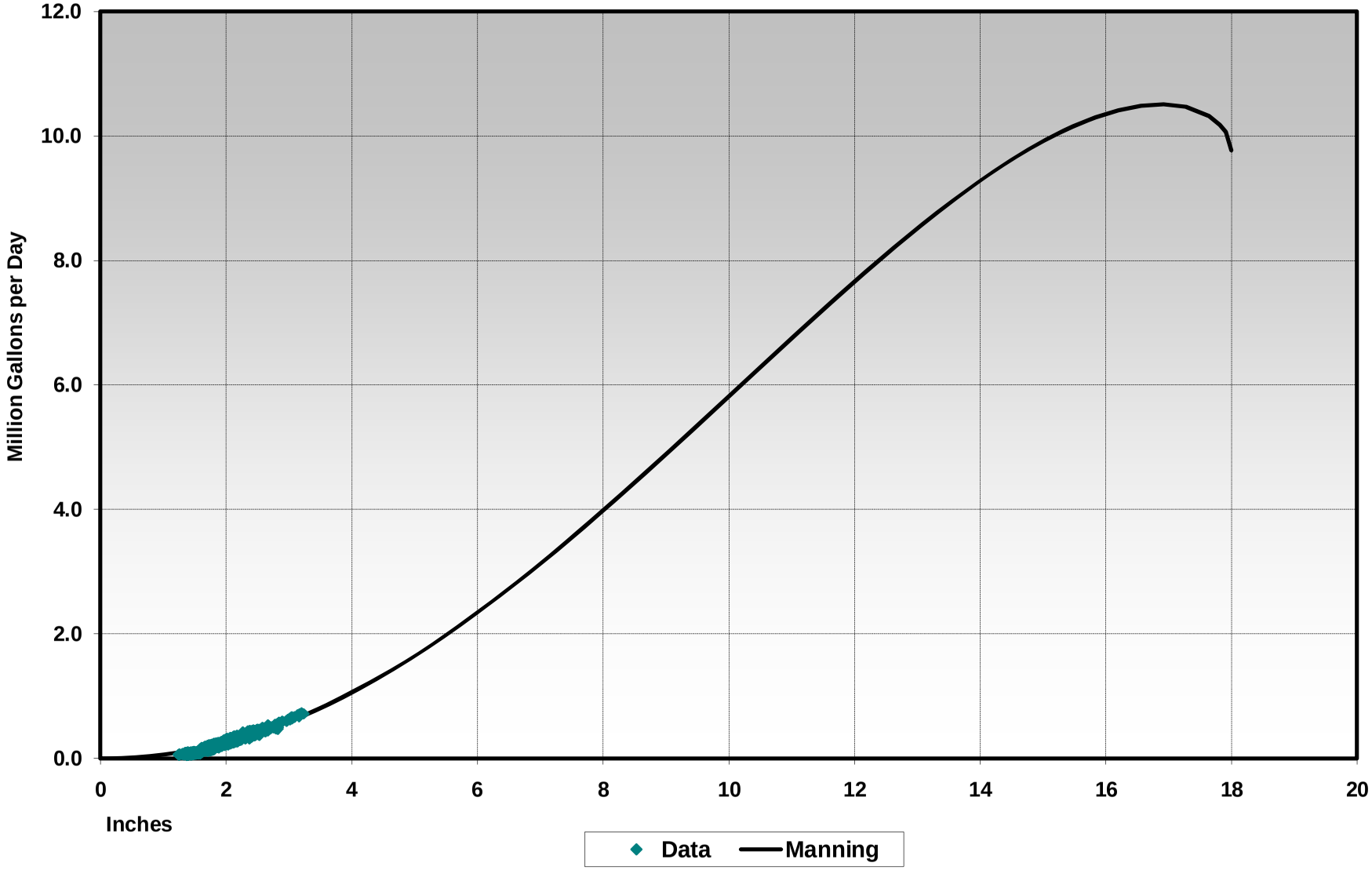
Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.88	1.83	2.12	1.80	1.97	1.68	1.85	1.82	2.02	2.20	2.02	1.95	2.01	2.22




Velocity vs. Depth Scattergraph
SSMH4N1WSW310016
Feet per Second
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning

Flow Rate vs. Depth Scattergraph

SSMH4N1WSW310016



Flow Rate - Tabular Output

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.22	0.23	0.21	0.17	0.19	0.21	0.21	0.20	0.18	0.19	0.19	0.20	0.18	0.19
1:00	0.15	0.15	0.16	0.14	0.12	0.15	0.15	0.15	0.13	0.13	0.14	0.14	0.12	0.13
2:00	0.08	0.08	0.09	0.07	0.08	0.08	0.09	0.09	0.08	0.08	0.09	0.08	0.09	0.09
3:00	0.07	0.06	0.08	0.07	0.07	0.07	0.08	0.09	0.06	0.08	0.07	0.06	0.07	0.07
4:00	0.07	0.09	0.08	0.07	0.08	0.08	0.09	0.09	0.06	0.08	0.07	0.08	0.07	0.08
5:00	0.11	0.09	0.08	0.07	0.08	0.09	0.09	0.08	0.09	0.09	0.08	0.08	0.07	0.08
6:00	0.15	0.13	0.11	0.09	0.10	0.12	0.15	0.14	0.13	0.10	0.09	0.14	0.13	0.12
7:00	0.26	0.26	0.42	0.15	0.23	0.26	0.28	0.26	0.27	0.34	0.22	0.26	0.27	0.32
8:00	0.40	0.40	0.40	0.28	0.38	0.38	0.40	0.37	0.40	0.59	0.36	0.38	0.36	0.31
9:00	0.45	0.42	0.55	0.42	0.44	0.40	0.43	0.41	0.44	0.65	0.49	0.42	0.39	0.35
10:00	0.40	0.42	0.55	0.43	0.39	0.36	0.41	0.37	0.40	0.70	0.50	0.37	0.36	0.33
11:00	0.38	0.37	0.49	0.41	0.35	0.34	0.35	0.33	0.35	0.61	0.48	0.32	0.31	0.31
12:00	0.30	0.32	0.43	0.40	0.31	0.32	0.30	0.29	0.33	0.54	0.46	0.30	0.32	0.28
13:00	0.30	0.27	0.38	0.37	0.28	0.33	0.29	0.26	0.28	0.49	0.42	0.28	0.22	0.23
14:00	0.29	0.27	0.35	0.33	0.24	0.28	0.26	0.24	0.25	0.41	0.38	0.24	0.21	0.22
15:00	0.26	0.23	0.31	0.31	0.25	0.26	0.25	0.23	0.23	0.39	0.33	0.21	0.19	0.20
16:00	0.23	0.22	0.30	0.29	0.25	0.25	0.23	0.22	0.22	0.36	0.30	0.21	0.19	0.19
17:00	0.23	0.23	0.28	0.29	0.25	0.24	0.22	0.23	0.22	0.32	0.32	0.20	0.19	0.20
18:00	0.26	0.26	0.27	0.27	0.25	0.24	0.23	0.27	0.22	0.34	0.31	0.21	0.20	0.19
19:00	0.26	0.24	0.26	0.28	0.25	0.26	0.26	0.30	0.23	0.33	0.33	0.24	0.21	0.23
20:00	0.29	0.25	0.25	0.29	0.27	0.28	0.28	0.30	0.24	0.32	0.31	0.23	0.23	0.24
21:00	0.28	0.23	0.26	0.28	0.26	0.27	0.27	0.28	0.23	0.30	0.29	0.25	0.23	0.23
22:00	0.27	0.24	0.24	0.26	0.24	0.26	0.26	0.23	0.22	0.26	0.27	0.22	0.23	0.22
23:00	0.28	0.28	0.20	0.24	0.25	0.27	0.28	0.23	0.23	0.24	0.25	0.22	0.23	0.21
Average	0.25	0.24	0.28	0.25	0.23	0.24	0.24	0.24	0.23	0.33	0.28	0.22	0.21	0.21
Median	0.27	0.24	0.27	0.28	0.25	0.26	0.25	0.24	0.23	0.32	0.30	0.22	0.21	0.21
Max Hr. Mean	0.45	0.42	0.55	0.43	0.44	0.40	0.43	0.41	0.44	0.70	0.50	0.42	0.39	0.35
Min Hr. Mean	0.07	0.06	0.08	0.07	0.07	0.07	0.08	0.08	0.06	0.08	0.07	0.06	0.07	0.07
Inst. Max	0.47	0.44	0.60	0.45	0.46	0.40	0.45	0.43	0.47	0.73	0.57	0.44	0.43	0.46
Inst. Min	0.06	0.06	0.07	0.06	0.06	0.06	0.08	0.08	0.05	0.07	0.06	0.06	0.07	0.07

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.51	3.56	3.39	2.89	3.54	3.50	3.50	3.35	3.28	3.38	3.28	3.37	3.27	3.34
1:00	2.81	2.53	2.74	2.47	2.40	2.66	2.58	2.60	2.55	2.48	2.69	2.48	2.38	2.60
2:00	1.93	1.71	1.94	1.60	2.03	1.93	1.88	1.85	1.76	1.94	2.16	1.99	1.87	1.91
3:00	1.67	1.48	1.96	1.67	1.76	1.64	1.77	1.80	1.48	1.98	1.81	1.71	1.72	1.70
4:00	1.70	1.77	1.90	1.60	1.92	1.79	1.88	1.83	1.53	2.05	1.73	1.84	1.70	1.75
5:00	2.14	1.79	1.99	1.64	1.95	1.95	1.91	1.82	1.89	2.19	1.79	1.79	1.78	1.76
6:00	2.87	2.39	2.24	1.90	2.12	2.26	2.68	2.48	2.45	2.37	2.06	2.56	2.51	2.49
7:00	4.01	3.80	4.18	2.53	3.82	3.89	3.93	3.85	3.97	4.00	3.48	3.90	3.77	4.09
8:00	4.67	4.65	4.38	3.83	4.76	4.59	4.55	4.47	4.68	4.96	4.30	4.41	4.31	4.37
9:00	4.71	4.57	4.98	4.83	4.78	4.57	4.55	4.53	4.74	5.03	4.70	4.55	4.42	4.54
10:00	4.45	4.62	4.76	4.78	4.62	4.33	4.49	4.34	4.58	5.20	4.81	4.38	4.38	4.37
11:00	4.40	4.36	4.34	4.67	4.40	4.13	4.07	4.22	4.21	4.97	4.62	4.08	4.23	4.19
12:00	3.98	4.04	4.09	4.56	4.11	4.01	3.90	3.87	4.05	4.80	4.53	4.06	4.27	3.92
13:00	3.93	3.75	3.99	4.39	3.92	4.09	3.78	3.71	3.81	4.67	4.31	3.87	3.71	3.56
14:00	3.70	3.77	3.85	4.25	3.64	3.83	3.68	3.60	3.67	4.36	4.19	3.68	3.68	3.57
15:00	3.79	3.55	3.74	4.14	3.73	3.79	3.61	3.53	3.62	4.22	3.92	3.48	3.51	3.46
16:00	3.61	3.58	3.72	4.07	3.68	3.68	3.53	3.54	3.61	4.15	3.94	3.51	3.45	3.36
17:00	3.61	3.55	3.64	4.04	3.74	3.64	3.54	3.62	3.56	3.96	4.01	3.47	3.42	3.56
18:00	3.76	3.50	3.45	3.96	3.72	3.63	3.61	3.76	3.63	4.09	3.94	3.61	3.47	3.45
19:00	3.79	3.47	3.47	4.05	3.71	3.77	3.73	3.98	3.63	4.02	4.11	3.74	3.74	3.70
20:00	3.98	3.47	3.39	4.04	3.89	3.87	3.95	4.00	3.73	3.96	3.89	3.68	3.69	3.85
21:00	3.89	3.46	3.50	4.08	3.82	3.80	3.83	3.85	3.75	3.87	3.88	3.88	3.73	3.63
22:00	3.80	3.43	3.32	4.00	3.66	3.80	3.77	3.56	3.63	3.72	3.74	3.60	3.64	3.62
23:00	3.86	3.57	3.02	3.86	3.81	3.82	3.90	3.65	3.70	3.59	3.77	3.66	3.71	3.66
Average	3.52	3.35	3.42	3.49	3.48	3.46	3.44	3.41	3.40	3.75	3.57	3.39	3.35	3.35
Median	3.76	3.53	3.52	3.99	3.73	3.76	3.69	3.67	3.62	3.95	3.90	3.63	3.60	3.53
Max Hr. Mean	4.71	4.65	4.98	4.83	4.78	4.59	4.55	4.53	4.74	5.20	4.81	4.55	4.42	4.54
Min Hr. Mean	1.67	1.48	1.90	1.60	1.76	1.64	1.77	1.80	1.48	1.94	1.73	1.71	1.70	1.70
Inst. Max	4.88	4.79	5.07	5.01	5.04	4.70	4.69	4.69	4.81	5.30	4.94	4.64	4.55	4.79
Inst. Min	1.58	1.38	1.79	1.44	1.56	1.49	1.57	1.65	1.34	1.89	1.63	1.51	1.60	1.63

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.85	1.90	1.83	1.76	1.68	1.79	1.83	1.82	1.72	1.70	1.75	1.81	1.71	1.74
1:00	1.65	1.75	1.73	1.70	1.58	1.70	1.72	1.78	1.65	1.65	1.63	1.72	1.63	1.61
2:00	1.41	1.47	1.49	1.41	1.36	1.43	1.51	1.54	1.56	1.39	1.46	1.42	1.53	1.49
3:00	1.40	1.41	1.45	1.42	1.36	1.47	1.55	1.55	1.41	1.38	1.39	1.26	1.41	1.41
4:00	1.42	1.55	1.45	1.42	1.38	1.47	1.55	1.54	1.41	1.40	1.39	1.46	1.42	1.50
5:00	1.56	1.56	1.43	1.43	1.38	1.49	1.51	1.52	1.58	1.37	1.43	1.44	1.40	1.51
6:00	1.68	1.66	1.56	1.48	1.54	1.61	1.71	1.70	1.68	1.40	1.42	1.63	1.57	1.55
7:00	1.92	1.95	2.55	1.81	1.79	1.92	2.01	1.97	1.97	2.25	1.89	1.95	2.02	2.14
8:00	2.31	2.32	2.41	2.06	2.20	2.26	2.34	2.26	2.31	2.87	2.26	2.30	2.27	2.04
9:00	2.48	2.41	2.74	2.33	2.43	2.35	2.49	2.41	2.45	3.07	2.66	2.43	2.37	2.16
10:00	2.37	2.40	2.83	2.39	2.30	2.28	2.40	2.30	2.35	3.15	2.64	2.29	2.25	2.11
11:00	2.31	2.28	2.81	2.36	2.20	2.23	2.29	2.19	2.28	2.96	2.64	2.18	2.08	2.09
12:00	2.14	2.21	2.65	2.34	2.13	2.20	2.17	2.10	2.23	2.79	2.61	2.10	2.08	2.03
13:00	2.12	2.06	2.48	2.26	2.06	2.21	2.12	2.01	2.09	2.66	2.52	2.08	1.82	1.89
14:00	2.20	2.02	2.38	2.15	1.95	2.08	2.02	1.94	1.96	2.47	2.40	1.92	1.76	1.82
15:00	2.00	1.93	2.26	2.11	1.96	1.98	1.99	1.90	1.88	2.41	2.26	1.83	1.72	1.77
16:00	1.87	1.85	2.22	2.05	1.94	1.96	1.92	1.85	1.83	2.33	2.15	1.81	1.68	1.75
17:00	1.86	1.92	2.15	2.02	1.92	1.94	1.84	1.90	1.83	2.22	2.22	1.78	1.72	1.74
18:00	2.00	2.07	2.16	1.98	1.95	1.95	1.88	2.06	1.85	2.25	2.16	1.80	1.77	1.74
19:00	2.00	2.02	2.12	2.01	1.93	2.00	1.98	2.10	1.90	2.26	2.20	1.92	1.75	1.86
20:00	2.04	2.03	2.07	2.03	2.01	2.04	2.05	2.13	1.89	2.24	2.18	1.85	1.84	1.86
21:00	2.04	1.94	2.08	1.97	1.99	2.03	2.01	2.07	1.84	2.15	2.10	1.91	1.83	1.86
22:00	2.02	2.04	2.06	1.92	1.94	1.98	1.99	1.91	1.82	2.01	2.03	1.84	1.89	1.81
23:00	2.04	2.14	1.92	1.83	1.92	2.00	2.03	1.88	1.85	1.94	1.96	1.79	1.84	1.77
Average	1.95	1.95	2.12	1.93	1.87	1.93	1.95	1.93	1.89	2.18	2.06	1.85	1.81	1.80
Median	2.01	2.00	2.12	1.99	1.95	1.98	1.97	1.93	1.85	2.24	2.15	1.83	1.78	1.79
Max Hr. Mean	2.48	2.41	2.83	2.39	2.43	2.35	2.49	2.41	2.45	3.15	2.66	2.43	2.37	2.16
Min Hr. Mean	1.40	1.41	1.43	1.41	1.36	1.43	1.51	1.52	1.41	1.37	1.39	1.26	1.40	1.41
Inst. Max	2.50	2.44	2.90	2.42	2.45	2.41	2.52	2.47	2.52	3.24	2.86	2.50	2.48	2.51
Inst. Min	1.38	1.39	1.36	1.36	1.34	1.41	1.48	1.47	1.37	1.31	1.26	1.25	1.37	1.39

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 13
Address: W Cactus W of N 153rd Avenue
MH ID# SSMH3N1WSW170115

Date: 6/11/2008
GPS: 33.354215N -112.232164W

Overview

Street Level - Night Photo

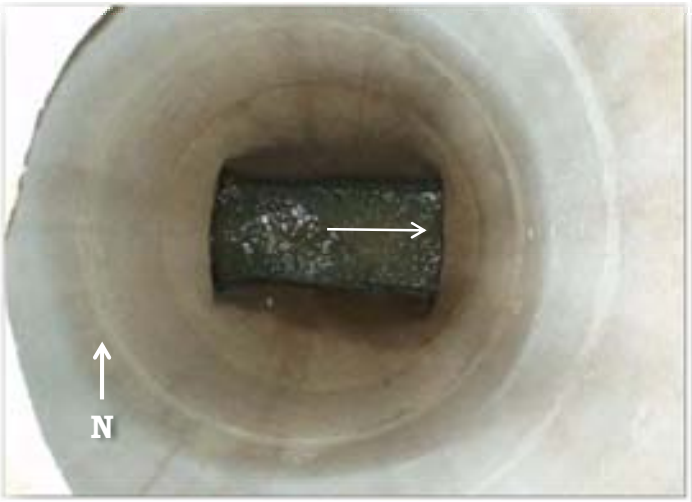
Meter Details

Meter Type	2150
Serial #	204L00442
Sensor Serial #	202D01608
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	30"	Horiz.	30"
Laterals	0			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole

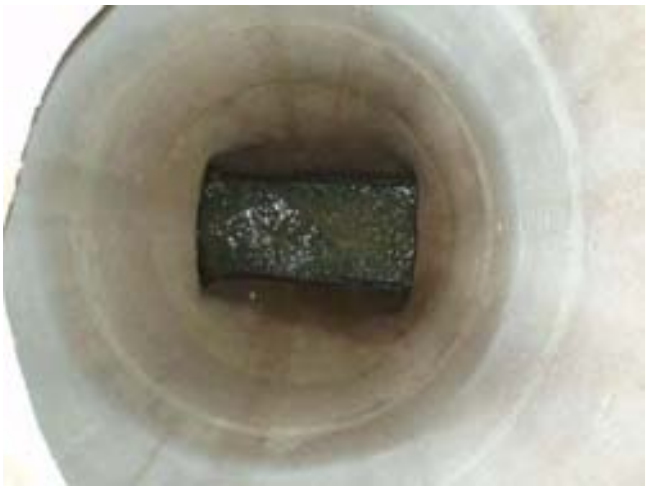


Hydraulics:
Fast flow conditions. Quick flow changes.

Comments:
Lots of turbulence in bench area

Photos
MH #SSMH3N1WSW170115
Site #13

Site ID



Down Manhole

30” Influent

30” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

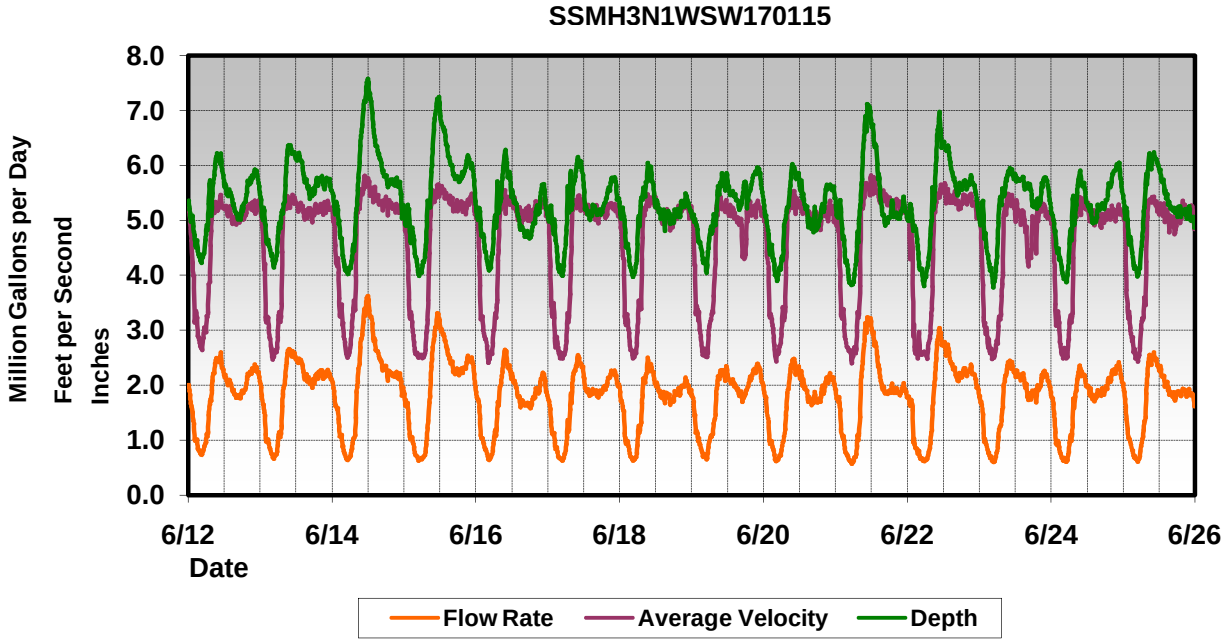
Site	**SSMH3N1WSW170115**	
Address	**Cactus Rd W of 153 Avenue**	
Diameter	**30**	Inches
GPS	**33.354215N**	**-112.232164W**

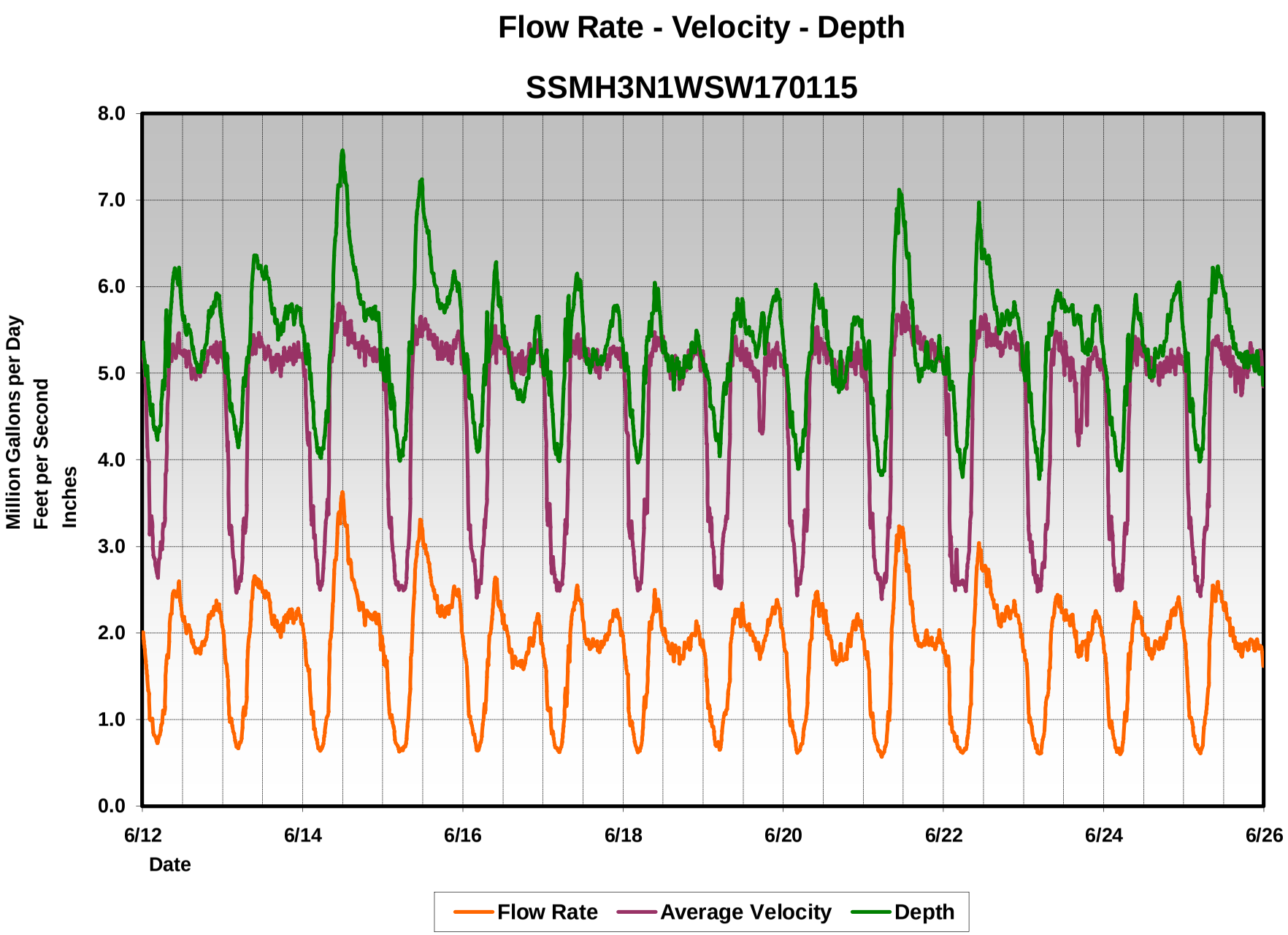
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	5.30
Maximum	7.57
Minimum	3.78
Max d/D	25.2%

Flow velocity	
	Feet per Second
Average	4.59
Maximum	5.81
Minimum	2.39

Flow Rate	
	Million Gallons per Day
Average	1.80
Maximum	3.62
Minimum	0.57
Peak Factor	2.01



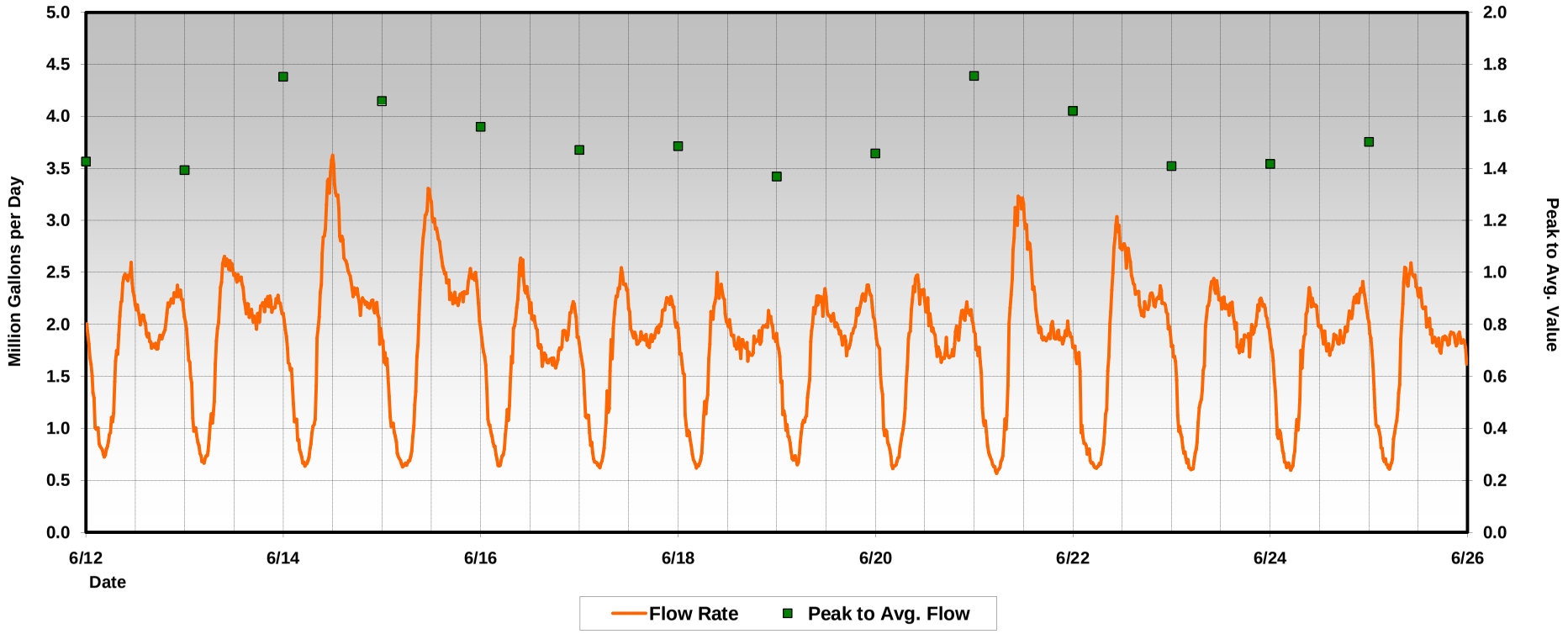

Flow Rate - Velocity - Depth
SSMH3N1WSW170115
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

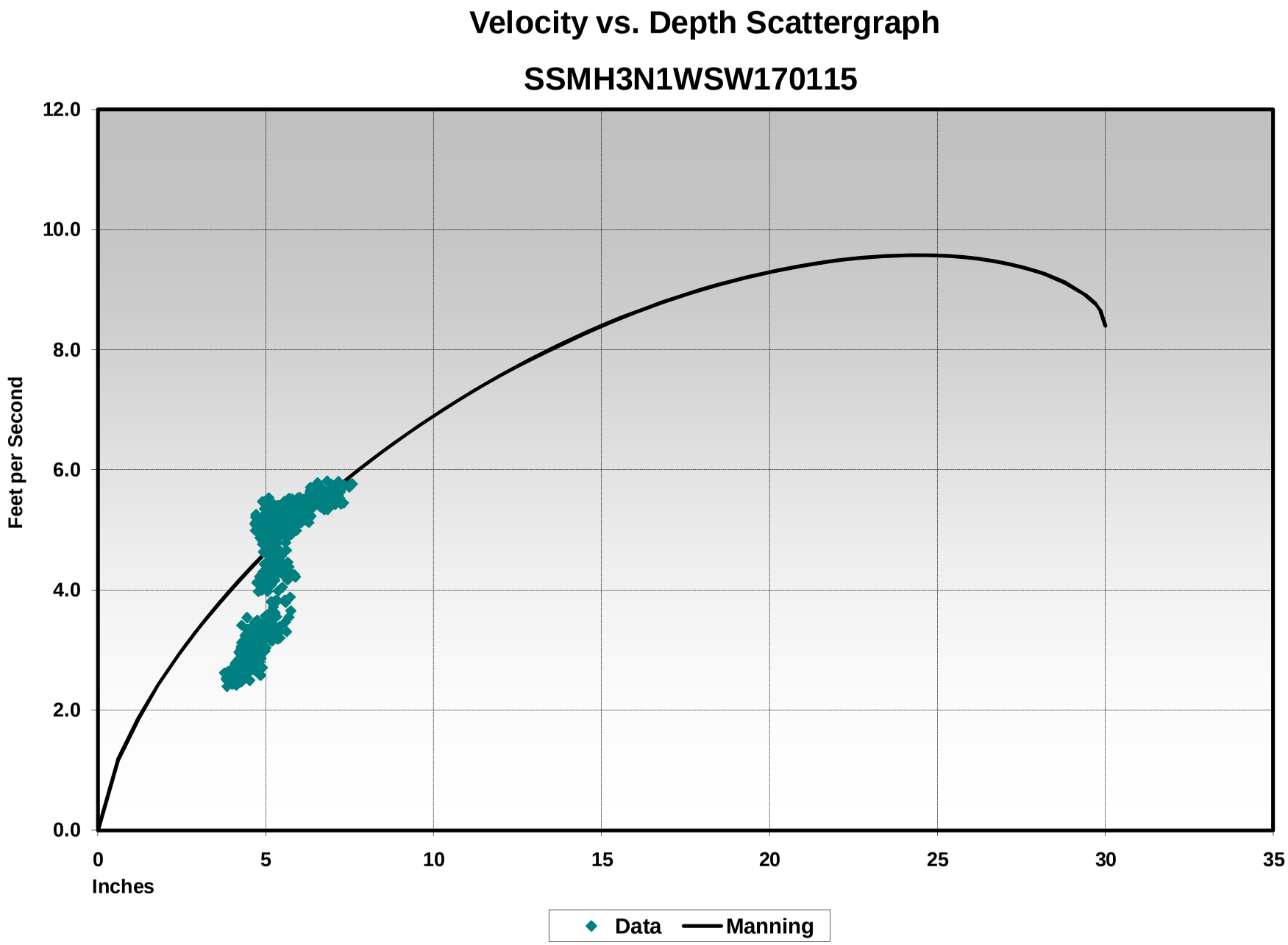
Peak to Average Flow Rate

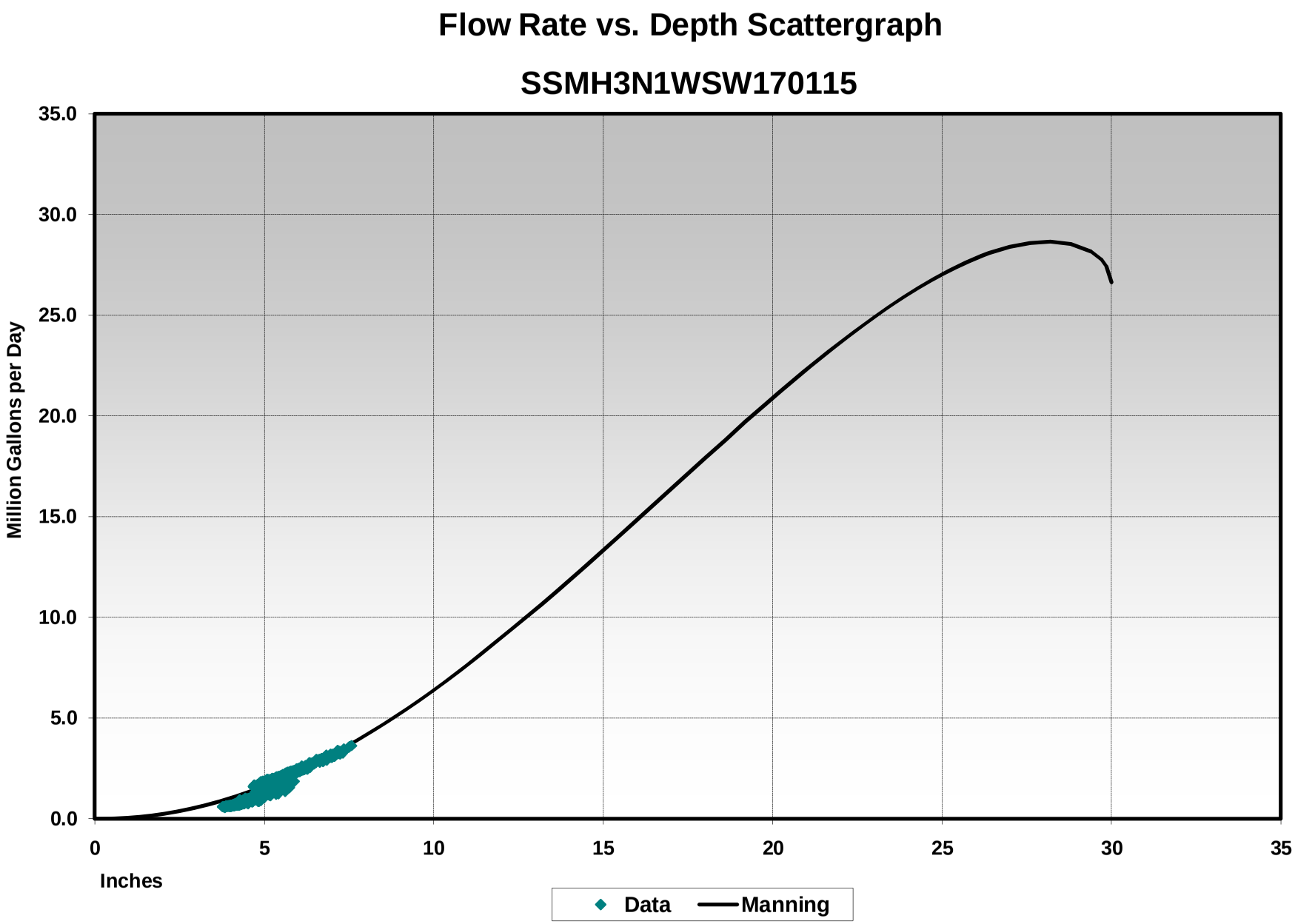
Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.43	1.39	1.75	1.66	1.56	1.47	1.48	1.37	1.46	1.76	1.62	1.41	1.42	1.50




Velocity vs. Depth Scattergraph
SSMH3N1WSW170115
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Feet per Second
0
5
10
15
20
25
30
35
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WSW170115
Million Gallons per Day
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
5
10
15
20
25
30
35
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.92	1.96	1.99	1.77	1.84	1.72	1.82	1.79	1.86	1.84	1.76	1.74	1.76	1.89
1:00	1.53	1.56	1.64	1.52	1.44	1.28	1.45	1.30	1.50	1.66	1.65	1.30	1.23	1.30
2:00	1.07	1.02	1.31	1.05	0.99	1.01	0.98	1.01	0.97	1.09	0.94	0.93	0.93	0.98
3:00	0.87	0.85	0.98	0.88	0.82	0.75	0.79	0.82	0.81	0.83	0.81	0.73	0.72	0.75
4:00	0.75	0.69	0.74	0.70	0.66	0.66	0.65	0.71	0.63	0.68	0.71	0.64	0.64	0.66
5:00	0.86	0.74	0.66	0.65	0.74	0.68	0.69	0.74	0.69	0.60	0.63	0.67	0.65	0.66
6:00	1.07	1.04	0.77	0.67	1.05	1.04	1.10	1.04	0.91	0.65	0.65	0.98	0.95	0.99
7:00	1.64	1.46	1.02	0.87	1.51	1.44	1.52	1.23	1.33	0.93	0.83	1.36	1.43	1.45
8:00	2.10	2.12	1.83	1.52	2.04	1.99	2.11	1.81	1.96	1.68	1.39	1.96	1.92	2.30
9:00	2.45	2.57	2.55	2.40	2.45	2.31	2.32	2.18	2.34	2.57	2.24	2.29	2.25	2.45
10:00	2.45	2.58	3.07	2.96	2.46	2.47	2.32	2.24	2.38	3.10	2.89	2.37	2.20	2.51
11:00	2.40	2.56	3.43	3.22	2.29	2.36	2.16	2.22	2.31	3.19	2.83	2.31	2.11	2.41
12:00	2.16	2.45	3.44	3.05	2.10	2.04	2.00	2.14	2.18	3.01	2.75	2.23	1.94	2.29
13:00	2.05	2.45	3.11	2.89	2.00	1.90	1.87	2.07	2.01	2.75	2.64	2.17	1.83	2.16
14:00	2.01	2.29	2.77	2.68	1.79	1.82	1.81	2.01	1.89	2.37	2.47	2.16	1.76	2.01
15:00	1.87	2.14	2.58	2.48	1.67	1.89	1.79	1.92	1.74	2.04	2.32	2.02	1.83	1.89
16:00	1.79	2.08	2.43	2.35	1.65	1.84	1.80	1.84	1.67	1.91	2.18	1.78	1.84	1.84
17:00	1.80	2.04	2.30	2.26	1.66	1.84	1.70	1.76	1.75	1.86	2.15	1.82	1.88	1.79
18:00	1.88	2.12	2.23	2.22	1.62	1.91	1.78	1.91	1.71	1.91	2.19	1.89	1.93	1.87
19:00	2.00	2.19	2.23	2.27	1.76	1.97	1.87	2.06	1.86	1.93	2.26	1.86	2.08	1.84
20:00	2.21	2.22	2.19	2.30	1.93	2.11	1.90	2.19	1.95	1.90	2.23	1.99	2.19	1.91
21:00	2.25	2.17	2.20	2.47	1.97	2.24	1.98	2.26	2.09	1.85	2.29	2.20	2.27	1.83
22:00	2.30	2.22	2.17	2.46	2.17	2.21	2.07	2.34	2.15	1.94	2.18	2.18	2.35	1.86
23:00	2.24	2.16	1.98	2.24	1.98	2.05	1.89	2.14	2.07	1.90	1.98	2.02	2.17	1.77
Average	1.82	1.90	2.07	1.99	1.69	1.73	1.68	1.74	1.70	1.84	1.87	1.73	1.70	1.72
Median	1.92	2.13	2.20	2.27	1.77	1.89	1.83	1.94	1.83	1.88	2.15	1.92	1.87	1.85
Max Hr. Mean	2.45	2.58	3.44	3.22	2.46	2.47	2.32	2.34	2.38	3.19	2.89	2.37	2.35	2.51
Min Hr. Mean	0.75	0.69	0.66	0.65	0.66	0.66	0.65	0.71	0.63	0.60	0.63	0.64	0.64	0.66
Inst. Max	2.60	2.65	3.62	3.31	2.64	2.54	2.50	2.38	2.48	3.23	3.04	2.44	2.41	2.59
Inst. Min	0.73	0.67	0.64	0.63	0.64	0.62	0.62	0.65	0.61	0.57	0.62	0.61	0.60	0.61

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.14	5.11	5.09	4.99	5.04	4.85	5.02	5.03	5.04	4.98	5.03	5.00	4.90	5.03
1:00	4.42	4.37	4.45	4.21	3.99	3.56	4.05	3.78	4.43	4.49	4.51	3.61	3.75	3.69
2:00	3.43	3.21	3.79	3.24	3.10	3.07	3.18	3.22	3.25	3.29	2.83	2.99	3.20	3.14
3:00	2.96	2.86	3.26	2.82	2.82	2.72	2.85	2.77	2.92	2.88	2.62	2.69	2.68	2.72
4:00	2.69	2.52	2.77	2.56	2.48	2.55	2.57	2.59	2.56	2.65	2.68	2.57	2.57	2.52
5:00	2.94	2.63	2.55	2.53	2.64	2.54	2.61	2.65	2.66	2.52	2.59	2.62	2.59	2.55
6:00	3.20	3.14	2.83	2.51	3.13	2.95	3.27	3.18	3.21	2.60	2.54	2.97	3.09	3.15
7:00	4.26	4.05	3.38	2.78	3.92	3.57	3.94	3.58	3.79	3.04	2.82	3.49	3.88	3.64
8:00	5.19	5.26	4.85	3.99	5.22	5.05	5.18	4.95	5.17	4.39	3.73	4.90	5.11	5.17
9:00	5.29	5.35	5.41	5.37	5.42	5.29	5.34	5.32	5.39	5.36	5.25	5.32	5.28	5.37
10:00	5.29	5.33	5.58	5.41	5.32	5.39	5.35	5.25	5.39	5.65	5.45	5.38	5.28	5.35
11:00	5.30	5.38	5.73	5.54	5.36	5.26	5.34	5.28	5.35	5.62	5.59	5.32	5.25	5.25
12:00	5.22	5.27	5.66	5.54	5.37	5.24	5.30	5.17	5.28	5.69	5.59	5.20	5.19	5.21
13:00	5.17	5.24	5.51	5.50	5.26	5.21	5.17	5.19	5.20	5.59	5.46	5.13	5.06	5.16
14:00	5.10	5.17	5.49	5.46	5.11	5.17	5.04	5.10	5.16	5.46	5.36	5.05	5.06	5.08
15:00	5.02	5.10	5.39	5.37	5.04	5.09	5.12	5.01	5.07	5.37	5.41	4.92	5.08	4.98
16:00	5.03	5.17	5.33	5.30	5.10	5.08	5.04	4.94	5.01	5.46	5.37	4.31	4.98	5.00
17:00	5.06	5.10	5.29	5.27	5.14	5.09	4.89	4.35	5.11	5.34	5.27	4.60	5.00	4.86
18:00	5.06	5.19	5.28	5.23	5.05	5.18	5.05	4.80	5.04	5.32	5.35	5.03	5.06	5.13
19:00	5.14	5.18	5.33	5.27	5.18	5.12	5.16	5.17	5.06	5.24	5.43	4.90	5.09	5.06
20:00	5.25	5.23	5.24	5.20	5.23	5.23	5.15	5.17	5.14	5.30	5.38	5.16	5.15	5.25
21:00	5.28	5.23	5.22	5.30	5.22	5.27	5.26	5.18	5.11	5.24	5.38	5.25	5.13	5.16
22:00	5.21	5.23	5.21	5.42	5.29	5.22	5.28	5.28	5.23	5.21	5.30	5.14	5.19	5.18
23:00	5.26	5.20	5.21	5.28	5.21	5.20	5.12	5.16	5.14	5.17	5.22	5.12	5.15	5.09
Average	4.66	4.65	4.74	4.59	4.61	4.54	4.59	4.50	4.61	4.66	4.59	4.45	4.53	4.53
Median	5.10	5.18	5.23	5.24	5.12	5.14	5.10	5.06	5.08	5.22	5.29	5.03	5.05	5.07
Max Hr. Mean	5.30	5.38	5.73	5.54	5.42	5.39	5.35	5.32	5.39	5.69	5.59	5.38	5.28	5.37
Min Hr. Mean	2.69	2.52	2.55	2.51	2.48	2.54	2.57	2.59	2.56	2.52	2.54	2.57	2.57	2.52
Inst. Max	5.46	5.47	5.81	5.65	5.54	5.45	5.47	5.42	5.53	5.81	5.67	5.48	5.42	5.43
Inst. Min	2.64	2.47	2.50	2.50	2.41	2.49	2.49	2.51	2.43	2.39	2.49	2.48	2.49	2.43

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.25	5.36	5.43	5.06	5.17	5.07	5.14	5.09	5.21	5.22	5.02	5.01	5.11	5.26
1:00	4.99	5.09	5.23	5.14	5.13	5.10	5.09	4.97	4.90	5.23	5.19	5.08	4.78	5.03
2:00	4.65	4.68	4.98	4.76	4.71	4.82	4.59	4.66	4.50	4.83	4.84	4.61	4.41	4.64
3:00	4.45	4.47	4.52	4.62	4.41	4.27	4.28	4.45	4.27	4.39	4.61	4.22	4.19	4.27
4:00	4.30	4.25	4.16	4.22	4.14	4.07	4.01	4.26	3.96	4.03	4.13	3.96	3.96	4.10
5:00	4.44	4.32	4.07	4.04	4.32	4.17	4.15	4.29	4.09	3.84	3.91	4.02	3.98	4.07
6:00	4.86	4.81	4.20	4.18	4.88	5.00	4.88	4.78	4.35	3.99	4.04	4.80	4.58	4.64
7:00	5.37	5.11	4.54	4.61	5.35	5.49	5.37	4.95	5.02	4.54	4.44	5.42	5.17	5.46
8:00	5.56	5.54	5.27	5.30	5.42	5.43	5.58	5.17	5.31	5.29	5.20	5.51	5.27	5.92
9:00	6.11	6.25	6.18	5.94	6.01	5.85	5.84	5.61	5.84	6.25	5.76	5.80	5.78	6.03
10:00	6.11	6.31	6.89	6.86	6.06	6.06	5.83	5.76	5.91	6.88	6.71	5.89	5.67	6.16
11:00	6.00	6.22	7.30	7.17	5.77	5.97	5.55	5.70	5.81	7.03	6.49	5.83	5.52	6.07
12:00	5.65	6.13	7.40	6.89	5.43	5.41	5.29	5.64	5.63	6.70	6.37	5.78	5.27	5.88
13:00	5.49	6.14	7.01	6.66	5.32	5.16	5.14	5.50	5.38	6.36	6.30	5.73	5.13	5.69
14:00	5.46	5.91	6.50	6.35	5.03	5.05	5.12	5.45	5.19	5.84	6.08	5.77	5.00	5.48
15:00	5.24	5.70	6.25	6.09	4.85	5.23	5.02	5.34	4.95	5.31	5.79	5.61	5.13	5.31
16:00	5.09	5.54	6.05	5.91	4.75	5.15	5.10	5.26	4.85	5.03	5.57	5.63	5.22	5.20
17:00	5.07	5.52	5.85	5.79	4.74	5.14	5.00	5.55	4.95	5.01	5.58	5.48	5.27	5.19
18:00	5.23	5.60	5.72	5.74	4.73	5.20	5.05	5.50	4.91	5.11	5.59	5.27	5.34	5.17
19:00	5.42	5.72	5.69	5.81	4.93	5.36	5.15	5.50	5.19	5.20	5.67	5.32	5.60	5.16
20:00	5.70	5.75	5.69	5.92	5.21	5.55	5.21	5.74	5.32	5.11	5.65	5.37	5.76	5.17
21:00	5.76	5.65	5.72	6.12	5.28	5.74	5.29	5.86	5.59	5.05	5.75	5.70	5.92	5.08
22:00	5.90	5.75	5.66	6.02	5.62	5.74	5.43	5.93	5.62	5.24	5.62	5.75	6.01	5.11
23:00	5.75	5.66	5.31	5.75	5.33	5.45	5.22	5.65	5.54	5.20	5.32	5.46	5.71	5.00
Average	5.33	5.48	5.65	5.62	5.11	5.23	5.10	5.28	5.10	5.28	5.40	5.29	5.16	5.21
Median	5.35	5.62	5.68	5.80	5.11	5.21	5.15	5.44	5.16	5.13	5.58	5.49	5.25	5.20
Max Hr. Mean	6.11	6.31	7.40	7.17	6.06	6.06	5.84	5.93	5.91	7.03	6.71	5.89	6.01	6.16
Min Hr. Mean	4.30	4.25	4.07	4.04	4.14	4.07	4.01	4.26	3.96	3.84	3.91	3.96	3.96	4.07
Inst. Max	6.22	6.36	7.57	7.24	6.28	6.15	6.04	5.96	6.03	7.12	6.97	5.96	6.05	6.23
Inst. Min	4.23	4.15	4.02	3.99	4.09	3.99	3.97	4.04	3.90	3.83	3.81	3.78	3.88	3.98

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 14**	**Date:**	**6/10/2008**
Address:	**Greenway Road E of Hwy 303**	**GPS:**	**33.372747N -112.250377W**
MH ID#	**SSMH3N2WSE010107**		

Overview

Street Level

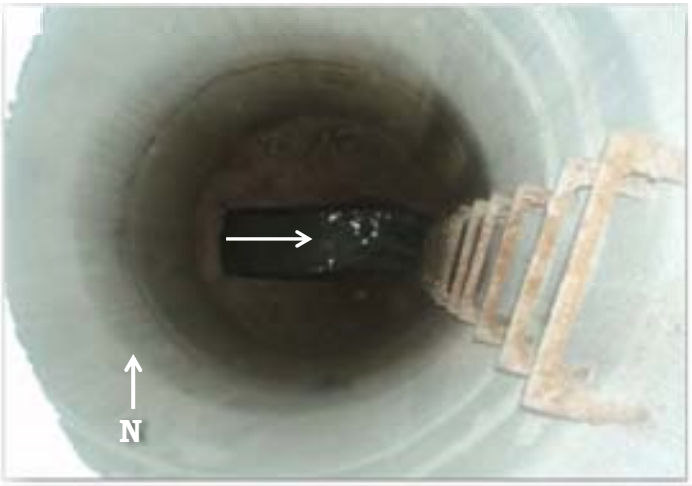
Meter Details

Meter Type	**2150**
Serial #	**203C00492**
Sensor Serial #	**203C01043**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**18"**	**Horiz.**	**18"**
Laterals	**0**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole



Hydraulics:
Slow flow conditions. Moderate depth.

Comments:

Photos
MH #SSMH3N2WSE010107
Site #14

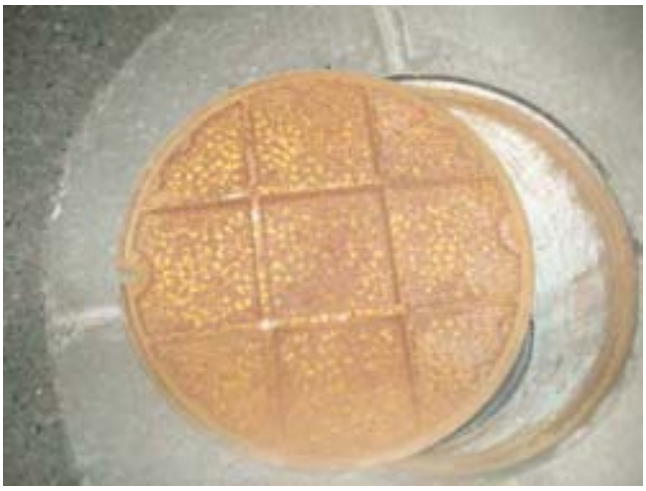
Site ID

Down Manhole

18” Influent

18” Effluent

Manhole Cover Top


Manhole Cover Bottom

Location Summary

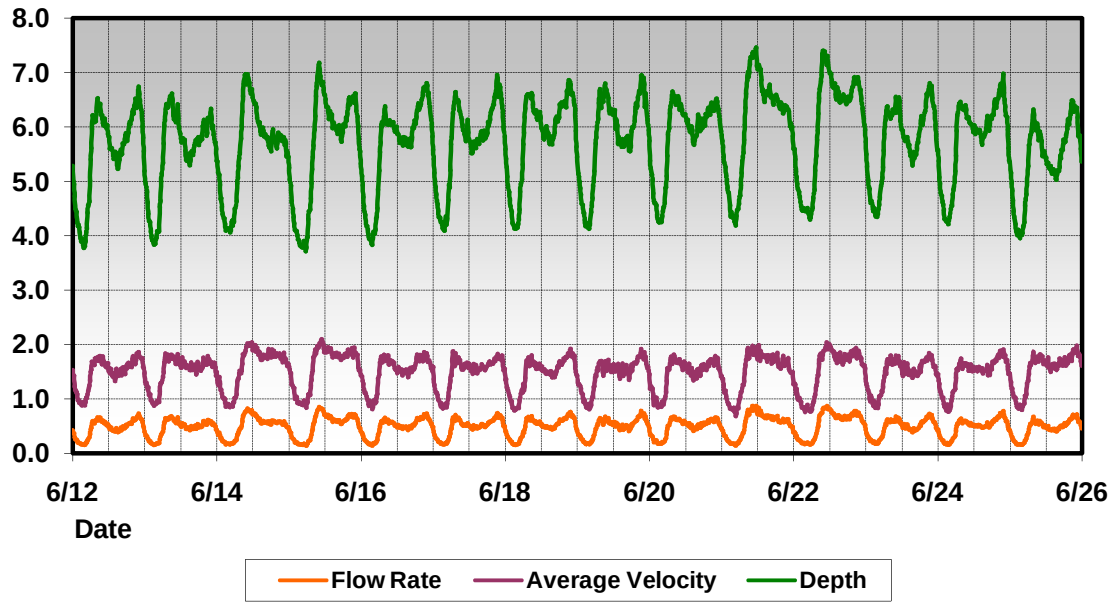
Site	**SSMH3N2WSE010107**	
Address	**Greenway Rd E of Hwy 303**	
Diameter	**18**	Inches
GPS	**33.372747N**	**-112.250377W**

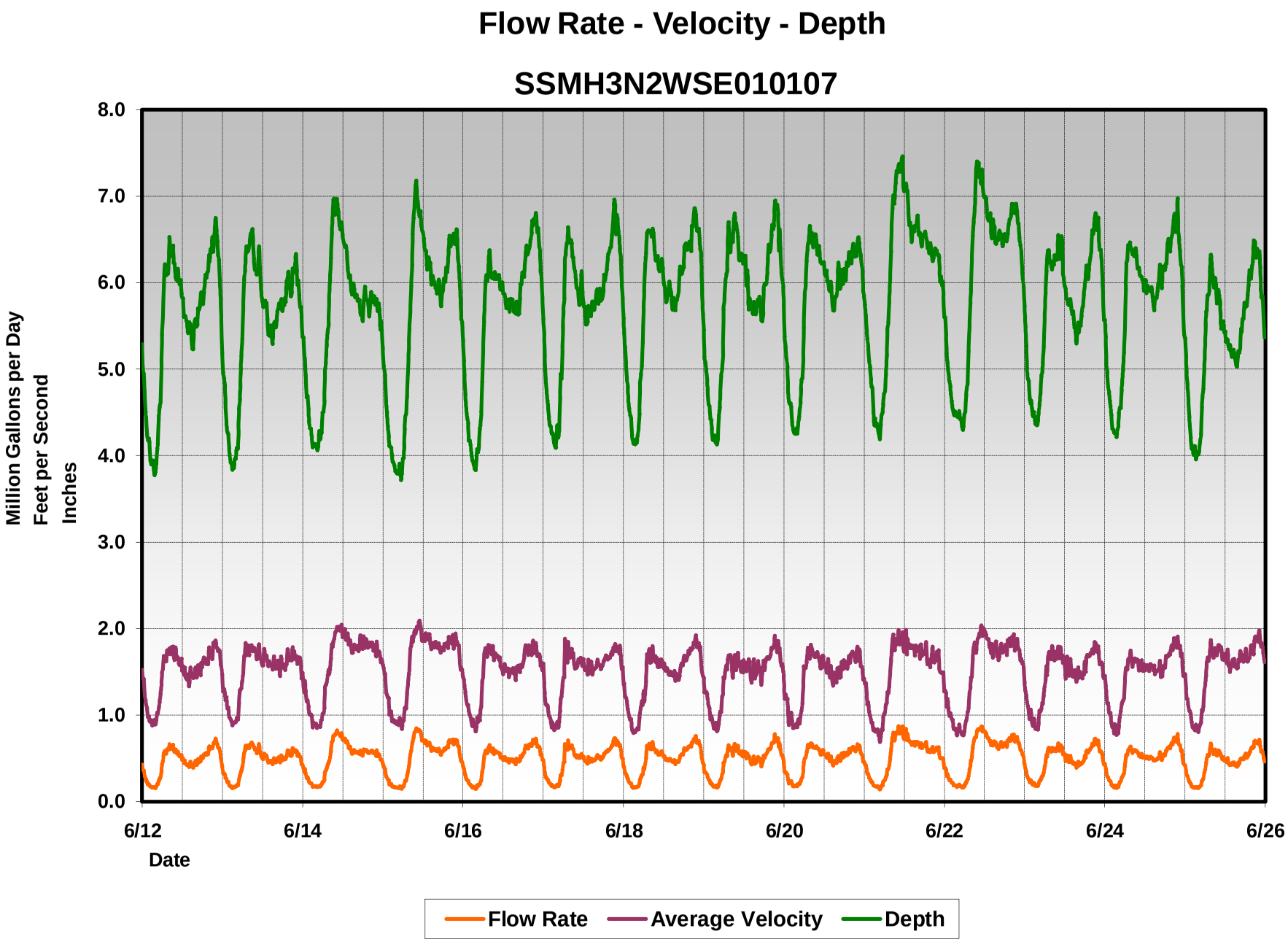
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	5.73
Maximum	7.46
Minimum	3.72
Max d/D	41.4%

Flow velocity	
	Feet per Second
Average	1.50
Maximum	2.09
Minimum	0.69

Flow Rate	
	Million Gallons per Day
Average	0.49
Maximum	0.87
Minimum	0.14
Peak Factor	1.78



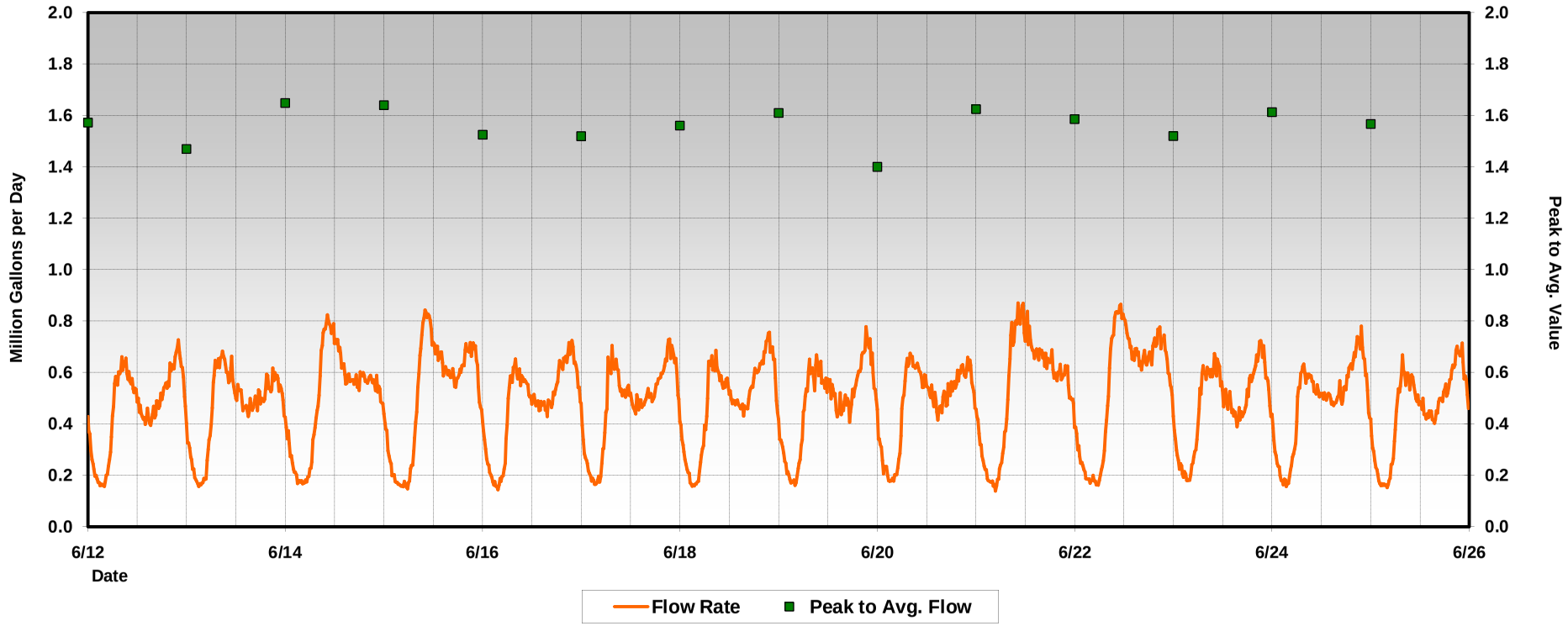

Flow Rate - Velocity - Depth
SSMH3N2WSE010107
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

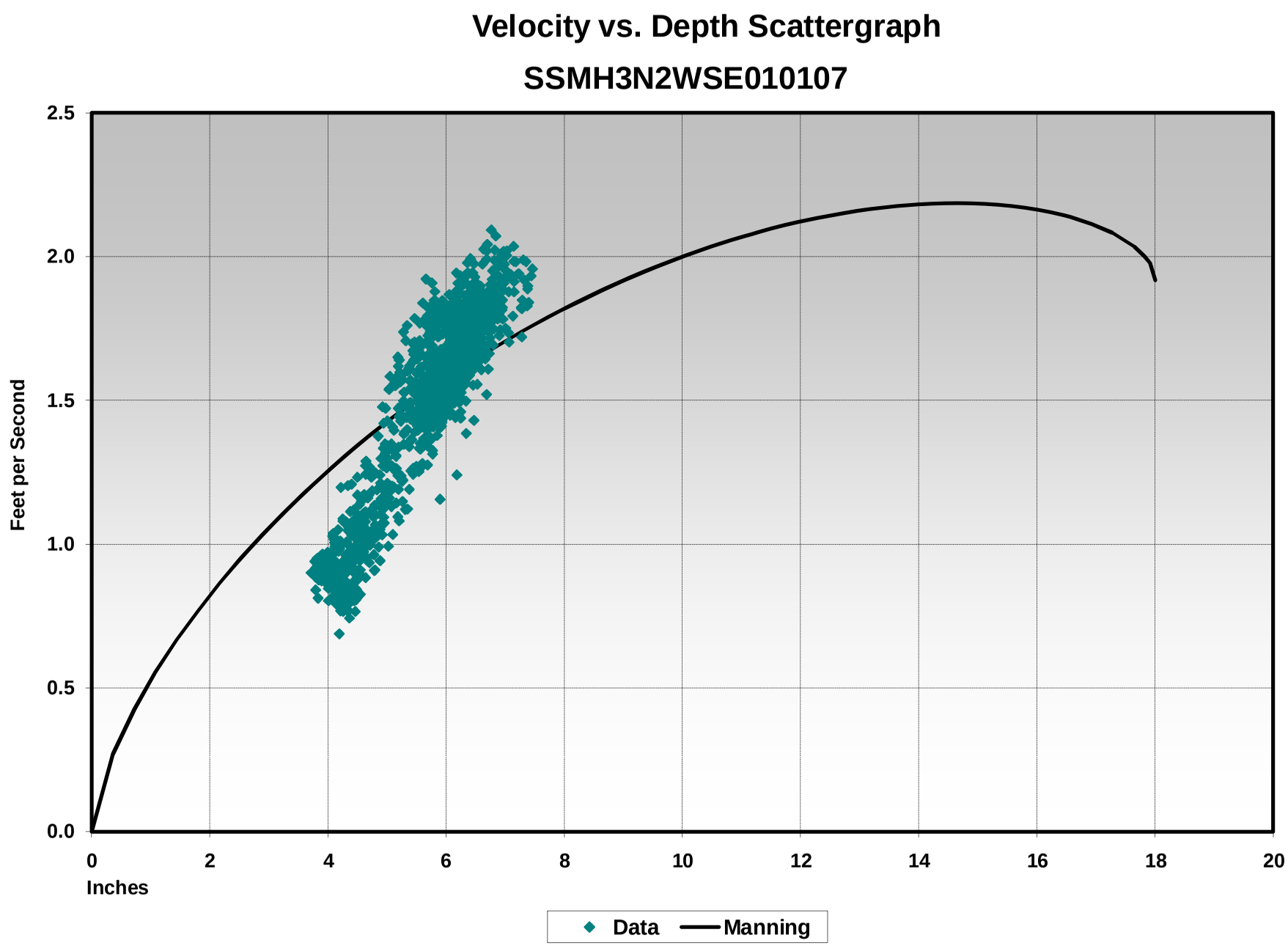
Peak to Average Flow Rate

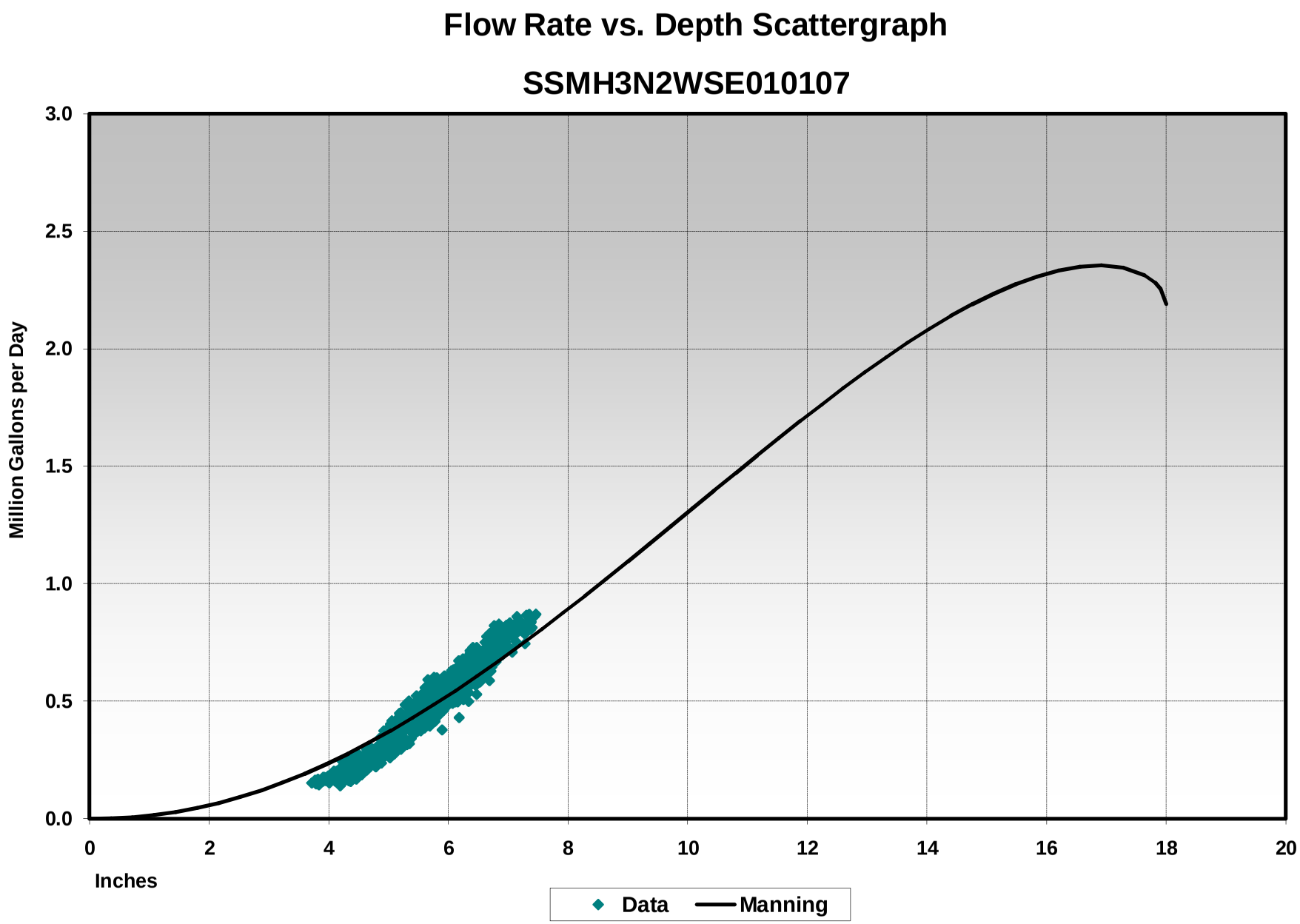
Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.57	1.47	1.65	1.64	1.52	1.52	1.56	1.61	1.40	1.62	1.59	1.52	1.61	1.57




Velocity vs. Depth Scattergraph
SSMH3N2WSE010107
Feet per Second
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N2WSE010107
Million Gallons per Day
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.36	0.34	0.38	0.40	0.36	0.37	0.36	0.36	0.36	0.42	0.36	0.36	0.36	0.34
1:00	0.23	0.24	0.28	0.27	0.24	0.25	0.25	0.27	0.25	0.29	0.27	0.25	0.25	0.23
2:00	0.18	0.18	0.21	0.19	0.18	0.19	0.19	0.20	0.21	0.22	0.21	0.21	0.18	0.17
3:00	0.16	0.16	0.17	0.17	0.16	0.17	0.16	0.17	0.18	0.18	0.18	0.19	0.17	0.16
4:00	0.18	0.18	0.17	0.16	0.18	0.19	0.18	0.19	0.20	0.16	0.18	0.22	0.21	0.17
5:00	0.28	0.31	0.19	0.16	0.25	0.30	0.29	0.29	0.28	0.19	0.17	0.30	0.30	0.27
6:00	0.51	0.50	0.26	0.20	0.51	0.55	0.43	0.49	0.51	0.27	0.21	0.48	0.50	0.46
7:00	0.58	0.63	0.40	0.32	0.60	0.63	0.64	0.59	0.63	0.41	0.33	0.60	0.61	0.58
8:00	0.63	0.65	0.56	0.56	0.60	0.63	0.63	0.59	0.65	0.69	0.57	0.60	0.58	0.58
9:00	0.61	0.64	0.75	0.76	0.58	0.56	0.60	0.63	0.63	0.76	0.76	0.59	0.58	0.57
10:00	0.58	0.59	0.80	0.83	0.57	0.51	0.56	0.60	0.60	0.81	0.83	0.64	0.53	0.56
11:00	0.53	0.58	0.77	0.78	0.52	0.53	0.56	0.55	0.57	0.83	0.84	0.59	0.53	0.49
12:00	0.48	0.52	0.72	0.70	0.50	0.49	0.50	0.55	0.54	0.77	0.79	0.51	0.51	0.48
13:00	0.43	0.50	0.67	0.67	0.47	0.47	0.49	0.53	0.50	0.72	0.72	0.49	0.51	0.43
14:00	0.43	0.46	0.60	0.63	0.47	0.48	0.47	0.44	0.47	0.68	0.67	0.45	0.49	0.44
15:00	0.41	0.46	0.58	0.61	0.46	0.48	0.46	0.47	0.46	0.67	0.67	0.42	0.48	0.41
16:00	0.45	0.48	0.57	0.59	0.48	0.52	0.47	0.49	0.51	0.66	0.64	0.44	0.52	0.47
17:00	0.48	0.50	0.56	0.56	0.51	0.50	0.54	0.45	0.52	0.65	0.65	0.45	0.51	0.50
18:00	0.52	0.49	0.58	0.60	0.59	0.55	0.60	0.53	0.55	0.65	0.66	0.55	0.58	0.53
19:00	0.55	0.55	0.58	0.64	0.63	0.59	0.62	0.59	0.57	0.58	0.71	0.59	0.63	0.57
20:00	0.62	0.53	0.58	0.69	0.66	0.63	0.66	0.66	0.61	0.60	0.75	0.65	0.69	0.64
21:00	0.66	0.59	0.57	0.70	0.70	0.70	0.74	0.73	0.60	0.60	0.72	0.70	0.73	0.68
22:00	0.67	0.56	0.55	0.67	0.65	0.68	0.68	0.68	0.64	0.57	0.65	0.63	0.65	0.65
23:00	0.54	0.49	0.50	0.49	0.54	0.56	0.54	0.54	0.52	0.49	0.55	0.50	0.50	0.53
Average	0.46	0.46	0.50	0.51	0.48	0.48	0.48	0.48	0.48	0.54	0.55	0.48	0.48	0.46
Median	0.49	0.50	0.56	0.59	0.51	0.51	0.51	0.52	0.53	0.60	0.65	0.50	0.52	0.49
Max Hr. Mean	0.67	0.65	0.80	0.83	0.70	0.70	0.74	0.73	0.65	0.83	0.84	0.70	0.73	0.68
Min Hr. Mean	0.16	0.16	0.17	0.16	0.16	0.17	0.16	0.17	0.18	0.16	0.17	0.19	0.17	0.16
Inst. Max	0.73	0.68	0.82	0.84	0.73	0.73	0.76	0.78	0.67	0.87	0.87	0.72	0.78	0.71
Inst. Min	0.16	0.16	0.17	0.15	0.14	0.17	0.16	0.16	0.18	0.14	0.16	0.18	0.16	0.15

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.40	1.32	1.38	1.52	1.36	1.34	1.28	1.31	1.27	1.35	1.23	1.25	1.30	1.29
1:00	1.09	1.14	1.17	1.23	1.11	1.07	1.06	1.15	1.04	1.07	1.07	1.04	1.05	1.05
2:00	0.94	0.96	1.01	1.00	0.94	0.92	0.89	0.95	0.94	0.90	0.93	0.94	0.85	0.87
3:00	0.90	0.90	0.89	0.93	0.88	0.86	0.81	0.87	0.87	0.82	0.82	0.87	0.84	0.85
4:00	0.97	0.94	0.88	0.90	0.94	0.90	0.87	0.89	0.91	0.77	0.83	0.96	0.92	0.87
5:00	1.20	1.26	0.90	0.91	1.12	1.20	1.10	1.13	1.13	0.85	0.79	1.14	1.16	1.12
6:00	1.60	1.57	1.11	1.01	1.65	1.62	1.26	1.49	1.57	1.08	0.90	1.44	1.50	1.51
7:00	1.69	1.76	1.43	1.29	1.74	1.69	1.70	1.63	1.71	1.33	1.17	1.69	1.68	1.72
8:00	1.74	1.76	1.62	1.75	1.74	1.71	1.67	1.58	1.77	1.78	1.58	1.72	1.62	1.72
9:00	1.71	1.75	1.87	1.91	1.71	1.61	1.65	1.62	1.68	1.81	1.81	1.68	1.64	1.75
10:00	1.70	1.70	1.99	2.02	1.67	1.59	1.60	1.64	1.67	1.86	1.92	1.75	1.55	1.79
11:00	1.61	1.68	2.02	1.99	1.57	1.62	1.60	1.55	1.61	1.90	1.98	1.66	1.57	1.67
12:00	1.52	1.64	1.95	1.90	1.54	1.57	1.54	1.58	1.56	1.84	1.93	1.57	1.54	1.69
13:00	1.44	1.64	1.89	1.90	1.50	1.55	1.50	1.61	1.52	1.82	1.83	1.55	1.55	1.56
14:00	1.44	1.60	1.81	1.83	1.50	1.53	1.48	1.43	1.45	1.79	1.75	1.47	1.55	1.61
15:00	1.45	1.57	1.77	1.82	1.48	1.53	1.46	1.51	1.45	1.75	1.79	1.45	1.50	1.56
16:00	1.51	1.57	1.77	1.80	1.54	1.60	1.43	1.56	1.51	1.73	1.70	1.48	1.53	1.67
17:00	1.53	1.59	1.81	1.75	1.55	1.56	1.57	1.48	1.55	1.74	1.76	1.45	1.51	1.66
18:00	1.62	1.56	1.82	1.79	1.70	1.65	1.66	1.60	1.60	1.72	1.76	1.61	1.65	1.68
19:00	1.62	1.66	1.83	1.83	1.74	1.66	1.70	1.66	1.60	1.60	1.85	1.69	1.71	1.70
20:00	1.74	1.64	1.82	1.86	1.76	1.70	1.77	1.76	1.71	1.68	1.88	1.74	1.81	1.78
21:00	1.79	1.71	1.78	1.88	1.81	1.78	1.87	1.82	1.66	1.65	1.80	1.80	1.86	1.88
22:00	1.79	1.64	1.74	1.82	1.71	1.76	1.79	1.77	1.73	1.62	1.73	1.67	1.77	1.88
23:00	1.66	1.58	1.66	1.55	1.59	1.64	1.59	1.58	1.51	1.49	1.60	1.52	1.56	1.73
Average	1.48	1.51	1.58	1.59	1.49	1.49	1.45	1.46	1.46	1.50	1.52	1.47	1.47	1.53
Median	1.56	1.60	1.77	1.78	1.56	1.58	1.53	1.55	1.55	1.64	1.73	1.54	1.55	1.64
Max Hr. Mean	1.79	1.76	2.02	2.02	1.81	1.78	1.87	1.82	1.77	1.90	1.98	1.80	1.86	1.88
Min Hr. Mean	0.90	0.90	0.88	0.90	0.88	0.86	0.81	0.87	0.87	0.77	0.79	0.87	0.84	0.85
Inst. Max	1.86	1.83	2.04	2.09	1.86	1.87	1.92	1.91	1.81	1.98	2.04	1.84	1.91	1.98
Inst. Min	0.88	0.88	0.85	0.84	0.81	0.83	0.79	0.81	0.85	0.69	0.77	0.83	0.77	0.80

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.99	4.96	5.26	5.05	5.02	5.26	5.34	5.17	5.37	5.66	5.45	5.38	5.24	5.08
1:00	4.34	4.38	4.71	4.42	4.38	4.60	4.72	4.70	4.76	5.18	4.92	4.75	4.68	4.41
2:00	4.05	3.98	4.31	4.07	4.07	4.30	4.33	4.33	4.46	4.75	4.59	4.54	4.34	4.07
3:00	3.87	3.89	4.11	3.89	3.88	4.15	4.16	4.18	4.27	4.38	4.47	4.38	4.26	4.03
4:00	3.98	4.05	4.10	3.80	4.05	4.28	4.29	4.34	4.40	4.26	4.46	4.55	4.49	4.12
5:00	4.66	4.83	4.25	3.81	4.50	4.92	5.03	4.95	4.87	4.48	4.35	5.05	4.95	4.75
6:00	5.80	5.80	4.65	4.18	5.62	6.02	6.03	5.90	5.89	4.89	4.62	5.96	5.97	5.62
7:00	6.12	6.35	5.33	4.84	6.13	6.52	6.59	6.41	6.50	5.70	5.33	6.30	6.42	6.06
8:00	6.37	6.51	6.17	5.82	6.16	6.43	6.58	6.48	6.49	6.71	6.35	6.20	6.35	6.06
9:00	6.32	6.38	6.88	6.82	6.09	6.16	6.39	6.72	6.51	7.09	7.12	6.28	6.30	5.89
10:00	6.07	6.14	6.89	7.00	6.07	5.87	6.22	6.43	6.36	7.32	7.31	6.42	6.13	5.75
11:00	5.98	6.11	6.66	6.72	5.96	5.92	6.21	6.30	6.23	7.34	7.16	6.29	6.01	5.49
12:00	5.72	5.76	6.47	6.46	5.85	5.68	5.92	6.20	6.14	7.09	6.95	5.88	5.97	5.36
13:00	5.53	5.62	6.26	6.25	5.76	5.63	5.89	5.92	5.97	6.82	6.75	5.77	5.92	5.25
14:00	5.49	5.42	5.98	6.13	5.76	5.70	5.82	5.69	5.85	6.58	6.63	5.64	5.81	5.19
15:00	5.35	5.44	5.91	6.01	5.69	5.75	5.77	5.68	5.80	6.65	6.51	5.41	5.84	5.09
16:00	5.57	5.61	5.83	5.95	5.71	5.86	5.92	5.78	6.03	6.62	6.54	5.50	6.10	5.29
17:00	5.78	5.77	5.69	5.84	5.98	5.84	6.14	5.63	6.03	6.50	6.49	5.73	6.09	5.59
18:00	5.86	5.75	5.79	6.00	6.17	6.03	6.37	5.97	6.13	6.53	6.52	6.10	6.25	5.76
19:00	6.10	5.99	5.77	6.23	6.38	6.28	6.41	6.30	6.26	6.40	6.68	6.19	6.45	6.06
20:00	6.33	5.91	5.77	6.49	6.56	6.49	6.52	6.56	6.33	6.32	6.87	6.55	6.64	6.35
21:00	6.49	6.16	5.80	6.49	6.72	6.79	6.80	6.86	6.33	6.37	6.86	6.73	6.77	6.37
22:00	6.54	6.12	5.75	6.43	6.60	6.65	6.58	6.67	6.45	6.23	6.58	6.51	6.43	6.17
23:00	5.91	5.72	5.54	5.73	6.10	6.12	6.07	6.13	6.14	5.97	6.12	5.93	5.79	5.66
Average	5.55	5.53	5.58	5.60	5.63	5.72	5.84	5.80	5.82	6.08	6.07	5.75	5.80	5.39
Median	5.77	5.75	5.77	5.99	5.88	5.83	6.11	5.98	6.09	6.39	6.50	5.86	6.03	5.47
Max Hr. Mean	6.54	6.51	6.89	7.00	6.72	6.79	6.80	6.86	6.51	7.34	7.31	6.73	6.77	6.37
Min Hr. Mean	3.87	3.89	4.10	3.80	3.88	4.15	4.16	4.18	4.27	4.26	4.35	4.38	4.26	4.03
Inst. Max	6.75	6.62	6.97	7.18	6.81	6.96	6.86	6.95	6.66	7.46	7.40	6.81	6.98	6.49
Inst. Min	3.78	3.84	4.06	3.72	3.83	4.09	4.13	4.13	4.25	4.19	4.30	4.35	4.21	3.96

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 15**	**Date:**	**6/10/2008**
Address:	**Waddell Road 1/4 mile off Hwy 303**	**GPS:**	**33.372801N -112.250286W**
MH ID#	**SSMH3N2WSE120003**		

Overview

Street Level

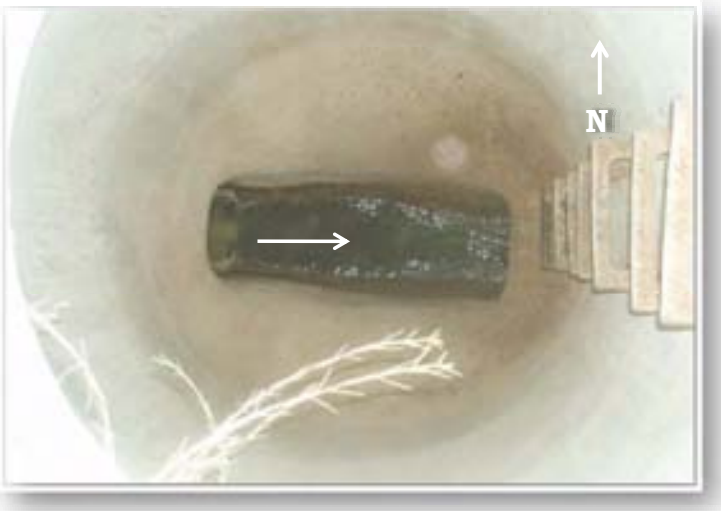
Meter Details

Meter Type	**2150**
Serial #	**204L00432**
Sensor Serial #	**203B00998**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**18"**	**Horiz.**	**18"**
Laterals	**0**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole



Hydraulics:

Moderate to fast flow conditions

Comments:

Photos
MH #SSMH3N2WSE120003
Site #15

Site ID

Down Manhole

18” Influent

18” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

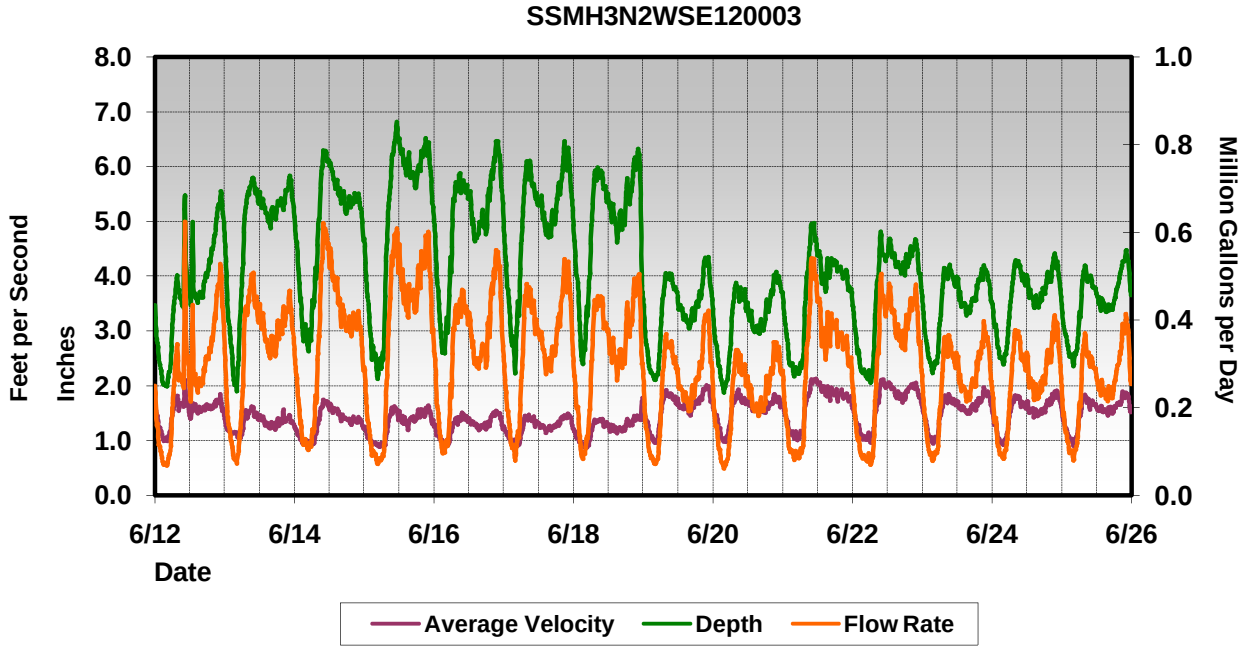
Site	**SSMH3N2WSE120003**	
Address	**Waddell Rd 1/4 mile from Hwy 303**	
Diameter	**18**	Inches
GPS	**33.372801N -112.250286W**	

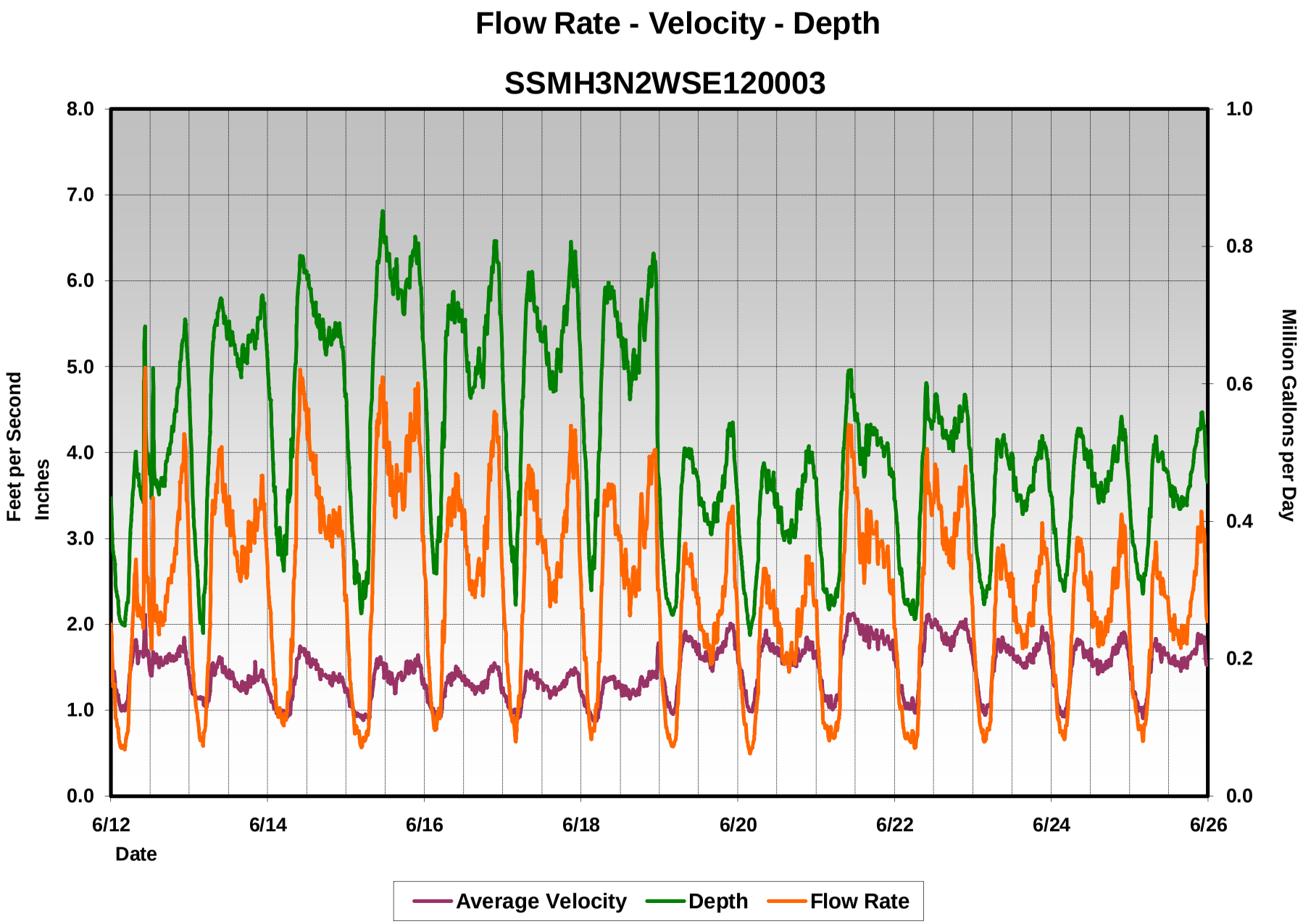
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.13
Maximum	6.81
Minimum	1.88
Max d/D	37.8%

Flow velocity	
	Feet per Second
Average	1.45
Maximum	2.12
Minimum	0.88

Flow Rate	
	Million Gallons per Day
Average	0.30
Maximum	0.62
Minimum	0.06
Peak Factor	2.09



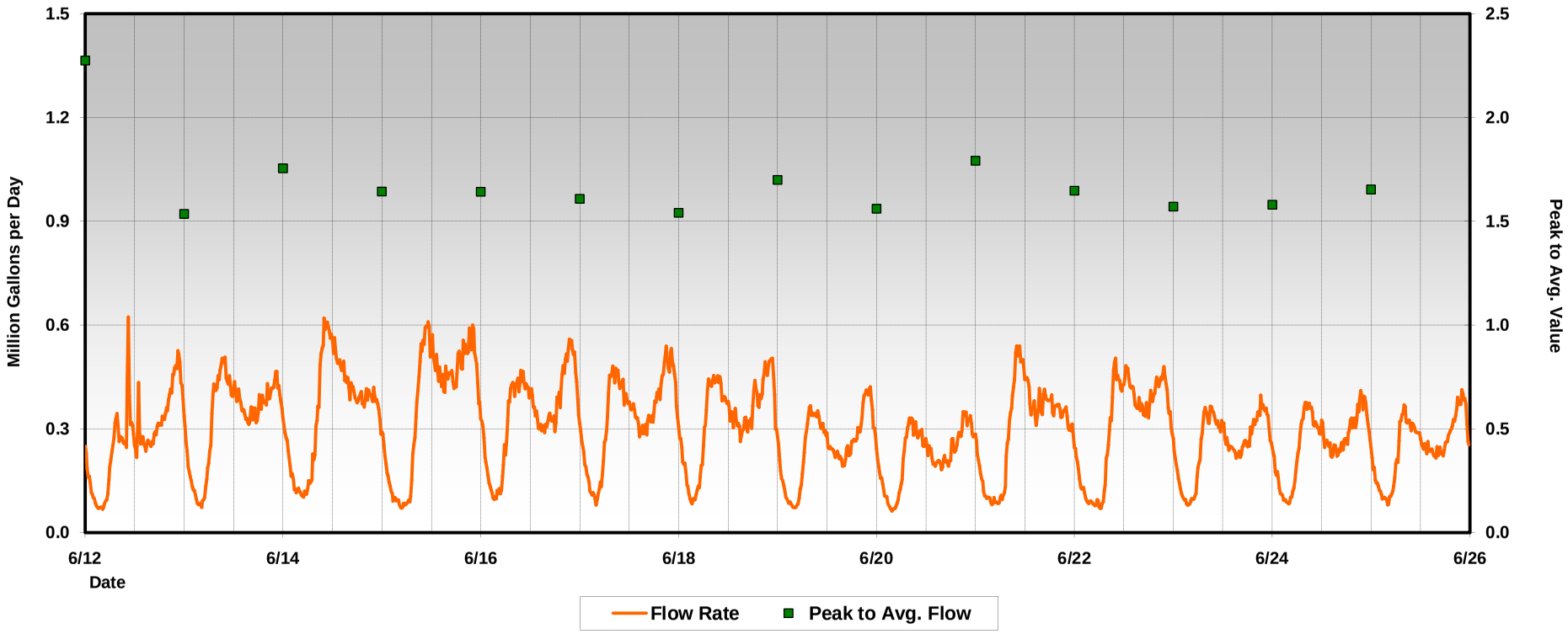

Flow Rate - Velocity - Depth
SSMH3N2WSE120003
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Feet per Second
Inches
1.0
0.8
0.6
0.4
0.2
0.0
Million Gallons per Day
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

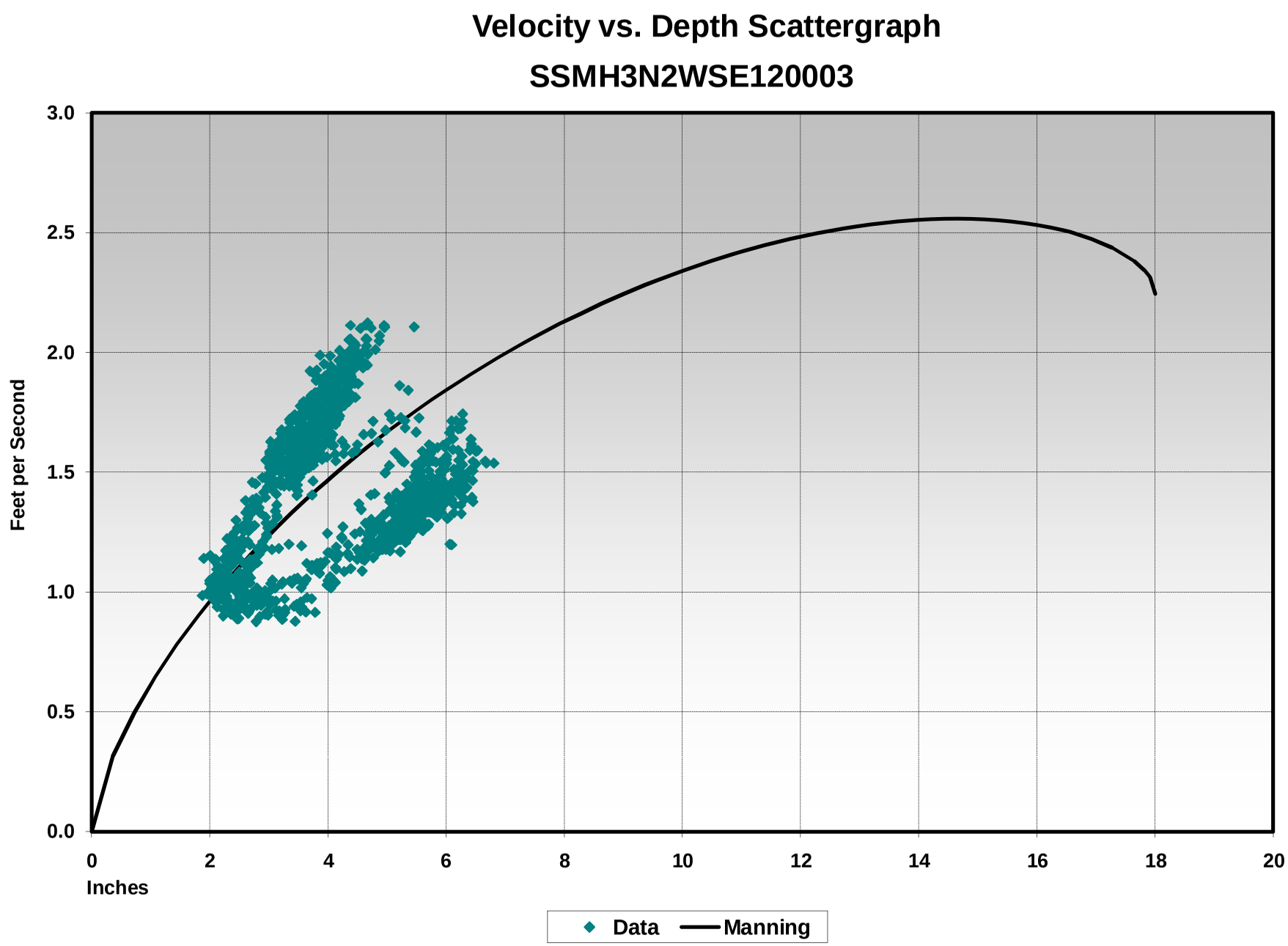
Peak to Average Flow Rate

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

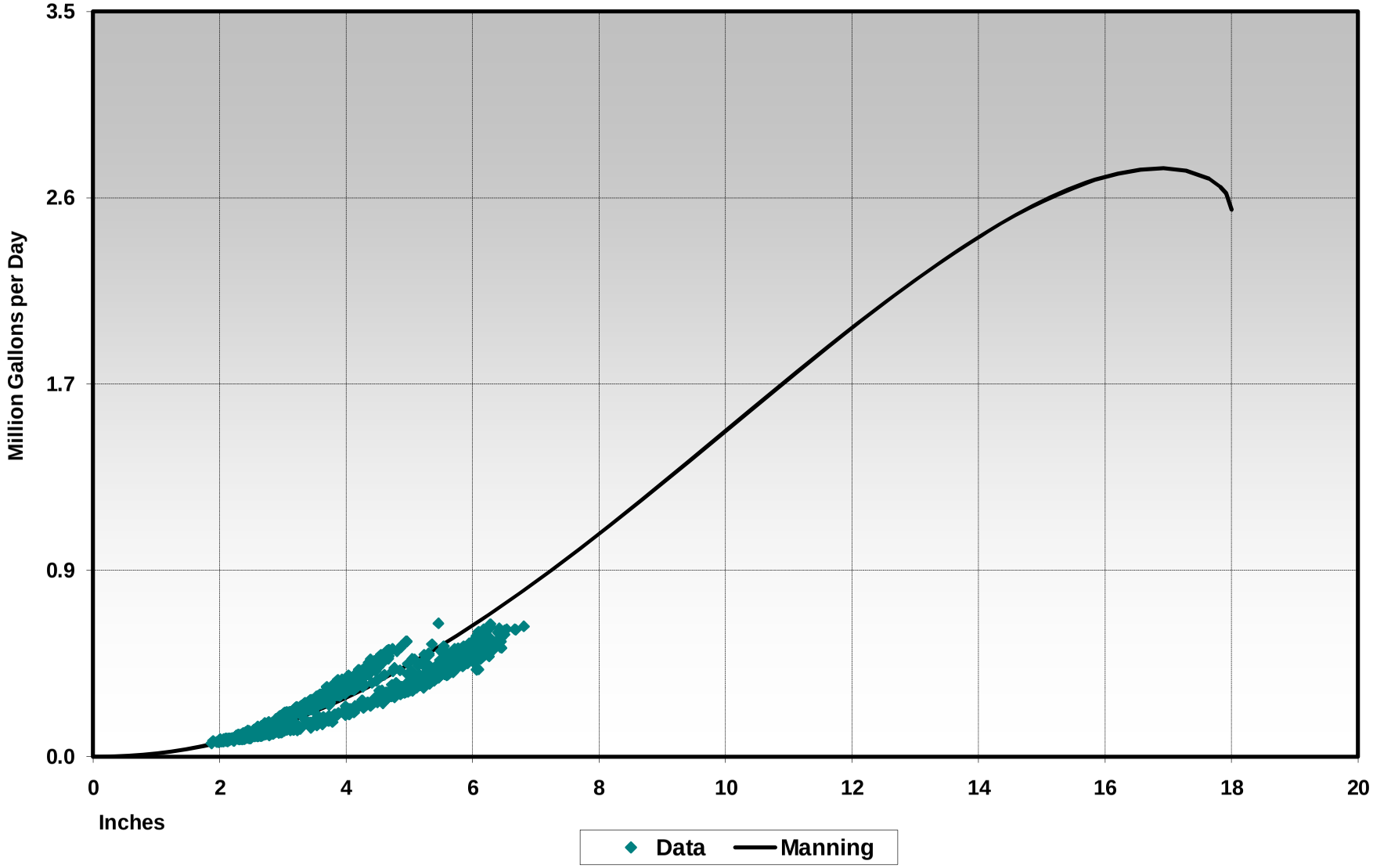
Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	2.27	1.54	1.75	1.64	1.64	1.61	1.54	1.70	1.56	1.79	1.65	1.57	1.58	1.65




Velocity vs. Depth Scattergraph
SSMH3N2WSE120003
Feet per Second
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning

Flow Rate vs. Depth Scattergraph

SSMH3N2WSE120003



Flow Rate - Tabular Output

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.21	0.29	0.30	0.26	0.31	0.28	0.27	0.23	0.21	0.25	0.23	0.23	0.22	0.21
1:00	0.13	0.17	0.23	0.17	0.19	0.20	0.19	0.14	0.14	0.17	0.15	0.15	0.16	0.14
2:00	0.09	0.12	0.15	0.11	0.13	0.14	0.12	0.09	0.10	0.11	0.12	0.10	0.11	0.11
3:00	0.07	0.09	0.12	0.10	0.10	0.11	0.09	0.08	0.07	0.10	0.09	0.08	0.09	0.10
4:00	0.07	0.09	0.11	0.08	0.12	0.10	0.12	0.08	0.07	0.09	0.09	0.09	0.09	0.09
5:00	0.11	0.14	0.11	0.08	0.18	0.16	0.17	0.11	0.10	0.09	0.09	0.12	0.14	0.13
6:00	0.22	0.26	0.14	0.09	0.30	0.29	0.30	0.22	0.19	0.10	0.08	0.22	0.24	0.22
7:00	0.32	0.41	0.20	0.18	0.41	0.44	0.43	0.33	0.29	0.18	0.14	0.33	0.33	0.33
8:00	0.28	0.45	0.34	0.35	0.42	0.46	0.44	0.35	0.33	0.33	0.28	0.33	0.37	0.34
9:00	0.26	0.50	0.52	0.50	0.44	0.45	0.44	0.34	0.30	0.44	0.42	0.36	0.36	0.31
10:00	0.43	0.46	0.60	0.57	0.44	0.42	0.41	0.32	0.28	0.53	0.46	0.32	0.31	0.31
11:00	0.31	0.42	0.58	0.58	0.42	0.38	0.38	0.30	0.26	0.49	0.42	0.31	0.29	0.29
12:00	0.26	0.40	0.54	0.52	0.40	0.36	0.35	0.26	0.25	0.44	0.46	0.29	0.29	0.25
13:00	0.31	0.39	0.50	0.47	0.34	0.35	0.34	0.24	0.22	0.37	0.44	0.25	0.26	0.25
14:00	0.25	0.35	0.48	0.45	0.30	0.30	0.31	0.23	0.20	0.35	0.40	0.24	0.23	0.24
15:00	0.26	0.32	0.44	0.44	0.30	0.30	0.28	0.21	0.20	0.37	0.37	0.22	0.24	0.22
16:00	0.26	0.34	0.41	0.46	0.33	0.31	0.31	0.21	0.21	0.38	0.36	0.23	0.24	0.24
17:00	0.30	0.33	0.40	0.44	0.33	0.33	0.32	0.23	0.20	0.39	0.36	0.26	0.26	0.23
18:00	0.32	0.37	0.39	0.48	0.34	0.38	0.41	0.27	0.25	0.38	0.38	0.27	0.28	0.27
19:00	0.34	0.38	0.38	0.50	0.41	0.41	0.38	0.28	0.25	0.36	0.40	0.31	0.32	0.30
20:00	0.39	0.39	0.40	0.53	0.49	0.48	0.42	0.33	0.29	0.36	0.44	0.34	0.33	0.34
21:00	0.45	0.42	0.39	0.56	0.53	0.49	0.48	0.40	0.35	0.35	0.46	0.37	0.38	0.38
22:00	0.50	0.45	0.39	0.55	0.53	0.51	0.50	0.40	0.32	0.32	0.41	0.35	0.38	0.40
23:00	0.43	0.39	0.34	0.42	0.41	0.40	0.36	0.31	0.29	0.30	0.32	0.29	0.30	0.30
Average	0.27	0.33	0.35	0.37	0.34	0.34	0.33	0.25	0.22	0.30	0.31	0.25	0.26	0.25
Median	0.27	0.37	0.38	0.45	0.35	0.35	0.34	0.25	0.24	0.34	0.36	0.26	0.27	0.25
Max Hr. Mean	0.50	0.50	0.60	0.58	0.53	0.51	0.50	0.40	0.35	0.53	0.46	0.37	0.38	0.40
Min Hr. Mean	0.07	0.09	0.11	0.08	0.10	0.10	0.09	0.08	0.07	0.09	0.08	0.08	0.09	0.09
Inst. Max	0.62	0.51	0.62	0.61	0.56	0.54	0.50	0.42	0.35	0.54	0.50	0.40	0.41	0.41
Inst. Min	0.07	0.07	0.10	0.07	0.10	0.08	0.08	0.07	0.06	0.08	0.07	0.08	0.08	0.08

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.53	1.32	1.22	1.22	1.27	1.20	1.17	1.58	1.54	1.60	1.56	1.53	1.47	1.47
1:00	1.31	1.19	1.11	1.07	1.09	1.10	1.07	1.33	1.38	1.39	1.32	1.32	1.25	1.20
2:00	1.13	1.14	1.02	1.00	1.02	1.01	0.98	1.11	1.17	1.16	1.20	1.06	1.02	1.07
3:00	1.02	1.14	0.99	0.94	0.95	0.99	0.91	1.02	1.02	1.12	1.06	0.99	0.95	1.02
4:00	1.03	1.10	0.97	0.93	0.93	0.92	0.90	0.98	1.01	1.07	1.05	1.02	0.97	0.97
5:00	1.21	1.06	0.96	0.90	1.03	0.97	0.97	1.19	1.18	1.04	1.08	1.13	1.20	1.16
6:00	1.54	1.23	0.94	0.93	1.22	1.18	1.18	1.56	1.48	1.14	1.00	1.48	1.54	1.48
7:00	1.77	1.48	1.10	1.01	1.37	1.40	1.35	1.82	1.73	1.40	1.28	1.73	1.74	1.76
8:00	1.64	1.49	1.35	1.30	1.36	1.42	1.35	1.85	1.86	1.75	1.63	1.73	1.80	1.77
9:00	1.67	1.58	1.60	1.53	1.43	1.38	1.37	1.83	1.78	1.94	1.89	1.79	1.77	1.68
10:00	1.85	1.48	1.71	1.58	1.42	1.37	1.32	1.77	1.73	2.09	2.08	1.71	1.65	1.69
11:00	1.64	1.43	1.68	1.50	1.38	1.33	1.30	1.71	1.70	2.11	2.00	1.69	1.63	1.65
12:00	1.45	1.41	1.62	1.44	1.35	1.29	1.24	1.66	1.70	2.04	2.01	1.65	1.62	1.57
13:00	1.59	1.39	1.55	1.36	1.33	1.27	1.24	1.60	1.61	1.95	1.97	1.60	1.55	1.59
14:00	1.57	1.30	1.56	1.36	1.28	1.20	1.21	1.63	1.57	1.92	1.89	1.57	1.47	1.54
15:00	1.56	1.24	1.49	1.28	1.23	1.21	1.18	1.57	1.56	1.90	1.83	1.52	1.51	1.51
16:00	1.56	1.29	1.42	1.42	1.25	1.23	1.21	1.54	1.57	1.88	1.80	1.54	1.51	1.55
17:00	1.61	1.25	1.41	1.38	1.28	1.25	1.21	1.64	1.55	1.88	1.79	1.61	1.55	1.52
18:00	1.61	1.31	1.38	1.48	1.27	1.31	1.34	1.70	1.63	1.86	1.84	1.61	1.59	1.62
19:00	1.60	1.34	1.34	1.49	1.35	1.33	1.31	1.75	1.63	1.81	1.94	1.70	1.69	1.66
20:00	1.66	1.40	1.39	1.49	1.48	1.42	1.33	1.82	1.69	1.85	1.99	1.75	1.75	1.71
21:00	1.70	1.38	1.36	1.54	1.51	1.43	1.41	1.95	1.82	1.80	2.00	1.89	1.83	1.82
22:00	1.74	1.42	1.38	1.57	1.49	1.46	1.42	1.96	1.74	1.78	1.91	1.86	1.86	1.83
23:00	1.57	1.33	1.29	1.39	1.33	1.33	1.56	1.79	1.66	1.73	1.75	1.72	1.71	1.62
Average	1.52	1.32	1.33	1.30	1.28	1.25	1.23	1.60	1.55	1.68	1.66	1.55	1.53	1.52
Median	1.58	1.32	1.37	1.37	1.30	1.27	1.26	1.66	1.62	1.81	1.82	1.62	1.57	1.58
Max Hr. Mean	1.85	1.58	1.71	1.58	1.51	1.46	1.56	1.96	1.86	2.11	2.08	1.89	1.86	1.83
Min Hr. Mean	1.02	1.06	0.94	0.90	0.93	0.92	0.90	0.98	1.01	1.04	1.00	0.99	0.95	0.97
Inst. Max	2.11	1.62	1.74	1.64	1.55	1.49	1.78	2.01	1.92	2.12	2.11	1.97	1.91	1.89
Inst. Min	0.99	1.04	0.92	0.89	0.91	0.90	0.88	0.96	0.98	1.01	0.97	0.95	0.93	0.91

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.13	4.38	4.84	4.37	4.78	4.62	4.64	3.29	3.13	3.44	3.34	3.38	3.37	3.26
1:00	2.59	3.28	4.25	3.54	3.81	3.84	3.89	2.66	2.64	2.91	2.79	2.82	2.99	2.90
2:00	2.20	2.69	3.40	2.82	3.02	3.12	2.96	2.30	2.29	2.44	2.51	2.50	2.63	2.64
3:00	2.01	2.12	2.97	2.63	2.66	2.70	2.58	2.18	1.99	2.33	2.26	2.31	2.48	2.52
4:00	2.06	2.17	2.83	2.31	3.04	2.76	3.07	2.14	2.01	2.26	2.23	2.39	2.49	2.48
5:00	2.41	3.14	2.84	2.38	3.78	3.67	3.78	2.43	2.34	2.25	2.20	2.63	2.90	2.78
6:00	3.29	4.27	3.41	2.48	4.76	4.82	4.96	3.25	2.99	2.39	2.11	3.33	3.49	3.36
7:00	3.85	5.27	3.92	3.81	5.58	5.75	5.81	3.86	3.69	2.99	2.68	4.01	4.02	4.00
8:00	3.72	5.53	4.88	5.10	5.67	5.92	5.87	3.98	3.80	3.94	3.70	4.02	4.23	4.07
9:00	3.52	5.73	5.87	5.95	5.67	5.89	5.86	3.99	3.64	4.58	4.46	4.15	4.21	3.95
10:00	4.63	5.65	6.24	6.37	5.66	5.62	5.71	3.84	3.62	4.94	4.48	4.01	4.01	3.88
11:00	3.97	5.45	6.14	6.66	5.56	5.40	5.49	3.75	3.49	4.63	4.33	3.87	3.88	3.79
12:00	3.78	5.39	6.03	6.37	5.45	5.34	5.35	3.48	3.35	4.41	4.54	3.80	3.83	3.59
13:00	4.04	5.34	5.83	6.18	5.00	5.20	5.16	3.38	3.22	4.03	4.49	3.54	3.68	3.51
14:00	3.59	5.16	5.69	5.99	4.69	4.91	5.00	3.23	3.03	3.88	4.35	3.49	3.50	3.49
15:00	3.67	5.00	5.52	6.09	4.82	4.82	4.76	3.14	3.04	4.10	4.20	3.37	3.56	3.36
16:00	3.69	5.10	5.45	5.86	5.03	4.94	5.03	3.19	3.10	4.16	4.14	3.40	3.54	3.44
17:00	3.96	5.10	5.35	5.75	4.97	5.02	5.02	3.27	3.07	4.23	4.16	3.57	3.68	3.43
18:00	4.13	5.30	5.27	5.87	5.15	5.40	5.61	3.49	3.43	4.21	4.23	3.63	3.76	3.63
19:00	4.36	5.37	5.34	6.05	5.61	5.64	5.46	3.58	3.45	4.14	4.27	3.88	3.97	3.86
20:00	4.65	5.29	5.40	6.27	5.96	6.02	5.77	3.85	3.72	4.05	4.45	4.06	4.02	4.11
21:00	5.05	5.57	5.41	6.36	6.30	6.16	6.05	4.27	4.02	4.05	4.58	4.07	4.31	4.27
22:00	5.38	5.77	5.37	6.24	6.29	6.17	6.24	4.26	3.96	3.89	4.39	4.02	4.21	4.40
23:00	5.23	5.47	5.00	5.56	5.62	5.51	4.72	3.76	3.79	3.75	3.91	3.69	3.81	3.93
Average	3.70	4.73	4.88	5.04	4.95	4.97	4.95	3.36	3.20	3.67	3.70	3.50	3.61	3.53
Median	3.71	5.25	5.32	5.87	5.17	5.23	5.23	3.44	3.34	3.97	4.16	3.58	3.72	3.58
Max Hr. Mean	5.38	5.77	6.24	6.66	6.30	6.17	6.24	4.27	4.02	4.94	4.58	4.15	4.31	4.40
Min Hr. Mean	2.01	2.12	2.83	2.31	2.66	2.70	2.58	2.14	1.99	2.25	2.11	2.31	2.48	2.48
Inst. Max	5.55	5.83	6.29	6.81	6.46	6.45	6.32	4.35	4.07	4.96	4.81	4.20	4.41	4.47
Inst. Min	1.99	1.90	2.63	2.13	2.59	2.23	2.40	2.11	1.88	2.17	2.06	2.23	2.39	2.36

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 16**	**Date:**	**6/9/2008**
Address:	**163rd Avenue near Desert Oasis**	**GPS:**	**33.430391N -112.244448W**
MH ID#	**SSMH4N2WSE010020**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**202C00856**
Sensor Serial #	**204K02274**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**24"**	**Horiz.**	**24"**
Laterals	**0**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole

Hydraulics:
Low flow conditions.

Comments:
Good monitoring site

Photos
MH #SSMH4N2WSE010020
Site #16

Site ID

Down Manhole

24” Influent

24” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

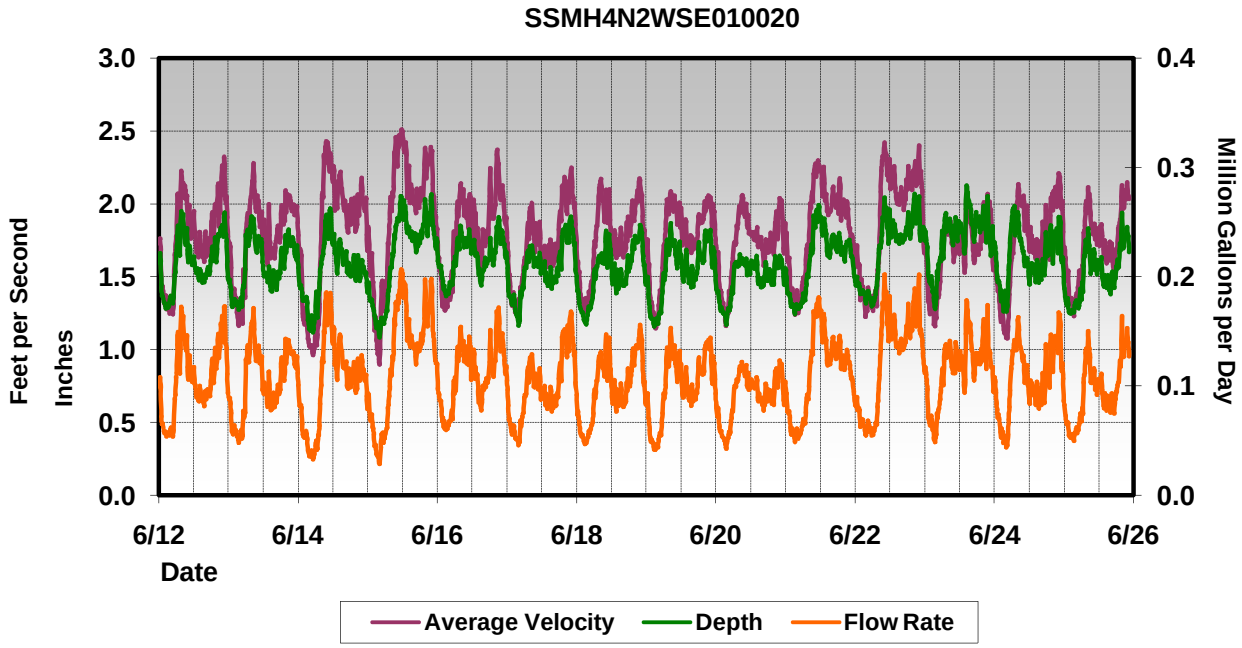
Site	**SSMH4N2WSE010020**
Address	**163rd Ave S of Desert Oasis Blvd**
Diameter	**24** Inches
GPS	**33.430391N -112.244448W**

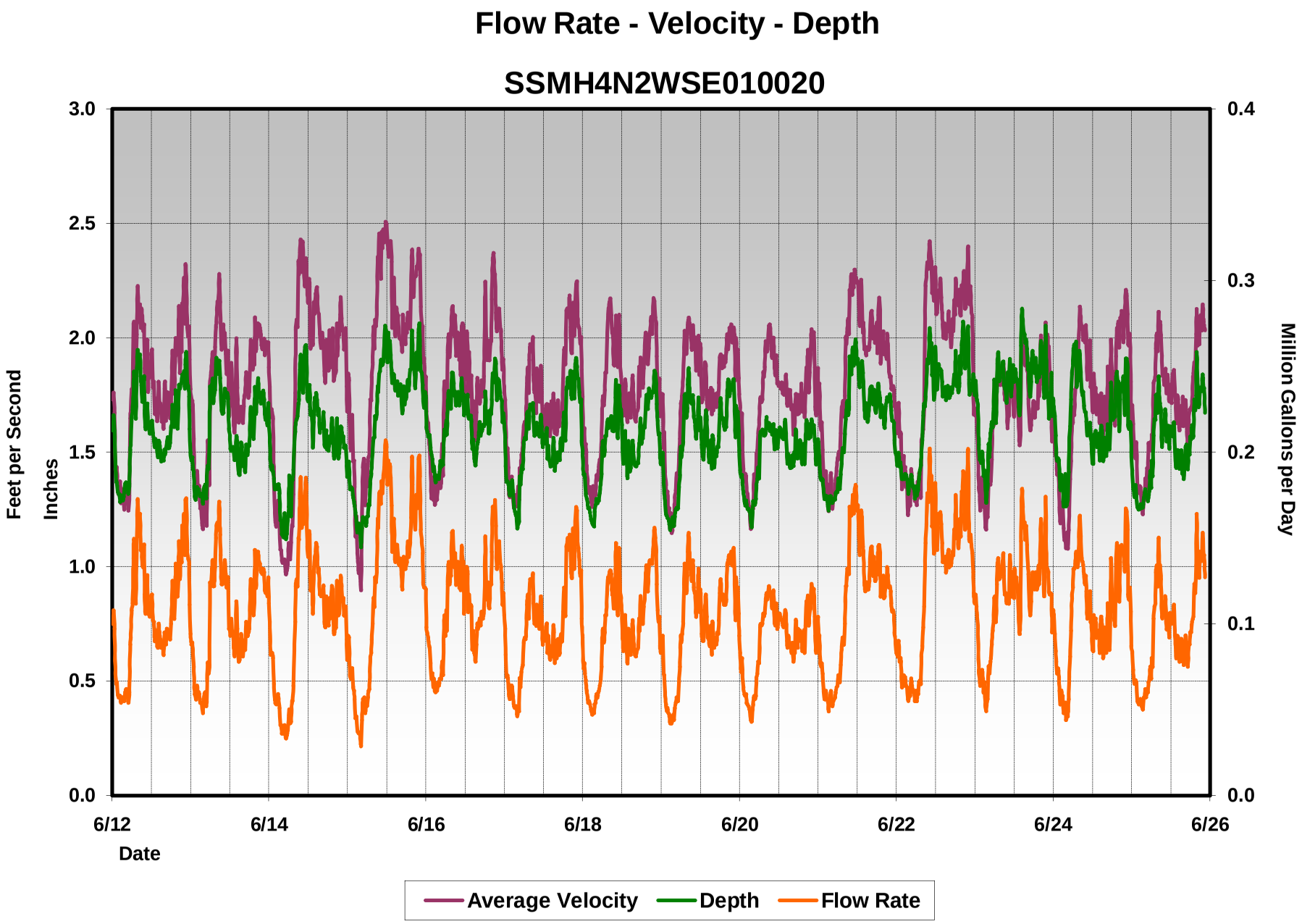
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	1.60
Maximum	2.12
Minimum	1.09
Max d/D	8.8%

Flow velocity	
	Feet per Second
Average	1.78
Maximum	2.51
Minimum	0.90

Flow Rate	
	Million Gallons per Day
Average	0.11
Maximum	0.21
Minimum	0.03
Peak Factor	1.94



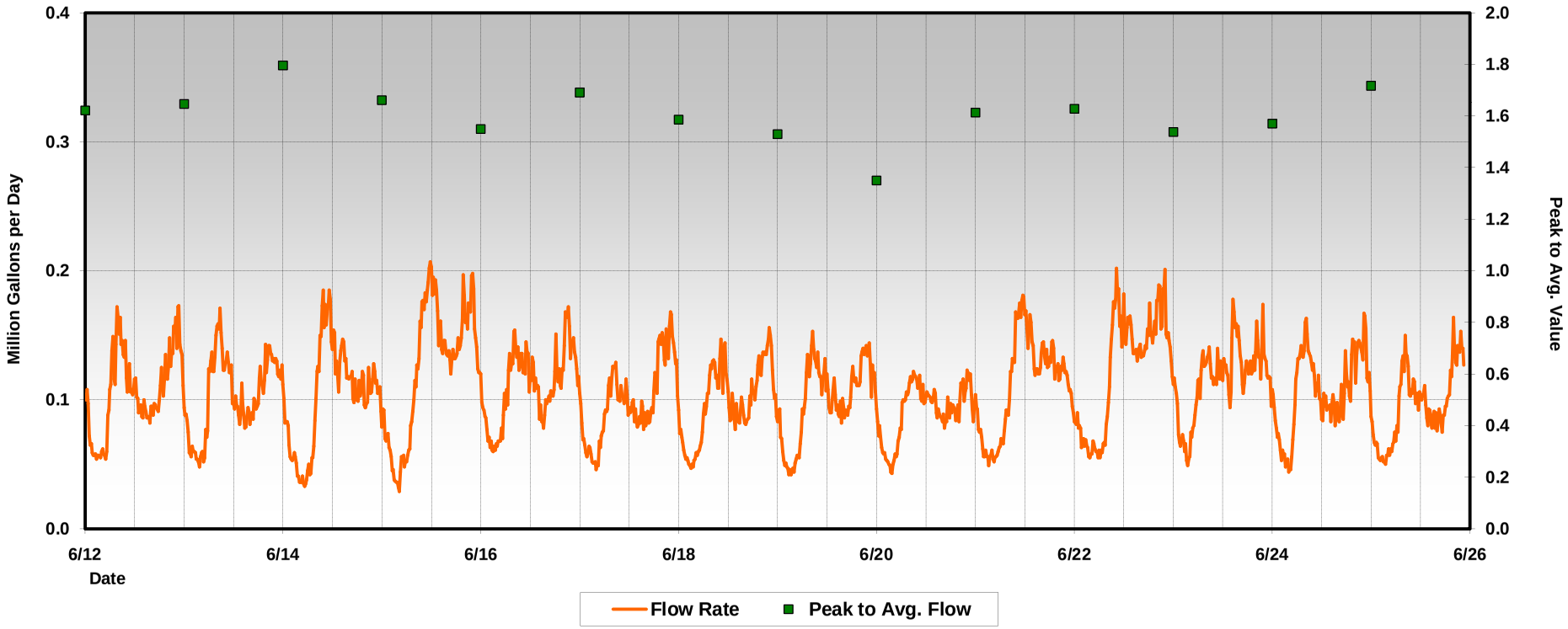

Flow Rate - Velocity - Depth
SSMH4N2WSE010020
Feet per Second
Inches
Million Gallons per Day
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.4
0.3
0.2
0.1
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

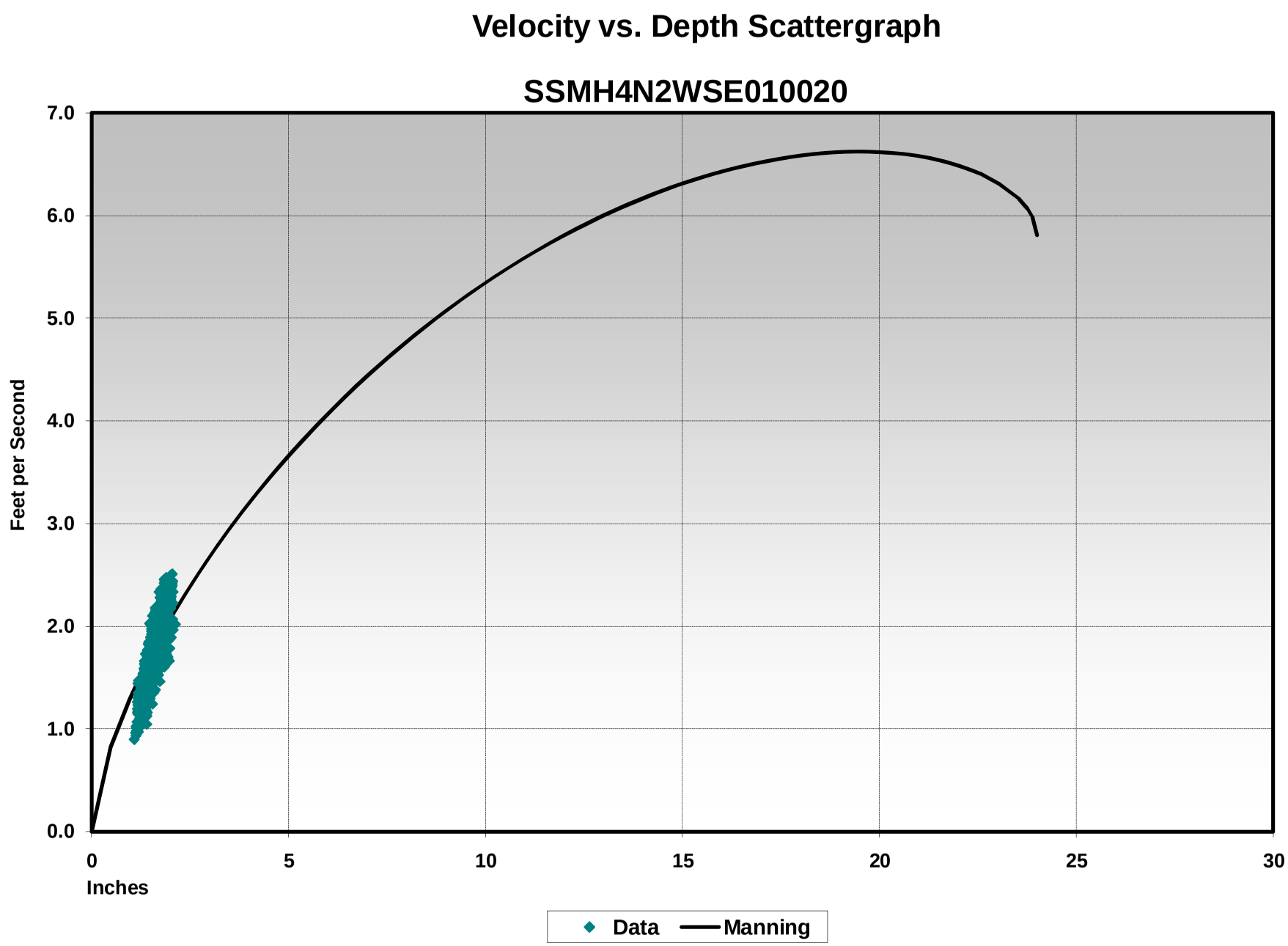
Peak to Average Flow Rate

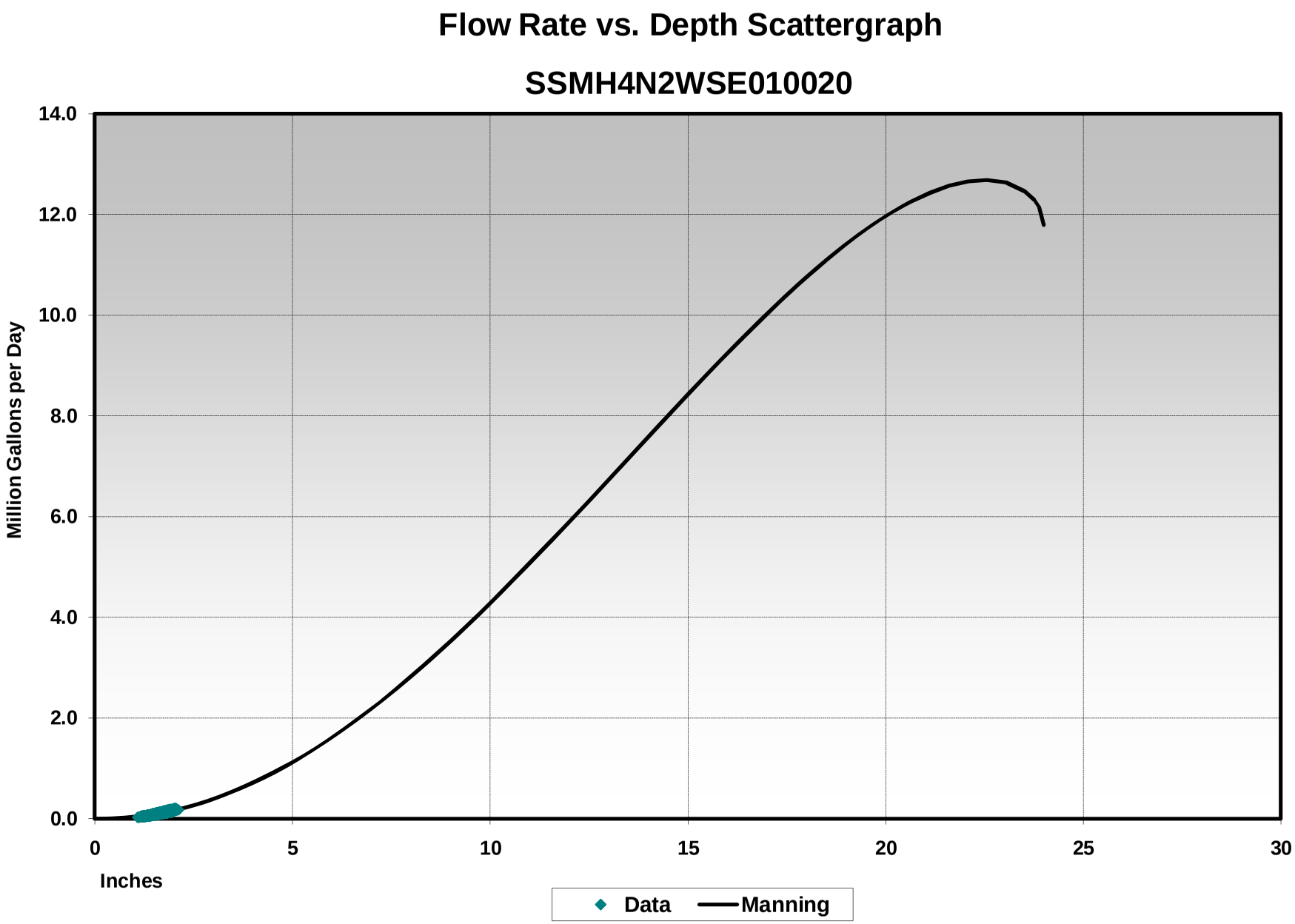
Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.62	1.65	1.80	1.66	1.55	1.69	1.59	1.53	1.35	1.61	1.63	1.54	1.57	1.73




Velocity vs. Depth Scattergraph
SSMH4N2WSE010020
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Feet per Second
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH4N2WSE010020
Million Gallons per Day
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.10	0.09	0.09	0.08	0.10	0.09	0.08	0.08	0.08	0.09	0.08	0.11	0.10	0.08
1:00	0.07	0.06	0.07	0.07	0.08	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.07	0.06
2:00	0.06	0.06	0.06	0.05	0.07	0.06	0.05	0.05	0.05	0.06	0.07	0.07	0.06	0.05
3:00	0.06	0.05	0.05	0.04	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05
4:00	0.06	0.06	0.04	0.04	0.07	0.05	0.06	0.05	0.05	0.06	0.06	0.07	0.05	0.06
5:00	0.07	0.07	0.04	0.05	0.09	0.07	0.07	0.06	0.07	0.06	0.06	0.09	0.09	0.07
6:00	0.13	0.13	0.05	0.06	0.11	0.09	0.09	0.09	0.09	0.07	0.06	0.11	0.13	0.08
7:00	0.14	0.13	0.06	0.09	0.13	0.11	0.11	0.13	0.10	0.09	0.07	0.13	0.14	0.12
8:00	0.16	0.16	0.12	0.12	0.15	0.13	0.13	0.14	0.12	0.11	0.11	0.13	0.15	0.14
9:00	0.14	0.13	0.16	0.16	0.13	0.10	0.11	0.13	0.12	0.14	0.16	0.12	0.13	0.11
10:00	0.12	0.13	0.16	0.18	0.13	0.10	0.13	0.12	0.11	0.17	0.19	0.12	0.12	0.11
11:00	0.11	0.12	0.17	0.20	0.13	0.10	0.13	0.12	0.10	0.18	0.15	0.12	0.11	0.10
12:00	0.11	0.10	0.14	0.19	0.12	0.09	0.09	0.10	0.10	0.16	0.16	0.13	0.09	0.10
13:00	0.09	0.09	0.12	0.17	0.11	0.09	0.09	0.10	0.10	0.16	0.16	0.11	0.10	0.09
14:00	0.09	0.09	0.14	0.15	0.09	0.08	0.09	0.10	0.10	0.13	0.14	0.15	0.10	0.09
15:00	0.09	0.09	0.12	0.14	0.09	0.09	0.09	0.09	0.09	0.12	0.14	0.16	0.09	0.09
16:00	0.09	0.09	0.12	0.13	0.10	0.08	0.08	0.09	0.08	0.14	0.14	0.13	0.09	0.09
17:00	0.09	0.10	0.10	0.13	0.11	0.09	0.10	0.09	0.09	0.13	0.14	0.12	0.11	0.08
18:00	0.11	0.11	0.11	0.14	0.13	0.11	0.11	0.12	0.09	0.14	0.16	0.13	0.11	0.10
19:00	0.12	0.12	0.11	0.16	0.12	0.15	0.12	0.11	0.09	0.13	0.15	0.12	0.13	0.12
20:00	0.13	0.13	0.10	0.17	0.15	0.14	0.13	0.13	0.10	0.12	0.18	0.14	0.13	0.14
21:00	0.15	0.13	0.11	0.18	0.16	0.15	0.14	0.14	0.11	0.13	0.17	0.14	0.14	0.14
22:00	0.16	0.13	0.12	0.17	0.14	0.16	0.14	0.13	0.12	0.12	0.16	0.13	0.15	0.10
23:00	0.13	0.12	0.10	0.13	0.12	0.12	0.10	0.12	0.09	0.10	0.13	0.11	0.11	0.10
Average	0.11	0.10	0.10	0.12	0.11	0.10	0.10	0.10	0.09	0.11	0.12	0.12	0.11	0.09
Median	0.11	0.10	0.11	0.14	0.11	0.10	0.10	0.10	0.10	0.12	0.14	0.12	0.11	0.09
Max Hr. Mean	0.16	0.16	0.17	0.20	0.16	0.16	0.14	0.14	0.12	0.18	0.19	0.16	0.15	0.14
Min Hr. Mean	0.06	0.05	0.04	0.04	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05
Inst. Max	0.17	0.17	0.19	0.21	0.17	0.17	0.16	0.15	0.12	0.18	0.20	0.18	0.17	0.16
Inst. Min	0.05	0.05	0.03	0.03	0.06	0.05	0.05	0.04	0.04	0.05	0.06	0.05	0.04	0.05

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.73	1.73	1.75	1.72	1.69	1.66	1.60	1.67	1.66	1.75	1.63	1.65	1.57	1.63
1:00	1.40	1.40	1.49	1.57	1.45	1.39	1.41	1.40	1.43	1.53	1.52	1.36	1.42	1.47
2:00	1.32	1.36	1.22	1.29	1.33	1.35	1.32	1.25	1.33	1.34	1.41	1.33	1.24	1.34
3:00	1.30	1.22	1.14	1.01	1.33	1.29	1.31	1.19	1.20	1.31	1.30	1.23	1.17	1.27
4:00	1.31	1.28	1.02	1.12	1.37	1.33	1.37	1.31	1.31	1.31	1.34	1.33	1.12	1.36
5:00	1.47	1.38	0.99	1.41	1.59	1.48	1.48	1.44	1.49	1.36	1.33	1.52	1.42	1.50
6:00	1.92	1.86	1.07	1.45	1.76	1.63	1.72	1.76	1.70	1.48	1.32	1.71	1.69	1.62
7:00	1.97	1.93	1.30	1.79	1.99	1.83	1.95	1.98	1.82	1.68	1.41	1.80	1.89	1.91
8:00	2.10	2.16	1.98	2.03	2.07	1.97	2.14	2.06	1.96	1.84	1.74	1.83	2.08	2.04
9:00	2.08	2.04	2.35	2.31	1.99	1.76	1.95	2.01	2.03	2.08	2.28	1.76	2.01	1.91
10:00	1.92	2.00	2.34	2.39	1.92	1.80	2.00	1.95	1.95	2.23	2.37	1.69	1.94	1.81
11:00	1.82	1.83	2.27	2.46	1.97	1.75	1.97	1.94	1.84	2.26	2.19	1.76	1.86	1.78
12:00	1.87	1.78	2.15	2.41	1.92	1.65	1.71	1.82	1.79	2.18	2.18	1.75	1.73	1.79
13:00	1.68	1.67	2.06	2.30	1.81	1.67	1.73	1.83	1.77	2.15	2.21	1.65	1.73	1.75
14:00	1.73	1.78	2.18	2.12	1.68	1.64	1.72	1.74	1.76	1.97	2.06	1.86	1.70	1.68
15:00	1.65	1.68	2.06	2.09	1.67	1.69	1.77	1.73	1.75	1.95	2.02	1.92	1.67	1.69
16:00	1.75	1.71	1.98	1.98	1.74	1.63	1.66	1.73	1.64	2.06	2.04	1.77	1.69	1.66
17:00	1.71	1.80	1.88	2.04	1.80	1.66	1.81	1.75	1.70	2.01	2.07	1.64	1.76	1.61
18:00	1.83	1.89	1.93	2.06	2.05	1.90	1.86	1.90	1.72	2.07	2.18	1.69	1.79	1.73
19:00	1.90	1.93	1.95	2.18	1.95	2.11	1.97	1.90	1.74	1.98	2.14	1.74	1.90	1.91
20:00	1.99	2.01	1.90	2.26	2.22	2.03	1.97	1.98	1.79	1.98	2.23	1.89	2.05	2.02
21:00	2.06	2.02	2.02	2.32	2.17	2.10	2.10	2.03	1.87	1.94	2.20	1.89	2.06	2.09
22:00	2.22	1.96	2.08	2.22	2.08	2.16	2.06	1.96	2.01	1.80	2.25	1.94	2.15	1.54
23:00	2.00	1.97	1.94	1.91	1.92	1.97	1.76	1.92	1.75	1.74	1.92	1.70	1.94	1.54
Average	1.78	1.77	1.79	1.94	1.81	1.73	1.76	1.76	1.71	1.83	1.89	1.68	1.73	1.69
Median	1.79	1.83	1.96	2.05	1.84	1.71	1.78	1.82	1.75	1.94	2.06	1.73	1.77	1.72
Max Hr. Mean	2.22	2.16	2.35	2.46	2.22	2.16	2.14	2.06	2.03	2.26	2.37	1.94	2.15	2.09
Min Hr. Mean	1.30	1.22	0.99	1.01	1.33	1.29	1.31	1.19	1.20	1.31	1.30	1.23	1.12	1.27
Inst. Max	2.32	2.28	2.43	2.51	2.37	2.25	2.17	2.09	2.06	2.30	2.42	2.07	2.21	2.15
Inst. Min	1.24	1.17	0.97	0.90	1.27	1.26	1.26	1.15	1.17	1.24	1.23	1.16	1.08	1.23

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.62	1.47	1.51	1.41	1.63	1.50	1.42	1.45	1.43	1.49	1.47	1.76	1.67	1.40
1:00	1.38	1.33	1.39	1.33	1.54	1.35	1.29	1.27	1.31	1.37	1.43	1.54	1.47	1.31
2:00	1.30	1.33	1.35	1.24	1.43	1.35	1.23	1.19	1.26	1.30	1.39	1.45	1.38	1.26
3:00	1.31	1.30	1.27	1.17	1.39	1.24	1.20	1.19	1.21	1.28	1.36	1.34	1.35	1.27
4:00	1.35	1.33	1.16	1.15	1.43	1.24	1.28	1.23	1.27	1.29	1.38	1.49	1.31	1.32
5:00	1.43	1.45	1.16	1.19	1.50	1.41	1.34	1.31	1.37	1.31	1.34	1.63	1.68	1.33
6:00	1.74	1.79	1.28	1.24	1.62	1.56	1.51	1.52	1.53	1.35	1.33	1.75	1.93	1.44
7:00	1.78	1.78	1.43	1.43	1.72	1.65	1.60	1.71	1.58	1.47	1.44	1.87	1.86	1.70
8:00	1.88	1.88	1.63	1.61	1.81	1.71	1.64	1.78	1.61	1.60	1.66	1.88	1.87	1.75
9:00	1.77	1.74	1.81	1.77	1.74	1.61	1.60	1.72	1.61	1.75	1.83	1.77	1.72	1.59
10:00	1.67	1.73	1.82	1.88	1.73	1.59	1.70	1.62	1.57	1.90	1.97	1.84	1.62	1.62
11:00	1.60	1.71	1.90	1.99	1.75	1.60	1.74	1.66	1.54	1.95	1.81	1.82	1.58	1.57
12:00	1.60	1.53	1.74	1.96	1.71	1.56	1.51	1.57	1.60	1.85	1.85	1.84	1.51	1.59
13:00	1.53	1.50	1.61	1.89	1.66	1.52	1.49	1.57	1.57	1.86	1.87	1.75	1.55	1.51
14:00	1.52	1.49	1.74	1.81	1.55	1.45	1.46	1.54	1.54	1.71	1.77	1.98	1.55	1.48
15:00	1.48	1.49	1.64	1.77	1.48	1.51	1.50	1.50	1.46	1.68	1.76	2.00	1.52	1.47
16:00	1.51	1.45	1.63	1.74	1.58	1.48	1.44	1.49	1.46	1.77	1.76	1.87	1.54	1.47
17:00	1.54	1.52	1.54	1.74	1.61	1.52	1.54	1.53	1.52	1.71	1.79	1.85	1.62	1.48
18:00	1.64	1.63	1.54	1.77	1.67	1.62	1.57	1.67	1.54	1.76	1.84	1.88	1.68	1.58
19:00	1.67	1.66	1.57	1.89	1.63	1.79	1.68	1.62	1.49	1.69	1.83	1.84	1.78	1.68
20:00	1.72	1.75	1.52	1.87	1.76	1.79	1.75	1.75	1.57	1.66	2.02	1.91	1.73	1.78
21:00	1.82	1.74	1.52	1.93	1.84	1.82	1.76	1.77	1.59	1.73	1.94	1.88	1.79	1.79
22:00	1.86	1.73	1.58	1.93	1.80	1.86	1.80	1.72	1.63	1.70	1.85	1.75	1.84	1.31
23:00	1.73	1.66	1.51	1.75	1.69	1.69	1.57	1.65	1.51	1.58	1.81	1.74	1.62	1.31
Average	1.60	1.58	1.54	1.64	1.64	1.56	1.53	1.54	1.49	1.62	1.69	1.77	1.63	1.50
Median	1.60	1.56	1.55	1.76	1.65	1.56	1.54	1.57	1.53	1.67	1.77	1.81	1.62	1.52
Max Hr. Mean	1.88	1.88	1.90	1.99	1.84	1.86	1.80	1.78	1.63	1.95	2.02	2.00	1.93	1.79
Min Hr. Mean	1.30	1.30	1.16	1.15	1.39	1.24	1.20	1.19	1.21	1.28	1.33	1.34	1.31	1.26
Inst. Max	1.95	1.91	1.97	2.06	1.91	1.91	1.86	1.87	1.65	1.99	2.07	2.12	1.98	1.94
Inst. Min	1.28	1.28	1.12	1.09	1.37	1.17	1.18	1.16	1.17	1.25	1.30	1.28	1.26	1.25

All Values in Inches

D. Reclaimed Water System Model Development and Calibration

This appendix contains the technical memorandum summarizing the following tasks in its entirety:

- Task 6.2 – Flow Model

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City of Surprise, Arizona
Water Services Department • 12425 West Bell Road • Surprise, AZ 85374-9002

Integrated Water Master Plan

Reclaimed Water Technical Memorandum:

Task 6.2 – Flow Model

November 2008

Report Prepared By:

Malcolm Pirnie, Inc.

4646 East Van Buren Street
Suite 400
Phoenix AZ 85009

4957-007

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1. Introduction

1.1. Background Information

The City of Surprise (City) Water Services Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

The City is expecting to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007). To prepare for this growth and additional growth as the City approaches build-out, the City prepared a *Water Resources Master Plan* and an *Infrastructure Master Plan* in June 2004. The Water Resources Master Plan was developed to ensure that the City's water supplies were adequate to meet the current and projected demands. The Infrastructure Master Plan addressed water, wastewater, reclaimed water, and groundwater recharge infrastructure. The master plans considered a municipal planning area (MPA) of 228 square miles that was broken up into five special planning areas (SPAs): SPA 1 through SPA 5. The master plans, however, did not consider the sixth, 71 square-mile expansion area in the north, SPA 6, that has since been added to the City's MPA.

The existing water resources and infrastructure master plans are in need of updating; they are now four years old, and considerable changes have been experienced in growth and development patterns, as well as the addition of SPA 6 to the City's MPA. In December 2007, the City retained Malcolm Pirnie, Inc., in association with Replenishment Services, LLC and ASU Decision Theater, to update the master plans into an *Integrated Water Master Plan*.

1.2. Project Purpose and Scope

The purpose of the *Integrated Water Master Plan* project is to provide a long-term guidance document for the orderly improvement and growth of the City's water supply portfolio and drinking water, wastewater, reclaimed water, and groundwater recharge infrastructure. Table 1-1 provides a summary of the scope of work technical tasks for each master plan component of the *Integrated Water Master Plan* project.

The purpose of the Water Resources Master Plan component is to identify the projected water demands as the City continues to grow and to develop a water resources strategy that will meet the demands in a cost-effective and sustainable manner. To prepare for the infrastructure master plan updates, the Water Resources Master Plan component also includes updates to projections of wastewater flows, reclaimed water availability, and

reclaimed water demands in an integrated fashion. Finally, the Water Resources Master Plan component includes a review and evaluation of water reuse options and reuse program alternatives as a critical element of the City's water resource portfolio.

The purpose of the Recharge Master Plan component is to support the Water Resources Master Plan by evaluating options and program alternatives to recharge reclaimed water supplies, and to develop a comprehensive plan and infrastructure improvements that allows the City to recharge reclaimed water in a legal, cost-effective, and sustainable manner.

The purpose of the Water Infrastructure, Wastewater, and Reclaimed Water Master Plan components is to enhance the existing plans where reasonable and to provide the City with comprehensive master plans that allow the City to manage its infrastructures in an effective and efficient manner and to provide for infrastructure expansions.

Table 1-1.
Integrated Water Master Plan Technical Scope of Work Tasks

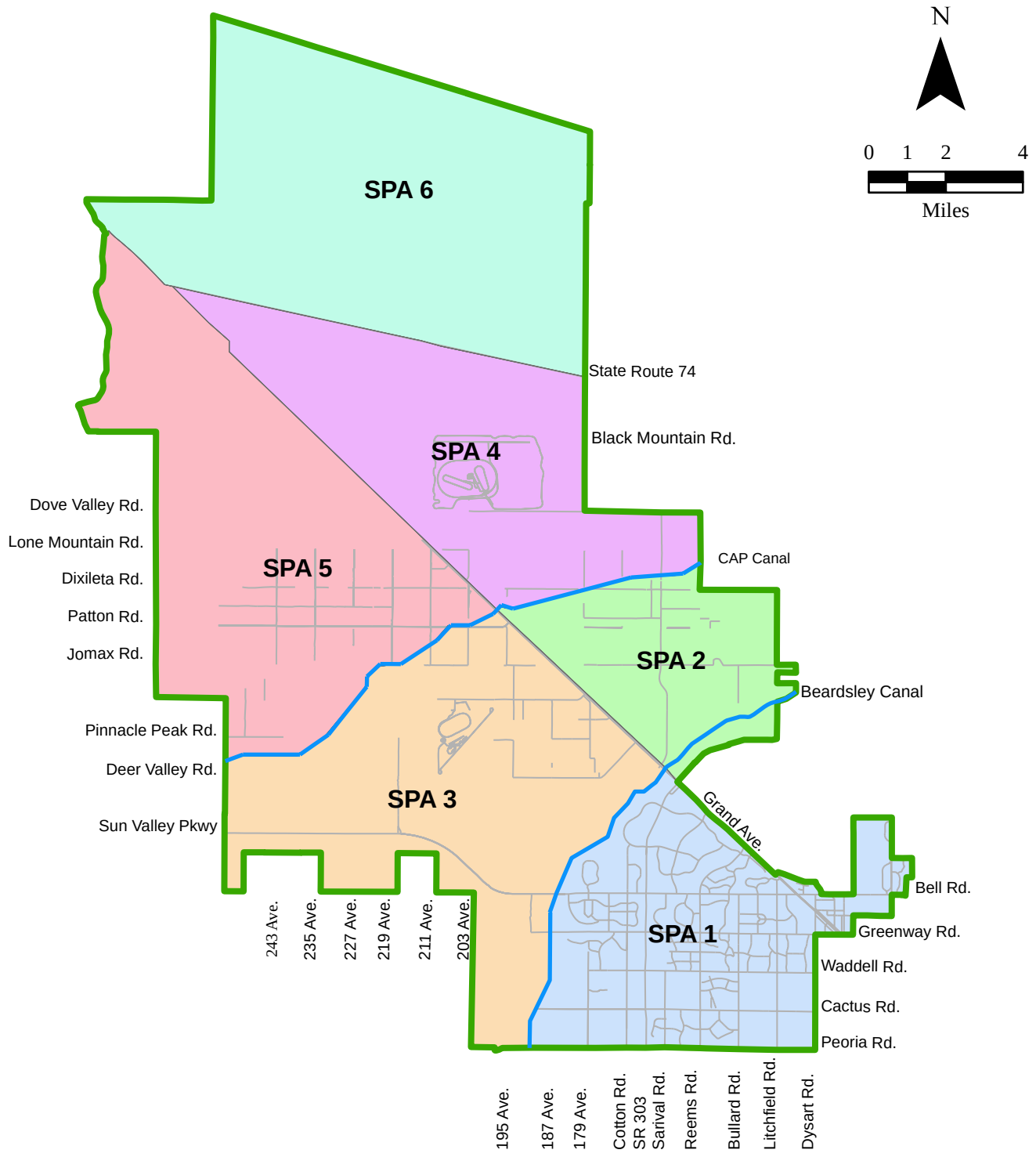
Water Resources Master Plan	**Drinking Water Infrastructure Master Plan**
2.1 Review of Regulations and Guidelines	4.1 Review of Regulations and Guidelines
2.2 Review of Background Information	4.2 Review of Background Information
2.3 Supplies	4.3 Fire Flow Testing
2.4 CAGRD Replenishment Obligations	4.4 Flow Model
2.5 Demand and Flow Factors	4.5 Evaluation of the Existing System
2.6 Demand Module	4.6 Improvements to the Existing System
2.7 Additional Water Supplies	4.7 Drinking Water Infrastructure Master Plan Report
2.8 Reclaimed Water Management	**Wastewater Master Plan**
2.9 Dual Water System Evaluation	5.1 Review of Regulations and Guidelines
2.10 Water Resource Model	5.2 Review of Background Information
2.11 Water Resource Scenarios	5.3 Wastewater Collection System Monitoring
2.12 Water Resource Management	5.4 Flow Model
2.13 Assured Water Supply Management	5.5 Evaluation of the Existing System
2.14 Water Resources Master Plan Report	5.6 Improvements to the Existing System
	5.7 Wastewater Master Plan Report
Recharge Master Plan	**Reclaimed Water Master Plan**
3.1 Regulations and Background Information	6.1 Review of Background Information
3.2 Recharge Methods and Evaluation	6.2 Flow Model
3.3 Recharge Improvements	6.3 Evaluation of the Existing System
3.4 Build-out of the Recharge System	6.4 Improvements to the Existing System
3.5 Recharge Master Plan Report	6.5 Reclaimed Water Master Plan Report

1.3. Purpose of Technical Memorandum

The purpose of this technical memorandum is to summarize the work conducted in Reclaimed Water Master Plan Task 6.2 (Flow Model). The technical memorandum includes the information available to build the existing reclaimed water model.

1.4. Study Area

The study area for this project, illustrated on Figure 1-1, includes all of the City's MPA. The MPA has been divided into six SPAs to maintain consistency with the City's previous master plan efforts and for convenience of wastewater and reclaimed water planning; i.e., the SPAs comprise logical drainage areas for existing, planned, and potential water reclamation facilities.



Legend

- Canals
- Streets
- Municipal Planning Area
- Special Planning Areas

MALCOLM PIRNIE

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Phoenix, AZ 85008

CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Study Area

November 2008 | **Figure 1-1**

m://4957007/GIS/Projects_MXD/Tech Memo 2/Figure 1_1_Study Area.mxd

2. Model Development

This section presents a brief summary of how the City's reclaimed water system model was developed. The City does not have an existing reclaimed water system model as the system that is currently built has not been utilized yet. As such, only a future system model can be developed that includes the infrastructure that has been constructed. Since the system has not been operated yet, there was be no information available to calibrate the model.

The reclaimed water system was modeled using personal computer based modeling software and related databases. The model served as a tool to aid in designing the system to support varying supply and demand conditions and to identify system modifications and expansions necessary to meet future demand.

2.1. Generic Model Description

The City's reclaimed water system pipelines, storage tanks, boosters, and valves were modeled using Bentley WaterCAD® V8 XM edition. The software uses an iterative procedure to determine the steady state system response to a given supply and demand scenario. The software is also capable of performing extended period simulations for known diurnal patterns of supply and demand and can simulate water quality fluctuations within the distribution systems. A steady state model was developed for the current master planning effort. The results obtained from such quantitative analysis are considered conservative for evaluating and planning for future improvements and system developments.

2.1.1. Transmission Pipelines

The City's existing reclaimed water system is represented by more than 90 pipes in its geographic information system (GIS) database. The existing reclaimed water distribution system consists of polyvinyl chloride (PVC) and ductile iron (DI) pipes, ranging in diameter from 2 inches through 30 inches. Most pipelines in the system follow existing streets and public rights-of-way.

Because this is a master planning effort, all existing pipes with diameters 8 inches and greater, and only future piping required to distribute the reclaimed water at a one square-mile grid were represented in the model. Table 2-1 provides the statistics on percentage of existing pipes to be represented in the model.

Table 2-1.
Summary of Existing Pipes Modeled

	Length (ft)			Volume (ft^3)		
Pipe Diameter (in)	**Total**	**In Model**	**% in Model**	**Total**	**In Model**	**% in Model**
2	69	-	0	2	-	0
8	464	464	100	162	162	100
12	5,473	5,473	100	4,298	4,298	100
16	14,164	14,164	100	19,777	19,777	100
24	5,143	5,143	100	16,157	16,157	100
30	2,273	2,273	100	11,158	11,158	100
Total	27,586	27,517	99.7	51,553	51,551	100

2.1.2. Model Nodes

Model nodes can serve a number of functions and contain vital information concerning supply, demand, and physical characteristics of certain facilities. Three types of nodes were used in the modeled system: boundary nodes, junction nodes and source nodes.

Tanks and reservoirs are classified as boundary nodes. The storage facilities in the system were represented as cylindrical tanks with known diameters, heights and base elevations. The initial tank levels represented the known hydraulic grade line (HGL).

Junction nodes occur at all pipeline endpoints that are not represented by a tank or reservoir. Each junction has specific information that identifies the node's elevation, demand, and demand type. Each node in the model was assigned an elevation that corresponded to the local surface elevation relative to the mean sea level, based on most recent United States Geological Survey (USGS) five-foot topographical data.

The existing South WRF and Desert Oasis WRF were represented as source nodes with fixed boundary conditions. Elevation information was assigned to the junctions based on most recent United States Geological Survey (USGS) five-foot topographical data. Future WRFs were added as additional source nodes.

Each pump in the system was modeled using a single design point pump curve. The point represented the design flow and head for the pump. The design point information was noted from the manufacturer's tag in the pumps during the field visit and was verified by the City.

2.1.3. Pumps

Pump information for booster stations at the WRFs were obtained during the site visit on May 1, 2008 and were verified by the City. Each pump in the system was modeled using

a single design point pump curve. The point represented the design flow and head for the pump. The design point information for each pump was developed from typical vendor pump design information. The elevation of the pumps were set the same as the base elevation of the tank associated with the pumps.

2.1.4. Valves

Pressure reducing valves (PRVs) may be located at various locations within the distribution system to prevent the downstream hydraulic grade from exceeding a preset value. The elevation, diameter, and pressure setting value for each PRV was assigned as system hydraulics dictated.

2.1.5. Water Demand Allocation

Reclaimed water demands were obtained from the Water Resource Demand Module developed as part of Water Resources Master Plan Tasks 2.5 (Demand Factors) and 2.6 (Demand Module). The nearest-node demand allocation method was used to allocate demands to the modeled junctions. This method used the spatial analysis capabilities of GIS to assign the water usage demand polygons from the Demand Module to the nearest demand node.

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3. Model Calibration

As indicated previously, the City did not have an existing reclaimed water model and the existing reclaimed water distribution system had not been operated as a distribution system yet. Portions of the system are currently used to convey reclaimed water to a farm. No information was available to calibrate the portions of the model representing the existing infrastructure.

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E. Drinking Water Infrastructure Alternatives

This appendix provides additional information on the development of the drinking water infrastructure alternatives.

E.1. Future System Demand Scenario

As described in the Water Resources component of the *Integrated Water Master Plan*, indoor and outdoor demands will be served with potable water, while landscape (large irrigation) demands will be served via the reclaimed water distribution system. The demand set used for all water system evaluations was the Mid-Population Scenario (i.e., population of approximately 700,000 at build-out) identified in the Water Resources component of the *Integrated Water Master Plan*. This scenario involved serving all private water company service areas within the City's MPA, with the exception of the Arizona American Water Company (AAWC) and City of El Mirage service areas. In this scenario, the City would control development densities to balance water demands with available supplies.

Table E-1 summarizes the preliminary build-out potable water demands obtained from the Demand Module and that were used for the purpose of the drinking water infrastructure evaluation. Because the alternative evaluations were preformed prior to the completion of the Water Resources component of the *Integrated Water Master Plan*, the demands used for the evaluation varied slightly from the demands used to phase the selected alternative in Section 7 of the Water Infrastructure component of the *Integrated Water Master Plan*. The preliminary and finalized demands varied by less than 2 percent.

Table E-1.
Build-out Drinking Water Demands Used for Infrastructure Alternatives

Special Planning Area	Indoor Demand (mgd)	Outdoor Demand (mgd)	Total Potable Water Demand (mgd)
SPA 1	5.8	3.1	8.8
SPA 2	8.9	4.8	13.7
SPA 3	19.4	10.3	29.7
SPA 4	12.2	6.9	19.1
SPA 5	15.4	8.2	23.7
SPA 6	10.7	5.6	16.3
TOTAL	**72.4**	**38.9**	**111.3**

All modeling of future scenarios was conducted for the build-out condition. As such, the comparisons presented in this memo represent infrastructure and costs at build-out. Based on comments received from the City, the selected alternative was remodeled prior to developing a phasing and implementation schedule for 2020 and build-out conditions.

E.2. System Performance and Design Criteria

Tables E-2 and E-3 summarize the preliminary performance and design criteria used for this evaluation. Because the alternative evaluations were preformed prior to the finalization of the system performance and design criteria, the values in Tables E-2 and E-3 may differ slightly with the criteria in Section 5 of this report.

E.3. Alternative Descriptions

The infrastructure alternatives considered the use of potable production wells, WSFs, a CAP surface WTP, regional recharge facilities, and City-owned surface spreading basins. The following specific alternatives were identified for evaluation:

- Alternative 1: All well supply
  - Alternative 1A: CAP Recharge at regional recharge facilities
  - Alternative 1B: CAP recharge at City-owned spreading basin recharge facilities
- Alternative 2: All well supply with fewer WSFs and larger interconnected systems
- Alternative 3: CAP WTP with wells for additional production and backup supply

E.3.1. Alternative 1: All Well Supply

Under this alternative, the City will continue with its current philosophy for water supply, treatment, and distribution. All potable water will be supplied with wells and the City's CAP allocation will be recharged. The system will be configured as follows:

- Each WSF will serve a 4 to 6 square mile area, creating 31 WSFs in addition to the WSFs already operating in SPA 1 and 2.
- The number of wells needed for each WSF will depend on the service area demand for the specific WSF.
- WSFs will consist of treatment (e.g., arsenic treatment and disinfection), storage, and booster pumping.
- Each WSF will have its own backup supply to ensure firm capacity (i.e., each WSF will provide the required production capacity with the largest well out of service). Emergency interconnects with the surrounding WSFs will also be provided.
- CAP water will be recharged.

Table E-2.
Preliminary Drinking Water System Performance and Design Criteria

			Used for Infrastructure Alternatives
Peaking Factors		**Max Day Peaking Factor**	2
		Peak Hour Peaking Factor	3
Wells/Production Facility		**Production Capacity**	1.1 x Maximum Day Demand
		Firm Capacity	Must Meet Maximum Day Demand with Largest Well Out of Service
Storage Facility		**Equalizing Storage**	20 % of Maximum Day Demand
		Fire Storage	Fire Flow x Duration
		Emergency Storage	10 % of Maximum Day Demand
		Max Height	-
Pipe	**Distribution**	**Velocity**	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Maximum Day + Fire Flow
	Transmission	**Velocity**	< 5 ft/s
		Headloss	< 2 ft / 1000 ft
		Design Criteria	Maximum Day + Fire Flow
	Fire Flow	**Velocity**	< 10 ft/sec
Fire Flow		**Single Family Residential**	2,000 gpm for 2 hours
		Multi Family Residential	2,000 gpm for 2 hours
		Commercial	3,000 gpm for 3 hours
		Industrial	3,000 gpm for 3 hours
System Pressure		**Maximum Pressure**	100 psi
		Max Day/Peak Hour Conditions	40 psi to 100 psi
		Fire Flow Conditions	20 psi Minimum
Booster Station		**With Storage**	Maximum Day + Fire Flow
		Without Storage	
		Firm Capacity	Largest Pump Out of Service

There were two alternatives for recharging CAP water: recharge at a regional recharge facility or recharge at City-owned spreading basins. If regional recharge is used, the City will continue its agreement with CAWCD regarding recharge. CAWCD will determine where the water is recharged. No additional infrastructure was required for this recharge method. Recharge at the Hieroglyphic Mountain Recharge Facility was preferred (if possible) because it would contribute to the physically available water beneath the City's planning area. If City-owned recharge was used, the City would be responsible for

Table E-3.
Preliminary Spreading Basin Design Criteria

Parameter	Used for Infrastructure Alternatives
Loading Rate (ft/year)	122
Loading Rate: Infiltration Rate (%)	33
Infiltration Rate (ft/day)	1
Wet/Dry Ratio	0.50
Application Period (days)	4
Drying Period (days)	8
Number of Basins (#)	3
Basin Depth (ft)	5
Sidewall Slope (Rise:Run)	1:3
Ramp Gradient (%)	10
Distance Between Basins (ft)	12

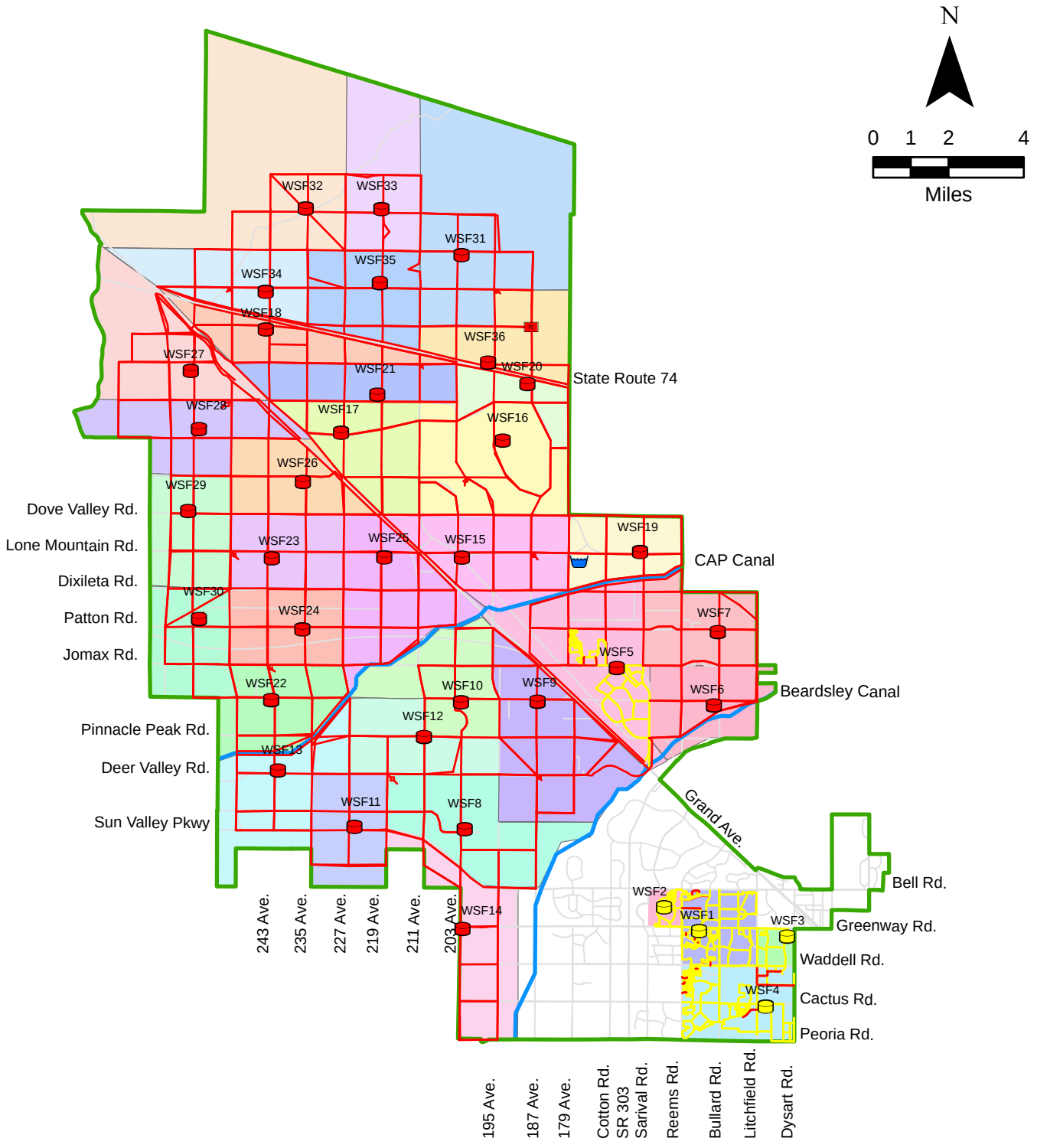
constructing and maintaining the recharge basins as well as the infrastructure to convey the water from the canal to the recharge location. The proposed infrastructure layouts for Alternatives 1A and 1B, including pipes and water supply facilities, are shown on Figures E-1 and E-2, respectively.

E.3.2. Alternative 2: All Well Supply with Fewer WSFs and a Larger Interconnected System

This alternative was similar to Alternative 1 in that wells supply all potable water and the City's CAP allocation was recharged. However, in this alternative, the service area and size of the WSFs will increase, creating a more interconnected system (Figure E-3). In general, each WSF in this alternative was a combination of two or three WSFs identified in Alternative 1. The WSFs currently operating in SPAs 1 and 2 will remain, resulting in a total of 16 WSFs. Elevation changes, geographic features, and anticipated demand patterns were used to determine the most appropriate configuration of the combined, larger WSFs. Either method of recharging CAP water could be used in this alternative; however, for the purposes of the cost evaluation, regional recharge was selected because it was the lower cost option identified in the analysis of Alternative 1.

E.3.3. Alternative 3: CAP Surface WTP with Wells for Additional Production and Backup Supply

In this alternative, instead of recharging CAP water, a CAP WTP will be constructed to treat the surface water prior to delivering to customers for potable use. The capacity of the WTP was assumed to be 13 mgd, which included the City's existing CAP allocation and the potential additional CAP allocation from Circle City Water Company. The



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Proposed CAP Recharge

- CAP Hieroglyphics Facility

Water Supply Facilities

- Existing
- Proposed and/or Improved

Distribution System Pipelines

- Existing
- Proposed and/or Improved

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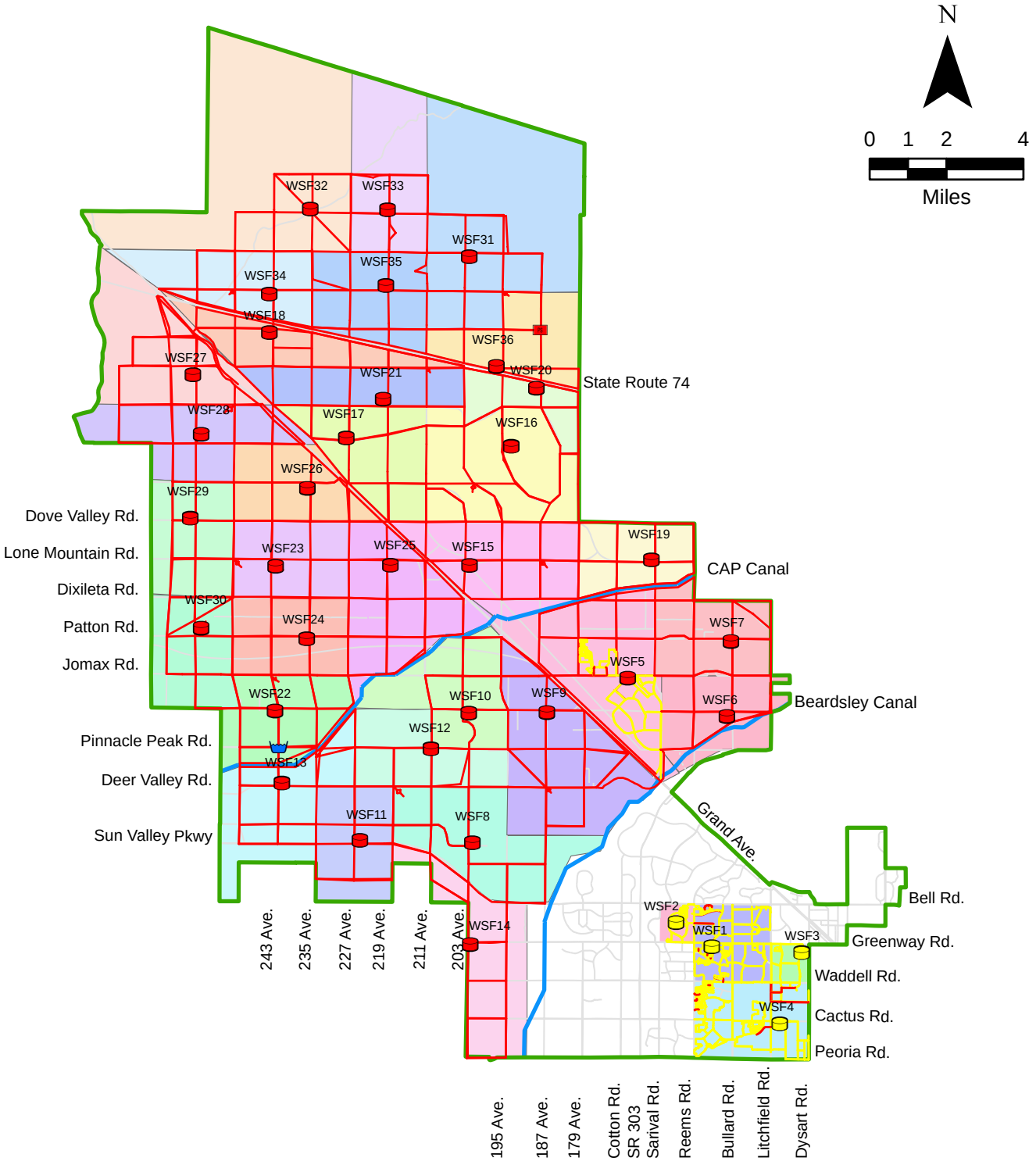
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1A: All Well Supply with CAP Recharge at Regional Recharge Facilities

July 2009

Figure E-1

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure E-1 Alternative 1A.mxd



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Proposed CAP Recharge

- City-owned Facility

Distribution System Pipelines

- Existing
- Proposed and/or Improved

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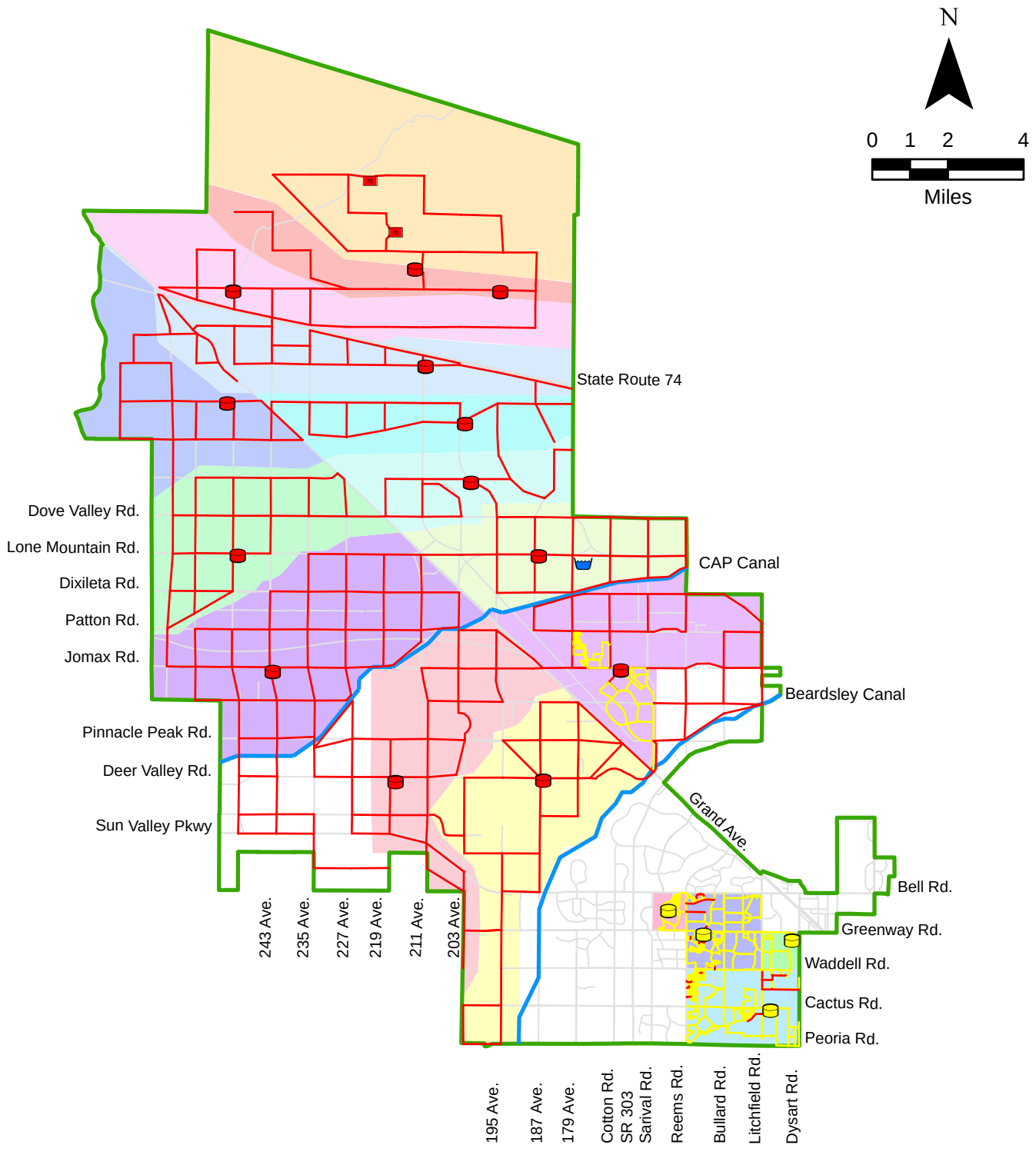
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1B: All Well Supply with CAP Recharge at City-Owned Spreading Basin Recharge Facilities

July 2009 | **Figure E-2**

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure E-2 Alternative 1B.mxd



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing

Additional Distribution Booster Stations

- Proposed

Proposed CAP Recharge

- CAP Hieroglyphics Facility

Distribution System Pipelines

- Existing
- Propsed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: All Well Supply with Fewer WSFs and a Larger Interconnected System

July 2009 | **Figure E-3**

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure E-3 Alternative 2.mxd

remainder of the City will be supplied with wells and the infrastructure for this alternative (shown on Figure E-4) will be similar to the distribution network shown for Alternative 2. The CAP WTP will be located near the intersection of the CAP Canal and Grand Avenue in SPA 5 and will serve customers generally in SPA 5.

Additional wells will be provided in this alternative to back up the CAP WTP in the event of a CAP Canal outage or shortage. Within the more than 20-year operational history of the CAP Canal in Arizona, maintenance outages have been minimal and typically occur in the winter. In the past, operators of the CAP system have also chosen to repair major portions of the delivery system (e.g., the corrosion problems associated with certain siphon crossings of major drainages) during the winter when domestic and agricultural demands for water are reduced. The CAP does routine shutdown of the Surprise delivery portions of the CAP pumping system in the summertime for maintenance; however, the maintenance is scheduled such that sufficient pumping capacity is maintained to satisfy all summertime demands. CAP shortages are even rarer. During times of shortages, however, the City would institute measures to reduce water demands in addition to using all available wells. The City of Peoria bases its planning for CAP WTPs to back up the plants with wells for average day demand conditions. As such, providing a backup well supply to serve an average day demand was considered appropriate for this analysis.

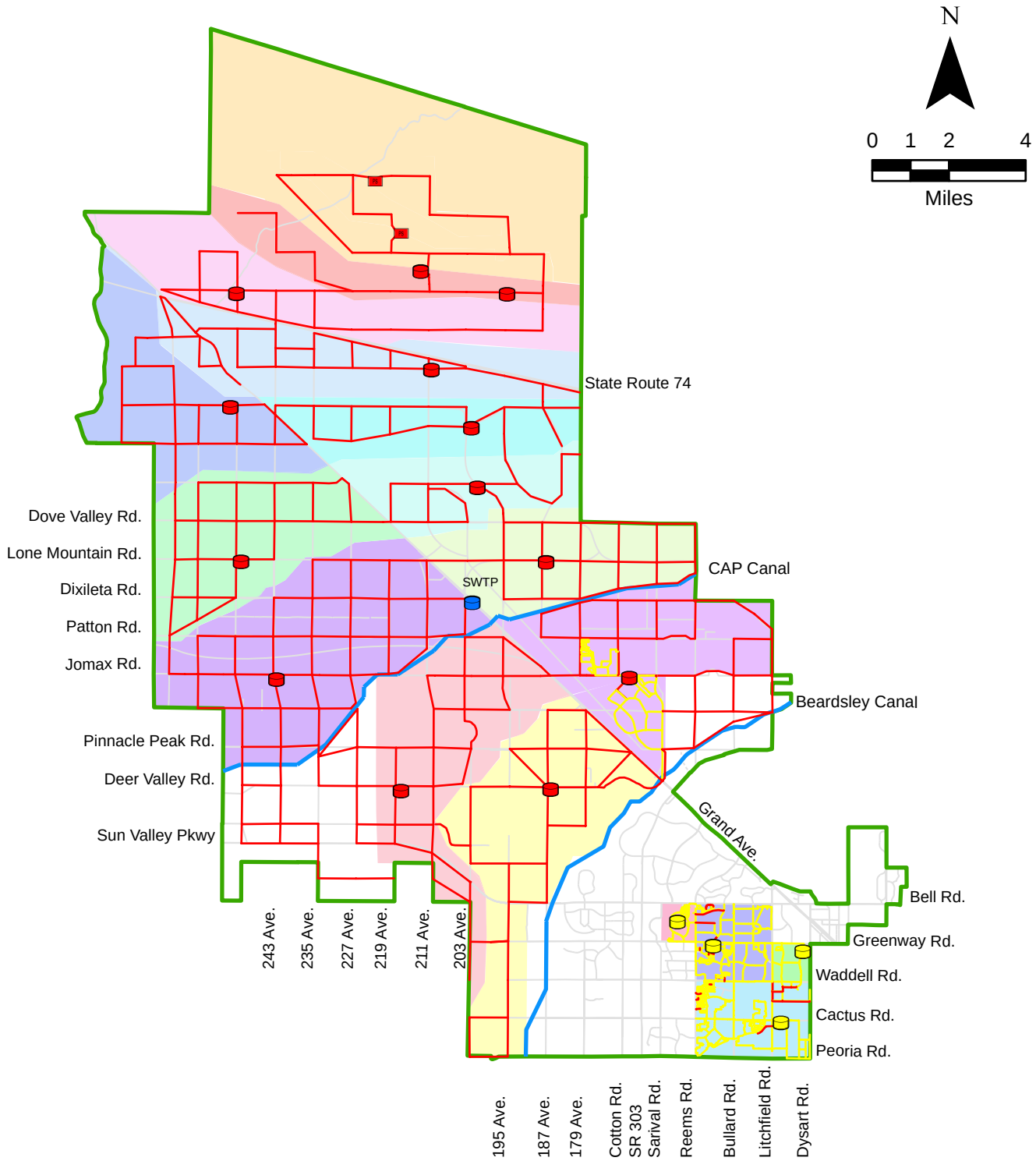
E.4. Water System Improvements

Improvements to the existing water system and future infrastructure were sized using the built-out demands from the Demand Module and peak demand and fire flow scenarios described above. The results for each alternative, including the number of WSFs, number of wells, amount of storage, booster pumping capacity, pipeline lengths, and necessary recharge are summarized in this section.

When analyzing the existing system in SPA 1 for fire flow under build-out demand conditions, additional deficiencies were identified (Section 5 of the Water Infrastructure component of the *Integrated Water Master Plan*). The improvements needed to overcome these deficiencies were common to all alternatives and, as such, have been added to each alternative.

E.4.1. Alternative 1: All Well Supply

Because the only difference between alternatives 1A and 1B was the method of recharge, the distribution system layouts were identical (Figures E-1 and E-2). This alternative followed the City's current philosophy of having individual WSFs serving an area of 4-6 square miles. The WSFs in some areas may be slightly larger due to the boundaries of existing, known, or currently planned developments in the municipal planning area.



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved
- Proposed CAP SWTP

Additional Distribution Booster Stations

- Proposed

Distribution System Pipelines

- Existing
- Propsed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 3: CAP Surface WTP with Wells for Additional Production and Backup Supply

July 2009 | **Figure E-4**

M:\4957002\GIS\Project_MXDs\R-2-FINAL\Figure E-4 Alternative 3.mxd

E.4.1.1. Water Supply Facilities (WSFs)

The City's water supply facilities typically consist of treatment (e.g., arsenic or fluoride removal, disinfection, etc.), a storage reservoir, and a booster pump station. Note that reclaimed water storage and booster pumping are often co-located with the potable infrastructure at the WSFs. A summary of the infrastructure present at each WSF along with the number of wells needed to supply each WSF is shown in Table E-4.

- **WSFs –** In addition to the five existing WSFs, Alternative 1 included 31 new WSFs. The size of the WSFs ranged from 2 mgd to 16 mgd, but a majority of these were 4 mgd to 7 mgd. Each new WSF had an estimated land requirement of two acres.
- **Wells -** Each of the 31 WSFs has its own set of wells supplying groundwater to it. The City's standard sets the maximum flow from a well at 1,500 gpm. The total capacity of the wells for a WSF was calculated using the preliminary system performance and design criteria. Each well will be located on a one-quarter acre parcel.
- **Storage** - The function of storage is to provide reserve supply for operational equalization, fire suppression reserves, and emergency needs. The storage was calculated using the system performance and design criteria.
- **Booster Stations** - The booster stations at the WSFs were designed to meet maximum day plus fire flow for that service area. In service areas with large elevation change, booster pumps are used to pump water to a higher elevation at the appropriate pressure. There were 32 booster stations: 31 at the WSFs and one within the distribution system.

E.4.1.2. Piping

Two types of piping were included in the water alternatives, and a summary of both types piping is shown in Table E-5.

- **Well transmission mains** refer to the pipelines carrying groundwater from the wells to the WSFs. Spacing of the wells and sizing of the transmission mains were based on the City's existing well systems. It was assumed that each well would be located a minimum of 0.5 miles apart from each another and a maximum of three wells would feed into each transmission main.
- **Distribution pipes** are used to convey water from the storage reservoirs at the WSFs to the customers throughout the distribution network. Although the mains cross from one service area to the other, they are closed at service area boundaries. Thus, a main in a particular service area only carries the demand to serve that area.

Table E-4.
Drinking Water Supply Infrastructure for Alternative 1

Map ID	Water Supply Facility Description	WSF Capacity (mgd)	Number of Additional Wells	Additional Storage Required (MG)	Additional Booster Station Requirements	
					Capacity (gpm)	TDH (ft)
SPA 1						
WSF1	**Ashton Ranch** [1]	7	--	--	--	--
WSF2	**Mountain Vista Ranch** [1]	2	--	--	--	--
WSF3	**Roseview** [1]	2	--	--	--	--
WSF4	**Rancho Gabriela** [1]	7	--	--	--	--
SPA 2						
WSF5	**Desert Oasis** [1]	16[2]	8	1.9	4,500	220
WSF6	**Rancho Mercado**	7	5	2.8	5,123	231
WSF7	**R-58**	4	4	1.9	2,921	407
SPA 3						
WSF8	**Surprise Foothills**	13	8	4.6	9,270	213
WSF9	**Austin Ranch**	13	8	4.4	8,371	250
WSF10	**R-52**	8	6	3	5,627	246
WSF11	**Mesquite Mountain Ranch**	7	5	2.7	4,936	401
WSF12	**Fox Trails**	7	5	2.7	4,864	244
WSF13	**R-48**	6	4	2.3	4,052	293
WSF14	**R-55**	5	4	2	3,179	280
SPA 4						
WSF15	**Sunhaven Ranch**	12	8	4.1	8,236	240
WSF16	**Grand Vista**	10	7	3.7	7,238	219
WSF17	**BNSF Commercial**	5	4	2	3,203	310
WSF18	**R-40**	4	4	1.8	2,806	176
WSF19	**Marisol Ranch**	3	3	1.5	2,183	272
WSF20	**R-39**	3	3	1.4	1,904	363
WSF21	**R-36**	2	3	1.1	1,115	532
SPA 5						
WSF22	**R-47**	7	5	2.7	4,904	241
WSF23	**R-44**	6	5	2.4	4,245	233
WSF24	**R-46**	6	5	2.4	4,211	250
WSF25	**Walden Ranch**	6	5	2.4	4,150	239
WSF26	**Broadstone Ranch**	5	4	2	3,257	304
WSF27	**R-41**	5	4	2	3,212	277
WSF28	**R-42**	4	3	1.7	2,631	226
WSF29	**R-43**	4	3	1.7	2,617	303
WSF30	**R-45**	4	3	1.7	2,459	322
SPA 6						
WSF31	**Lake Pleasant 5000**	10	6	3.4	6,610	539
WSF32	**R-60**	7	5	2.6	4,596	258
					850	465
WSF33	**R-29**	5	4	2.1	3,471	400
WSF34	**R-31**	4	4	1.9	3,094	320
WSF35	**R-34**	4	3	1.7	2,631	376
WSF36	**R-38**	2	3	1.3	1,610	403

Notes:
(1) Existing WSF
(2) Includes the existing capacity of Desert Oasis WSF

Table E-5.
Summary of Pipe Improvements for Alternative 1

Diameter (in)	Transmission Main Length (feet)	Distribution Pipe Length (feet)
8	-	22,900
12	240,200	400
16	-	2,461,300
20	147,800	41,700
24	5,300	81,100
30	-	600
Total	393,300	2,608,000

E.4.1.3. Pressure Reducing Valves

Eleven pressure reducing valves (PRVs) were needed in this alternative in order to reduce the high pressure (more than 100 psi) experienced in some areas due to large elevation change within the service area. The PRVs range in size from16 inches to 36 inches in diameter.

E.4.1.4. CAP Recharge

For Alternative 1A, CAP water will be recharged at the Hieroglyphic Mountains Recharge Facility. No additional infrastructure is needed for this alternative.

For Alternative 1B, CAP water will be recharged in SPA 5 near the intersection of 243rd Avenue and Pinnacle Peak Road. This location was selected because it is favorable from a hydrogeologic perspective (i.e., the depth to groundwater is high), and it is located a sufficient distance from the surrounding regional recharge projects. To accommodate the CAP allocations, 129 acres of spreading basins will be needed. A 30-inch transmission main (2,640 ft) was included to convey the CAP water from the canal to the recharge location. It was assumed that the water would be conveyed by gravity.

E.4.2. Alternative 2: All Well Supply with Fewer WSFs and a Larger Interconnected System

Alternative 2 is similar to Alternative 1 in that all water is supplied from wells; however, it is characterized by larger service areas and fewer WSFs than Alternative 1. The water distribution system in this alternative is divided into 12 preliminary pressure zones (Figure E-3). The existing infrastructure in SPA 1 is combined together as one pressure zone and the remainder of the planning area is divided into 11 pressure zones, each spanning approximately 120 feet in elevation change. Physical boundaries such as canals and major roads were considered while delineating the pressure zone boundaries. Each pressure zone was further divided according to the SPA boundaries such that water from one SPA was not supplied to another SPA. Interconnects have been provided between

the pressure zones and SPAs that can be opened to move water across zone boundaries in case of emergencies. The interconnects will remain closed under normal operating conditions.

E.4.2.1. Water Supply Facilities (WSFs)

Similar to Alternative 1, the WSFs in this alternative consist of treatment, storage reservoirs, and a booster pump station. However, due to system hydraulic constraints, an additional storage facility and three additional booster stations were located within the distribution system in this alternative. A summary of the infrastructure present at each WSF along with the numbers of wells needed is presented in Table E-6.

- **WSFs** – In addition to the five existing WSFs, Alternative 2 includes 11 new WSFs. In general, each pressure zone contains one or two WSFs. However, because accessing groundwater is more challenging in mountainous regions, pressure zones 10, 11, and 12 do not have their own WSFs, but instead they are supplied water from a storage tank in pressure zone 9. No changes to the existing WSFs are needed. Because the WSFs have a larger capacity and will serve a larger area, 4 acres was assumed for each new WSF.
- **Wells -** Each WSF is supplied by several wells using the criteria described above. Each well will be located on a one-quarter acre parcel.
- **Storage -** Each WSF includes storage for equalization, fire flow, and emergency purposes. The storage tank in pressure zone 9 is sized to provide one maximum day demand to pressure zones 10, 11, and 12. The storage for other tanks was calculated using the method described above.
- **Booster Stations -** There are 14 new booster stations needed in this alternative (11 located at WSFs and 3 located in the distribution system). In addition, the capacity of the booster station at Desert Oasis was increased.

E.4.2.2. Piping

Transmission piping and distribution piping serve the same functions as described in Alternative 1. The piping summary for Alternative 2 is shown in Table E-7. Because this alternative is more interconnected, fewer pipes are needed to serve the area. Although the total length of pipes needed in Alternative 2 is less than in Alternative 1, the piping diameters tend to be larger.

E.4.2.3. PRVs

There were no PRVs needed in this alternative.

E.4.2.4. CAP Recharge

CAP water will be recharged at the Hieroglyphic Mountains Recharge Facility. No additional infrastructure was needed for this alternative.

Table E-6.
Water Supply Infrastructure for Alternative 2

Map ID	Water Supply Facility Description	Pressure Zone	WSF Capacity (mgd)	Number of Additional Wells	Additional Storage Required (MG)	Additional Booster Station	
						Capacity (gpm)	TDH (ft)
WSF1	Ashton Ranch [1]	1	7	--	--	--	--
WSF2	Mountain Vista Ranch [1]	1	2	--	--	--	--
WSF3	Roseview [1]	1	2	--	--	--	--
WSF4	Rancho Gabriela [1]	1	7	--	--	--	--
WSF5	Desert Oasis [1]	2 and 3	25[2]	12	4.6	15,000	220
WSF37	R-61	2	21	12	6.9	15,000	203
WSF38	R-63	3	31	17	9.8	21,400	167
WSF39	R-64	4	35	19	11.2	24,600	187
WSF40	R-65	4	12	8	4.3	8,500	152
WSF42	R-67	5	12	8	4.3	8,600	140
WSF41	R-66	5	14	9	4.8	9,800	182
WSF43	R-68	6	5	4	2.2	3,700	218
WSF44	R-75	6	5	4	2	3,350	240
WSF45	R-71	7	10	7	3.6	7,100	225
WSF46	R-72	8	8	5	2.9	5,400	225
WSF47	R-73	9	6	4	2.3	4,000	305
B1	T-3	10	NA	NA	16	11,800	238
B2		11	NA	NA	NA	7,000	230
B3		12	NA	NA	NA	4,000	300

NOTES:
(1) Existing WSF
(2) Includes the existing capacity of Desert Oasis WSF

Table E-7.
Summary of Pipes Improvements for Alternative 2

Diameter (in)	Transmission Main Length (feet)	Distribution Pipe Length (feet)
8	-	25,300
12	110,900	57,200
16	-	1,314,000
20	103,000	51,600
24	71,300	514,200
30	-	27,800
36	-	31,700
Total	285,200	2,021,800

E.4.3. Alternative 3: CAP WTP with Wells for Additional Production and Backup Supply

Alternative 3 is very similar to Alternative 2 except that the City's CAP allocations will be treated and distributed from a surface WTP (Figure E-4).

E.4.3.1. Water Supply Facilities (WSFs)

Similar to Alternative 2, the WSFs in this alternative consist of treatment, storage reservoirs, and a booster pump station. Further, an additional storage facility and three additional booster stations are located within the distribution system away from WSFs. The CAP WTP in this alternative is located within pressure zone 4. A summary of the infrastructure present at each WSF along with the numbers of wells needed is presented in Table E-8.

- **WSFs -** This alternative has the same number of WSFs as Alternative 2; however, because a surface WTP is provided, the size of the R-64 WSF in pressure zone 4 is smaller.
- **CAP WTP -** The CAP WTP will utilize conventional treatment technologies (coagulation/flocculation followed by filtration) to treat the water to potable water standards. Approximately 90 percent of the raw water will be recovered from the treatment process as potable water, resulting in approximately 11 mgd available for distribution. The remaining 10 percent will be lost in the solids handling process.
- **Storage –** Storage is provided at each WSF, including the CAP WTP. The storage volume was calculated as described in section 3. All the storage reservoirs, except for Tank T-3, are located at the WSFs.
- **Wells -** Each WSF is supplied by several wells using the criteria described in Section 3. In addition, the CAP WTP has back up wells in case of interruption in CAP water supply. The back wells can provide one average day of demand to the CAP WTP's service area. Each well will be located on a one-quarter acre parcel.
- **Booster Stations –** As compared to Alternative 2, one additional booster station is present in the alternative at the CAP WTP. Also, there is a reduction in the capacity of the booster station at WSF R-64.

E.4.3.2. Piping

Transmission piping and distribution piping serve the same functions as described in Alternative 1. The total length of the improvement pipes in this alternative is the same as in Alternative 2, but they differ in sizes needed. There are fewer 16 inch pipes and more 24 inch and 30 inch pipes in Alternative 3. The piping summary for Alternative 3 is shown in Table E-9.

E.4.3.3. PRVs

There are no PRVs needed in this alternative.

E.4.3.4. CAP Recharge

Because CAP water will be used at the surface water treatment plant, no recharge facilities for CAP water were needed.

Table E-8.
Water Supply Infrastructure for Alternative 3

Map ID	Water Supply Facility Description	Pressure Zone	WSF Capacity (mgd)	Number of Additional Wells	Additional Storage Required (MG)	Additional Booster Station Requirements	
						Capacity (gpm)	TDH (ft)
WSF1	Ashton Ranch [1]	1	7	--	--	--	--
WSF2	Mountain Vista Ranch [1]	1	2	--	--	--	--
WSF3	Roseview [1]	1	2	--	--	--	--
WSF4	Rancho Gabriela [1]	1	7	--	--	--	--
WSF5	Desert Oasis [1]	2 and 3	25[2]	12	4.6	15,000	220
WSF37	R-61	2	21	12	6.9	15,000	203
WSF38	R-63	3	31	17	9.8	21,400	167
SWTP	CAP Surface WTP	4	11	4 [3]	4	7,900	301
WSF39	R-64	4	24	14	7.8	16,600	226
WSF40	R-65	4	12	8	4.3	8,500	152
WSF42	R-67	5	12	8	4.3	8,600	140
WSF41	R-66	5	14	9	4.8	9,800	182
WSF43	R-68	6	5	4	2.2	3,700	218
WSF44	R-75	6	5	4	2	3,350	240
WSF45	R-71	7	10	7	3.6	7,100	225
WSF46	R-72	8	8	5	2.9	5,400	225
WSF47	R-73	9	6	4	2.3	4,000	305
B1	T-3	10	NA	NA	16	11,800	238
B2		11	NA	NA	NA	7,000	230
B3		12	NA	NA	NA	4,000	300

Notes:
(1) Existing WSF
(2) Includes the existing capacity of Desert Oasis WSF
(3) Backup supply to serve average day demand

Table E-9.
Summary of Pipes Improvements for Alternative 3

Diameter (in)	Transmission Main Length (feet)	Distribution Pipe Length (feet)
8	-	25,300
12	110,900	57,200
16	-	1,324,800
20	105,600	51,600
24	66,000	498,100
30	-	32,600
36	-	31,700
Total	282,500	2,021,300

E.5. Basis of Costs

Preliminary capital and O&M cost estimates were developed for the required system improvements and upgrades identified for each drinking water infrastructure alternative. The cost estimates presented herein are based on capital improvement plan budgets, bid tabulations, and unit cost data from the cities of Surprise, Phoenix, Peoria, Avondale, and El Mirage. Existing studies, recent projects with similar components, manufacturer's budget estimates, standard construction cost estimating manuals, and engineering judgment were also used to refine the estimated costs when necessary. The level of accuracy for the cost estimates corresponds to the Class 4 estimate as defined by the Association for the Advancement of Cost Engineering (AACE) International. This level of engineering cost estimating is approximate and generally made without detailed engineering data and site layouts, but is appropriate for preliminary budget-level estimating. The accuracy range of a Class 4 estimate is minus 15 to plus 20 percent in the best case and minus 30 percent to plus 50 percent in the worst case.

The unit capital costs include materials of construction, installation, contractor costs (overhead, profit, bonding, mobilization), and engineering. For infrastructure calculated from equipment and concrete costs, a 30 percent level of planning contingency was added (i.e. CAP WTP). The unit O&M costs include labor, power, chemicals, maintenance, and materials. All costs are in October 2008 dollars referenced to an Engineering News Record Construction Cost Index (ENR CCI) of 8,623.

The relative economic feasibility of the alternatives was compared based on an equivalent present worth cost basis. The equivalent present worth cost for each alternative is the sum of total capital cost plus the estimated annual O&M cost, annualized over a 20-year study period at an interest rate of 7 percent.

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F. Wastewater, Reclaimed Water, and Recharge Infrastructure Alternatives

This appendix provides additional information on the development of the wastewater, reclaimed water, and recharge infrastructure alternatives.

F.1. Future System Demand Scenario

The demand set used for the wastewater, reclaimed water, and recharge system evaluations was the Mid-Population Scenario (i.e., population of approximately 700,000 at build-out) identified in the Water Resources component of the *Integrated Water Master Plan*. This scenario involves collecting wastewater from all customers within the City's sewer planning area, and reclaimed water service to all private water company service areas within the City's MPA, with the exception of the Arizona American Water Company (AAWC) and City of El Mirage service areas. In this scenario, the City will plan to control future development densities to balance water demands with available water supplies.

As described in the Water Resources component of the *Integrated Water Master Plan*, indoor and outdoor demands will be served with potable water and landscape (large irrigation) demands will be served via the reclaimed water distribution system. It is assumed that all potable water used indoors returns through the wastewater system. The reclaimed water availability is assumed to be 90 percent of the wastewater generated throughout the area.

Preliminary build-out wastewater flows, reclaimed water availability, and landscape (large irrigation uses served with reclaimed water) demands were obtained from the Demand Module. These values, shown in Table F-1, were used for the preliminary wastewater, reclaimed water, and recharge infrastructure evaluations. Because the alternative evaluations were preformed prior to the completion of the Water Resources component of the *Integrated Water Master Plan*, the demands used for the evaluation varied slightly from the demands used to phase the selected alternative in Section 7 of the Water Infrastructure component of the *Integrated Water Master Plan*.

All modeling of future scenarios was conducted for the build-out condition. As such, the comparisons presented in this memo represent infrastructure and costs at build-out. Based on comments received from the City, the selected alternative was remodeled prior to developing a phasing and implementation schedule for 2020 and build-out conditions.

Table F-1.
Build-out Wastewater Flows, Reclaimed Water Availability, and Landscape (Reclaimed Water) Demands Used for Infrastructure Alternatives

Special Planning Area	Annual Average Wastewater Flow (mgd)	Reclaimed Water Availability (mgd)	Landscape (Reclaimed Water) Demand (mgd)
SPA 1	20.9	18.9	2.2
SPA 2	9.1	8.2	1.6
SPA 3	20.2	18.2	2.4
SPA 4	12.2	11.0	2.5
SPA 5	15.4	13.9	3.5
SPA 6	10.7	9.6	3.1
TOTAL	88.6	79.7	15.3

F.2. System Performance and Design Criteria

Tables F-2 through F-4 summarize the preliminary performance and design criteria used for this evaluation. Because the alternative evaluations were preformed prior to the finalization of the system performance and design criteria, the values in Tables F-2 through F-4 may differ slightly with the criteria in Section 5 of this report.

Table F-2.
Preliminary Collection System Performance and Design Criteria Summary

Element	Design Criteria	Used for Infrastructure Alternatives
Maximum Month Flow	Peaking Factor (based on average annual flow)	1.2
Peak Hour Flow	Peaking Factor (based on maximum month flow)	2.5
Gravity Sewers	Depth Ratio	<0.8
Force Mains	Velocity Range	2 ft/s - 8 ft/s
Pump Stations	Firm Capacity	Exceeds Peak Flow

F.3. Alternative Descriptions

The wastewater and reclaimed water infrastructure alternatives were developed in a workshop with the City's Steering Committee and Technical Committees. The following general alternatives were identified for evaluation:

- Alternative 1: Construct and Operate 6 WRFs
- Alternative 2: Construct and Operate 4 WRFs
- Alternative 3: Construct and Operate 3 WRFs

Table F-3.
Preliminary Reclaimed Water System Performance and Design Criteria Summary

Design Parameters			Used for Infrastructure Alternatives
Peaking Factors		Maximum Day	2 x Average Day Demand
		Peak Hour	3 x Maximum Day Demand
Reclaimed Water Production			0.9 x Wastewater Treatment Capacity
Storage Facility			Maximum Day Demand
Pipe Sizing	Distribution	Velocity	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Peak hour of maximum day
	Transmission	Velocity	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Maximum Recharge Demand
	Recharge Mains	Velocity	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Maximum Recharge Demand
System Pressure		Maximum Pressure	80 psi
		Minimum Pressure (Peak Hour Conditions)	25 psi
Booster Station Design Criteria		at WSF	Peak Hour
		at Distribution System	
		at WRF	Maximum Recharge
		at Transmission Mains Boosting to WSF only	Maximum Day Demand

Each alternative is generally described in the following sections, followed by detailed descriptions, including design considerations, concept schematics, and anticipated infrastructure requirements (WRFs, collection system piping, reclaimed water piping and pumps, and recharge basins).

F.3.1. Alternative 1: Construct and Operate 6 WRFs

Under this alternative, the City will design and construct a WRF in each SPA (Figure F-1). In essence, the City would continue with recommendations provided in the previous wastewater and reclaimed water master plans. Reclaimed water demands (large irrigation

Table F-4.
Preliminary Recharge System Performance and Design Criteria

Parameter	Used for Infrastructure Alternatives
Loading Rate (ft/year)	122
Loading Rate: Infiltration Rate (%)	33
Infiltration Rate (ft/day)	1
Wet/Dry Ratio	0.50
Application Period (days)	4
Drying Period (days)	8
Number of Basins (#)	3
Basin Depth (ft)	5
Sidewall Slope (Rise:Run)	1:3
Ramp Gradient (%)	10
Distance Between Basins (ft)	12

uses) will be met with reclaimed water from the 6 WRFs. Reclaimed water will be pumped from the WRF to storage and booster facilities that are co-located with water supply facilities (WSFs) throughout the municipal planning area (Figure F-2). All surplus reclaimed water will be recharged.

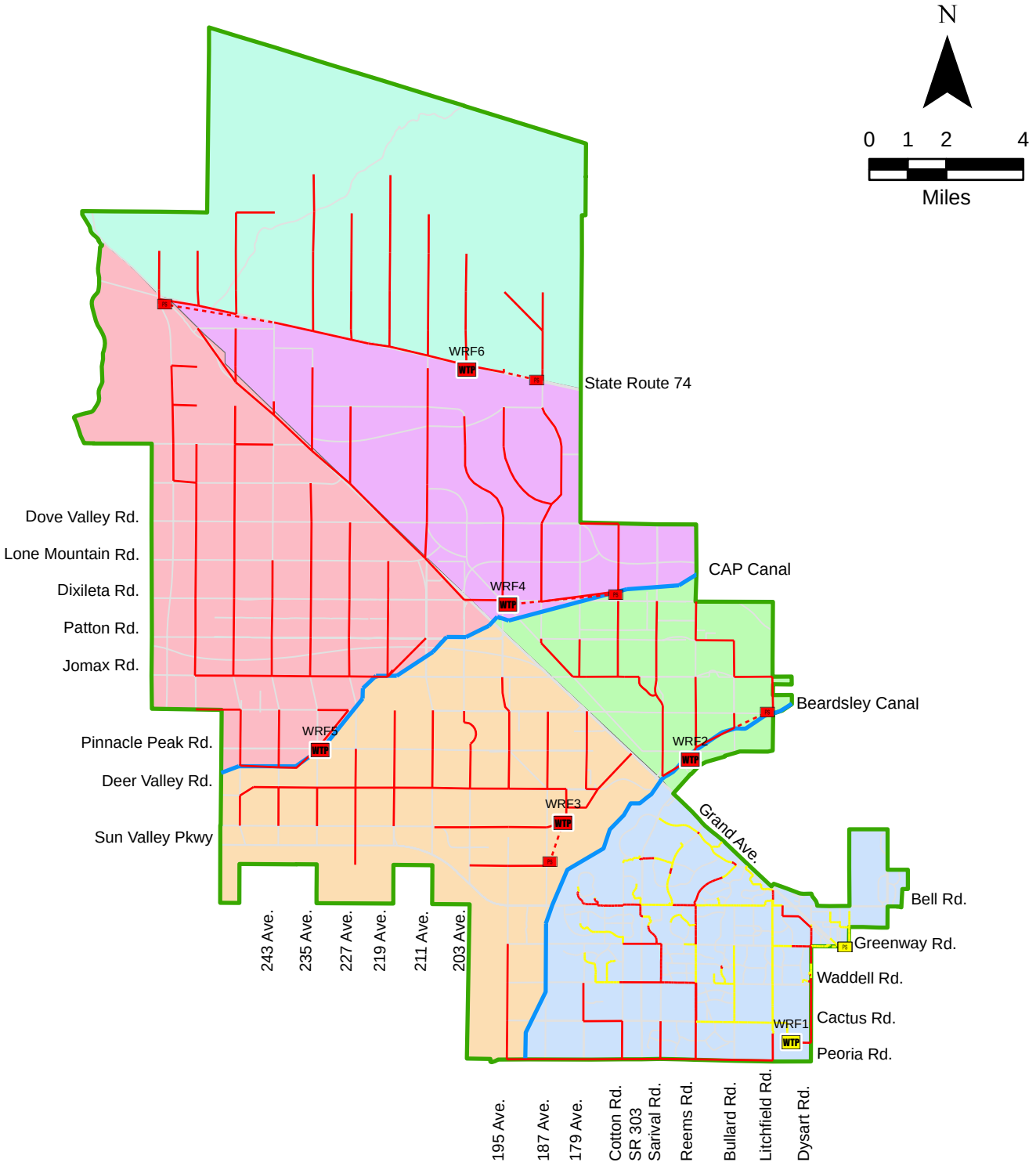
In this configuration, the wastewater collection systems in each SPA remained separate; no areas of one SPA are served by another SPA WRF except for the southernmost area of SPA 3, which conveys wastewater to the SPA 1 collection system. This diversion is common to all of the alternatives analyzed.

F.3.2. Alternative 2: Construct and Operate 4 WRFs

Under this alternative, the City will design and construct 4 WRFs: one each in SPAs 1, 2, 3, and 5 (Figure F-3). The SPA 1, 2, and 3 WRFs will receive flows from their respective SPA. The SPA 4 WRF will receive wastewater flows from SPAs 4, 5, and 6. Reclaimed water storage, distribution, and recharge will be similar to Alternative 1; however, reclaimed transmission mains and booster pumping will change (Figure F-4).

F.3.3. Alternative 3: Construct and Operate 3 WRFs

Under this alternative, the City will only design and construct 3 WRFs in SPAs 1, 2, and 3 (Figure F-5). Collection system flows from SPA 5 will be routed to the WRF in SPA 3. Flows from SPAs 4 and 6 will flow into the WRF in SPA 2. Reclaimed water storage, distribution, and recharge will be similar to Alternatives 1 and 2, but reclaimed water transmission and booster pumping will vary (Figure F-6).



Legend

- Streets
- Canals
- Municipal Planning Area

Drainage Basins

- SPA 1
- SPA 2
- SPA 3
- SPA 4
- SPA 5
- SPA 6

Water Reclamation Facilities

- Existing
- Proposed

Pump Stations

- Existing
- Proposed

Gravity Sewers

- Existing
- Proposed and/or Improved

Force Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1: 6 WRFs (Wastewater Infrastructure)

July 2009

Figure F-1

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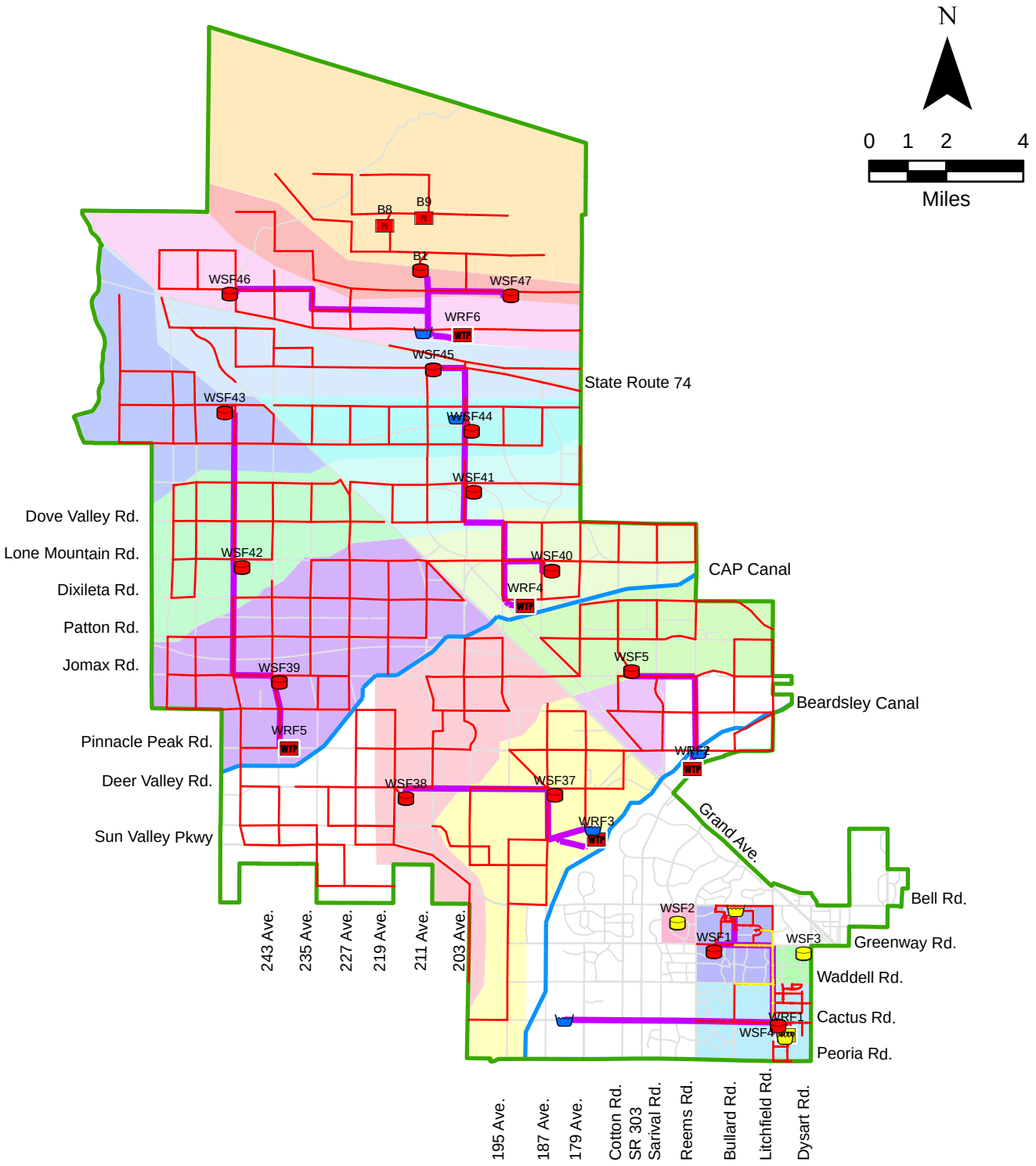

Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Water Reclamation Facilities

- Existing
- Proposed

Recharge Facilities

- Existing/Planned
- Proposed

Additional Distribution Booster Stations

- Proposed

Transmission Mains

- Proposed and/or Improved

Distribution Mains

- Existing
- Proposed and/or Improved

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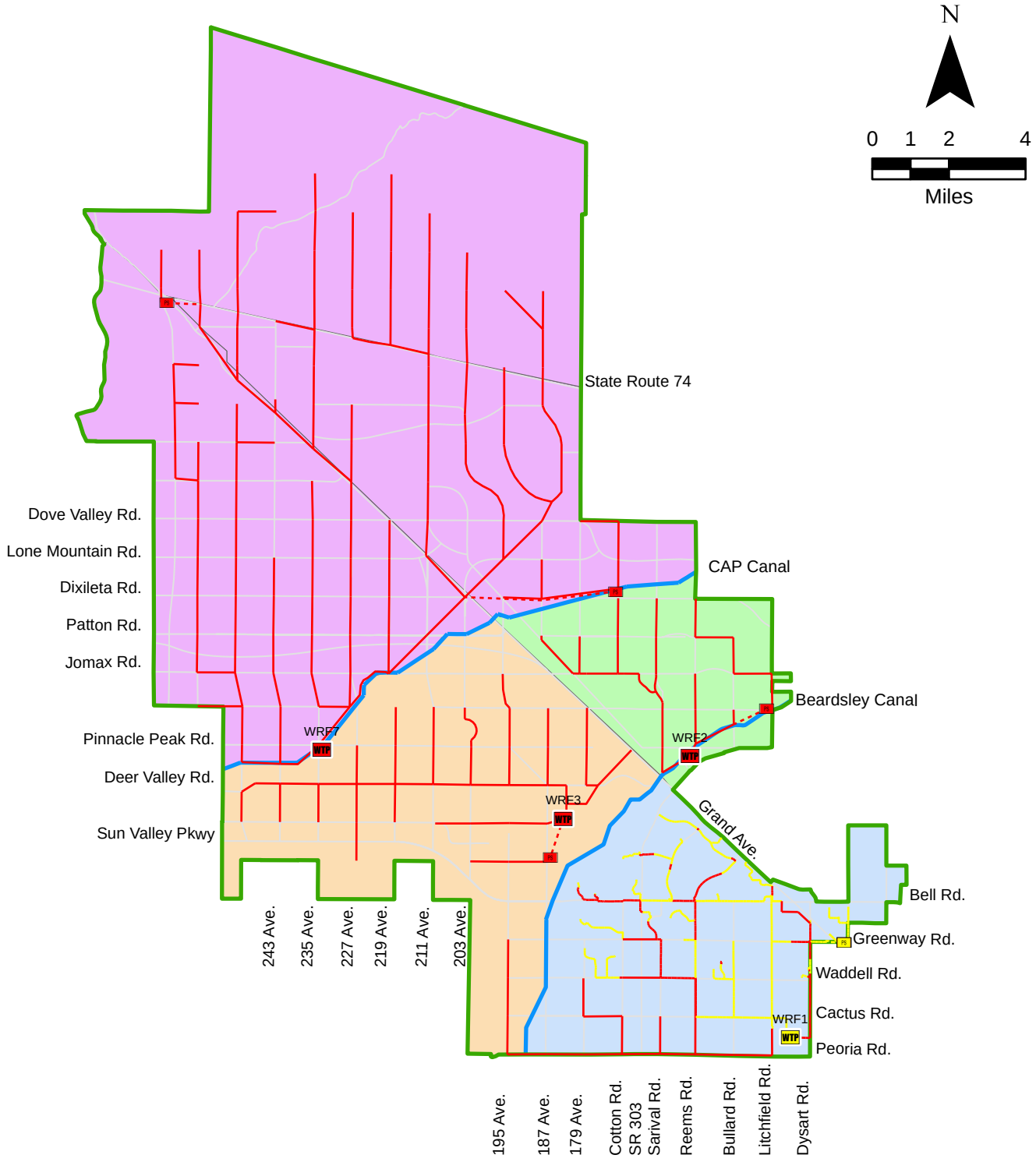
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1: 6 WRFs (Reclaimed Water Infrastructure)

July 2009

Figure F-2

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure F-2 6 WRFs RW.mxd



Legend

- Streets
- Canals
- Municipal Planning Area

Drainage Basins

- SPA 1
- SPA 2
- SPA 3
- SPA 4/5/6

Water Reclamation Facilities

- Existing
- Proposed

Pump Stations

- Existing
- Proposed

Gravity Sewers

- Existing
- Proposed and/or Improved

Force Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: 4 WRFs (Wastewater Infrastructure)

July 2009

Figure F-3

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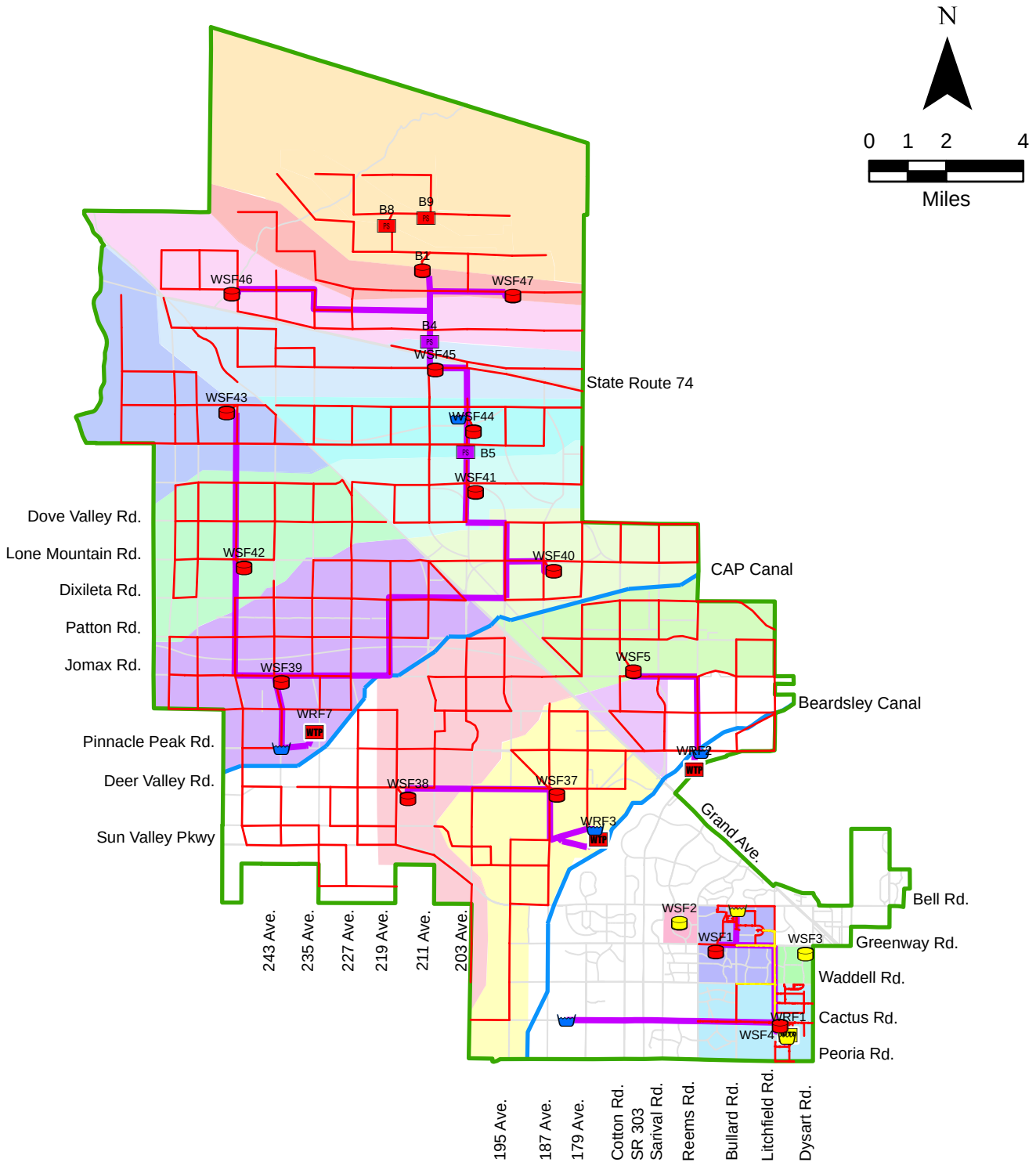

Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Water Reclamation Facilities

- Existing
- Proposed

Recharge Facilities

- Existing/Planned
- Proposed

Additional Transmission Booster Station

- Proposed

Additional Distribution Booster Station

- Proposed

Transmission Mains

- Proposed and/or Improved

Distribution Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: 4 WRFs (Reclaimed Water Infrastructure)

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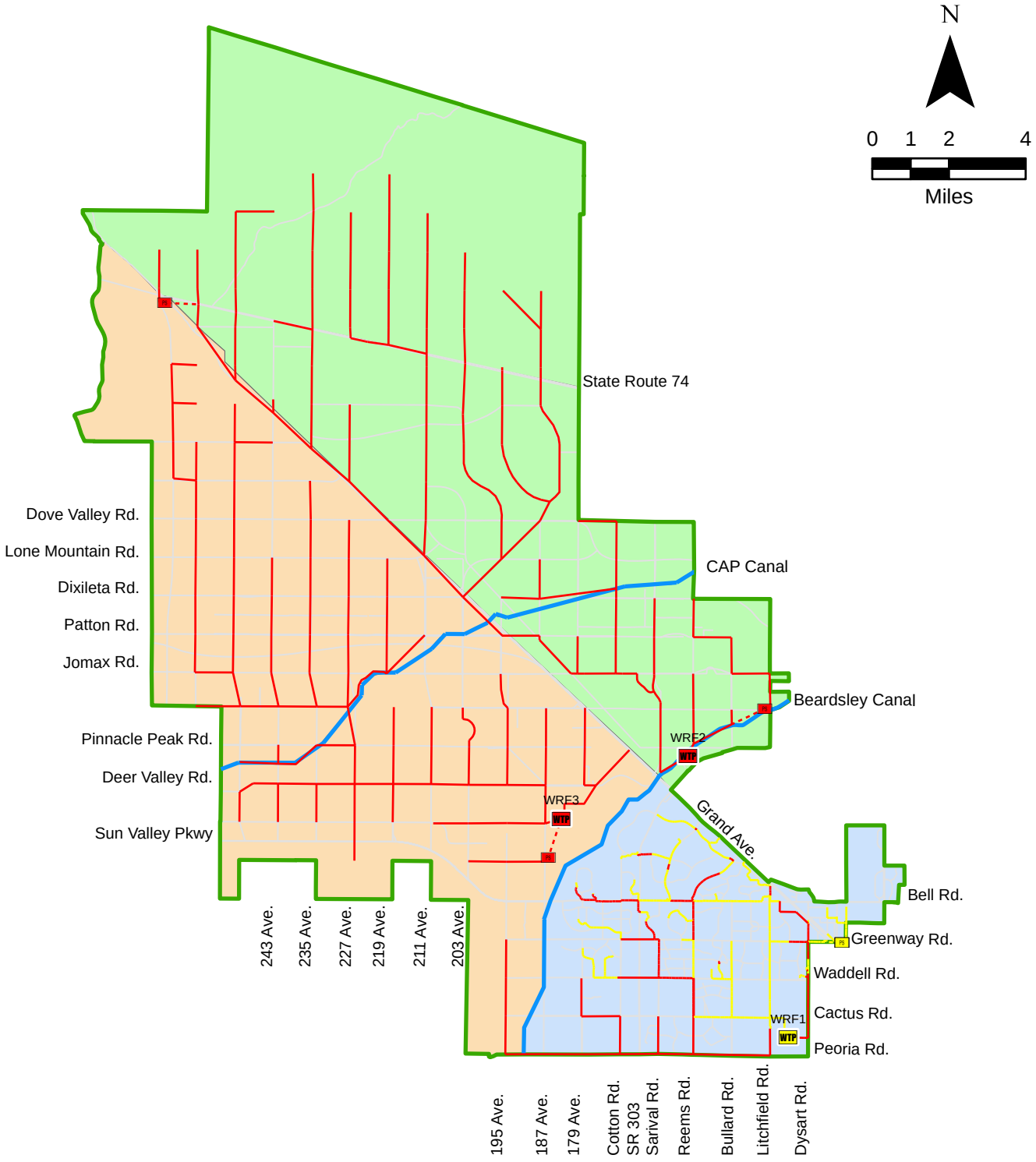
Figure F-4

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure F-4 4 WRFs RW.mxd



Legend

- Streets
- Canals
- Municipal Planning Area

Drainage Basins

- SPA 1
- SPA 2/4/6
- SPA 3/5

Water Reclamation Facilities

- Existing
- Proposed

Pump Stations

- Existing
- Proposed

Gravity Sewers

- Existing
- Proposed and/or Improved

Force Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 3: 3 WRFs (Wastewater Infrastructure)

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Figure F-5

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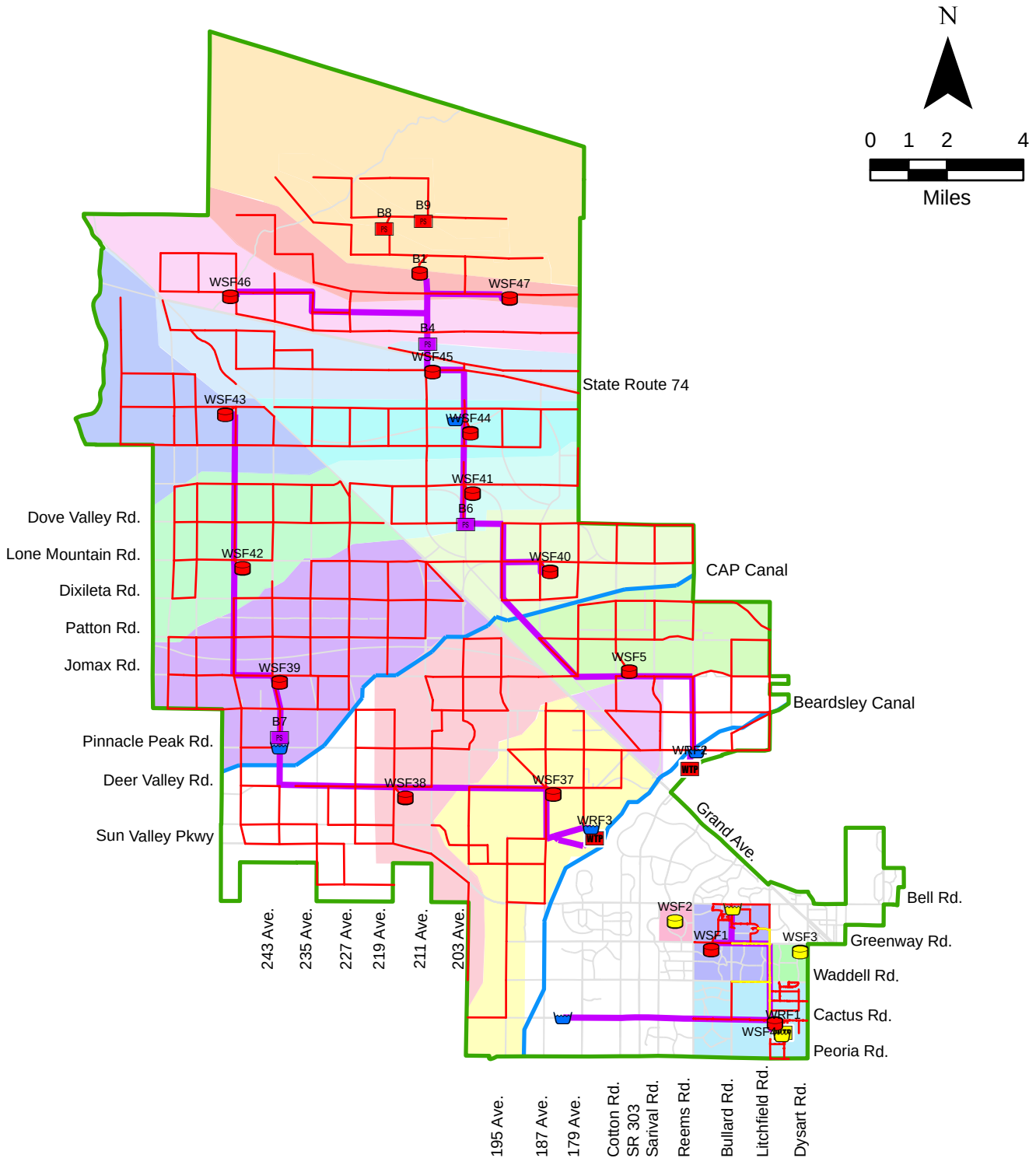

Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Water Reclamation Facilities

- Existing
- Proposed

Recharge Facilities

- Existing/Planned
- Proposed

Additional Transmission Booster Stations

- Proposed

Additional Distribution Booster Stations

- Proposed

Transmission Mains

- Proposed and/or Improved

Distribution Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: 3 WRFs (Reclaimed Water Infrastructure)

July 2009

Figure F-6

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure F-6 6 WRFs RW.mxd

F.4. Infrastructure Components for Alternatives

Each wastewater, reclaimed water, and reclaimed water recharge alternative will consist of the following components:

- Water Reclamation Facilities (WRFs)
- Gravity Collection System
- Pump Stations and Force Mains
- Reclaimed Water System (Transmission, Storage, Pumping, and Distribution)
- Recharge Facilities

F.4.1. Water Reclamation Facilities

The primary difference between the alternatives is the number and size of the WRFs. Using the appropriate sewer shed boundaries and the annual average wastewater loading from the Demand Module, the WRF capacities listed in Table F-5 were calculated. The collection system model assumes that each of the WRFs is able to accept the peak flow without any restrictions or back-ups into the collection system. With the exception of the SPA 1 WRF, all WRFs were assumed to use the membrane bioreactor (MBR) technology.

Table F-5.
Water Reclamation Facility Capacity and Land Requirements

	Facility Service Area	Annual Average Wastewater Load (mgd)	Land (acres)[1]
Alternative 1 (6 WRFs)	SPA 1	20.9	--
	SPA 2	9.1	92
	SPA 3	20.2	95
	SPA 4	12.2	93
	SPA 5	15.4	94
	SPA 6	10.7	93
Alternative 2 (4 WRFs)	SPA 1	20.9	--
	SPA 2	9.1	92
	SPA 3	20.2	95
	SPAs 4, 5, and 6	38.3	100
Alternative 3 (3 WRFs)	SPA 1	20.9	--
	SPAs 2, 4, and 6	32.0	99
	SPAs 3 and 5	35.6	100

NOTE:
(1) Land requirements assume no odor and noise control. Estimates were taken from the WateReuse Foundation WRF Decision Support System Tool. No additional land was needed for SPA 1.

F.4.2. Gravity Collection System

To develop sizing requirements for the future systems, the wastewater model was loaded with the preliminary, anticipated build-out flows determined using the Demand Module. In addition to the piping needed to serve new areas of the system, the system improvements summarized in this section also include items necessary for alleviating the system deficiencies identified in Section 5 in the main report.

The lengths of each diameter pipe needed at build-out for each alternative is summarized in Table F-6. As seen in the table, as the number of WRFs decreases, the total amount of collection system piping as well as the average diameter of the collection system piping increase. None of the piping in the alternatives listed below account for deterioration of the collection system that occurs as the natural part of aging. Any component of the collection system that is replaced as part of the City's buried infrastructure management program or otherwise known to be in a deteriorated station should be considered separate from these analyses.

Table F-6.
Gravity Sewer Upgrade Summary for the 6 WRF Alternative

Gravity Sewer Diameter (in)	Length of Gravity Sewer Improvement (ft)		
	Alternative 1 (6 WRFs)	Alternative 2 (4 WRFs)	Alternative 3 (3 WRFs)
8 inch	106,784	96,364	96,381
10 inch	161,321	122,254	117,923
12 inch	106,862	107,436	88,705
15 inch	224,452	193,555	213,484
18 inch	142,289	144,664	149,936
21 inch	111,991	127,698	133,334
24 inch	73,777	90,346	83,578
27 inch	37,030	72,469	73,202
30 inch	73,260	81,591	62,162
36 inch	68,478	57,620	39,736
42 inch	15,433	15,433	13,826
48 inch	21,045	8,822	27,226
54 inch	15,430	21,689	54,279
60 inch	-	-	16,021
66 inch	-	14,500	-
72 inch	-	-	4,430
78 inch	-	7,528	-
Total	**1,158,152**	**1,161,969**	**1,174,223**

F.4.3. Pump Stations and Force Mains

Due to the topography constraints, it was not possible to convey the wastewater to the WRF in each SPA entirely by gravity sewers. For areas that are located at lower elevation than the adjacent service area, it was necessary to include pump stations and force mains to transport the wastewater to a higher elevation in the collection system. The pump station capacities are assumed to be the firm capacity of the pump station to convey the peak flow, and the force mains were sized to maintain the optimal velocity range. All of the force mains discharge either to a trunk sewer or directly to the WRF. None of the force mains are manifolded.

As seen in Tables F-7 and F-8, as the number of WRFs decreases, the number of pump stations, the total pumping capacity, and the total length of force mains also decrease.

Table F-7.
Collection System Pump Station Improvements Summary

	Service Area	Capacity (gpm)	TDH[1] (ft)
Alternative 1 (6 WRFs)	SPA 2	2,938	115
	SPA 3	4,369	50
	SPA 4	7,623	120
	SPA 6 (east)	5,387	40
	SPA 6 (west)	5,625	85
	Total	30,968	NA
Alternative 2 (4 WRFs)	SPA 2	2,938	145
	SPA 3	4,369	40
	SPA 4	6,070	145
	SPA 6	1,316	180
	Total	14,693	NA
Alternative 3 (3 WRFs)	SPA 2	2,938	145
	SPA 3	4,369	40
	SPA 6	1,316	180
	Total	8,623	NA

NOTE:
(1) TDH requirements will change depend on the actual constructed elevations of the pump station wetwell and the discharge point.

F.4.4. Reclaimed Water System

The components of the reclaimed water system are as follows:

- **Reclaimed Water Transmission** includes high service pumping and large-diameter piping used to transfer water from the WRF to the storage reservoir at water supply facilities.

Table F-8.
Force Main Improvement Summary

Force Main Diameter (in)	Length of Force Main Improvement (ft)		
	Alternative 1 (6 WRFs)	Alternative 2 (4 WRFs)	Alternative 3 (3 WRFs)
10	-	5,411	5,411
16	5,400	5,400	5,400
20	11,815	6,202	6,202
24	31,182	21,222	-
Total	**48,397**	**38,235**	**17,013**

- **Reclaimed Water Storage and Distribution** includes reclaimed water storage tanks at the WSFs, booster pumping at the WSFs, and distribution mains used to distribute the reclaimed water to the one square-mile grid.

Because the location of the WRFs changes in this evaluation, the amount and size of piping and pumping needed to convey water from the WRFs to the reclaimed water storage tanks at the WSFs differs. However, because the WSF locations and the reclaimed water demands are the same in all alternatives, the reclaimed water storage and distribution components do not change among the alternatives. The reclaimed water storage and booster pumping is co-located with the water supply facilities so that untreated groundwater can be used to supplement the reclaimed water distribution system in periods of high demand or in the event that development and reclaimed water demand exceed the available supply.

F.4.4.1. Reclaimed Water Transmission

The pumping requirements and transmission mains needed to convey reclaimed water from the WRFs to the reclaimed water storage facilities are summarized in Tables F-9 and F-10, respectively. Transmission pumping (Table F-9) includes pumping at the WRF as well as booster pumping needed at pressure zone boundaries to convey reclaimed water to the storage tanks at higher elevations. As shown in Table F-9, although the number of transmission pumping stations stays the same in each alternative, the total pumping capacity needed increases as the number of WRFs decreases. In Alternatives 2 and 3, because of the large elevation difference between the WRF location and the reclaimed storage locations, intermediate transmission booster pumping was needed to alleviate high pressures at the WRF. The intermediate pumping was not needed in Alternative 1 because the elevation differences are considerably smaller. As shown in Table F-10, transmission piping quantities and diameters increase as the number of WRFs decreases.

F.4.4.2. Reclaimed Water Storage and Distribution

As noted previously, because reclaimed water storage locations and demands do not change between the alternatives, the amount of storage (Table F-11), booster pumping

Table F-9.
Reclaimed Transmission Pumping Summary

Alternative	Location / Map ID	Type	Pressure Zone	Total Flow (gpm)	Head (ft)
Alternative 1 (6 WRFs)	WRF 1	HSP	1	7,274	218
	WRF 2	HSP	2	5,750	245
	WRF 3	HSP	2	12,600	282
	WRF 4	HSP	4	7,600	467
	WRF 5	HSP	4	9,500	513
	WRF 6	HSP	8	6,700	415
Alternative 2 (4 WRFs)	WRF 1	HSP	1	7,274	218
	WRF 2	HSP	2	5,750	245
	WRF 3	HSP	2	12,600	282
	WRF 7	HSP	4	23,961	350
	B4	TBP	7 to 8	3,560	222
	B5	TBP	5 to 6	13,576	90
Alternative 3 (3 WRFs)	WRF 1	HSP	1	7,274	218
	WRF 2	HSP	2	19,990	396
	B6	TBP	4 to 5	13,329	312
	B4	TBP	7 to 8	2,072	287
	WRF 3	HSP	2	22,270	311
	B7	TBP	3 to 4	5,188	343

Note: HSP= High Service Pumps at WRFs, TBP= Transmission Booster Pump

Table F-10.
Reclaimed Transmission Mains Summary

Reclaimed Transmission Main Diameter (in)	Length of Transmission Main (ft)		
	Alternative 1 (6 WRFs)	Alternative 2 (4 WRFs)	Alternative 3 (3 WRFs)
12	41,641	34,822	34,822
16	75,204	75,225	35,968
20	21,865	45,204	39,053
24	37,292	23,977	33,979
30	28,686	6,819	6,819
36	38,919	38,170	38,329
42	0	83,697	120,929

Table F-11.
Proposed Additional Reclaimed Water Storage

SPA	Location	Type.	Status	Capacity (MG)
SPA 1	WSF 4 (Rancho Gabriela)	Ground Tank	Future	1.75
	WSF 1 (Ashton Ranch)	Ground Tank	Future	2.76
SPA 2	WSF 5 (Desert Oasis)	Ground Tank	Future	0.75
SPA 3	WSF 38	Ground Tank	Future	2.00
	WSF 37	Ground Tank	Future	2.00
SPA 4	WSF 40	Ground Tank	Future	1.44
	WSF 42	Ground Tank	Future	0.76
	WSF 45	Ground Tank	Future	2.00
	WSF 44	Ground Tank	Future	1.42
SPA 5	WSF 39	Ground Tank	Future	4.00
	WSF 41	Ground Tank	Future	1.98
	WSF 43	Ground Tank	Future	1.47
SPA 6	WSF 46	Ground Tank	Future	1.86
	WSF 47	Ground Tank	Future	1.12
	B1*	Ground Tank	Future	3.16

Note: *Storage facility offsite than WSF, supplies PZ 10, 11, and 12

capacity (Table F-12), and distribution piping (Table F-13) is the same in all alternatives. The reclaimed storage tanks and booster pumps were located at the WSF locations identified in the drinking water infrastructure alternatives. The purpose of co-locating these facilities is so that untreated ground water can be used to supplement the reclaimed distribution system in the event that reclaimed water demand exceeds the supply or if the reclaimed water supply is interrupted for any reason. The purpose of the booster pumps is to provide sufficient pressure within the distribution mains such that the minimum pressure is achieved at the pressure zone boundaries. The distribution mains supply reclaimed water throughout service area. The layout of the new distribution mains was similar to the piping layout established in the most economical drinking water infrastructure alternative. The existing reclaimed distribution mains in portions of SPA 1 and SPA2 were also included in the model analysis.

Table F-12.
Proposed Additional Reclaimed Water Booster Pumping

Location	Pressure Zone	Total Flow (gpm)	Head (ft)
WSF 4 (Rancho Gabriela)	1	3,650	110
WSF 1 (Ashton Ranch)	1	5,400	75
WSF 5 (Desert Oasis)	2	3,300	60
WSF 5 (Desert Oasis)	3	3,250	185
WSF 37	3	4,200	166
WSF 38	3	3,900	128
WSF 40	4	3,000	130
WSF 42	5	1,600	125
WSF 44	6	3,000	135
WSF 45	7	4,000	150
WSF39	4	8,400	140
WSF 41	5	4,150	145
WSF 43	6	3,100	130
WSF 46	8	3,900	127
WSF 47	9	2,350	170
B1	9 to 10	6,000	200
B8	10 to 11	3,200	125
B9	11 to 12	1,500	130

Table F-13.
Proposed Additional Reclaimed Water Distribution Mains

Diameter (in)	Total Length (ft)
4	998
8	109,259
10	514
12	889,206
16	914,525
20	59,838
24	32,425
30	25,526
36	9,566

F.4.5. Recharge Facilities

All reclaimed water that is not reused is recharged using surface spreading basins. Recharge facilities (Table F-14) were designed and sized using the preliminary criteria described above. The land requirements in the table account for the wet/dry ratio, berms, ramps, and roads. The piping and pumping requirements to convey water to the recharge basins were included above with the reclaimed water transmission infrastructure. The total amount of water needing to be recharged is the same in all alternatives; however, the amount of recharge capacity needed in each location changes:

- In Alternative 1, reclaimed water is recharged in the SPA where it is generated.
- In Alternative 2, reclaimed water from SPAs 1, 2, and 3 is recharged in the SPA where it is generated. Two-thirds of the reclaimed water from the SPA 4/5/6 WRF will be recharged in SPA 4. The remaining one-third will be recharged in SPA 5, and no water will be recharged in SPA 6.
- In Alternative 3, reclaimed water from SPA 1 is recharge in SPA 1. One-third of the reclaimed water from the SPA 2/4/6 WRF will be recharged in SPA 2. The remaining two-thirds will be recharged in SPA 4. One third of the reclaimed water from the SPA 3/5 WRF will be recharged in SPA 3. The remaining two-thirds will be recharged in SPA 5. No water will be recharged in SPA 6.

F.5. Basis of Costs

Capital and O&M cost estimates were developed for the required system improvements and upgrades identified for each infrastructure alternative. The cost estimates presented herein are primarily based on capital improvement plan budgets, bid tabulations, and unit cost data from the cities of Surprise, Phoenix, Peoria, Avondale, and El Mirage. Existing studies, recent projects with similar components, manufacturer's budget estimates, standard construction cost estimating manuals, and engineering judgment were also used to refine the estimated if necessary. The level of accuracy for the cost estimates corresponds to the Class 4 estimate as defined by the Association for the Advancement of Cost Engineering (AACE) International. This level of engineering cost estimating is approximate and generally made without detailed engineering data and site layouts, but is appropriate for preliminary budget-level estimating. The accuracy range of a Class 4 estimate is minus 15 to plus 20 percent in the best case and minus 30 percent to plus 50 percent in the worst case.

The unit capital costs include materials of construction, installation, contractor costs (overhead, profit, bonding, mobilization), and engineering. For infrastructure calculated from equipment and concrete costs, a 30 percent level of planning contingency was added (i.e., WRF facilities). The unit O&M costs include labor, power, chemicals, maintenance, and materials. All costs are in October 2008 dollars referenced to an Engineering News Record Construction Cost Index (ENR CCI) of 8,623.

Table F-14.
Recharge Capacity and Land Requirements

Alternative	Recharge Location	Total Recharge Capacity (mgd)	Existing Recharge Capacity (mgd)	Additional Recharge Capacity Needed (mgd)	Additional Land Requirements (acres)
Alternative 1 (6 WRFs)	SPA 1	22.6	6.9[1]	15.7	159
	SPA 2	8.2	-	8.2	86
	SPA 3	18.2	-	18.2	182
	SPA 4	11.0	-	11.0	113
	SPA 5	13.9	-	13.9	141
	SPA 6	9.6	-	9.6	100
	Total	**83.5**	**6.9**	**76.6**	**780**
Alternative 2 (4 WRFs)	SPA 1	22.6	6.9[1]	15.7	159
	SPA 2	8.2	-	8.2	86
	SPA 3	18.2	-	18.2	182
	SPA 4	23.0	-	11.0	229
	SPA 5	11.5	-	13.9	118
	Total	**83.5**	**6.9**	**76.6**	**773**
Alternative 3 (3 WRFs)	SPA 1	22.6	6.9[1]	15.7	159
	SPA 2	9.6	-	9.6	99
	SPA 3	10.7	-	10.7	110
	SPA 4	19.2	-	19.2	192
	SPA 5	21.4	-	21.4	213
	Total	**83.5**	**6.9**	**76.6**	**774**

NOTE:
(1) Assumes 24 vadose zones (200 gpm each) are already planned or constructed and the existing SPA 1 WRF spreading basins are lined and used for reclaimed water storage.

The relative economic feasibility of the alternatives was compared based on an equivalent present worth cost basis. The equivalent present worth cost for each alternative is the sum of total capital costs, plus the estimated annual O&M cost, annualized over a 20-year study period at an interest rate of 7 percent.

Summary of Capital Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Oct. 2008)	SOURCE
CAPITAL COSTS					
Land	$40,000	$/acre	8090	$40,000	2008 land appraisal for SPA 5 WRF
Gravity Sewers					
8"	$104	$/LF	7751	$116	City of Phoenix 2006 Infrastructure
10"	$122	$/LF	7751	$136	Financing Plan (< 20 ft depth)
12"	$144	$/LF	7751	$160	
15"	$169	$/LF	7751	$188	
18"	$202	$/LF	7751	$225	
21"	$240	$/LF	7751	$267	
24"	$285	$/LF	7751	$317	
27"	$322	$/LF	7751	$358	
30"	$342	$/LF	7751	$380	
36"	$386	$/LF	7751	$429	
42"	$436	$/LF	7751	$485	
48"	$505	$/LF	7751	$562	
54"	$574	$/LF	7751	$639	
60"	$635	$/LF	7751	$706	
66"	$695	$/LF	7751	$774	
72"	$756	$/LF	7751	$841	
78"	$816	$/LF	7751	$908	
Lift Stations					
0 to < 2 mgd	$2,161,875	$/MGD	7751	$2,410,000	City of Phoenix 2006 Infrastructure
2 to < 4 mgd	$1,012,708	$/MGD	7751	$1,130,000	Financing Plan
4 to < 7 mgd	$792,250	$/MGD	7751	$880,000	
7 to < 10 mgd	$627,781	$/MGD	7751	$700,000	
10 to < 18 mgd	$510,344	$/MGD	7751	$570,000	
Force Mains					
4"	$104	$/LF	7751	$116	City of Phoenix 2006 Infrastructure
6"	$118	$/LF	7751	$131	Financing Plan
8"	$151	$/LF	7751	$168	
10"	$186	$/LF	7751	$207	
12"	$201	$/LF	7751	$224	
14"	$231	$/LF	7751	$257	
16"	$257	$/LF	7751	$286	
18"	$283	$/LF	7751	$315	
20"	$309	$/LF	7751	$344	
24"	$362	$/LF	7751	$402	
Water Reclamation Facilities					
0 to < 7 mgd	$9.65	$/gal	7888	$10.55	MBR Facility (WaterReuse Foundation
7 to < 13 mgd	$8.59	$/gal	7888	$9.39	Decision Support System)
13 to < 18 mgd	$7.45	$/gal	7888	$8.14	
18 to < 30 mgd	$6.78	$/gal	7888	$7.41	
Reclaimed Water Pipelines					
4"	$68	$/LF	8623	$68	$17/in-ft ≤ 18 inch-diameter, $20/in-ft >
6"	$102	$/LF	8623	$102	20 inch-diameter (rounded averages
8"	$136	$/LF	8623	$136	from recent City of Phoenix bid
10"	$170	$/LF	8623	$170	tabulations, City of Avondale 2008-
12"	$204	$/LF	8623	$204	2009 CIP, City of Peoria 2008-2009
14"	$238	$/LF	8623	$238	CIP and Bid Tabulations, and City of
16"	$272	$/LF	8623	$272	Surprise 2008-2009 CIP)
18"	$306	$/LF	8623	$306	
20"	$400	$/LF	8623	$400	
24"	$480	$/LF	8623	$480	
30"	$600	$/LF	8623	$600	
36"	$720	$/LF	8623	$720	
42"	$840	$/LF	8623	$840	

Summary of Capital Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Oct. 2008)	SOURCE
Recharge Basins					
Basins	$96,667	$/acre	8090	$100,000	Goodyear Adaman Design Concept Report
Monitoring Wells and Piezometers	$500,000	per location	8623	$500,000	Engineering Judgement
Reservoirs (covered)					
0.0 to < 2.5 MG	$1,366,850	$/MG	7751	$1,520,000	Adapted from City of Phoenix Water
2.5 to < 4.0 MG	$1,202,667	$/MG	7751	$1,340,000	System Master Plan and City of Peoria
4.0 to < 7.5 MG	$929,140	$/MG	7751	$1,030,000	2008-2009 CIP
Reclaimed Water Booster Pump Stations					
0 to < 7 mgd	$ 326,180	$/MGD	7751	$360,000	City of Phoenix 2006 Infrastructure
7 to < 13 mgd	$ 206,870	$/MGD	7751	$230,000	Financing Plan
13 to < 17 mgd	$ 171,900	$/MGD	7751	$190,000	
17 to < 25 mgd	$ 147,740	$/MGD	7751	$160,000	
25 to < 35 mgd	$ 115,520	$/MGD	7751	$130,000	
Pressure Reducing Valves					
3 to < 6 mgd	$ 350,600	$/MGD	7751	$390,000	City of Phoenix Water System Master

NOTES:

(1) October 2008 Costs (ENR CCI = 8,623).

(2) Unit capital costs include materials of construction, installation and contractor overhead and profit.

Summary of Operations and Maintenance Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Oct. 2008)	SOURCE
O&M COSTS					
Gravity Sewers	$3,200	$/mile/year	7355	$3,800	Peoria Water Reuse Master Plan
Lift Stations					
Power	$0.08	$/kWh	8623	$0.08	Engineering Judgment
Maintenance	3% of capital			3% of capital	Engineering Judgment
Water Reclamation Facilities					
0 to < 7 mgd	0.43	$/1,000 gal	7888	$0.47	WateReuse Foundation WRF Decision Support System
7 to < 13 mgd	0.29	$/1,000 gal	7888	$0.32	
13 to < 18 mgd	0.24	$/1,000 gal	7888	$0.26	
18 to < 30 mgd	0.2	$/1,000 gal	7888	$0.22	
Pipelines	$3,200	$/mile/year	7355	$3,800	Peoria Water Reuse Master Plan
Recharge Basin	$0.05	$/1,000 gal	7355	$0.06	Peoria Water Reuse Master Plan
CAGRD Recharge	$281.00	$/AF	8623	$281.00	CAGRD 2008/09 Published Rate
Reservoir	$6,400.00	$/yr-each	7355	$7,500.00	Peoria Water Reuse Master Plan
Booster Pump Station					
Power	$0.08	$/kWh	8623	$0.08	Engineering Judgment
Maintenance	3% of capital			3% of capital	Engineering Judgment
Pressure Reducing Valves	1% of capital			1% of capital	Engineering Judgment

NOTES:

(1) October 2008 Costs (ENR CCI = 8,623).

Present Worth Assumptions	
Discount Rate	**7%**
Term	**20**

Alternative 1: Six WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
CAPITAL COSTS				
Land	1365	acres	$ 40,000	$ 54,600,000
Gravity Sewers				
8"	106784	LF	$ 116	$ 12,354,927
10"	161321	LF	$ 136	$ 21,895,324
12"	106862	LF	$ 160	$ 17,119,317
15"	224452	LF	$ 188	$ 42,199,843
18"	142289	LF	$ 225	$ 31,975,942
21"	111991	LF	$ 267	$ 29,901,640
24"	73777	LF	$ 317	$ 23,391,954
27"	37030	LF	$ 358	$ 13,265,091
30"	73260	LF	$ 380	$ 27,873,639
36"	68478	LF	$ 429	$ 29,406,208
42"	15433	LF	$ 485	$ 7,485,788
48"	21045	LF	$ 562	$ 11,823,361
54"	15430	LF	$ 639	$ 9,859,389
60"	0	LF	$ 706	$ -
66"	0	LF	$ 774	$ -
72"	0	LF	$ 841	$ -
78"	0	LF	$ 908	$ -
Lift Stations				
0 to < 2 mgd	0	MGD	$ 2,410,000	$ -
2 to < 4 mgd	0	MGD	$ 1,130,000	$ -
4 to < 7 mgd	10.5	MGD	$ 880,000	$ 9,240,000
7 to < 10 mgd	15.9	MGD	$ 700,000	$ 11,130,000
10 to < 18 mgd	11	MGD	$ 570,000	$ 6,270,000
Force Mains				
4"	0	LF	$ 116	$ -
6"	0	LF	$ 131	$ -
8"	0	LF	$ 168	$ -
10"	0	LF	$ 207	$ -
12"	0	LF	$ 224	$ -
14"	0	LF	$ 257	$ -
16"	5400	LF	$ 286	$ 1,542,728
18"	0	LF	$ 315	$ -
20"	11815	LF	$ 344	$ 4,064,189
24"	31182	LF	$ 402	$ 12,543,913
Water Reclamation Facilities				
0 to < 7 mgd	68,000,000	gallon	$ 11	$ 717,344,397
7 to < 13 mgd	0	gallon	$ 9	$ -
13 to < 18 mgd	0	gallon	$ 8	$ -
18 to < 30 mgd	0	gallon	$ 7	$ -
Reclaimed Water Pipelines				
4"	998	LF	$ 68	$ 67,864
6"	0	LF	$ 102	$ -
8"	109,259	LF	$ 136	$ 14,859,259
10"	514	LF	$ 170	$ 87,380
12"	930,847	LF	$ 204	$ 189,892,864
14"	0	LF	$ 238	$ -
16"	989,729	LF	$ 272	$ 269,206,280
18"	0	LF	$ 306	$ -
20"	81,703	LF	$ 400	$ 32,681,200
24"	69,716	LF	$ 480	$ 33,463,852
30"	54,212	LF	$ 600	$ 32,527,344
36"	48,485	LF	$ 720	$ 34,908,948
42"	0	LF	$ 840	$ -
Recharge Basins				
Basins	898	acres	$ 100,000	$ 89,800,000
Monitoring Wells and Piezometers	6	locations	$ 500,000	$ 3,000,000
Reservoirs (covered)				
0.0 to < 2.5 MG	21.31	MG	$ 1,520,000	$ 32,391,200
2.5 to < 4.0 MG	3.16	MG	$ 1,340,000	$ 4,234,400
4.0 to < 7.5 MG	4	MG	$ 1,030,000	$ 4,120,000

Alternative 1: Six WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
Reclaimed Booster Pump Stations				
0 to < 7 mgd	93	MGD	$ 360,000	$ 33,480,000
7 to < 13 mgd	57	MGD	$ 230,000	$ 13,110,000
13 to < 17 mgd	13	MGD	$ 190,000	$ 2,470,000
17 to < 25 mgd	0	MGD	$ 160,000	$ -
25 to < 35 mgd	0	MGD	$ 130,000	$ -
Pressure Reducing Valves				
3 to < 6 mgd	22.5	MGD	$ 390,000	$ 8,775,000
TOTAL CAPITAL COST				$ 1,894,363,242
O&M COSTS				
Gravity Sewers	219	miles	$ 3,800	$ 833,518
Lift Stations				
Power	2545163	kwh	$ 0.08	$ 203,613
Maintenance	1	3% of capital	$ 799,200	$ 799,200
Water Reclamation Facilities				
0 to < 7 mgd	24,820,000	1,000 gallons	$ 0.47	$ 11,667,068
7 to < 13 mgd	0	1,000 gallons	$ 0.32	$ -
13 to < 18 mgd	0	1,000 gallons	$ 0.26	$ -
18 to < 30 mgd	7,646,248	1,000 gallons	$ 0.22	$ 1,671,744
Pipelines	433	miles	$ 3,800	$ 1,644,841
Recharge Basin	29,091,303	1,000 gallons	$ 0.06	$ 1,705,332
CAGRD Recharge	2,679	AF	$ 281.00	$ 752,664
Reservoirs	15	each	$ 7,500.00	$ 112,500
Reclaimed Booster Pump Stations				
Power	38,761,125	kwh	$ 0.08	$ 3,100,890
Maintenance	1	3% of Capital	$ 1,471,800	$ 1,471,800
Pressure Reducing Valves	1	1% of Capital	$ 87,750.00	$ 87,750
TOTAL O&M COST				$ 24,050,921
PRESENT WORTH OF O&M[2]				$ 254,795,799
TOTAL PRESENT WORTH[2]				$ 2,149,159,040

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.

Alternative 2: Four WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
CAPITAL COSTS				
Land	1178	acres	$ 40,000	$ 47,120,000
Gravity Sewers				
8"	96364	LF	$ 116	$ 11,149,331
10"	122254	LF	$ 136	$ 16,592,948
12"	107436	LF	$ 160	$ 17,211,272
15"	193555	LF	$ 188	$ 36,390,812
18"	144664	LF	$ 225	$ 32,509,665
21"	127698	LF	$ 267	$ 34,095,415
24"	90346	LF	$ 317	$ 28,645,370
27"	72469	LF	$ 358	$ 25,960,245
30"	81591	LF	$ 380	$ 31,043,381
36"	57620	LF	$ 429	$ 24,743,504
42"	15433	LF	$ 485	$ 7,485,788
48"	8822	LF	$ 562	$ 4,956,317
54"	21689	LF	$ 639	$ 13,858,736
60"	0	LF	$ 706	$ -
66"	14500	LF	$ 774	$ 11,216,768
72"	0	LF	$ 841	$ -
78"	7528	LF	$ 908	$ 6,836,667
Lift Stations				
0 to < 2 mgd	1.9	MGD	$ 2,410,000	$ 4,579,000
2 to < 4 mgd	0	MGD	$ 1,130,000	$ -
4 to < 7 mgd	10.5	MGD	$ 880,000	$ 9,240,000
7 to < 10 mgd	8.7	MGD	$ 700,000	$ 6,090,000
10 to < 18 mgd	0	MGD	$ 570,000	$ -
Force Mains				
4"	0	LF	$ 116	$ -
6"	0	LF	$ 131	$ -
8"	0	LF	$ 168	$ -
10"	5411	LF	$ 207	$ 1,119,673
12"	0	LF	$ 224	$ -
14"	0	LF	$ 257	$ -
16"	5400	LF	$ 286	$ 1,542,728
18"	0	LF	$ 315	$ -
20"	6202	LF	$ 344	$ 2,133,398
24"	21222	LF	$ 402	$ 8,537,199
Water Reclamation Facilities				
0 to < 7 mgd	20,000,000	gallon	$ 11	$ 210,983,646
7 to < 13 mgd	48,000,000	gallon	$ 9	$ 450,739,777
13 to < 18 mgd	0	gallon	$ 8	$ -
18 to < 30 mgd	0	gallon	$ 7	$ -
Reclaimed Water Pipelines				
4"	998	LF	$ 68	$ 67,864
6"	0	LF	$ 102	$ -
8"	109,259	LF	$ 136	$ 14,859,259
10"	514	LF	$ 170	$ 87,380
12"	924,029	LF	$ 204	$ 188,501,827
14"	0	LF	$ 238	$ -
16"	989,750	LF	$ 272	$ 269,212,033
18"	0	LF	$ 306	$ -
20"	105,042	LF	$ 400	$ 42,016,900
24"	56,401	LF	$ 480	$ 27,072,672
30"	32,345	LF	$ 600	$ 19,406,970
36"	47,736	LF	$ 720	$ 34,370,129
42"	83,697	LF	$ 840	$ 70,305,589
Recharge Basins				
Basins	890	acres	$ 100,000	$ 89,000,000
Monitoring Wells and Piezometers	5	locations	$ 500,000	$ 2,500,000
Reservoirs (covered)				
0.0 to < 2.5 MG	21.31	MG	$ 1,520,000	$ 32,391,200
2.5 to < 4.0 MG	3.16	MG	$ 1,340,000	$ 4,234,400
4.0 to < 7.5 MG	4	MG	$ 1,030,000	$ 4,120,000

Alternative 2: Four WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
Reclaimed Booster Pump Stations				
0 to < 7 mgd	74	MGD	$ 360,000	$ 26,640,000
7 to < 13 mgd	57	MGD	$ 230,000	$ 13,110,000
13 to < 17 mgd	13	MGD	$ 190,000	$ 2,470,000
17 to < 25 mgd	20	MGD	$ 160,000	$ 3,200,000
25 to < 35 mgd	35	MGD	$ 130,000	$ 4,550,000
Pressure Reducing Valves				
3 to < 6 mgd	22.5	MGD	$ 390,000	$ 8,775,000
TOTAL CAPITAL COST				$ 1,901,672,862
O&M COSTS				
Gravity Sewers	220	miles	$ 3,800	$ 836,266
Lift Stations				
Power	1,679,906	kwh	$ 0.08	$ 134,392
Maintenance	1	3% of capital	$ 597,270	$ 597,270
Water Reclamation Facilities				
0 to < 7 mgd	7,300,000	1,000 gallons	$ 0.47	$ 3,431,490
7 to < 13 mgd	17,520,000	1,000 gallons	$ 0.32	$ 5,554,226
13 to < 18 mgd	0	1,000 gallons	$ 0.26	$ -
18 to < 30 mgd	7,646,248	1,000 gallons	$ 0.22	$ 1,671,744
Pipelines	445	miles	$ 3,800	$ 1,691,124
Recharge Basin	29,091,303	1,000 gallons	$ 0.06	$ 1,705,332
CAGRD Recharge	2,679	AF	$ 281.00	$ 752,664
Reservoirs	15	each	$ 7,500.00	$ 112,500
Reclaimed Booster Pump Stations				
Power	42,816,543	kwh	$ 0.08	$ 3,425,323
Maintenance	1	3% of Capital	$ 1,499,100	$ 1,499,100
Pressure Reducing Valves	1	1% of Capital	$ 87,750.00	$ 87,750
TOTAL O&M COST				$ 21,499,182
PRESENT WORTH OF O&M[2]				$ 227,762,645
TOTAL PRESENT WORTH[2]				$ 2,129,435,508

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.

Alternative 3: Three WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
CAPITAL COSTS				
Land	1089	acres	$ 40,000	$ 43,560,000
Gravity Sewers				
8"	96381	LF	$ 116	$ 11,151,298
10"	117923	LF	$ 136	$ 16,005,122
12"	88705	LF	$ 160	$ 14,210,562
15"	213484	LF	$ 188	$ 40,137,719
18"	149936	LF	$ 225	$ 33,694,416
21"	133334	LF	$ 267	$ 35,600,230
24"	83578	LF	$ 317	$ 26,499,488
27"	73202	LF	$ 358	$ 26,222,824
30"	62162	LF	$ 380	$ 23,651,121
36"	39736	LF	$ 429	$ 17,063,657
42"	13826	LF	$ 485	$ 6,706,311
48"	27226	LF	$ 562	$ 15,295,929
54"	54279	LF	$ 639	$ 34,682,941
60"	16021	LF	$ 706	$ 11,315,196
66"	0	LF	$ 774	$ -
72"	4430	LF	$ 841	$ 3,725,044
78"	0	LF	$ 908	$ -
Lift Stations				
0 to < 2 mgd	1.9	MGD	$ 2,410,000	$ 4,579,000
2 to < 4 mgd	4.2	MGD	$ 1,130,000	$ 4,746,000
4 to < 7 mgd	6.3	MGD	$ 880,000	$ 5,544,000
7 to < 10 mgd	0	MGD	$ 700,000	$ -
10 to < 18 mgd	0	MGD	$ 570,000	$ -
Force Mains				
4"	0	LF	$ 116	$ -
6"	0	LF	$ 131	$ -
8"	0	LF	$ 168	$ -
10"	5411	LF	$ 207	$ 1,119,673
12"	0	LF	$ 224	$ -
14"	0	LF	$ 257	$ -
16"	5400	LF	$ 286	$ 1,542,728
18"	0	LF	$ 315	$ -
20"	6202	LF	$ 344	$ 2,133,398
24"	0	LF	$ 402	$ -
Water Reclamation Facilities				
0 to < 7 mgd	4000000	gallon	$ 11	$ 42,196,729
7 to < 13 mgd	64000000	gallon	$ 9	$ 600,986,369
13 to < 18 mgd	0	gallon	$ 8	$ -
18 to < 30 mgd	0	gallon	$ 7	$ -
Reclaimed Water Pipelines				
4"	998	LF	$ 68	$ 67,864
6"	0	LF	$ 102	$ -
8"	109,259	LF	$ 136	$ 14,859,259
10"	514	LF	$ 170	$ 87,380
12"	924,029	LF	$ 204	$ 188,501,827
14"	0	LF	$ 238	$ -
16"	950,493	LF	$ 272	$ 258,534,096
18"	0	LF	$ 306	$ -
20"	98,891	LF	$ 400	$ 39,556,380
24"	66,404	LF	$ 480	$ 31,874,006
30"	32,345	LF	$ 600	$ 19,406,970
36"	47,895	LF	$ 720	$ 34,484,184
42"	120,929	LF	$ 840	$ 101,580,360
Recharge Basins				
Basins	891	acres	$ 100,000	$ 89,100,000
Monitoring Wells and Piezometers	5	locations	$ 500,000	$ 2,500,000
Reservoirs (covered)				
0.0 to < 2.5 MG	21.31	MG	$ 1,520,000	$ 32,391,200
2.5 to < 4.0 MG	3.16	MG	$ 1,340,000	$ 4,234,400
4.0 to < 7.5 MG	4	MG	$ 1,030,000	$ 4,120,000

Alternative 3: Three WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
Reclaimed Booster Pump Stations				
0 to < 7 mgd	78	MGD	$ 360,000	$ 28,080,000
7 to < 13 mgd	31	MGD	$ 230,000	$ 7,130,000
13 to < 17 mgd	13	MGD	$ 190,000	$ 2,470,000
17 to < 25 mgd	19	MGD	$ 160,000	$ 3,040,000
25 to < 35 mgd	61	MGD	$ 130,000	$ 7,930,000
Pressure Reducing Valves				
3 to < 6 mgd	22.5	MGD	$ 390,000	$ 8,775,000
TOTAL CAPITAL COST				$ 1,901,092,682
O&M COSTS				
Gravity Sewers	222	miles	$ 3,800	$ 845,085
Lift Stations				
Power	819,169	kwh	$ 0.08	$ 65,534
Maintenance	1	3% of capital	$ 446,070	$ 446,070
Water Reclamation Facilities				
0 to < 7 mgd	1460000	1,000 gallons	$ 0.47	$ 686,298
7 to < 13 mgd	23360000	1,000 gallons	$ 0.32	$ 7,405,635
13 to < 18 mgd	0	1,000 gallons	$ 0.26	$ -
18 to < 30 mgd	7646247	1,000 gallons	$ 0.22	$ 1,671,744
Pipelines	445	miles	$ 3,800	$ 1,692,552
Recharge Basin	29,091,303	1,000 gallons	$ 0.06	$ 1,705,332
CAGRD Recharge	2,679	AF	$ 281.00	$ 752,664
Reservoirs	15	each	$ 7,500.00	$ 112,500
Reclaimed Booster Pump Stations				
Power	50,152,393	kwh	$ 0.08	$ 4,012,191
Maintenance	1	3% of Capital	$ 1,459,500	$ 1,459,500
Pressure Reducing Valves	1	1% of Capital	$ 87,750.00	$ 87,750
TOTAL O&M COST				$ 20,942,855
PRESENT WORTH OF O&M[2]				$ 221,868,908
TOTAL PRESENT WORTH[2]				$ 2,122,961,590

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.

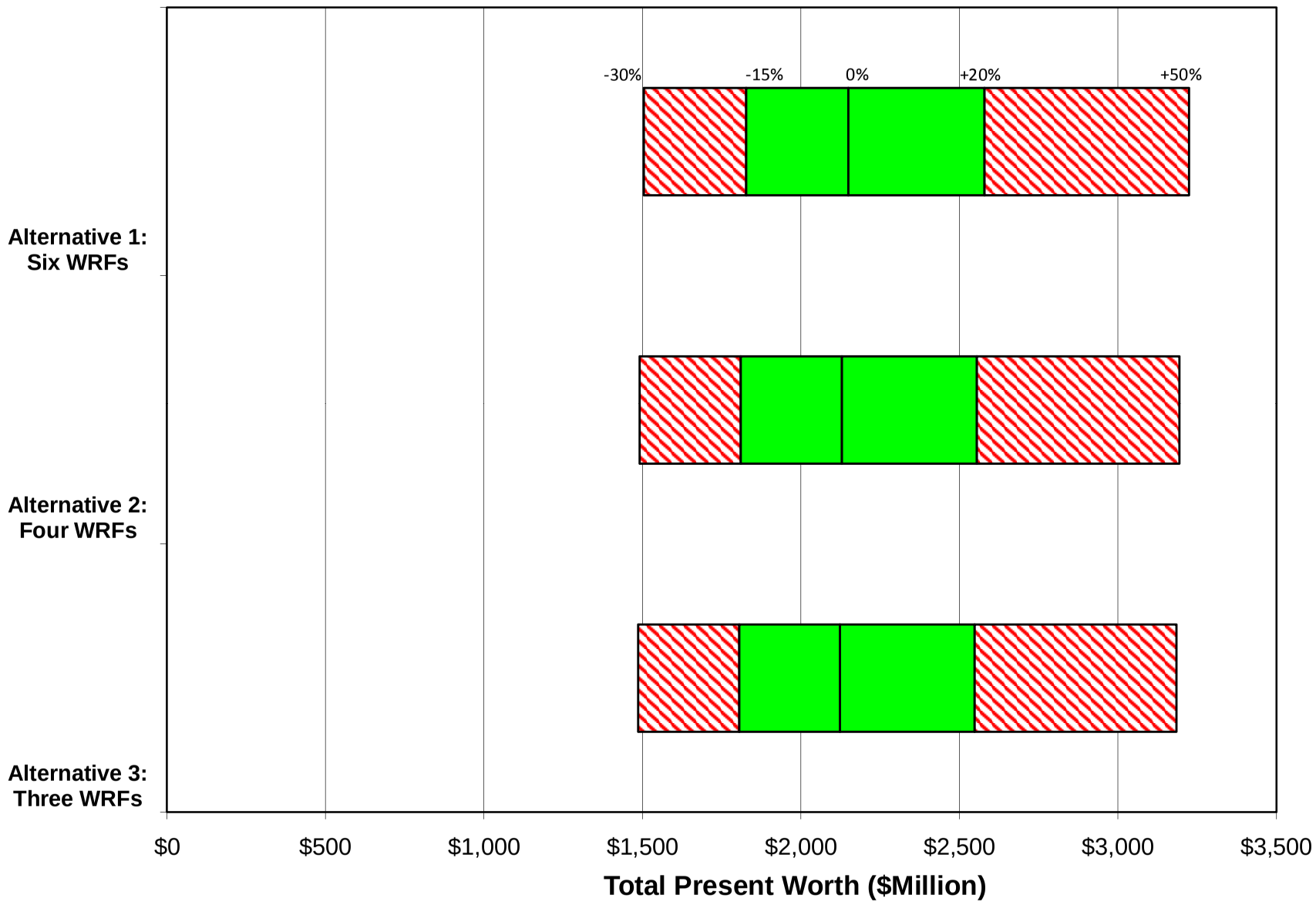
Comparison Cost Summary of Wastewater and Reclaimed Water Alternatives

	Present Value ($)		
	Alternative 1: Six WRFs	**Alternative 2: Four WRFs**	**Alternative 3: Three WRFs**
Capital			
Land	$54,600,000	$47,120,000	$43,560,000
Gravity Sewers	$278,552,423	$302,696,219	$315,961,858
Lift Stations	$26,640,000	$19,909,000	$14,869,000
Force Mains	$18,150,830	$13,332,998	$4,795,799
Water Reclamation Facilities	$717,344,397	$661,723,423	$643,183,098
Reclaimed Water Pipelines	$607,694,992	$665,900,623	$688,952,327
Recharge Basins	$92,800,000	$91,500,000	$91,600,000
Reservoirs (covered)	$40,745,600	$40,745,600	$40,745,600
Reservoirs (uncovered)	$0	$0	$0
Booster Pump Stations	$49,060,000	$49,970,000	$48,650,000
Pressure Reducing Valves	$8,775,000	$8,775,000	$8,775,000
TOTAL CAPITAL COST ($)	**$1,894,363,242**	**$1,901,672,862**	**$1,901,092,682**
Operation and Maintenance			
Gravity Sewers	$833,518	$836,266	$845,085
Lift Stations			
Power	$203,613	$134,392	$65,534
Maintenance	$799,200	$597,270	$446,070
Water Reclamation Facility	$13,338,812	$10,657,461	$9,763,678
Pipelines	$1,644,841	$1,691,124	$1,692,552
Recharge Basins	$1,705,332	$1,705,332	$1,705,332
CAGRD Replenishment	$752,664	$752,664	$752,664
Reservoirs	$112,500	$112,500	$112,500
Booster Pump Stations			
Power	$3,100,890	$3,425,323	$4,012,191
Maintenance	$1,471,800	$1,499,100	$1,459,500
Pressure Reducing Valves	$87,750	$87,750	$87,750
ANNUAL O&M COST ($)	**$24,050,921**	**$21,499,182**	**$20,942,855**
PRESENT WORTH O&M COST($)	**$254,795,799**	**$227,762,645**	**$221,868,908**
TOTAL PRESENT WORTH COST ($)	**$2,149,160,000**	**$2,129,436,000**	**$2,122,962,000**

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.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Alternative 1: Six WRFs
Alternative 2: Four WRFs
Alternative 3: Three WRFs
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$2,500
$3,000
$3,500
Total Present Worth ($Million)

G. Unit Costs for Recommended Infrastructure Master Plans

Summary of Capital Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Jan. 2009)	SOURCE
DRINKING WATER CAPITAL COSTS					
Land	$40,000	$/acre	8090	$42,270	2008 land appraisal for SPA 5 WRF
Pipelines, in					
6	$102	$/LF	8623	$ 101	$17/in-ft ≤ 18 inch-diameter, $20/in-ft > 20 inch-diameter (rounded averages from recent City of Phoenix bid tabulations, City of Avondale 2008-2009 CIP, City of Peoria 2008-2009 CIP and Bid Tabulations, and City of Surprise 2008-2009 CIP)
8	$136	$/LF	8623	$ 135	
10	$170	$/LF	8623	$ 169	
12	$204	$/LF	8623	$ 202	
14	$238	$/LF	8623	$ 236	
16	$272	$/LF	8623	$ 270	
18	$280	$/LF	8623	$ 278	
20	$395	$/LF	8623	$ 392	
24	$420	$/LF	8623	$ 416	
30	$520	$/LF	8623	$ 516	
36	$610	$/LF	8623	$ 605	
42	$700	$/LF	8623	$ 694	
48	$790	$/LF	8623	$ 783	
54	$880	$/LF	8623	$ 872	
60	$970	$/LF	8623	$ 962	
Reservoirs (covered), MG					
0 to < 2.5	$1,366,850	$/MG	7751	$ 1,507,584	City of Phoenix 2006 Infrastructure Financing Plan and City of Peoria 2008-2009 CIP
2.5 to < 4.0	$1,202,667	$/MG	7751	$ 1,326,496	
4 to < 7.5	$929,140	$/MG	7751	$ 1,024,806	
7.5 to < 12.5	$813,040	$/MG	7751	$ 896,752	
12.5 to < 17.5	$766,413	$/MG	7751	$ 845,325	
17.5 to < 25	$745,145	$/MG	7751	$ 821,867	
25 to < 35	$720,277	$/MG	7751	$ 794,438	
35 to < 40	$727,263	$/MG	7751	$ 802,143	
Booster Pump Stations					
0 to < 7 mgd	$ 326,180	$/MGD	7751	$ 359,764	City of Phoenix 2006 Infrastructure Financing Plan
7 to < 13 mgd	$ 206,870	$/MGD	7751	$ 228,170	
13 to < 17 mgd	$ 171,900	$/MGD	7751	$ 189,599	
17 to < 25 mgd	$ 147,740	$/MGD	7751	$ 162,952	
25 to < 35 mgd	$ 115,520	$/MGD	7751	$ 127,414	
35 to < 50 mgd	$ 100,935	$/MGD	7751	$ 111,327	
50 to < 60 mgd	$ 84,597	$/MGD	7751	$ 93,307	
Pressure Reducing Valves					
3 to < 6 mgd	$ 350,600	$/MGD	7751	$ 386,699	City of Phoenix Water System Master Plan
6 to < 15 mgd	$ 139,290	$/MGD	7751	$ 153,632	
15 to < 20 mgd	$ 82,400	$/MGD	7751	$ 90,884	
20 to < 50 mgd	$ 44,580	$/MGD	7751	$ 49,170	
50 to < 60 mgd	$ 33,167	$/MGD	7751	$ 36,582	
Production Well	$2,200,000	$/well	8623	$ 2,181,136	City of Surprise CIP (1,500 gpm); comparable to City of
Arsenic Treatment	$1,225,000	$/MGD	8090	$ 1,294,512	Evaluation of Lease or Purchase of Skid-mounted Arsenic
Water Treatment Plant (~15 mgd)	$2,830,000	$/MGD	7888	$ 3,067,170	City of Avondale Surface Water Treatment and Opportunities (2007)
RECLAIMED WATER AND WASTEWATER CAPITAL COSTS					
Gravity Sewers, in					
8	$104	$/LF	7751	$ 115	City of Phoenix 2006 Infrastructure Financing Plan (< 20 ft depth)
10	$122	$/LF	7751	$ 135	
12	$144	$/LF	7751	$ 159	
15	$169	$/LF	7751	$ 186	
18	$202	$/LF	7751	$ 223	
21	$240	$/LF	7751	$ 265	
24	$260	$/LF	7751	$ 287	
27	$285	$/LF	7751	$ 314	
30	$310	$/LF	7751	$ 342	
36	$360	$/LF	7751	$ 397	
42	$410	$/LF	7751	$ 452	
48	$460	$/LF	7751	$ 507	
54	$525	$/LF	7751	$ 579	
60	$590	$/LF	7751	$ 651	
66	$655	$/LF	7751	$ 722	
72	$720	$/LF	7751	$ 794	
78	$785	$/LF	7751	$ 866	

ITEM		COST	UNITS	CCI	COST (Jan. 2009)	SOURCE
Lift Stations, mgd						
0	**to < 2**	$2,161,875	$/MGD	7751	$ 2,384,466	City of Phoenix 2006 Infrastructure Financing Plan
2	**to < 4**	$1,012,708	$/MGD	7751	$ 1,116,979	
4	**to < 7**	$792,250	$/MGD	7751	$ 873,822	
7	**to < 10**	$627,781	$/MGD	7751	$ 692,419	
10	**to < 18**	$510,344	$/MGD	7751	$ 562,890	
18	**to < 32**	$375,530	$/MGD	7751	$ 414,195	
32	**to < 40**	$285,788	$/MGD	7751	$ 315,213	
Force Mains, in						
4		$104	$/LF	7751	$ 115	City of Phoenix 2006 Infrastructure Financing Plan
6		$118	$/LF	7751	$ 130	
8		$151	$/LF	7751	$ 167	
10		$186	$/LF	7751	$ 205	
12		$201	$/LF	7751	$ 222	
14		$231	$/LF	7751	$ 254	
16		$257	$/LF	7751	$ 283	
18		$283	$/LF	7751	$ 312	
20		$309	$/LF	7751	$ 341	
24		$362	$/LF	7751	$ 399	
30		$440	$/LF	7751	$ 486	
Water Reclamation Facilities, mgd						
0	**to < 7**	$9.65	$/gal	7888	$ 10.46	MBR Facility (WaterReuse Foundation Decision Support System)
7	**to < 13**	$8.59	$/gal	7888	$ 9.31	
13	**to < 18**	$7.45	$/gal	7888	$ 8.07	
18	**to < 30**	$6.78	$/gal	7888	$ 7.35	
30	**to < 60**	$5.88	$/gal	7888	$ 6.37	
60	**to < 80**	$5.01	$/gal	7888	$ 5.43	
Reclaimed Water Transmission and Distribution Mains, in						
4		$68	$/LF	8623	$ 67	$17/in-ft ≤ 18 inch-diameter, $20/in-ft > 20 inch-diameter (rounded averages from recent City of Phoenix bid tabulations, City of Avondale 2008-2009 CIP, City of Peoria 2008-2009 CIP and Bid Tabulations, and City of Surprise 2008-2009 CIP)
6		$102	$/LF	8623	$ 101	
8		$136	$/LF	8623	$ 135	
10		$170	$/LF	8623	$ 169	
12		$204	$/LF	8623	$ 202	
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36		$610	$/LF	8623	$ 605	
42		$700	$/LF	8623	$ 694	
48		$790	$/LF	8623	$ 783	
54		$880	$/LF	8623	$ 872	
60		$970	$/LF	8623	$ 962	
Recharge Basins						
Basins		$96,667	$/acre	8090	$ 102,152	Goodyear Adaman Design Concept Report
Monitoring Wells and Piezometers		$500,000	per location	8623	$ 495,713	Engineering Judgement
Reservoirs (covered), MG						
0	**to < 2.5**	$1,366,850	$/MG	7751	$ 1,507,584	Adapted from City of Phoenix Water System Master Plan and City of Peoria 2008-2009 CIP
2.5	**to < 4.0**	$1,202,667	$/MG	7751	$ 1,326,496	
4	**to < 7.5**	$929,140	$/MG	7751	$ 1,024,806	
7.5	**to < 12.5**	$813,040	$/MG	7751	$ 896,752	
12.5	**to < 17.5**	$766,413	$/MG	7751	$ 845,325	
17.5	**to < 25**	$745,145	$/MG	7751	$ 821,867	
25	**to < 35**	$720,277	$/MG	7751	$ 794,438	
35	**to < 40**	$727,263	$/MG	7751	$ 802,143	
Reclaimed Water Booster Pump Stations, mgd						
0	**to < 7**	$ 326,180	$/MGD	7751	$ 359,764	City of Phoenix 2006 Infrastructure Financing Plan
7	**to < 13**	$ 206,870	$/MGD	7751	$ 228,170	
13	**to < 17**	$ 171,900	$/MGD	7751	$ 189,599	
17	**to < 25**	$ 147,740	$/MGD	7751	$ 162,952	
25	**to < 35**	$ 115,520	$/MGD	7751	$ 127,414	
35	**to < 50**	$ 100,935	$/MGD	7751	$ 111,327	
50	**to < 60**	$ 84,597	$/MGD	7751	$ 93,307	
Pressure Reducing Valves, mgd						
1	**to < 3 mgd**	$ 491,473	$/MGD	7751	$ 542,077	City of Phoenix Water System Master Plan
3	**to < 6**	$ 350,600	$/MGD	7751	$ 386,699	
6	**to < 15**	$ 139,290	$/MGD	7751	$ 153,632	
15	**to < 20**	$ 82,400	$/MGD	7751	$ 90,884	
20	**to < 50**	$ 44,580	$/MGD	7751	$ 49,170	
50	**to < 60**	$ 33,167	$/MGD	7751	$ 36,582	

NOTES:

(1) January 2009 Costs (ENR CCI = 8,549).

(2) Unit capital costs include engineering/design, materials of construction, installation and contractor overhead and profit.

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