City of Kingman

Water System Master Plan

May 25, 2005

Submitted by:

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Scope of Work

System Inventory

Existing Data Collection

Water Sampling

Existing System Computer Model

Existing System Calibration

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Future System Computer Model

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Section 1 - Scope of Work

The following report is the culmination of our efforts to prepare a water master plan for the city of Kingman. The planning period for this report is for 20 year period from 2004 to 2024.

The scope of work for the study is outlined in the Agreement signed between C5 Engineering, Inc. and the city of Kingman. In general, the scope of work includes the following major tasks:

- Visually inspect and inventory the major water system components
- Gather existing technical data pertaining to the system
- Examine the current chlorine disinfection efforts for improvements
- Develop a water model of the existing system
- Test and calibrate the water model
- Develop a future water system layout
- Develop the future water system computer model data bases
- Produce AutoCAD drawings of the future water system
- Develop construction costs for improvements
- Identify operational issues and possible solutions
- Develop the Water System Master Plan

The following is the detailed Scope of Work:

SCOPE OF WORK

The following statements are used as background and provide a general listing of the Project assumptions:

1. The current population being served by the City's water system (in and out of the City limits) is approximately 38,500 persons with an ultimate, 20 year projected population of approximately 81,000 persons (based on 4.5% growth compounded over 20 years).

2. A major goal of the Project is to determine the most efficient and cost effective means to deliver water to users (i.e., less power costs and less "hassle" for operational staff). The Consultant will review the City's current pressure zone boundaries and recommend adjustments to and/or

consolidation of zones and the associated infrastructure needs, in order to meet the goal. The City desires to eliminate as many pressure reducing valves as possible. In addition, the City is seeking to find the best locations for future water storage tanks and associated booster pumping stations.

3. Though the City is somewhat divided by foothills (i.e., the Beale Street area versus the areas to the north), the vast majority of the City is fed and is pressurized off of one connected water system and water storage tank farm. There are four major pressure zones throughout the City and the static pressure throughout these zones ranges from approximately 40 to 100 psi. Last, approximately 70% of the water is pumped to the highest pressure zone and allowed to feed / flow to the rest of the City.

4. There is a mix of pipeline types that need to be taken into consideration during the modeling efforts (i.e., AC, steel, DIP and, new PVC C-900 pipe materials). The City desires to limit the modeling efforts to pipelines 8" and larger. However, areas that are serviced by pipelines less than 8" may be simulated within the computer model, if such pipelines are a critical component of the water system (i.e., if such pipelines provide a sole source, loop or secondary feed to a particular area).

5. The City has e-files of AutoCAD (i.e., version 14, 2000 or DXF files) format drawings of 98% or so of the City's existing system including the City's water pipelines, water storage tanks, pumping stations, and wells that shall be included within this Project. These drawings are of such a quality and revision that they can be imported directly into the water model to be used as background maps (i.e., they show the water system components with street information) to develop the computer model data bases. The remaining 2% or so, of the City's water pipelines, water storage tanks, pumping stations, and wells are sufficiently documented on hard copy drawings already existing in TIFF format and shall be incorporated into the water modeling data base via approximating pipeline layouts within the data base. In other words, the Consultant shall not redraw these hard copy drawings into AutoCAD as "record drawings" of the hard copy drawings.

6. The water model shall be developed in WaterCAD so that the City can expand the water model data base with the use of the City's own WaterCAD software. Further, it has been determined that the City does not own a sufficiently sized WaterCAD modeling software package for this Project. Last, though water hammer is not a current major issue, this issue needs to be kept in mind throughout the modeling development so as to minimize the creation of any future water hammer issues.

7. No survey nor geotechnical work / studies shall be provided in this Project. The City has topographic AutoCAD files to be imported into the water model. Last, the City has sufficient background information to provide input into the construction cost estimates for soil conditions (i.e., rock areas, ground water areas, etc.).

8. This Project is to identify any major projects for the City's CIP program. Those projects identified for the CIP program within the near term (i.e., the next 10 years) shall be folded into the City's planned rate study by City staff. In addition, the General Use Plan (GUP) that the City is just completing shall be incorporated into this Project. The GUP shall act as the basis for potential future growth within the City's Water Service Area. Finally, the City is experiencing growth more to the north and east. Therefore, this shall be the area of most new water system expansion.

9. In general, as end products, the City staff is seeking:

a. A listing of current issues / problems related to the overall water system.

b. Solutions to those issues / problems.

c. Associated construction costs of those solutions.

d. Suggested phasing of those solutions in two 10 year increments.

e. Master plan maps delineating the current and future pipelines, tanks, wells, and booster pumping station locations.

f. A water model (in WaterCAD) and associated data bases that can be upgraded in future years by City staff.

Having established the above Project assumptions and general background, the specific Scope of Work for the Water System Master Plan is as follows:

Task 1 - Project Kick-Off Meeting: The Consultant shall meet with City staff to kick-off the Project, establish, among other items: City and Consultant introductions; establish lines of communication; Project schedule with major and intermediate milestones; City reporting requirements; invoicing requirements; insurance requirements; review Project scope with all team members, etc.

Task 1 deliverables shall include meeting minutes from that meeting.

Task 2 - System Inventory: the Consultant shall visually inspect and inventory the accessible major water distribution system components (i.e., wells, pumping stations, tankage, PRV stations, accessible major valving and major pipelines, electrical components, instrumentation components, natural gas engines, etc.). Photographic documentation shall be taken where possible.

No pot holing shall be required.

Task 2 deliverables shall include a written report documenting the system inventory. This report shall ultimately be a section of the overall Water System Master Plan.

Task 3 - Existing Data Collection: Gather existing technical data pertaining to the existing system such as:

a. With the help of City staff, gather existing e-files and hard copy maps of the water system pipeline sizes and configuration (for pipelines 8" and above).

b. With the help of City staff, gather motor information such as:

    i. Pump curves for booster pumping stations and wells.
    ii. Motor types, sizes and efficiencies.
    iii. Power costs.

c. With the help of City staff, gather system pressures during various times of a 24 hour cycle over several days.

d. From City records, gather and analyze water usage, by area, for the past three years.

e. With the help of City staff, gather well production rates and discharge pressures.

f. With the help of City staff, gather City provided topographic e-files and hard maps.

g. With the input of City staff, develop a listing of operational issues needing to be solved or improved.

h. With the help of City staff, gather valve and PRV sizes, locations and pressure settings along with any changes implemented over the past three years and identify zone valves and pressure zone boundaries.

i. With the help of City staff, gather storage tank information (i.e., size, tank age, condition, fill and draw cycles, maintenance history, etc.).

j. Interview City Management, Engineering Staff and Operational staff to determine known issues with the existing water system.

k. Interview City Management, Engineering and Operational staff to determine goals for the future water system (i.e., growth areas, wants, wishes and desires, etc.).

l. With the help of City staff, evaluate existing visible electrical components for functionality and remaining life expectancy.

m. With the help of City staff, evaluate existing visible instrumentation components for functionality and remaining life expectancy.

Task 3 deliverables shall include a written report documenting the gathered information. This report shall ultimately be a section of the overall Water System Master Plan.

Task 4 - Water System Sampling: the Consultant, with the help of City staff, shall take water samples at strategic locations for laboratory testing to analyze for corrosion and/or corrosion potential, bacteria build-up, and chlorine residual within the water distribution system. This information shall be used to help determine the remaining useful life of the major existing pipelines as well as general issues dealing with water quality, stagnation, disinfection, etc.

With existing City water sampling data, and with the help of City staff, the Consultant shall establish water distribution areas that need additional sampling for chlorine residual. Given that City staff has chlorine residual sampling equipment, there shall be no additional testing fees for these extra samples. With the use of the WaterCAD model, the Consultant shall then develop a brief water disinfection model to help determine possible areas of low chlorine concentration. This chlorine residual modeling shall then be used to determine areas within the water distribution system that need possible attention related to disinfection.

Task deliverables shall include a written report documenting the gathered water quality information. This report shall ultimately be a section of the overall Water System Master Plan.

Task 5 - Develop Existing Water System Computer Model Data Base: Compile the existing AutoCAD files of the water system and make ready for and insert that information into the WaterCAD computer model data base. The City desires to limit the modeling efforts to 8" pipelines and larger. However, areas that are serviced by pipelines less than 8" may be simulated within the computer model, if such pipelines are a critical component of the water system (i.e., if such pipelines provide a sole source, loop or secondary feed to a particular area).

To ensure that the City has a working water model when the Project is completed, the Consultant shall utilize the City's existing WaterCAD water model software, initially on the Consultant's computers, to build the modeling data base. This data base shall ultimately be transferred to the City's computer.

As the data base is being developed, City staff shall provide input as to the format and information the City wishes to have as to the final computer model output report(s).

It is currently estimated that the water model data base for the existing water lines that are 8" and larger shall consist of approximately 4,500 pipes.

Given that the City does not have a sufficiently sized water model (i.e., not enough pipes), the City shall purchase upgraded water model software and the Consultant shall import the information developed in this Project into that new model software, develop what the City would like for specific output information / reports, and ultimately install the new software and developed data bases onto the City's computer.

Given the unknown total cost at this time, the cost for a WaterCAD software upgrade is not included in this Scope. When this purchase is necessary, it shall be purchased directly by the City for the Project's use.

Task 5 deliverables shall include a water model data base of the above identified water system.

Task 6 - Computer Model Test and Calibration of Existing System: Test and calibrate the computer model data base with known system pressures, flow rates, pumping flows, tank levels, etc. gathered by the City staff.

Task 6 deliverables shall include a computer model data base that closely simulates the water system's existing conditions. Note: given that this is a computer simulation, it is understood that exact existing system conditions may not be simulated. However, close approximations can be achieved but the accuracy is very dependent upon the information provided by the City (i.e., mapping information, system pressures, pump sizes, etc.).

Task 7 - Future Water System Layout: With the input of City staff, the Consultant shall develop an estimated water system layout of the future water system feeding the new areas of the City in accordance with the City's General Use Plan. This information shall be developed in two 10 year phases (i.e., the master plan shall go out 20 years) in AutoCAD format so that it can be imported into WaterCAD. Pipeline sizes shall not be calculated at this time (this shall be done in the next computer model phase). This task is to only estimate the water system pipeline configuration and alignment.

In addition, the City recently developed a future well location report. This report shall be utilized by the Consultant as a bases for possible locations of future well sites.

The Consultant shall present the ultimate future water system layout to City staff for formal review and comment to ensure that the Consultant has covered all the areas of concern.

After review and input by the City staff is complete, both the City staff and the Consultant can now divide the ultimate water system layout into 10 year phases estimating future City growth over the next 20 years.

Task 7 deliverables shall include 10 and 20 years into the future, phased, water system AutoCAD drawings of the expanded water system. This information shall ultimately become a section of the overall Water System Master Plan.

Task 8 - Develop Future Water System Computer Model Data Bases (two): Compile the future AutoCAD files of the two future distribution system expansions, make ready for and insert that information into the WaterCAD computer model data base. The City desires to limit the future modeling efforts to 8" pipelines and larger. However, there can be several areas that can have fairly high water demands that are piped with less than 8" pipelines. These areas shall be simulated with one (or more) 8" pipelines.

The following new items shall be sized using the computer model:

a. Pipeline sizes to meet the future phased water demands. Determine under and over sized water pipelines for the ultimate water distribution system and adjust their size accordingly in the computer water data base (this usually takes a few integrations to get the correct balance between pipeline size, cost, velocity and flow).

b. Possible new water storage tanks sized to meet potable water demands as well as fire suppression demands established by City staff.

c. Possible booster pumps.

d. Possible jockey pumps to maintain system pressures but to not run larger, costly pumps under very low flow conditions (this is a potential power savings measure). However, the City pressure floats off of tank head so these pumps may not become necessary.

10 and 20 years into the future, phased, water model data bases of the expanded water system shall be developed. Each phase shall be placed in a logical growth order, as jointly decided by the City staff and the Consultant.

As the Project is divided down into phases, the computer model shall be re-addressed for each phase to ensure that:

a. Water can be moved around the City as the City operational staff desires.

b. Power costs shall be addressed with an eye towards minimizing the existing power costs as well as future power costs.

c. Given the new regulations governing distribution system disinfection, the entire existing, and phased improvements, shall be studied to determine the most cost effective locations and means to inject disinfection chemicals (i.e, use gaseous, liquid, tablet or salt chlorination systems or a combination thereof).

d. Measures to minimize water hammer issues shall be addressed to help minimize accidently incorporating future water hammer issues into the water system.

As these data bases are being developed, City staff shall provide input as to the format and information the City wishes to have as to the final computer model output reports.

It is currently estimated that the 20 year water model data base shall consist of approximately 9,500 pipes.

Task 8 deliverables shall include 10 (approximately 6,400 pipes) and 20 years (approximately 9,500 pipes) into the future, phased, water model data bases of the above identified water system.

Task 9 - Future Water System Layout Update: With the input of the Future Water System Computer Model Data Bases (two), the phased future water system maps shall be updated and presented to the City for review and comment. City comments shall be incorporated into the final maps.

Task 9 deliverables shall include updated 10 and 20 years into the future, phased, water system AutoCAD drawings of the expanding water system. This information shall ultimately become a section of the overall Water System Master Plan.

Task 10 - Construction Cost Estimates: Each 10 year phase shall have a construction cost developed at today's costs and, if requested by the City, projected into the appropriate future year. Each phase shall be placed in a logical growth order, as jointly decided by the City staff and Consultant. The Consultant shall use three tools or methods to develop these construction costs estimates:

a. Review of City contracts for water system construction over the last three years.

b. Dodge Cost Guide (Timberline)

c. Sweet's Unit Cost Guide

A comparison of these three tools shall be blended together to achieve the most accurate cost estimate possible, tailored to the Kingman area.

As will become apparent during this process, logical CIP project boundaries shall be identified and construction estimated costs shall be assigned to those future projects.

Task 10 deliverables shall include future water system CIP projects, with associated construction costs, grouped in10 and 20 year phases. This information shall ultimately become a section of the overall Water System Master Plan.

Task 11 - Operational Issues: Operational issues shall be identified and possible solutions suggested effecting, for example, power, chemical and/or operation efficiency changes. Possible issues that may be investigated could include:

a. The use of smaller pumps pumping longer hours. This leads to minimizing pump power start surges / spikes.

b. Replace existing, out dated pumps with more efficient pumps and / or motors.

c. Possible use of soft starts on pumps to decrease start power surges for equipment.

d. Possibly use tank level indicators linked to a pump timer / limit switches to keep pumps from starting during peak hours.

e. Consolidation of pressure zones / elimination of pressure reducing valves.

f. Adjustments to zone boundaries.

g. Use of distribution lines for transmission.

Task 11 deliverables shall include a written report documenting the operational issues and possible solutions. These solutions, as logically as possible, shall be grouped into CIP projects for inclusion into the City's planning process. This report shall ultimately be a section of the overall Water System Master Plan.

Task 12 - Develop Draft Water System Master Plan: the Consultant shall consolidate all of the above reports and information into a concise, useable, and up-gradable Water System Master Plan and deliver five (5) copies to the City for review and comment.

Task 12 deliverables shall include five (5) copies of the draft Water System Master Plan delivered to the City.

Task 13 - Review Draft Water System Master Plan: After a set time has passed to allow City staff to review the draft report, a formal meeting shall take place to review the City's comments. Each and every comment shall then be addressed and, if necessary, incorporated into the final draft report.

Task 13 deliverables shall include a meeting summary report addressing City's review comments.

Task 14 - Finalize Water System Master Plan: the Consultant shall take the information and input developed at the review meeting of the draft Master Plan and incorporate that information into the final master plan.

Task 14 deliverables shall include five (5) copies of the final Water System Master Plan delivered to the City.

Task 15 - Review Finalized Water System Master Plan: After a set time has passed to allow City staff to review the final report, a formal meeting shall take place to review the City's comments. Each and every comment shall then be addressed and, if necessary, incorporated into the final report.

Task 15 deliverables shall include a meeting summary report addressing City's review comments.

Task 16 - Project Management and Communication: Communication with City staff shall be key throughout this Project. Though our Team has the technical expertise to complete this Project, we do not have the critical background information to ensure that all of the Project's less visible issues are met (i.e., political issues and / or long standing promises to citizens for example).

During the development of this entire Project, as the City Staff desires, the design Team shall make formal, or informal, presentations to City Management, Staff, and /or to the public to provide status reports and to receive input. For example, the Consultant can make brief presentations to the general public via a short work session prior to, for example, a scheduled City Council meeting.

It is currently estimated that the Consultant shall make an average of two trips per month to Kingman for a total of 8 trips over the life of the Project for this task.

To ensure that the City's Project is developed and completed on time and within budget, the Consultant shall use Microsoft Project 2000. Project schedule updates can be provided to the City upon request.

Task 17 - Final Deliverables: Final deliverables shall include five (5) copies of the final Water System Master Plan and all final computer model data bases and e-files of all text, figures, and drawings so that the City can reproduce the report for additional distribution at a later time.

PROJECT SCHEDULE

It is currently envisioned that this total Project shall last approximately 5 months. This schedule depends heavily upon the condition of the existing data and the City's meeting and review times and schedule.

UPDATE

It has become clear that the information that the entire Team was relying upon (i.e., the City Staff and C5 Engineering staff), is not as accurate nor as complete as all originally thought. Therefore, working together as a Team, the City and C5 Engineering have been diligently working to fill the gaps and / or correct assumed correct or missing data. However, as the City and C5 Engineering Team has delved deeper into the existing information and databases, it has become apparent that some informed assumptions will need to be made due to the lack of accurate historical information once thought to be available. These assumptions will be made jointly by City and C5 Engineering staff in an effort to be as accurate as possible.

Section 2 - System Inventory

City and C5 Engineering staff visually inspected and inventoried the accessible major water distribution system components (i.e., wells, pumping stations, tankage, PRV stations, accessible major valving and major pipelines, electrical components, instrumentation components, natural gas engines, etc.). Photographic documentation was taken where possible. The following is that documentation. Also, contained on the enclosed CD (please see the back of this Master Plan) is a CD containing all of the field pictures taken during this task.

City Well # 1 (CW 1)

- 775 gpm; 200 Hp; 1770 RPM; 460 V

City Well # 2 (CW 2)

- 1,000 gpm; 250 Hp; 1770 RPM; 460 V

City Well # 3 (CW 3)

- 1,150 gpm; 300 Hp; 1785 RPM; 460 V

City Well # 4 (CW 4)

- 950 gpm; 250 Hp; 1765 RPM; 460 V

City Well # 5 (CW 5)

- 2,500 gpm; 600 Hp; 1770 RPM; 460 V

City Well # 6 (CW 6)

- 1,750 gpm; 500 Hp; 1775 RPM; 460 V

City Well # 7 (CW 7)

- 2,200 gpm; 600 Hp; 1770 RPM; 460 V

Long Mountain Well # 4 (LM 4) and Booster Pump

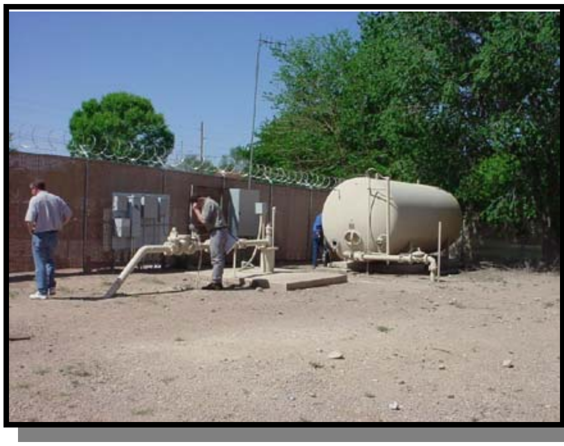
- 875 gpm; 250 Hp; 1770 RPM; 460 V

Long Mountain Well # 6 (LM 6)

- 1,600 gpm; 450 Hp; 1770 RPM; 220/440 V

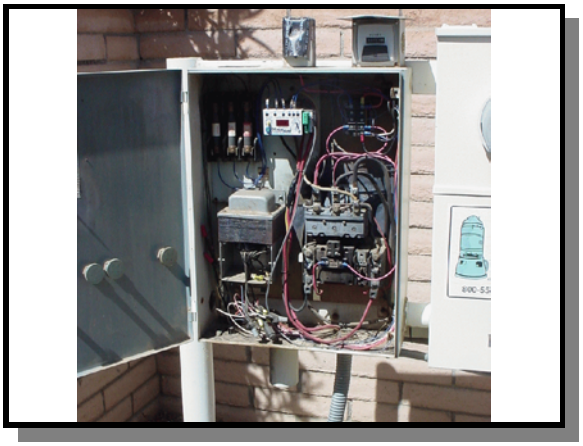
Hubbs Well

- 179 gpm



Pamona Well

- 187 gpm



<u>**Santa Fe Well**</u>

- 112 gpm

Byron Jackson Well

- 129 gpm

Bank Street Well

- 500 gpm; 180 Hp; 1760 RPM;

Castle Rock Booster Station

Hualapai 1.5 MG Tank and Booster Station

Hualapai 2 Tank /Foothills Pneumatic Tank and Pumps

Main Tanks

This section outlines the gathering of existing technical data pertaining to the existing system such as:

a. With the help of City staff, gather existing e-files and hard copy maps of the water system pipeline sizes and configuration (for pipelines 8" and above).

b. With the help of City staff, gather motor information such as:

   i. Pump curves for booster pumping stations and wells.
   ii. Motor types, sizes and efficiencies.
   iii. Power costs.

c. With the help of City staff, gather system pressures during various times of a 24 hour cycle over several days.

d. From City records, gather and analyze water usage, by area, for the past three years.

e. With the help of City staff, gather well production rates and discharge pressures.

f. With the help of City staff, gather City provided topographic e-files and hard maps.

g. With the help of City staff, gather valve and PRV sizes, locations and pressure settings along with any changes implemented over the past three years and identify zone valves and pressure zone boundaries.

h. With the help of City staff, gather storage tank information (i.e., size, tank age, condition, fill and draw cycles, maintenance history, etc.).

i. With the help of City staff, evaluate existing visible electrical components for functionality and remaining life expectancy.

j. With the help of City staff, evaluate existing visible instrumentation components for functionality and remaining life expectancy.

The following is a summary of that gathered information:

GENERAL SYSTEM INFORMATION

The system consists of sixteen (16) active wells and one (1) inactive well and nine (9) storage tanks as well as three (3) booster stations, one (1) hydropneumatic tank, and thirty-four (34) Pressure Reducing Valves and (2) pressure sustaining valves to supply the water demands for the City of Kingman. The City also owns an allotment of Colorado River water, which they may need in the future, but at this time they have transferred this allocation to the Mohave County Water Authority.

WATER SOURCES

Kingman's water is drawn from two aquifers, the Sacramento Basin and the Hualapai Basin. The four Downtown Wells draw from the Sacramento Basin and the rest of the wells draw from the Hualapai Basin. In 2003 171,415,200 gallons (526.05 acre-feet) were pumped from the Sacramento Basin, and 2,638,220,000 gallons (8,096.34 acre-ft) were pumped from the Hualapai Basin.

Hualapai Basin

According to Chapter 7 of the "City of Kingman, Arizona General Plan 2020" dated November 17, 2003, the Hualapai basin contains 1,820 square miles, and is bounded on the west by the Cerbat Mountains, on the east by the Grand Wash Cliffs and Music Mountains, on the south by the Peacock and Hualapai Mountains, and on the North by Lake Mead. The Hualapai Valley basin fill sediments are as thick as 6,400 feet and have been divided in three separate units. A younger alluvium, an intermediate alluvium and an older alluvium. The older alluvium is the main aquifer in the Hualapai Valley basin and can transmit large volumes of water. City Wells 5 and 7 both produce over 2,000 gallons per minute, and many of the other wells produce over 1,000 gallons per minute. Depth to water is from 500 to 900 feet in the central and southern parts of the basin and 300 feet near Red Lake.

The "Kingman Area Groundwater Basin Study" by the Arizona Department of Water Resources dated March 24, 1994 estimates there to be 5,000,000 acre-feet of water stored in the Hualapai Basin to a depth of 1,200 feet, of which 3.0 million acre-feet are practically available to a depth of 1,000 feet; 1.9 million acre-feet south of Long Mountain and 1.1 million acre-feet north of Long Mountain. ADWR further estimates that 30,000 acre-feet per year can be removed from the Hualapai Basin for 100 years before depths to water reach 1,200 feet. This report contains no estimates of aquifer recharge.

Sacramento Basin

According to the City's General Plan, the Sacramento Basin covers 1,400 square miles, and is bounded on the west by the Black Mountains, on the southwest by the Mohave Mountains, and on the east by the Cerbat and Hualapai Mountains. The older alluvium, which is the principal aquifer in the basin, is unconfined and covers 500 square miles. Depth to water is from 1,000 feet in the northern part of the basin to less than 100 feet where the Sacramento Wash enters the Colorado River Valley.

The "Kingman Area Groundwater Basin Study" estimates there to be 7,000,000 acre-feet of groundwater stored in the entire basin. An estimated 800,000 acre-feet of this total is stored in the aquifer under the Golden Valley area. The total available groundwater in this area of the basin to 1,200 feet is 2.3 million acre-feet. The annual water supply from the Sacramento Basin is estimated to be 4,000 acre-feet per year for 100 years in Golden Valley, and an additional 16,000 acre-feet per year in the rest of the basin before water levels reach 1,200 feet. As noted above, no estimates of aquifer recharge are included in this report.

Groundwater Decline

According to the Well Siting / Basin Study Report prepared by Clear Creek Associates, the water level in the central well field of the Hualapai Basin has declined by an average of 1.55 feet per year since 1967.

WELLS

There are sixteen (16) wells (**see Table 1**) which supply all the water for the system which can produce approximately 19 million gallons per day (mgd) at full capacity. The highest well production month for 2004 was July when 357.15 million gallons (mg) were produced. At this time only fourteen (14) of the wells are active. Long Mountain Well 1 is a standby well and Castle Rock Well 1 is new and not on line at this time (however the computer modeling will include this well).

The downtown wells (Byron Jackson, Santa Fe, Hubbs, and Pomona) have a combined design discharge capacity of 607 gpm and fills the Beale Springs Tank. These wells primarily serve the Downtown area.

City Wells 1, 2, 3, 4, 5, and 7 and Long Mountain Well 6, with a combined capacity of 9,380 gpm are used to fill the Main tanks and the Hualapai Tank, although Long Mountain Well 6 is diverted occasionally to the College Tank. The Castle Rock Well 1 will contribute an additional 1,600 gallons per minute (gpm) (2.3 mgd) when it comes on line.

Long Mountain Well 4, City Well 6 and the Bank Street Well with a combined design discharge capacity of 2,870 gpm fill the College Tank. The Long Mountain Booster #4 fills the Camelback Tank from the College Tank.

Long Mountain Well 1 is normally inactive but can be used when necessary.

The electric service to six of the wells is on an interruptible basis and Unisource Electric can shutdown service to the wells for up to six hours a day without notice and for this consideration the City receives electricity at a reduced rate. The wells included in this program are City Wells 2, 4, 6, and 7, Long Mountain 6, and the Castle Rock well with a combined capacity of 13.1 mgd.

TANKS

The water is pumped from the wells to the nine (9) storage tanks (**see Table 2**) in the system with a total storage volume of 10.9 mg. There are currently five pressure zones in the system defined by the static pressure exerted by the tanks in those zones.

The three Main Tanks, with a combined volume of 3.9 mg operate together with the 1.5 mg Hualapai Tank, which is controlled by an altitude valve, and serves the Hilltop area.

The Beale Springs Tank, with a volume of 1.0 mg, serves the downtown area. The Main Tanks and Hualapai Tank are also connected to the Downtown area with pressure reducing valves, which are set to operate only when the pressure in the zone drops below a desired setting.

The booster station at the Hualapai Tank is used to charge the 0.5 mg Foothills Tank and the 1.5 mg Rancho Santa Fe Tank which serve the higher Foothills region. There is also a hydropneumatic tank at the Foothills Tank which boosts the pressure in the Foothills area.

The 1.5 mg College Tank is the largest zone geographically and serves the Northeast section of the service area.

The 1.0 mg Camelback Tank serves Northwest section of the service area. Zone valves are used to restrict flow to and from the Main Tanks and the College zone.

Arizona Administrative Code R-18-4-504 requires that the minimum storage capacity for a multiple well system shall be equal to the average daily demand during the peak month of the year minus the total production minus the production from the largest producing well. The peak month for 2004 was July when 357.15 mg was produced which averages out to 11.52 mgd. Total production capacity is approximately 20 mgd. City well #7 is the largest well at 2,350 gpm = 3 mgd. Therefore, the required storage capacity is 11.78 - (20 - 3.00) = - 5.22 mgd. Therefore, the system is in compliance at this time.

BOOSTER STATIONS

There are three booster stations (**see Table 3**) to help distribute water to the tanks throughout the system. The main booster station is the Castle Rock Pump Station which has four pumps with a combined design discharge capacity of 7,500 gpm. Water from the City Wells and Long Mountain Well 6 is pumped to the two forebay tanks at the station and then to the Hilltop area and " floats" on the Main Tanks and Hualapai Tank.

The Hualapai booster station has three pumps with a combined design discharge capacity of 2,400 gpm and pumps water from the Hualapai tank to the Foothills Tank and the Rancho Santa Fe Tank.

The Long Mountain Well 4 booster with a capacity of 1,090 gpm is used to fill the Camelback Tank.

PRESSURE REDUCING VALVES

There are thirty-one (31) Pressure Reducing Valves (PRV) throughout the system which are used to control the eighteen (18) pressure zones within the service area. Most of the PRV's are necessary because much of the service in the Hilltop area is taken from the high pressure transmission mains between the Castle Rock Booster Station and the Main Tanks and the Hualapai Tank.

ZONE VALVES

There are approximately forty (40) zone valves in the system which are used to limit flow between zones and maintain desired pressures within zones.

CHLORINE INJECTION

Chlorine is injected into the system at the Castle Rock Pumping Station and at the Long Mountain 4 Well and booster. 150 pound cylinders of chlorine gas are used and controlled with Regal automatic feeding equipment.

EMERGENCY GENERATOR

There is a mobile 500 kW generator which can be towed to where it is needed if there is an electrical failure. The generator can operate the largest of the well pumps which is CW7.

GENERAL OVERALL WATER SYSTEM SCHEMATICS

The following three drawings depict the City's existing system. The first drawing, "Water Distribution System Schematic" provides and overall City-wide system layout.

The second drawing depicts a more detailed schematic showing the various PRV's and associated pressure zones.

The third drawing depicts the physical layout of the entire water system by pressure zones.

ADDITIONAL INFORMATION

With the help of City staff and others, information necessary for the report and the water model was collected, including AutoCAD files and topographic maps of the existing system, pump curves from City files and pump suppliers, pumping records, consumption records, cost reports, chemical sampling reports, area maps, and general operating information. A copy of these records is included within the CD for this section (i.e., Section 3).

AutoCAD Files:

- AutoCAD files of the existing water system were provided in electronic format. This file was loaded into the water model and was utilized as the basis for the modeling efforts.

Topographic Map:

- A topographic map of part of the service area was provided by the City on E-file and is used as the datum for the model.
- Where the topographic map did not cover the service area, USGS topographic maps from DeLorme were used as a supplement.

Well Information:

- Well production for all of 2003 and 2004 were provided.
- These reports show the total monthly production and the cost for electricity to operate each well.
- From these reports we ascertained the maximum usage month for 2003 and 2004 was July. In July,2004, 357,154,200 gallons were produced.
- The well inventory of April, 2003 produced for ADEQ, was also used in the study. The land elevations and static water levels from this report were used in the water model to model the wells.

Pump Information:

- Pump curves for some of the pumps were provided by the City and others were obtained from pump suppliers.
- No pump curves could be obtained for the Pomona, Santa Fe, Byron Jackson, and Hubbs wells, so City staff performed pump tests on these wells and curves were then developed.
- The discharge and flow rates from these curves were used in the model.

- The design discharge rates from the curves do not match exactly the actual production rates that are recorded on the SCADA system and the model is somewhat inaccurate as a result.

- In order for the model to more accurately reflect the actual conditions, the City will need to run pump tests for all the pumps and enter this information into the model.

Tank Information:

- Tank information was obtained from construction drawings provided by the City.

- Tank dimensions and elevations were taken from these drawings and used in the model.

- City staff provided start and stop fill levels for each tank and tank volumes which are also used in the model.

Water Consumption Reports:

- Water and irrigation consumption reports for all of 2003 and up to May 2004 were provided by the City.

- These reports are broken down by the 18 different billing zones in the City which are called cycles.

- The Team tried to use this report to determine the demands for the model but due to large differences between the consumption report and the production report, the production report was used.

- The percentage of total usage for each cycle was determined from the consumption report. These percentages were then applied to the production totals to determine the demands that were used in the model.

Pressure Reduction Valve list:

- A list of all the Pressure Reducing Valves in the various service area were provided by the City. The list has the locations, outlet pressures, and some of the elevations of the valves which were entered into the model.

- This information was used in conjunction with the pressure zone map (provided by the City) to establish the pressure zone boundaries.

- Where no elevations were provided, elevations from the topographic map or DeLorme maps were used.

Chemical Sampling Information:

- Test results for ADEQ compliance monitoring and reporting were provided by the City, as well as chlorine residual sampling from forty (40) different locations in the service area and a map of their respective locations.
- The chlorine dosage concentrations that are added at the Castle Rock Booster Station (0.2 mg/l) and Long Mountain Well #4 (0.5 mg/l) were also provided by City staff.

SCADA Results:

- 24 hour flow totals and run times for the wells were recorded from the SCADA system for Wednesday, May 12, 2004.
- This information was entered into the model as a way to calibrate the model by simulating actual conditions for one full day.

Well Siting / Basin Study Report:

- This report prepared by Clear Creek Associates was referred to for future well locations.

City of Kingman Utility Regulations:

- The requirements for fire flows were obtained from this document.

City of Kingman General Plan 2020:

- Population figures, both current and future, were obtained from this document.
- Other information about the water system and future goals were also obtained from this document.

Additional Data

Section 4 - Water Sampling

Title 18, Chapter 4 of the Arizona Administrative Code requires that all public water systems perform routine monitoring and reporting for certain bacteriological, chemical, and radioactive contaminants in drinking water. The Arizona Department of Environmental Quality (ADEQ), which has jurisdiction over water systems in Arizona, has established Maximum Contaminant Levels (MCL) that are allowable for those contaminants which must be complied with by public water systems. Violations of these requirements can result in fines or imprisonment. The city performs the required monitoring and reporting and a copy of those results is included at the end of this section.

The test results show that Kingman's water supply is of very good quality and is in compliance with the ADEQ requirements. City well #4 does exceed the MCL for chromium and fluoride but this water is blended with water from City Wells 1, 2, 3, 5, 7, and Long Mountain Well #6 in the Forebay Tanks at the Castle Rock Booster Station before distribution. The test results show the blending to be effective with no violations.

There have been bacteriological violations in the past and as a result the City disinfects the water with chlorine. The requirement (R18-4-304) for groundwater treatment is that disinfection must be provided if there is a violation of the MCL for total coliform, however no minimum concentration level is mandated. There are two existing chlorine addition stations in the system. One is at Long Mountain Well #4, and the other is at the Castle Rock Booster Station. 0.5 mg/l of chlorine is added to the system at Long Mountain Well # 4, and 0.2 mg/l is added at Castle Rock. City staff provided a list of chlorine residuals from different sampling points throughout the service area which shows that there are many places in the system where the concentration is less than 0.2 mg/l which may be insufficient for disinfection.

A water model for the City of Kingman Water System was developed using Haestad Method's WaterGems for GIS, Geospatial Water Distribution Modeling Software for 10,000 pipes. The model is a graphical representation of Kingman's water system and will allow the City to analyze the behavior of the water system under varying conditions. WaterGems can be used to perform steady state analyses or extended period simulations, water quality simulations, fire flow analyses, and can be used for energy consumption and cost reporting. The model is a powerful tool for planning, and any changes to the water system the City is anticipating can be simulated in the model and the results observed in cyberspace before any money is spent. There are a wide variety of reports that are produced by WaterGems that give a detailed account of the elements in the model and the behavior of the system.

The City of Kingman's AutoCAD files of the existing water system were loaded into WaterGems and are the basis of the model. Information on the wells, pumps, tanks, and pressure reduction valves was also included in the model as well as elevation information from the topographic map provided by the City.

System water demands for the eighteen billing cycles within the City were calculated from City consumption and production reports and entered into the model. The City contracted with C5 Engineering to model the system down to 8" pipes, however in some instances smaller 4" and 6" connecting pipes were included for continuity within the model. Flow readings from the SCADA system were used for comparison with the model results.

Pipes and Nodes

The model takes elements (i.e., pipes, tanks, and wells, etc.) that are in the AutoCAD files and locates them in the same position within the WaterGems Model. Each piece of pipe is entered as a line segment and is joined to other pipes or devices with nodes, which can represent junctions, fittings, or pipe size changes, and it is also a representation of how the AutoCAD file was drawn. If a pipe is drawn in a two-foot. section in AutoCAD, it will be drawn that way in WaterGems. There were many of these short sections of pipe which were removed and the adjoining pipe extended in its place to reduce the complexity of the model and the overall pipe count.

All connections to tanks, wells, and pumps are all entered manually and a great deal of time was spent trying to figure out the plumbing for the different components within the system. Information about the pipes, which were physically read from the AutoCAD files, including diameter and material, and the elevation of each node is entered manually into the model.

The model will automatically determine the Hazen-Williams pipe roughness coefficient for the selected pipe material. This number can be changed manually and probably should be changed to match the estimated real pipe conditions. There is also a window to enter minor loss coefficients for fittings, and the user can select from the WaterGems menu of fittings or enter one manually. No minor loss coefficients were used in this model.

Examples of actual Pipe and Junction (Node) Reports for the City of Kingman of the finished input process are as follows:

Scenario: Demand (July 20, 2004)
Extended Period Analysis: 0.00 hr / 24.00
Pipe Report

Label	Length (ft)	Dia (in)	Material	Hazen-Williams C	Check Valve?	Minor Loss Coefficient	Control Status	Discharge (gpm)	Upstream Struct Hydr Grade (ft)	Dnstream Struc Hydr Grade (ft)	Pressure Pipe Headloss (ft)	Headloss Gradient (ft/1000ft)
P-4	240.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-6.12	3,563.57	3,563.57	0.00	0.00
P-7	145.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-4.08	3,563.57	3,563.57	0.00	0.00
P-10	322.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-31.42	3,563.33	3,563.36	0.03	0.09
P-12	3,399.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-650.42	3,629.71	3,633.10	3.39	1.00
P-13	160.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-655.91	3,633.10	3,633.26	0.16	1.01
P-15	81.00	12.0	Asbestos Cement	140.0	false	0.00	Open	962.95	3,633.59	3,633.42	0.17	2.06
P-16	7.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-30.60	3,563.35	3,563.35	0.00	0.10
P-19	40.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-2.30	3,561.01	3,561.01	0.00	0.00
P-20	382.00	12.0	Asbestos Cement	140.0	false	0.00	Open	968.44	3,634.39	3,633.59	0.80	2.08
P-21	249.00	12.0	Asbestos Cement	140.0	false	0.00	Open	979.42	3,635.78	3,635.25	0.53	2.13
P-22	412.00	12.0	Asbestos Cement	140.0	false	0.00	Open	973.93	3,635.25	3,634.39	0.87	2.10
P-23	40.00	8.0	Asbestos Cement	70.0	false	0.00	Open	91.03	3,563.80	3,563.77	0.03	0.68
P-24	792.00	6.0	Asbestos Cement	140.0	false	0.00	Open	-2.58	3,524.97	3,524.97	0.00	0.00
P-25	780.00	6.0	Asbestos Cement	140.0	false	0.00	Open	-4.15	3,524.97	3,524.98	0.00	0.00
P-26	8.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-93.07	3,563.80	3,563.80	0.01	0.70
P-27	641.00	6.0	Asbestos Cement	140.0	false	0.00	Open	-0.16	3,524.95	3,524.95	0.00	0.00
P-28	493.00	6.0	Asbestos Cement	140.0	false	0.00	Open	-1.68	3,524.95	3,524.95	0.00	0.00
P-29	455.00	6.0	Asbestos Cement	140.0	false	0.00	Open	-3.20	3,524.95	3,524.95	0.00	0.00
P-30	468.00	6.0	Asbestos Cement	140.0	false	0.00	Open	-4.72	3,524.95	3,524.95	0.00	0.00
P-31	500.00	6.0	Asbestos Cement	140.0	false	0.00	Open	-6.24	3,524.95	3,524.95	0.00	0.01
P-32	150.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-63.65	3,632.16	3,632.17	0.00	0.01
P-33	280.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-66.79	3,632.17	3,632.17	0.00	0.01
P-34	39.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-764.73	3,705.70	3,705.75	0.05	1.35
P-35	659.00	8.0	Asbestos Cement	140.0	false	0.00	Open	-208.48	3,718.76	3,719.33	0.58	0.87
P-36	533.00	8.0	Asbestos Cement	140.0	false	0.00	Open	-29.36	3,716.56	3,716.57	0.01	0.02
P-37	198.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-65.22	3,632.17	3,632.17	0.00	0.01
P-38	55.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-764.73	3,705.75	3,705.83	0.07	1.34
P-39	465.00	8.0	Asbestos Cement	140.0	false	0.00	Open	20.51	3,775.00	3,774.99	0.01	0.01
P-40	346.00	8.0	Asbestos Cement	140.0	false	0.00	Open	-5.66	3,707.47	3,707.47	0.00	0.00
P-41	129.00	8.0	Asbestos Cement	140.0	false	0.00	Open	2.04	3,711.23	3,711.23	0.00	0.00
P-42	753.00	8.0	Asbestos Cement	140.0	false	0.00	Open	36.54	3,707.69	3,707.67	0.03	0.03
P-43	38.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-0.00	3,705.75	3,705.75	0.00	0.00
P-44	287.00	8.0	Asbestos Cement	140.0	false	0.00	Open	-56.56	3,636.04	3,636.06	0.02	0.08
P-45	29.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-0.00	3,923.60	3,923.60	0.00	0.00
P-46	641.00	8.0	Asbestos Cement	70.0	false	0.00	Open	122.71	3,566.21	3,565.45	0.76	1.18
P-47	21.00	8.0	Asbestos Cement	70.0	false	0.00	Open	115.81	3,565.12	3,565.10	0.02	1.06
P-48	13.00	8.0	Asbestos Cement	70.0	false	0.00	Open	106.61	3,564.89	3,564.87	0.01	0.90
P-49	207.00	8.0	Asbestos Cement	70.0	false	0.00	Open	111.21	3,565.09	3,564.89	0.20	0.98
P-50	8.00	8.0	Asbestos Cement	70.0	false	0.00	Open	113.51	3,565.10	3,565.09	0.01	1.04
P-51	10.00	8.0	Asbestos Cement	70.0	false	0.00	Open	2.30	3,564.48	3,564.48	0.00	0.00
P-52	130.00	8.0	Asbestos Cement	70.0	false	0.00	Open	2.30	3,564.89	3,564.89	0.00	0.00
P-53	11.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-118.11	3,565.12	3,565.13	0.01	1.11
P-54	277.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-120.41	3,565.13	3,565.45	0.32	1.14
P-55	41.00	12.0	Asbestos Cement	140.0	false	0.00	Open	-0.00	3,923.65	3,923.65	0.00	0.00
P-57	554.00	8.0	Asbestos Cement	70.0	false	0.00	Open	-2.30	3,565.77	3,565.77	0.00	0.00
P-58	34.00	12.0	Asbestos Cement	140.0	false	0.00	Open	763.13	3,923.65	3,923.60	0.05	1.34
P-59	1,345.00	8.0	Asbestos Cement	140.0	false	0.00	Open	289.16	3,674.81	3,672.66	2.15	1.60
P-60	344.00	8.0	Asbestos Cement	140.0	false	0.00	Open	286.61	3,672.66	3,672.12	0.54	1.57
P-61	89.00	8.0	Asbestos Cement	140.0	false	0.00	Open	284.06	3,672.12	3,671.98	0.14	1.55

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City of Kingman
Project Engineer: Jim Christian
WaterGEMS v2.0 [6.5120i]
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Pipe Report

Scenario: Demand (July 20, 2004)
Extended Period Analysis: 0.00 hr / 24.00
Junction Report

Label	Elevation (ft)	Zone	Type	Base Flow (gpm)	Pattern	Demand (Calculated) (gpm)	Calculated Hydraulic Grade (ft)	Pressure (psi)
J-1303	3,415.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,561.01	63.17
J-2092	3,353.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.33	91.00
J-1362	3,437.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.41	116.99
J-1549	3,339.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.33	97.06
J-1698	3,375.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.66	81.62
J-1714	3,335.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.33	98.79
J-1875	3,411.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,562.89	65.72
J-1113	3,447.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.41	112.67
J-1521	3,423.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.03	60.58
J-2241	3,447.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,562.99	50.18
J-1550	3,335.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.33	98.79
J-2006	3,391.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,561.01	73.56
J-1211	3,409.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,562.89	66.58
J-1921	3,449.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,562.99	49.32
J-3596	3,443.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.43	114.41
J-3632	3,443.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.41	114.40
J-3583	3,411.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,562.89	65.72
J-3640	3,497.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.48	91.07
J-3584	3,411.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,562.89	65.72
J-3670	3,399.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,562.89	70.91
J-3658	3,477.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.42	99.69
J-1112	3,447.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.41	112.67
J-1168	3,356.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.33	89.70
J-1715	3,331.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.33	100.52
J-1304	3,415.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,561.01	63.17
J-1363	3,441.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.41	115.26
J-1724	3,369.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.66	84.22
J-53	3,343.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,565.13	96.11
J-433	3,325.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.77	103.30
J-402	3,345.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,566.21	95.71
J-245	3,347.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.60	93.71
J-59	3,341.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,564.89	96.87
J-139	3,388.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,561.01	74.85
J-392	3,357.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,565.77	90.32
J-45	3,335.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,564.48	99.29
J-60	3,341.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,564.87	96.86
J-303	3,445.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,565.45	52.11
J-30	3,343.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,565.10	96.09
J-449	3,363.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.66	86.82
J-44	3,335.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,564.48	99.29
J-138	3,388.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,561.01	74.85
J-1699	3,377.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.66	80.76
J-1083	3,365.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.11	85.71
J-1739	3,441.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.41	115.26
J-1883	3,337.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.32	97.92
J-1399	3,447.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,707.41	112.67
J-1352	3,385.00	Cycle-1	Demand	10.56	July 20, 2004 (Diurnal)	10.56	3,566.20	78.40
J-1219	3,353.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.32	91.00
J-945	3,335.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,564.50	99.29
J-72	3,334.00	Cycle-1	Demand	2.30	July 20, 2004 (Diurnal)	2.30	3,563.33	99.22

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City of Kingman

Project Engineer: Jim Christian
WaterGEMS v2.0 [6.5120i]
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Junction (Node) Report

Pumps

The pump settings in the model require head and discharge values for each pump to be entered into the model, which were taken from the pump curves shown in Section 3 - Existing Data Collection. The model was initiated using the three-point curve which uses the shut-off, design, and maximum operating heads and discharges at each of these points.

These pump curves on file did not seem to exactly match the real pumps characteristics. Therefore, it is suggested that the City should consider doing pump tests for each well and using this information in the model.

The model will calculate the system head curve for each pump based on the various input data and plot it on the same axes with the pump curve. Where the two curves intersect is the modeled operating point of the pump. This also shows the discharge flow that will pass through the pump and the head the pump will add.

An example of an actual Pump Report for the City of Kingman of the finished input process is as follows:

Scenario: Demand (July 20, 2004)
Extended Period Analysis: 0.00 hr / 24.00
Pump Report

Label	Elevation (ft)	Control Status	Intake Pump Grade (ft)	Discharge Pump Grade (ft)	Discharge (gpm)	Pump Head (ft)	Calculated Water Power (Hp)
PMP-BANK ST	2,746.00	Off	2,746.00	3,528.98	0.00	0.00	0.00
PMP-BY JACK	3,187.00	Off	3,193.00	3,563.91	0.00	0.00	0.00
PMP-CR B-1	3,379.00	On	3,396.50	3,802.97	1,246.46	406.46	127.91
PMP-CR B-2 (NG)	3,379.00	Off	3,396.88	3,802.45	0.00	0.00	0.00
PMP-CR B-3	3,379.00	On	3,396.08	3,803.58	2,031.45	407.50	209.00
PMP-CR B-4	3,379.30	On	3,395.19	3,804.81	2,921.73	409.62	302.16
PMP-CRW-1	2,590.00	Off	2,740.00	3,396.82	0.00	0.00	0.00
PMP-CW-1	2,695.00	Off	2,750.00	3,418.97	0.00	0.00	0.00
PMP-CW-2	2,667.00	Off	2,742.00	3,419.04	0.00	0.00	0.00
PMP-CW-3	2,714.00	On	2,744.72	3,411.49	1,284.24	666.77	216.19
PMP-CW-4	2,724.00	On	2,741.83	3,419.66	966.22	677.83	165.35
PMP-CW-5	2,613.00	On	2,739.42	3,490.33	2,255.58	750.91	427.62
PMP-CW-6	2,608.00	On	2,694.79	3,535.90	1,523.35	841.11	323.49
PMP-CW-7	2,626.00	Off	2,748.00	3,451.81	0.00	0.00	0.00
PMP-FTHILLS PNUE N	3,889.00	On	3,911.71	4,005.19	942.40	93.47	22.24
PMP-FTHILLS PNUE S	3,889.00	On	3,911.38	4,005.37	1,670.17	93.99	39.63
PMP-HUA B-1	3,679.00	On	3,705.70	3,923.69	764.73	217.99	42.09
PMP-HUA B-2	3,679.00	Off	3,705.75	3,923.60	0.00	0.00	0.00
PMP-HUA B-3	3,679.00	Off	3,705.81	3,923.65	0.00	0.00	0.00
PMP-HUBBS	3,175.00	On	3,194.97	3,568.99	175.74	374.01	16.59
PMP-LM-4	2,757.00	On	2,738.54	3,528.22	850.51	789.68	169.57
PMP-LM-4 B	3,437.00	On	3,527.71	3,656.19	1,320.62	128.49	42.84
PMP-LM-6	2,599.00	On	2,746.99	3,462.17	1,340.05	715.18	241.96
PMP-POMONA	3,189.00	On	3,191.96	3,574.19	185.13	382.23	17.87
PMP-SANTA FE	3,184.00	On	3,187.99	3,567.45	112.21	379.45	10.75

Pump Report

Wells

Wells are represented with a pump and a reservoir in the model. Pump information is entered as explained above. The elevation of the static water level in the well is the only information used for a reservoir. Static water levels were obtained from the ADEQ Public Water Supply System and Well Inventory dated April 2003.

An example of an actual Well (Reservoir) Report for the City of Kingman of the finished input process is as follows:

Scenario: Demand (July 20, 2004)
Extended Period Analysis: 0.00 hr / 24.00
Reservoir Report

Label	Elevation (ft)	Zone	Inflow (gpm)	Calculated Hydraulic Grade (ft)
W-BANK ST	2,746.00	Zone	0.00	2,746.00
W-BY JACK	3,193.00	Cycle-1	0.00	3,193.00
W-CRW-1	2,740.00	Cycle-12	0.01	2,740.00
W-CW-1	2,750.00	Cycle-8	0.00	2,750.00
W-CW-2	2,742.00	Cycle-9	0.00	2,742.00
W-CW-3	2,745.00	Cycle-8	-1,284.24	2,745.00
W-CW-4	2,742.00	Cycle-8	-966.22	2,742.00
W-CW-5	2,741.00	Cycle-13	-2,255.58	2,741.00
W-CW-6	2,695.00	Zone	-1,523.35	2,695.00
W-CW-7	2,748.00	Zone	0.00	2,748.00
W-HUBBS	3,195.00	Cycle-2	-175.74	3,195.00
W-LM-4	2,739.00	Zone	-850.51	2,739.00
W-LM-6	2,747.00	Zone	-1,340.05	2,747.00
W-POMONA	3,192.00	Cycle-2	-185.13	3,192.00
W-SANTA FE	3,188.00	Cycle-1	-112.21	3,188.00

Well (Reservoir) Report

Tanks

The tanks diameter, height, base elevation, maximum and minimum water elevation, operating level, start and stop fill elevations, and base water elevation, are entered manually into the model and were all obtained from City staff and data.

An example of an actual Tank Report for the City of Kingman of the finished input process is as follows:

Scenario: Demand (July 20, 2004)
Extended Period Analysis: 0.00 hr / 24.00
Tank Report

Label	Zone	Base Elevation (ft)	Minimum Elevation (ft)	Initial HGL (ft)	Maximum Elevation (ft)	Inactive Volume (gal)	Tank Diameter (ft)	Inflow (gpm)	Current Status	Calculated Hydr Grade (ft)	Calculated Percent Full (%)
T-BEALE SPRGS	Cycle-2	3,535.25	3,535.75	3,563.60	3,565.00	0.00	75.00	-33.10	Draining	3,563.60	95.2
T-CAMELBACK	Cycle-18	3,600.00	3,600.05	3,628.35	3,629.75	0.00	75.00	171.33	Filling	3,628.35	95.3
T-COLLEGE	Zone	3,498.00	3,498.00	3,527.61	3,529.50	0.00	90.00	458.76	Filling	3,527.61	94.0
T-CR1	Cycle-12	3,381.00	3,381.42	3,397.48	3,405.00	0.00	44.70	-443.27	Draining	3,397.48	68.1
T-FTHILLS PNUE	Cycle-6	3,889.00	3,963.00	4,003.00	4,004.00	0.00	4.56	1,138.91	Filling	4,003.00	97.6
T-HUA	Cycle-6	3,678.30	3,678.90	3,705.80	3,707.80	0.00	93.00	291.34	Filling	3,705.80	93.1
T-HUA 2	Cycle-6	3,889.50	3,890.42	3,917.78	3,918.80	0.00	54.00	-2,107.08	Draining	3,917.78	96.4
T-MAIN 1	Cycle-8	3,678.50	3,679.00	3,706.53	3,708.00	0.00	75.00	1,103.46	Filling	3,706.53	94.9
T-MAIN 2	Cycle-8	3,678.50	3,679.00	3,706.53	3,707.80	0.00	90.00	1,501.58	Filling	3,706.53	95.6
T-MAIN 3	Cycle-8	3,680.50	3,681.00	3,708.53	3,709.80	0.00	97.00	-2,299.66	Draining	3,708.53	95.6
T-R SANTA FE	Cycle-6	3,886.30	3,886.30	3,914.58	3,917.80	0.00	90.00	301.42	Filling	3,914.58	89.8

Tank Report

Valves

Flow Control Valves were added in the model where it was necessary to control the pressures according to the pressure zone map provided by the City. The AutoCAD files were consulted but City staff verified many valve locations for accuracy. Given the City staff input, the model was then adjusted to the real world conditions within the existing system.

Pressure Reduction Valves

Location, size, elevation, and outlet pressure information of each PRV was obtained from City staff and entered into the model.

An example of an actual Valve Report (including valves and PRV's) for the City of Kingman of the finished input process is as follows:

Scenario: Demand (July 20, 2004)
Extended Period Analysis: 0.00 hr / 24.00
Valve Report

Label	Elevation (ft)	Diameter (in)	Minor Loss Coefficient	Control Status	Discharge (gpm)	From HGL (ft)	To HGL (ft)	Headloss (ft)
FCV-1	3,301.00	12.0	0.00	Closed	0.00	3,526.32	3,449.96	0.00
FCV-2	3,370.00	12.0	0.00	Closed	0.00	3,418.97	3,524.07	0.00
FCV-3	3,433.00	6.0	0.00	Closed	0.00	3,521.26	3,627.59	0.00
FCV-4	3,408.00	6.0	0.00	Closed	0.00	3,520.70	3,627.88	0.00
FCV-5	3,398.00	8.0	0.00	Closed	0.00	3,706.73	3,733.37	0.00
FCV-6	3,365.00	6.0	0.00	Closed	0.00	3,520.30	3,483.96	0.00
FCV-7	3,375.00	6.0	0.00	Closed	0.00	3,484.23	3,520.03	0.00
FCV-8	3,349.00	8.0	0.00	Closed	0.00	3,523.75	3,625.69	0.00
FCV-9	3,391.00	6.0	0.00	Closed	0.00	3,520.03	3,637.79	0.00
FCV-10	3,399.00	8.0	0.00	Closed	0.00	3,522.67	3,626.97	0.00
FCV-11	3,407.00	8.0	0.00	Closed	0.00	3,563.13	3,630.88	0.00
FCV-12	3,402.00	8.0	0.00	Closed	0.00	3,563.18	3,562.94	0.00
FCV-13	3,333.00	16.0	0.00	Closed	0.00	3,456.72	3,534.45	0.00
FCV-14	3,460.00	8.0	0.00	Closed	0.00	3,707.83	3,630.98	0.00
FCV-15	3,478.00	12.0	0.00	Closed	0.00	3,710.56	3,711.25	0.00
FCV-16	3,405.00	8.0	0.00	Closed	0.00	3,644.20	3,641.54	0.00
FCV-17	3,444.00	8.0	0.00	Closed	0.00	3,627.29	3,636.00	0.00
FCV-18	3,475.00	6.0	0.00	Closed	0.00	3,711.52	3,712.61	0.00
FCV-19	3,419.00	12.0	0.00	Closed	0.00	3,644.17	3,707.46	0.00
FCV-20	3,505.00	12.0	0.00	Closed	0.00	3,711.24	3,712.58	0.00
FCV-21	3,423.00	8.0	0.00	Closed	0.00	3,627.14	3,627.27	0.00
FCV-22	3,425.00	8.0	0.00	Closed	0.00	3,642.15	3,627.29	0.00
FCV-23	3,437.00	6.0	0.00	Closed	0.00	3,642.16	3,627.29	0.00
FCV-24	3,449.00	6.0	0.00	Closed	0.00	3,644.36	3,651.77	0.00
FCV-25	3,443.00	6.0	0.00	Closed	0.00	3,641.87	3,680.26	0.00
FCV-26	3,473.00	8.0	0.00	Closed	0.00	3,707.70	3,711.05	0.00
FCV-27	3,317.00	16.0	0.00	Closed	0.00	3,454.28	3,524.16	0.00
FCV-28	3,448.00	6.0	0.00	Closed	0.00	3,632.55	3,631.37	0.00
FCV-29	3,315.00	6.0	0.00	Throttling	0.00	3,464.19	3,448.60	0.00
FCV-30	3,407.00	8.0	0.00	Closed	0.00	3,632.10	3,632.54	0.00
FCV-31	3,360.00	12.0	0.00	Closed	0.00	3,625.34	3,798.60	0.00
FCV-32	3,473.00	8.0	0.00	Closed	0.00	3,636.06	3,650.53	0.00
FCV-33	3,429.00	12.0	0.00	Closed	0.00	3,641.80	3,716.07	0.00
FCV-34	3,476.00	8.0	0.00	Closed	0.00	3,707.68	3,710.50	0.00
FCV-35	3,472.00	8.0	0.00	Closed	0.00	3,711.50	3,707.83	0.00
FCV-36	3,477.00	6.0	0.00	Closed	0.00	3,708.25	3,711.68	0.00
FCV-37	3,586.00	8.0	0.00	Closed	0.00	3,716.41	3,774.99	0.00
FCV-38	3,463.00	6.0	0.00	Closed	0.00	3,650.54	3,647.78	0.00
FCV-39	3,465.00	6.0	0.00	Closed	0.00	3,647.78	3,651.61	0.00
FCV-40	3,414.00	8.0	0.00	Closed	0.00	3,627.14	3,641.53	0.00
FCV-41	3,403.00	6.0	0.00	Closed	0.00	3,520.07	3,629.53	0.00
FCV-45	3,305.00	8.0	0.00	Closed	0.00	3,474.55	3,523.97	0.00
PRV-1	3,475.00	12.0	0.00	Throttling	3.94	3,727.08	3,659.91	67.17
PRV-2	3,358.30	8.0	0.00	Throttling	4.04	3,626.07	3,501.60	124.47
PRV-3	3,355.50	8.0	0.00	Throttling	300.32	3,625.20	3,528.85	96.35
PRV-4	3,393.50	6.0	0.00	Throttling	219.29	3,635.69	3,504.44	131.25
PRV-5	3,670.50	6.0	0.00	Throttling	64.00	3,915.49	3,797.62	117.86
PRV-6	3,384.40	6.0	0.00	Throttling	89.87	3,798.76	3,569.31	229.45
PRV-7	3,396.80	8.0	0.00	Closed	0.00	3,733.15	3,562.90	0.00
PRV-8	3,359.80	12.0	0.00	Closed	0.00	3,798.60	3,524.82	0.00

Title: City of Kingman
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12/28/04 09:47:23 AM 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

City of Kingman

Project Engineer: Jim Christian
WaterGEMS v2.0 [6.5120i]
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Valve Report

Chlorine Addition

To simulate the chlorination process a "scenario" is set up and the chlorine addition concentrations provided by the City are entered into the model. 0.5 mg/l of chlorine was added at Long Mountain Well #4, and 0.2 mg/l were added at the Castle Rock Booster Station. The model can be used to predict the residual chlorine concentrations throughout the system.

Fire Flow

Fire flow is also set up as a "scenario". The fire flow requirements were obtained from the City of Kingman Utility Regulations. The requirements are 3,500 gpm from two adjacent fire hydrants for commercial developments, 1,000 gpm from two adjacent hydrants for single family residential, and 500 gpm from a single hydrant for rural residential developments.

Results

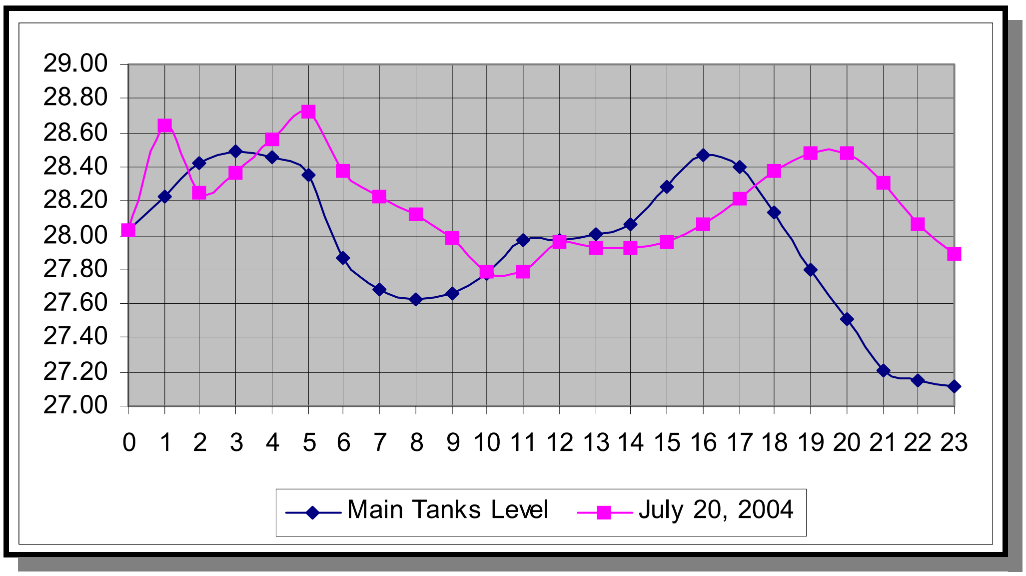
The results from the model at this point are inconclusive due to:

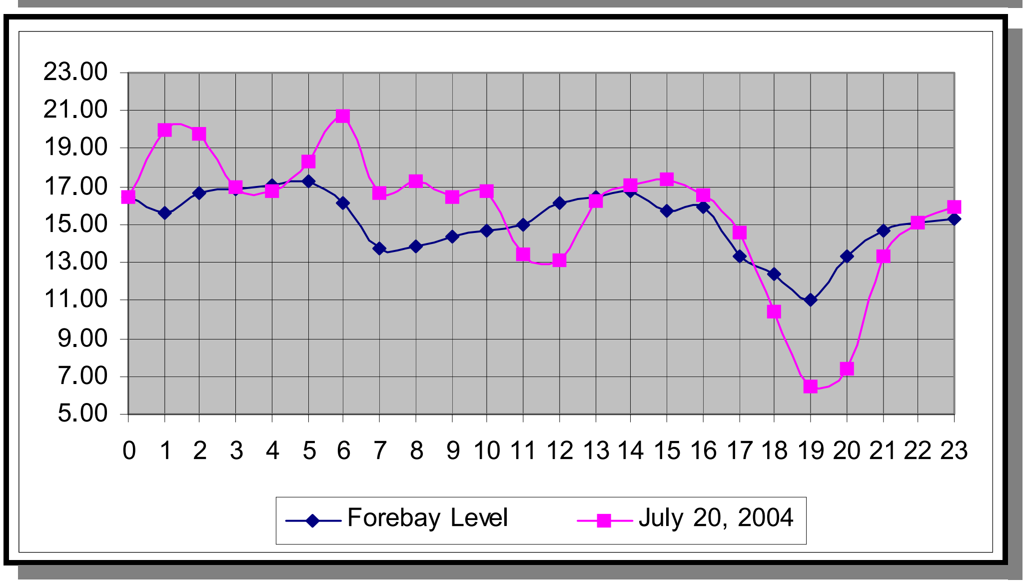
- It appears that not all the base data information used is accurate.
- Some of the elements are not functioning as expected and contradict field data.
- There appear to be discrepancies between billing and production records.
- Pump curves do not match the actual pumps thereby resulting in an inaccurate modeling situation.
- The modeling Team has no way of determining the accuracy of the AutoCAD files. Therefore, the base model needs to be reviewed by City staff and corrected for any errors that may be a result of errors in the AutoCAD files. The same goes for the valving within the system.

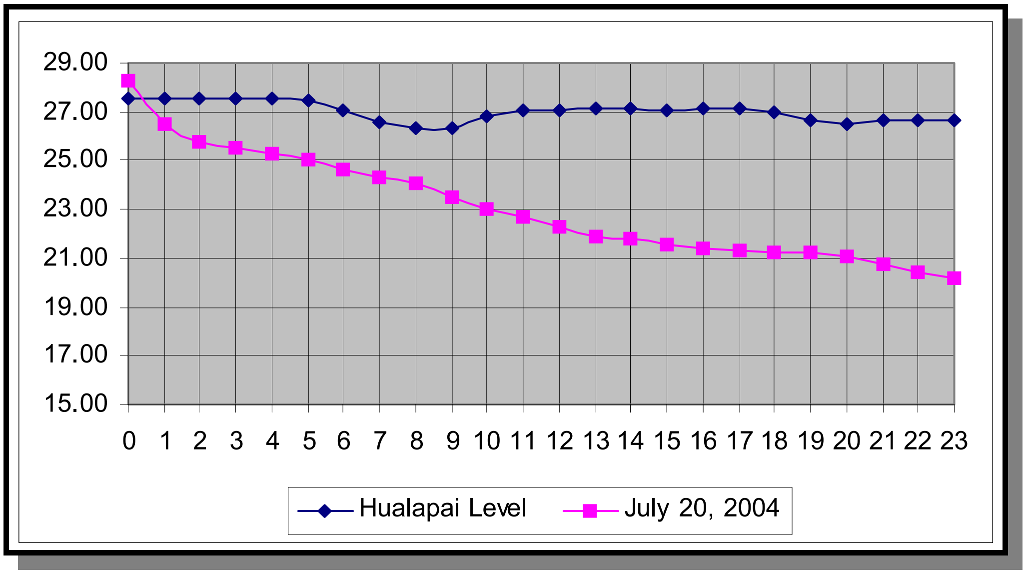
It is the goal of the entire Team (City and C5 Engineering staff) to address and satisfy these issues in a meeting scheduled for early January, 2005.

To calibrate the water model, field data from the SCADA system for 24 hours on July 20, 2004 was selected to try to simulate the actual conditions for that day. City staff provided us with the well run times and production rates for this day. This information was entered into the model and run in steady state and for an extended period.

At this point in time, December, 2004, the modeling Team is not completely satisfied with the modeling results. Though there is a strong correlation between the model and the real world results (i.e., SCADA data), this correlation does not hold true throughout the entire 24 hour period modeled as seen in the following graphs (**dark blue** is SCADA information for that tank and **pink** is the resulting generated WaterGEMS computer modeling results):



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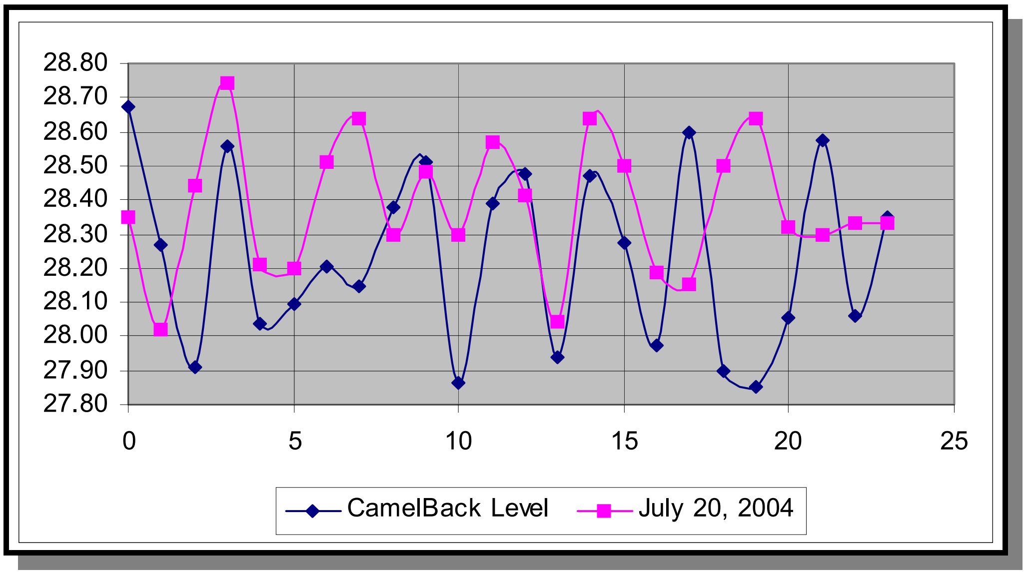
Hualapai Level
July 20, 2004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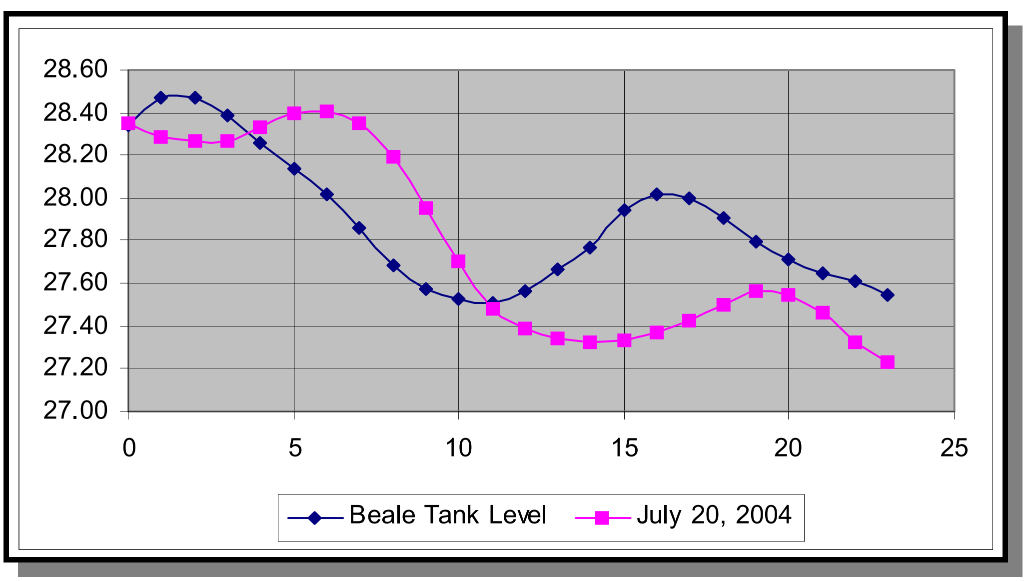
CamelBack Level
July 20, 2004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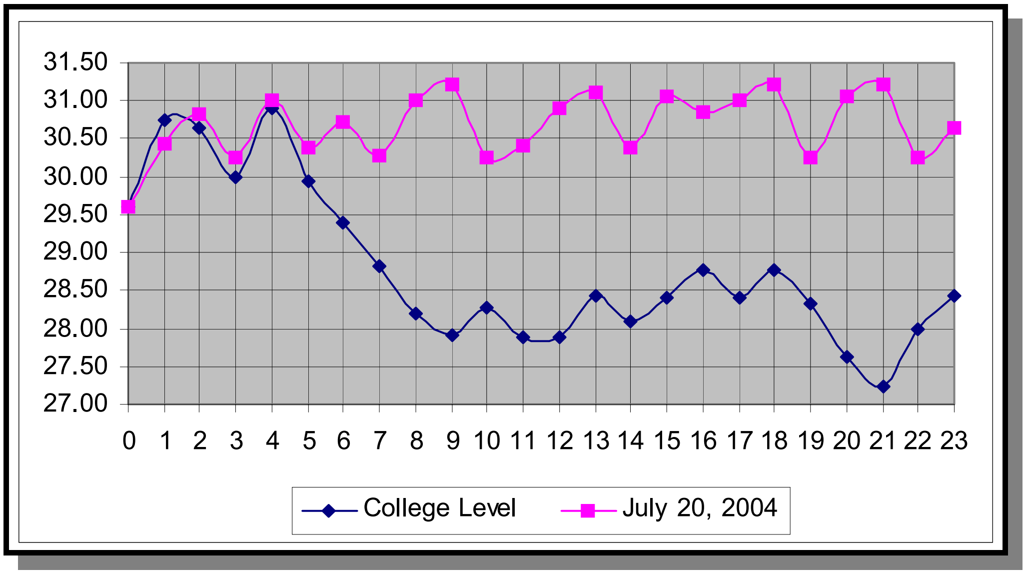
Beale Tank Level
July 20, 2004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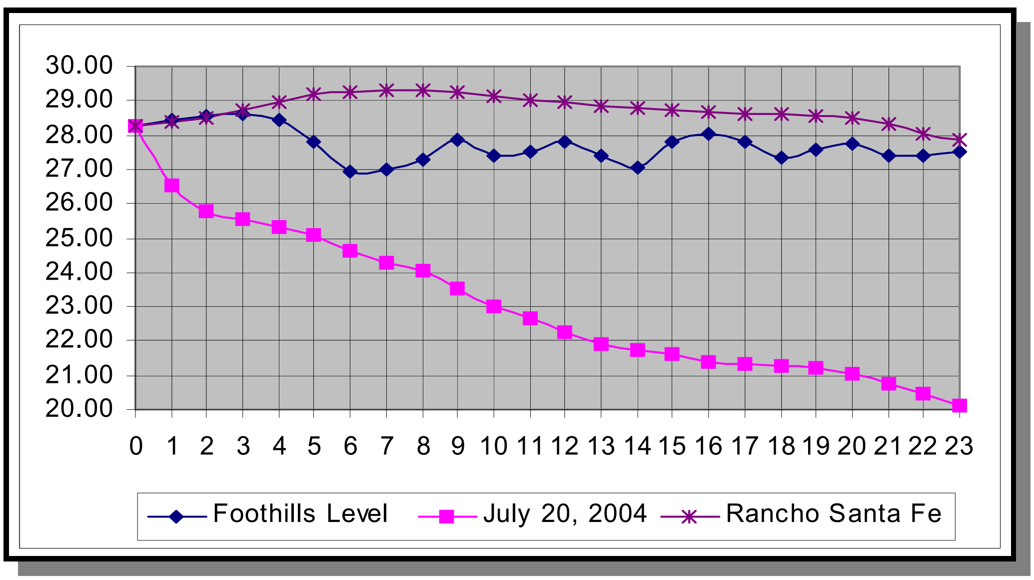
College Level
July 20, 2004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Foothills Level
July 20, 2004
Rancho Santa Fe

In summary, please see the following table describing the variance in water levels between the SCADA data and the computer generated water levels in the tanks:

Tank Name	Average Difference in Water Level Over a 24 Hour Period
Main Tank	0.24-feet higher
Forebay Tank	0.39-feet higher
Hualapai Tank	3.92-feet lower
Camelback Tank	0.15-feet higher
Beale Tank	0.11-feet lower
College Tank	1.91-feet higher
Foothills Tank	4.63-feet lower
Rancho Santa Fe Tank	5.67-feet lower

Though some tanks are fairly close in modeling terms (i.e., the Main, Forebay, Camelback, and Beale Tanks), other are suspect (i.e., Hualapai, College, Foothills, and Rancho Santa Fe Tanks). The modeling Team estimates that the following items could be contributing to this correlation slippage:

- There are major discrepancies (volumes and time of readings) between water billing and water production records. In general, water billings always seem to be lower than production records. Also, actual meter readings are at the start of end of the month and may not coincide with the instantaneous SCADA meter readings. In addition, some major water users (i.e., City parks and the golf course) appear to have major discrepancies between the amount of water billed and the amount of water used. This water usage discrepancy has a very large impact on the water model.

- Not all pump curves were available therefore, estimated pump curves may not match the actual pump curves.

- There is no way of determining the accuracy of the AutoCAD file, which is the basis of the pipe modeling efforts. Therefore, the model needs to be fully reviewed by City staff and corrected for any errors (i.e., missing pipelines and / or wrong pipe materials and / or wrong pipe sizes) that may be a result of errors in the AutoCAD file.

- The Modeling Team was able to get pressures in most of the pressure zones to a reasonable level and are confident that some of the smaller pressure zones are correct. There is still a need for City staff's input on flow control valve locations and functions.

- System pipe roughness coefficients (i.e., "C" factors) are being estimated from fire hydrant test flows recorded by the City of Kingman Fire Department.

- When the SCADA system goes off-line (i.e., power failure, SCADA system component failure, etc.), the pumps default to the on position and continue to run. The issue is that the SCADA system does not record that the pumps are running. Therefore, this needed information is not entered into the computer model database.

- The SCADA system daily summary report and, say, for example, the SCADA five minute report for that same 24-hour period do not always agree. One or the other report may say that a pump is running while the other says that that pump never ran that entire day. Also, critical flow totals disagree. The SCADA information has always been intended to be the foundation for the modeling efforts, along with the AutoCAD files. Given that there are known discrepancies in this critical data, the modeling efforts are greatly effected.

It should be noted that these types of computer models are rarely, if ever, exact. A normal plus / minus range would be in the 5 to 10% variance range for output information versus real world data. However, as shown above, some of our output data is outside this range. A very possible reason, through no fault of any Team member, is the old saying "poor data in, poor data out'.

Therefore, given the above issues, the proposed solution is to have a full Team meeting (City and C5 Engineering) to discuss these issues and bring closure thereby solving the issues of the modeling calibration (i.e., is this close enough for the purposes of this study given the lack or inaccuracy of the available information).

Growth

The future water system growth area projection is based on direction from City staff and from the City of Kingman General Plan 2020. The General Plan 2020 Projected Plan Use Map was used to determine future water demands within the General Plan Study Area (GPSA), which is about 79 square miles in size.

Based on the Camelback zone expanded to I-40, 75% of future growth will occur in the new Hualapai 3, Camelback, and College zones. The population projection for 2024 is estimated to be 97,105. The population of the areas shown is 81,755. The remaining growth is distributed between the Downtown, Main Tanks/Hualapai zones and the Foothills zones. The population projections in these areas are determined by taking the total acreage and removing 30% for roads, open space, etc., and multiplying the reduced acreage by the densities shown in the Kingman General Plan 2020 Projected Land Use Map.

Demand

Using the population of 38,530 for the year 2003 and a growth rate of 4.5% as provided by the City, population projections for the study and future demands are shown in the following table:

Future Water Demand Projection

Year	2004	2009	2014	2019	2024
Population	40,264*	50,176	62,529	77,922	97,105
Average Day of Year (gpcd)	200	200	200	200	200
Average Day Demand (mg)	8.05	10.04	12.51	15.58	19.42
Acre-Ft / Year	9,020	11,421	14,008	17,457	21,754
Average Day of Maximum Month (gpcd)	306	306	306	306	306
Maximum Month Demand (mg)	12.32	15.35	19.13	23.84	29.71
Maximum Day (gpcd)	402	402	402	402	402
Maximum Day Demand (mg)	16.17	20.16	25.12	31.30	39.01

* Population from City of Kingman Water Department General Operating Statistics recorded a population of 38,530 for 2003, a growth rate of 2.7% for the 3 years from 2000. Population projections calculated using fp=pp(1+rate)^years

Water Sources

The water demand forecast for 2024 is that the City will need 21,754 acre-feet of water. This is below the 30,000 acre-feet that are estimated by ADWR to be safely available in the Hualapai Basin.

Production

The production capacity is the total production for the maximum day of the year plus an allowance for out of service wells. For this report we held the largest producing well, City Well #7, with a production rate of 2,350 gpm or 3.0 mgd in reserve. We also assumed the current six hour interruptible power policy will continue and that the ratio of interruptible to uninterruptible well capacities will be the same in the future and that one 3 mgd well will be held in reserve. City wells 2, 4, 6, and 7 and Long Mountain 6, with a total capacity of 13.10 mgd are on the interruptible basis, as well as Castle Rock Boosters 1 and 3. During the six hour interruptible period, production is decreased to 41% of total capacity if the entire interruption is exercised. Future production requirements are shown in the following table:

Future Production Requirements					
Year	**2004**	**2009**	**2014**	**2019**	**2024**
Maximum Day Demand (mg)	16.17	20.16	25.12	31.30	39.01
Reserve (mgd)	3.00	3.00	3.00	3.00	3.00
Total Production Needed (mgd)	19.17	23.16	28.12	34.30	42.01
Interruptible Capacity (Total production Needed x 41% x 6 hr / 24) (mg)	1.98	2.39	2.90	3.54	4.34
Uninterruptible Capacity (Total Production Needed x 18/24) (mg)	14.38	17.37	21.09	25.73	31.50
Total Capacity (Interruptible + Uninterruptible)(mg)	16.36	19.76	23.99	29.27	35.84
Ratio (Total Capacity/ Total Production Needed)	.8533	.8533	.8533	.8533	.8533
Total Production (Total Capacity / Ratio) (mgd)	22.47	27.14	32.95	40.20	49.23

The new wells were located according to the Well Siting/Basin Study Report by Clear Creek Associates. New wells will be located near the airport and in the Long Mountain area. Depending on whether the city continues the interruptible power option, and on the new wells discharge, 28 new wells may be needed to satisfy the requirements to 2024.

The future water system layout was designed using the water model and the conclusions reached herein are based on responses in the water model. The following are our recommendations to meet future demand, production, and storage requirements

Mainline Piping

Most of the mainline piping will be completed in the 10 year horizon to accommodate the cities rapid growth and will occur mainly in the College, Camelback East, Rancho Santa Fe and Camelback districts, as well as a new parallel line between the Castle Rock Booster Station and the Main Tanks and the Hualapai Tank in order to facilitate increased flows.

Parallel Lines

28,700 ft. of 18" will be added from Castle Rock to the Hualapai Tank along the existing 16" mainline alignment. 12,550 feet of 14" will be added from the junction at Hoover and Kingman along the existing 12" alignment along the Kingman Ave., Pasadena and Western Ave. Alignment.

College

2,700 feet of new 16" mainline will be added from Long Mountain Well 4 to Grace Neal Drive and run parallel to the existing 12" pipe that runs South from the Long Mountain 4 Booster Pump to Grace Neal Drive between Lomita St. and Roosevelt St. From this junction 2,560 feet of 16" mainline will be added and joined to the 16" pipe that runs North and South on Bank St. From Bank St. 2,670 feet of 16 " will be added and joined to a new 12" pipe that will run North on Marshall from Jagerson. From the junction at Marshall and Gum Dr. 2,670 feet of 16" pipe will be added and joined to the existing 16" pipe that runs North-South on Castle Rock Rd. 8,500 ft. of 16" line to future wells 4 & 5 is also included in the capital improvements, but this could change drastically depending on actual well locations.

Camelback East

Mainline piping in the new Camelback East area will be from the well fields near the airport to the new tank near Lamar St. and Mohave Dr. The new pipe will be joined to the existing 12" pipe on Berry where it turns to the Northeast to go to city wells 1 & 4. A new 12" valve will need to be added to divert city wells 1 & 4 to the new tank. 16,100 ft. of 16" will be added from this valve to the new tank. We also recommend the installation of a new 8" bypass line between city well 1 and city well 4 to give the city the flexibility to use these wells to fill either the new tank or the Castle Rock tank as conditions dictate. 3,400 ft. of 16" to future well 2 is also included in the capital improvements, but this could change drastically depending on actual well locations. 8,100 ft. of 12" line was also added from the 16" on Wagon Wheel at Diamond Joe and extended to the Kingman Crossing area.

Hualapai 3

We were unable to get the Rancho Santa Fe tank to “float” with the Foothills tank in the computer model so 6,800 ft. of 12" pipe was added between the 14" mainline by the Foothills tank and the Rancho Santa Fe tank This improved the tanks performance and more closely approximates actual field conditions and so we have added this pipe to the capital improvements. Another 17,800 ft. of 12" pipe will be added to serve this new zone.

Camelback

The city wants to extend service North on Stockton Hill Rd., however, pressures in the area are currently to low to provide adequate service to customers. We added 8,275 of 12" pipe along Gum Dr. from Stockton Hill Rd. to the 12" that runs North-South from Long Mountain 4 to try to solve this problem, however the pressure didn’t change significantly and remained in the 30 to 40 psi range in the computer model. This line will be needed at some time to serve future populations and is included in the capital improvements. No further effort was made at this time to solve the pressure problem and if the city continues to grow in this direction a new higher tank zone may be needed.

Storage

Reservoir storage for the system should be enough to provide for operational equalization, fire fighting requirements, and a reserve for emergency needs. Operational equalization includes diurnal fluctuations and for recovery of reduced production during interrupted power periods.

Operational equalization for the system will be estimated at 25% of the maximum daily demand.

Fire flow storage used for the Master Plan includes one commercial fire at 3500 gpm for two hours = 0.42 mg and one residential fire at 1000 gpm for two hours = 0.12 mg, for a total concurrent fire flow storage of 0.56 mg. Emergency reserve used is 5%.

A new tank zone was added East of the Rancho Santa Fe Tank. The new Hualapai 3 tank will serve the higher elevations in this area and has a base elevation of 4020 and a maximum water elevation of 4050. The static pressure in this tank can serve an elevation of 3928 with a pressure of 40 psi and an elevation of 3842 with a pressure of 90 psi. A new 500 gpm booster pump station will be needed at the Rancho Santa Fe tank to serve this new tank.

The population in each of the tank zones was determined by placing the eighteen meter reading cycles in their respective tank zones and counting the number of residential meters, taken from the 2003 consumption report, in each tank zone. The population for each of the tank zones was calculated by multiplying the percentage of water meters times the population in 2003.

The storage capacity needed in 2024 is 15.06 mg, but due to the distribution of future populations, 5 new tanks with 8.0 mg of capacity are needed and the new the system will have 18.90 mg of storage capacity.

Tanks

Downtown

The percentage of the total population in the Downtown zone is projected to decline from the current 8% to 6% in 2024. The storage capacity in 2024 is projected to be 1.26, which is more than the current 1.0 mg. The area can be supplemented from the Main Tanks and Hualapai tanks, which already serve this zone and will be over capacity in 2024.

Main Tanks/Hualapai

Due to the expansion of the Camelback zone, this zone will be reduced in size and growth will be mainly infill. The future percentage of the total population will drop from the current 23% to 20%. The current tank capacity in this zone is 5.4 mg which is much more than the 2.90 mg that will be needed in 2024 and no new storage capacity will be needed to satisfy the requirements to 2024. The additional capacity can be used to supplement the downtown area which will be under capacity by 2014 according to the Future Tank Projections Table (see below).

Foothills

The growth in the southeastern section of the City will affect the Foothills and Hualapai 3 Tank zones. The current population of the Foothills zone is estimated to be 2,312 based on the number of residential meters in this zone. The Hualapai 3 area is currently undeveloped and the population is 0. According to City staff, the area to be developed in this area will have a density of 2 DU/AC. There are approximately 950 acres to be developed and the population in 20 years is estimated to be 6,967. Approximately half of the increase (2,327) will be in the new Hualapai 3 zone and half in the Foothills zone.
According to the Future Tank Projections Table (see below), the Foothills zone at 2.0 mg, is over capacity at this time and will need 1.15 mg of capacity by 2024. No additional storage will be needed to satisfy the requirements to 2024. A 1.0 mg tank is recommended for the Hualapai 3 tank due to the limited size of this zone, which is constrained by the topography of the area which steepens into the nearby hills.

College

The growth in the northern section of the city will affect the Airport zone between Lomita Street and Route 66 and between Grace Neal Drive (West side) and Mohave Airport Dr. (East side). The current population of the College zone is estimated to be 13,100 based on the number of residential meters in that zone. From the General Plan 2020 Projected Land Use Map, the development in this area will be medium density residential (3-8 DU/AC). For this Master Plan we used an average of 5.5 DU/AC. There are 1,683 acres in this area and the population in 2024 is estimated to be 35,781 an increase of 22,681. According to the Future Tank Projections Table (see below), the College zone is under capacity at this time by .71 mg. and will need 4.89 mg of capacity by 2024. An additional 3.5 mg of storage will be needed to satisfy the requirements to 2024. This can be accomplished in 2 phases, with a 2.0 mg tank being added now and another 1.5 mg tank being added by 2019.

Camelback

The growth in the eastern section of the City will affect the expanded Camelback zone which will work in conjunction with the new Camelback East tank. The current population of this zone is estimated to be 11,174 based on the number of residential meters in this zone. The future population of this area is based on City staff assessments of pending developments. These developments include a 1,150 home subdivision (Kingman Crossing), a 288 home subdivision, 156 acres and 822.5 acres of medium density residential development (5.5 DU/AC). The population in the expanded Camelback zone in 20 years is estimated to be 29,391.
According to the Future Tank Projections Table (see below), the expanded Camelback zone is under capacity at this time by .97 mg. and will need 4.07 mg of capacity by 2024. An additional 3.5 mg of storage will be needed to satisfy the requirements to 2024. The new Camelback East tank at 1.5 mg will be added in the 10 year capital improvements plan to accommodate the new developments that are proposed in the area.. A new 2.0 mg tank should also be installed at the Camelback Tank location within the 10 year plan to satisfy requirements.

Castle Rock Forebay

We are recommending to increase the size of the Castle Rock Forebay Tank to a minimum of 1.0 mg, to accommodate future flow requirements and to help minimize water level fluctuations that cause the pumps to cycle on and off more than is necessary.

The following tables summarizes the above information

Tank Population Projections

Tank Zone	Down town	Main Tanks /Hualapai	Foothills	College	Camel back	Hualapai 3	Total
2003 % of Total Water Meters	8%	23%	6%	34%	29%	0%	100.00%
Population 2003	38,530	38,530	38,530	38,530	38,530	38,530	
Population by Zone	3,082	8,862	2,312	13,100	11,174	0	38,530
Pop adjusted 2009	3,650	11,028	2,800	17,416	14,700	582	97,106
2009 % of Total	7%	22%	6%	35%	29%	1%	100%
Pop adjusted 2014	4,267	12,627	3,476	23,122	17,874	1,164	62,530
2014 % of Total	7%	20%	6%	37%	29%	2%	100%
Pop adjusted 2019	4,905	15,950	3,900	28,120	23,302	1,745	77,922
2019 % of Total	6%	20%	5%	36%	30%	2%	100%
Pop Adjusted 2024	5,734	19,234	4,640	35,781	29,391	2,327	97,106
2024 % of Total	6%	20%	5%	37%	30%	2%	100%
Rate of growth adjusted	0.03	0.03759	0.03373	0.04901	0.04713	0.446	

Future Tank Storage Projections

Year	**2004**	**2009**	**2014**	**2019**	**2024**	**Additional Tank Capacity**
Maximum Day Demand	16.17	20.16	25.12	31.3	39.01	
Downtown						
% of Total Population	8%	7%	7%	6%	6%	
Demand (mg)	1.29	1.41	1.76	1.88	2.34	
Fire Flow	0.56	0.56	0.56	0.56	0.56	
Diurnal fluctuation (25% of max day demand)	0.32	0.35	0.44	0.47	0.59	
Reserve (5%)	0.06	0.07	0.09	0.09	0.12	
TotalCapacity Needed	0.95	0.98	1.09	1.12	1.26	
Capacity	1.00	1.00	1.00	1.00	1.00	0.0
Under (-)/Over(+) Total Capacity needed	0.05	0.02	-0.09	-0.12	-0.26	
Main Tanks/Hualapai						
% of Total Population	23%	22%	20%	20%	20%	

Demand (mg)	3.72	4.44	5.02	6.26	7.80	
Fire Flow	0.56	0.56	0.56	0.56	0.56	
Diurnal fluctuation (25% of max day demand)	0.93	1.11	1.26	1.57	1.95	
Reserve (5%)	0.19	0.22	0.25	0.31	0.39	
TotalCapacity Needed	1.68	1.89	2.07	2.44	2.90	
Capacity	5.40	5.40	5.40	5.40	5.40	0.0
Under (-)/Over(+) Total Capacity needed	3.72	3.51	3.33	2.96	2.50	

Foothills

% of Total Population	6%	6%	6%	5%	5%	
Demand (mg)	0.97	1.21	1.51	1.57	1.95	
Fire Flow	0.56	0.56	0.56	0.56	0.56	
Diurnal fluctuation (25% of max day demand)	0.24	0.30	0.38	0.39	0.49	
Reserve (5%)	0.05	0.06	0.08	0.08	0.10	
TotalCapacity Needed	0.85	0.92	1.01	1.03	1.15	
Capacity	2.00	2.00	2.00	2.00	2.00	0.0
Under (-)/Over(+) Total Capacity needed	1.15	1.08	0.99	0.97	0.85	

College

% of Total Population	34%	35%	37%	37%	37%	
Demand (mg)	5.50	7.06	9.29	11.58	14.43	
Fire Flow	0.56	0.56	0.56	0.56	0.56	
Diurnal fluctuation (25% of max day demand)	1.37	1.76	2.32	2.90	3.61	
Reserve (5%)	0.27	0.35	0.46	0.58	0.72	
TotalCapacity Needed	2.21	2.68	3.35	4.03	4.89	
Capacity	1.50	3.50	3.50	5.00	5.00	3.5
Under (-)/Over(+) Total Capacity needed	-0.71	0.82	0.15	0.97	0.11	

Camelback

% of Total Population	29%	29%	29%	30%	30%	
Demand (mg)	4.69	5.85	7.28	9.39	11.70	
Fire Flow	0.56	0.56	0.56	0.56	0.56	
Diurnal fluctuation (25% of max day demand)	1.17	1.46	1.82	2.35	2.93	
Reserve (5%)	0.23	0.29	0.36	0.47	0.59	
TotalCapacity Needed	1.97	2.31	2.75	3.38	4.07	
Capacity	1.00	2.50	4.50	4.50	4.50	3.5

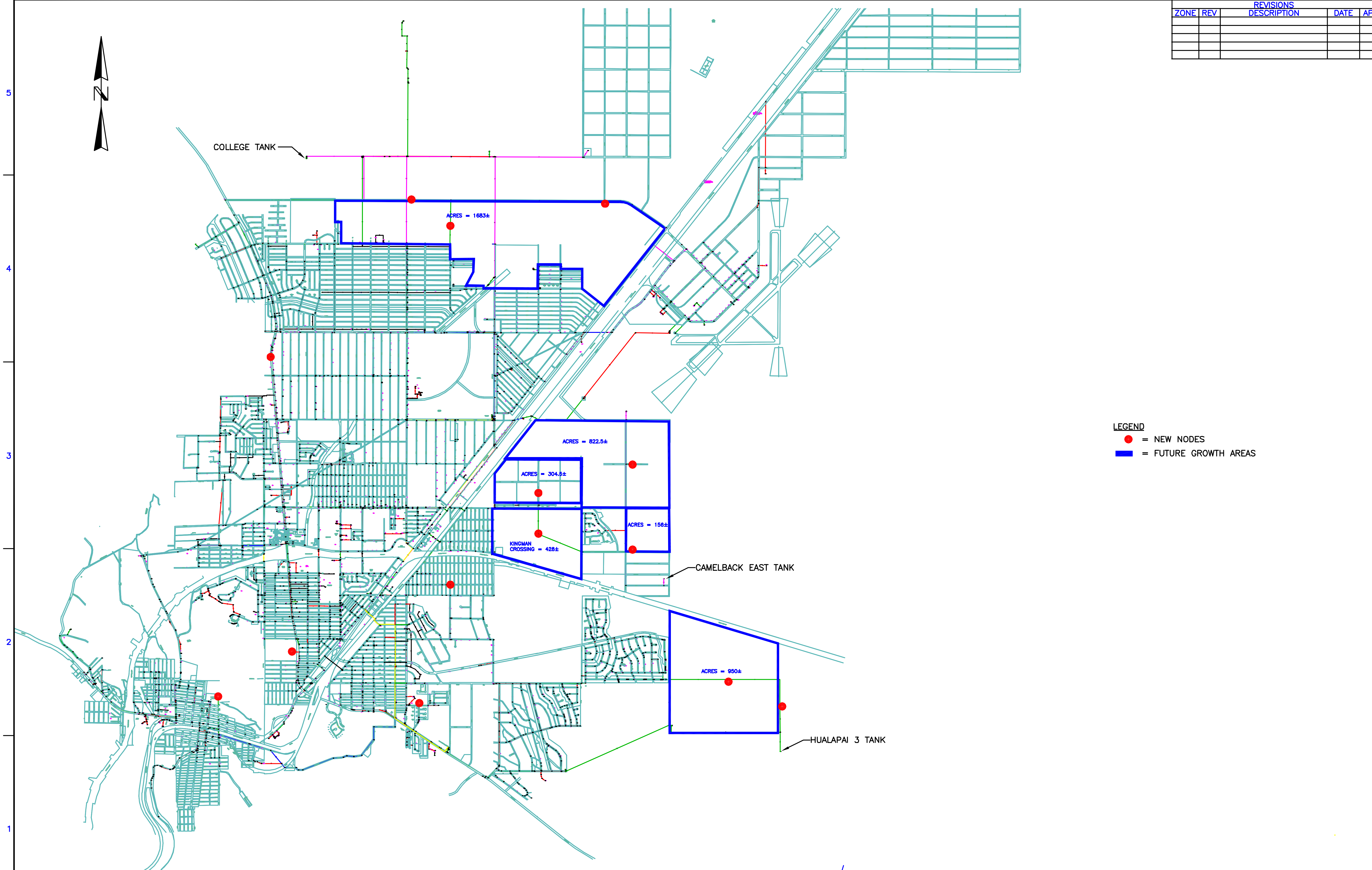
Under (-)/Over(+) Total Capacity needed	-0.97	0.19	1.75	1.12	0.43	
Hualapai 3						
% of Total Population	0%	1%	2%	2%	2%	
Demand (mg)	0.00	0.20	0.50	0.63	0.78	
Fire Flow	0	0.56	0.56	0.56	0.56	
Diurnal fluctuation (25% of max day demand)	0.00	0.05	0.13	0.16	0.20	
Reserve (5%)	0.00	0.01	0.03	0.03	0.04	
TotalCapacity Needed	0.00	0.62	0.71	0.75	0.79	
Capacity	0.00	1.00	1.00	1.00	1.00	1.0
Under (-)/Over(+) Total Capacity needed	0.00	0.38	0.29	0.25	0.21	
Total System Storage Requirement	**7.65**	**9.41**	**10.97**	**12.75**	**15.06**	**8.0**
Capacity	10.90	15.40	17.40	18.90	18.90	
Under (-)/Over(+) Total Capacity needed	3.25	5.99	6.43	6.15	3.84	

Operation

The city wishes to reduce the number of pressure regulated areas in the system. At this time there are 31 pressure regulating valves in the system. By expanding the Camelback tank zone South to I-40 and East from Western Ave. to the Camelback East area, the city can eliminate the need for 10 of the prv's which serve the City Shop Regulated District, the Kino Avenue District, and the Hilltop Regulated District.

Given the above population / water demand projections, the following are conceptual maps delineating the new, major, water transmission pipelines, tanks, and wells.

ZONE	REV	REVISIONS DESCRIPTION	DATE	APVD



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DRAWN BY: SOS

JOB No. KM 1062
DATE MAY 23, 2005

CITY OF KINGMAN
WATER SYSTEM MASTER PLAN

FUTURE GROWTH AREAS

DRAWING NUMBER
SHEET

Chapter 8 - Future System Computer Model

The 10 and 20 year water models were developed by expanding the existing system model that was developed and described in chapter 5 of this report. Production and demand for the future models is based on the average water usage of the maximum month of the year (see chapter 7 of this report). The average water usage during the peak month of the year (July) is 306 gpcd, and includes all users, residential, industrial, and commercial. The existing system model was expanded based on the growth patterns discussed in chapter 7, and new elements (tanks, pipe, wells, valves) were added to meet the future system requirements. Only major elements and mainlines over 8" diameter are included in the models. The 20 year model was developed first and based on those results the 10 year model was then developed. Three different tank zone scenarios were considered to try to reduce the number of pressure zones in the system by eliminating the need for as many of the pressure reduction valves as possible. First, we left the zones as they are now. Second, we expanded the Camelback zone to the North side of I-40. Third, we expanded the Camelback zone to Pasadena Avenue. Each of these scenarios is feasible and was made to work successfully, however, the second of these scenarios was chosen for this report. The Camelback zone was expanded to the South to I-40, and East to the Vista Bella area, which decreases the size of the Main Tanks/Hualapai Tank zone accordingly. Zone valves were added to prevent flow across I-40 and west of Western Ave. as needed to provide adequate pressures in each zone.

Demand

The demands were allocated in accordance with the growth patterns discussed in chapter 7. New nodes were added to the models to carry the future flows as can be seen in the drawings at the end of this chapter. Three nodes were added in the College zone, 4 in the Vista Bella zone, 2 in the Hualapai 3 zone, 1 in the Camelback zone, 1 in the Downtown zone, and 3 in the Main Tanks/Hualapai zone. The demand of the 50 largest water users was also included in the model at their respective nodes at their 2004 level of consumption. Demands at all other nodes were also left at the 2004 level of consumption.

Mainline Piping

Mainline piping is in accordance with the drawings in chapter 7. A parallel pipeline was also added between the Castle Rock booster Station and the Hualapai Tank The 12" line from the junction at Hoover and Kingman to the 14" line at Western Ave. And Beverly Ave. was increased to 18". We are recommending however, to add a 14" line parallel to the 12", not replacing the 12" with 18".

Tanks

The new tanks were sized in accordance with chapter 7 of this report. The College tank was expanded from 1.5 mg to 3.5 mg. The Camelback tank was expanded from 1 mg to 3.0 mg and a new 1.5 mg tank was added Southeast of the Camelback East subdivision, which is at the same elevation as the Camelback tank. A new 1 mg tank was added Southeast of the Rancho Santa Fe Tank. The Castle Rock forebay tanks were changed to one 1 mg tank.

Wells

New wells were added to the system in accordance with the cities direction and the Well Siting/Basin Study Report by Clear Creek Associates. The majority of the new wells are in the Long Mountain region

North of the Airport zone. The others are near the airport in the Camelback East region. Only enough wells were added to the model to make it work for the average day of the maximum month. More wells will be required to satisfy the maximum day demands discussed in chapter 7.

10 Year Model

Demand

The average daily demand for July in 2014 is estimated to be 19.13 mgd (13,284 gpm). The Airport zone with an increase in population of 10,022 will have an increase in demand of 2,130 gpm which was distributed evenly over the three new nodes. The Main Tanks/Hualapai zone with an increase in population of 3,765 will have an increase in demand of 800 gpm which was distributed evenly over the three new nodes. The Foothills and the new Hualapai 3 Tank zone with an increase in population of 2,328 will have an increase in demand of 495 gpm which was distributed evenly over the two new nodes, one of which is in the new tank zone and one in the Foothills zone. The expanded Camelback zone which also includes the new Camelback East Tank will see an increase in population of 6,700 mainly in the Camelback East area and will have an increase in demand of 1,423 gpm which was distributed evenly over the 4 new nodes. The Downtown zone with an increase in population of 1,185 will have an increase in demand of 252 gpm which was assigned to a single node.

Mainline Piping

Mainline piping was reduced from that shown in the 20 year model to what is necessary to make the 10 year model run effectively.

Tanks

The College tank was expanded from 1.5 mg to 3.5 mg. The Camelback tank was expanded from 1 mg to 3.0 mg and a new 1.5 mg tank was added Southeast of the Camelback East subdivision, which is at the same elevation as the Camelback tank. A new 1 mg tank was added Southeast of the Rancho Santa Fe Tank. The Castle Rock forebay tanks were changed to one 1 mg tank.

Well Configuration

Wells were configured to distribute water to the requisite tanks as shown below

Main Tanks/Hualapai Zone

City Wells 2,3,5 and the Castle Rock Well with a combined discharge capacity of 5,750 gpm were used to serve the Main tanks and the Hualapai Tanks zone. The Castle rock boosters are also dedicated to these tanks. No changes to the booster station were needed in the 10 year model.

Camelback East Zone

This is a new zone East of Route 66 between the airport and I-40. City wells 1 and 4 and one new 2,000 gpm well with a combined discharge capacity of 3,725 gpm were needed to keep the new 1.5 mg Camelback East tank full.

College Zone

City wells 6 and 7, Long Mountain wells 4 and 6 with the Bank Street well in reserve with a combined discharge capacity of 6,150 gpm are dedicated to the College tank. No new wells were needed in the 10 year model to keep the College tank full.

Camelback Zone
In order to keep the Camelback tank full, the Long Mountain 4 booster production was increased to 2,500 gpm.

Downtown Zone
No changes were made to the existing Downtown well scheme. The four Downtown wells are used to fill the Beale Street tank in conjunction with the water received from the Main Tanks/Hualapai zone via the two pressure reduction valves which control flow into the Downtown zone.

20 Year Model

Demand
The average daily demand for July in 2024 is estimated to be 29.71 mgd (20,632 gpm). The College zone with an increase in population of 22,678 will have an increase in demand of 4,819 gpm which was distributed evenly over the three new nodes. The Main Tanks/Hualapai zone with an increase in population of 10,372 will have an increase in demand of 2,204 gpm which was distributed evenly over the three new nodes. The Foothills and the new Hualapai 3 Tank zone with an increase in population of 4,655 will have an increase in demand of 989 gpm which was distributed evenly over the two new nodes, one of which is in the new tank zone and one in the Foothills zone. The expanded Camelback zone which also includes the new Camelback East Tank will see an increase in population of 18,218 mainly in the Camelback East area and will have an increase in demand of 3,871 gpm which was distributed evenly over the 4 new nodes. The Downtown zone with an increase in population of 2,652 will have an increase in demand of 564 gpm which was assigned to a single node.

Mainline Piping
Mainline piping was installed in accordance with the growth patterns discussed in chapter 7.

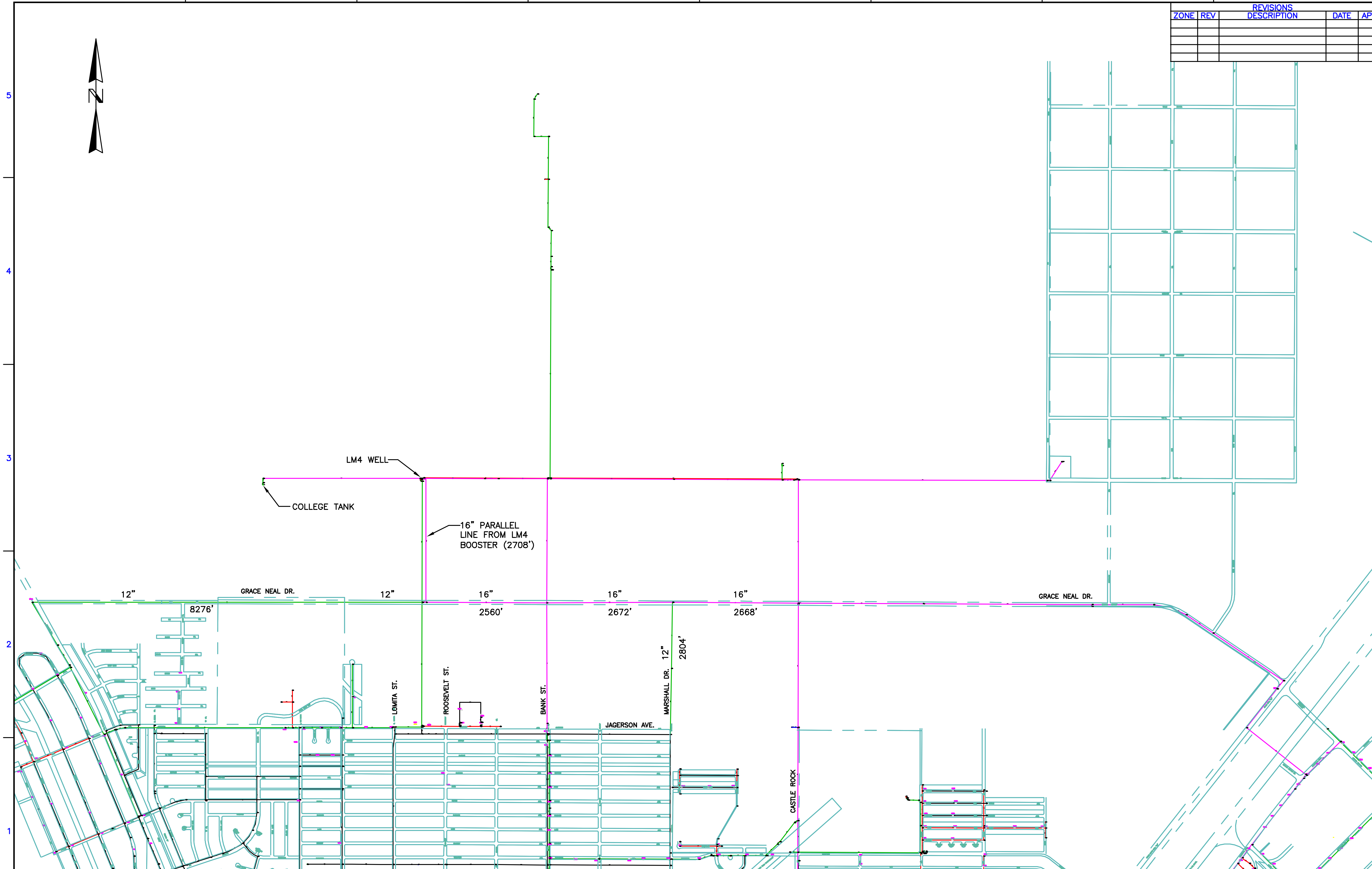
Tanks
The College tank was increased to5.0 mg.
All other tanks are the same as they are in the 10 year model.

Well Configuration
Wells were configured to distribute water to the requisite tanks as shown below

Main Tanks/Hualapai Zone
City Wells 2,3,4,5,and 7 and the Castle Rock Well with a combined discharge capacity of 8,875 gpm were needed to serve the Main tanks and the Hualapai Tanks zone. The Castle rock boosters are also dedicated to these tanks. One additional 1,000 gpm booster pump was added at the Castle Rock booster Station in the 20 year model to keep the Main Tanks full.

Camelback East Zone
City well 1 and two 2,000 gpm wells with a combined discharge capacity of 4,800 gpm were needed to fill the Camelback East tank and serve the expanded Camelback/Camelback East zone.

College Zone
City well 6, Long Mountain wells 4 and 6 and Bank Street well as well as 3 new 2,000 gpm wells with a



REVISIONS

ZONE	REV	DESCRIPTION	DATE	APVD

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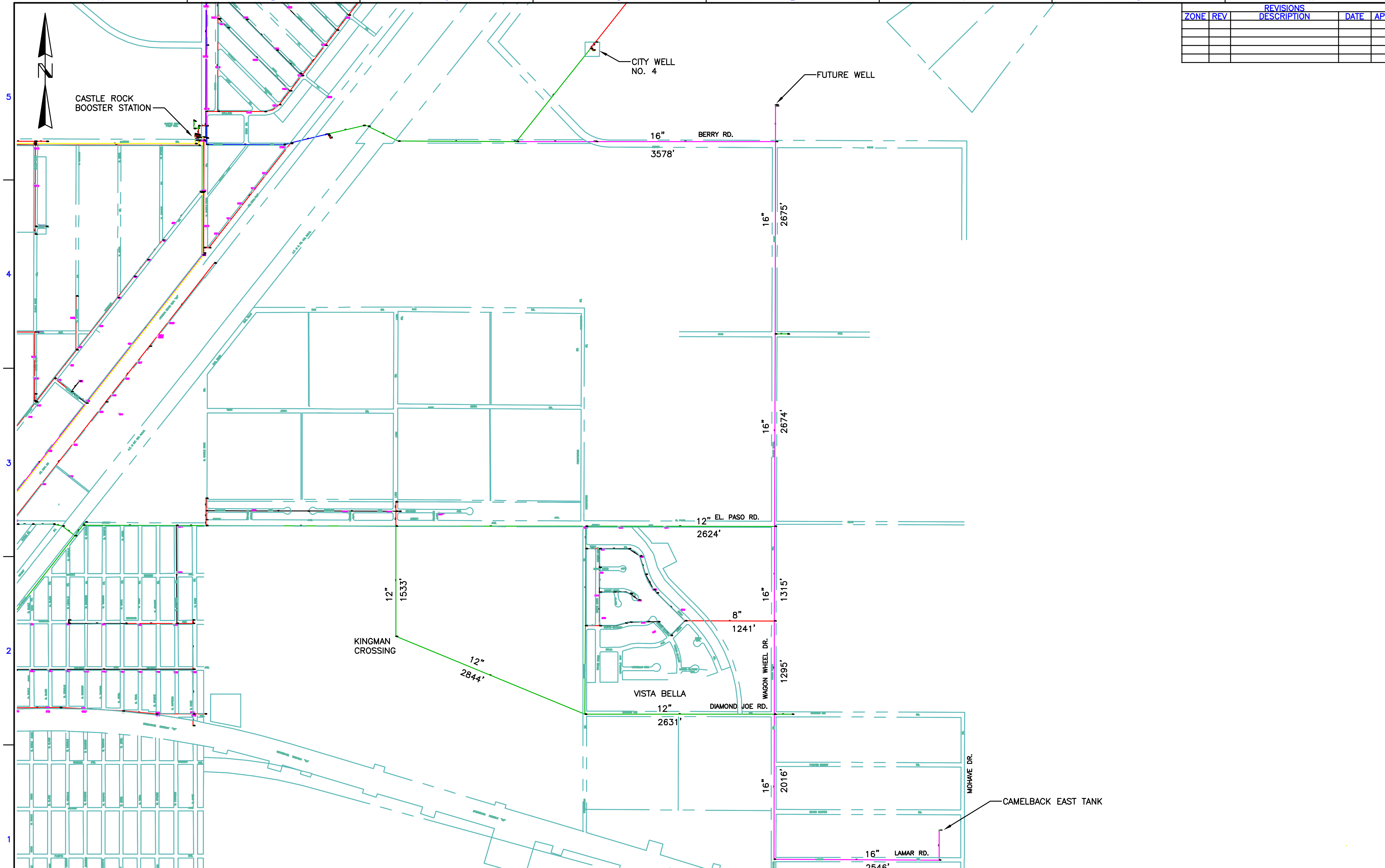
JOB No. KM 1062
DATE MAY 23, 2005

CITY OF KINGMAN
WATER SYSTEM MASTER PLAN

10 YEAR PLAN
COLLEGE TANK AREA

DRAWING NUMBER
SHEET



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CHECKED JHC
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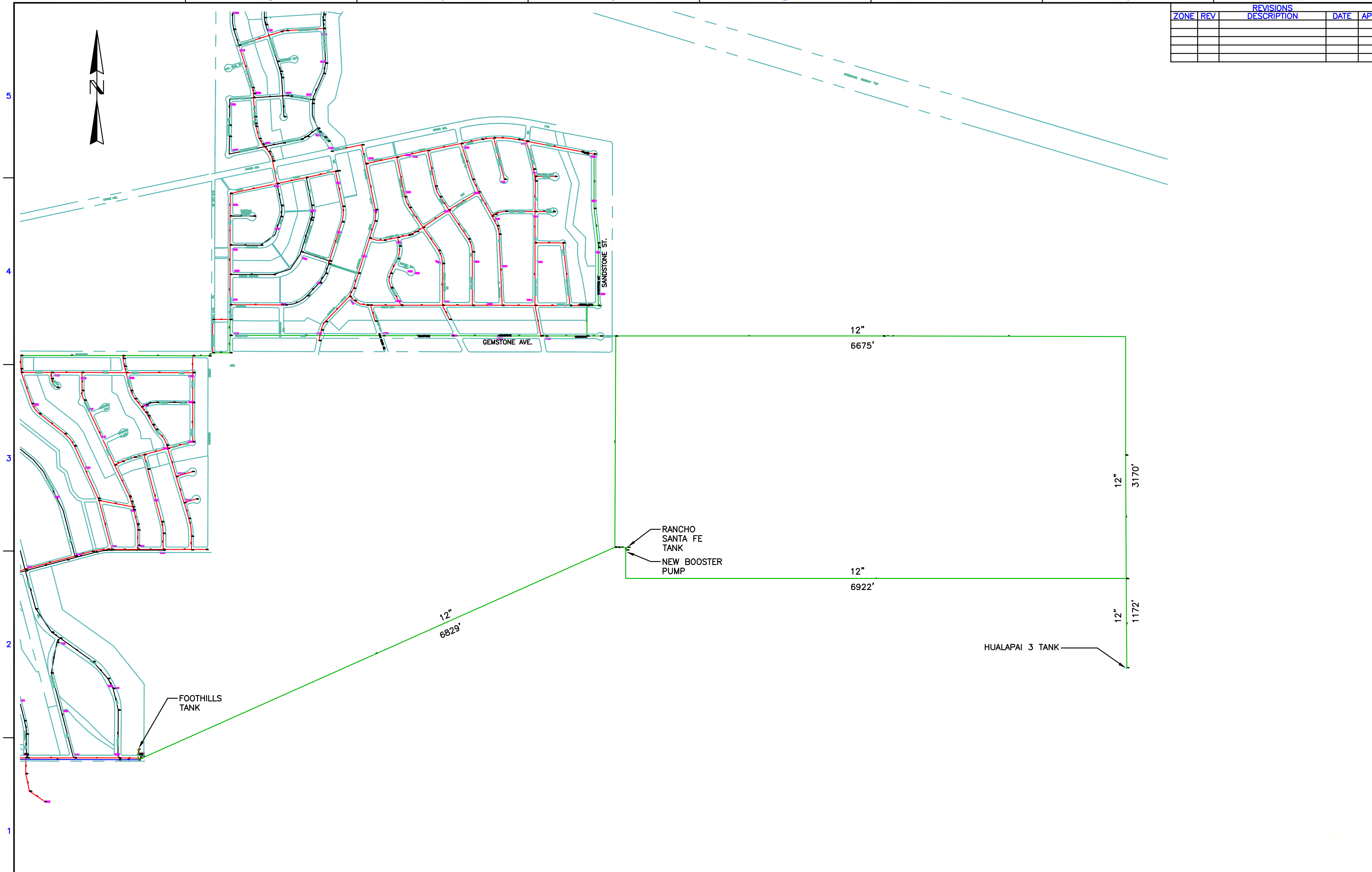
CITY OF KINGMAN
WATER SYSTEM MASTER PLAN

10 YEAR PLAN
VISTA BELLA AREA

DRAWING NUMBER

SHEET

ZONE	REV	REVISIONS DESCRIPTION	DATE	APVD



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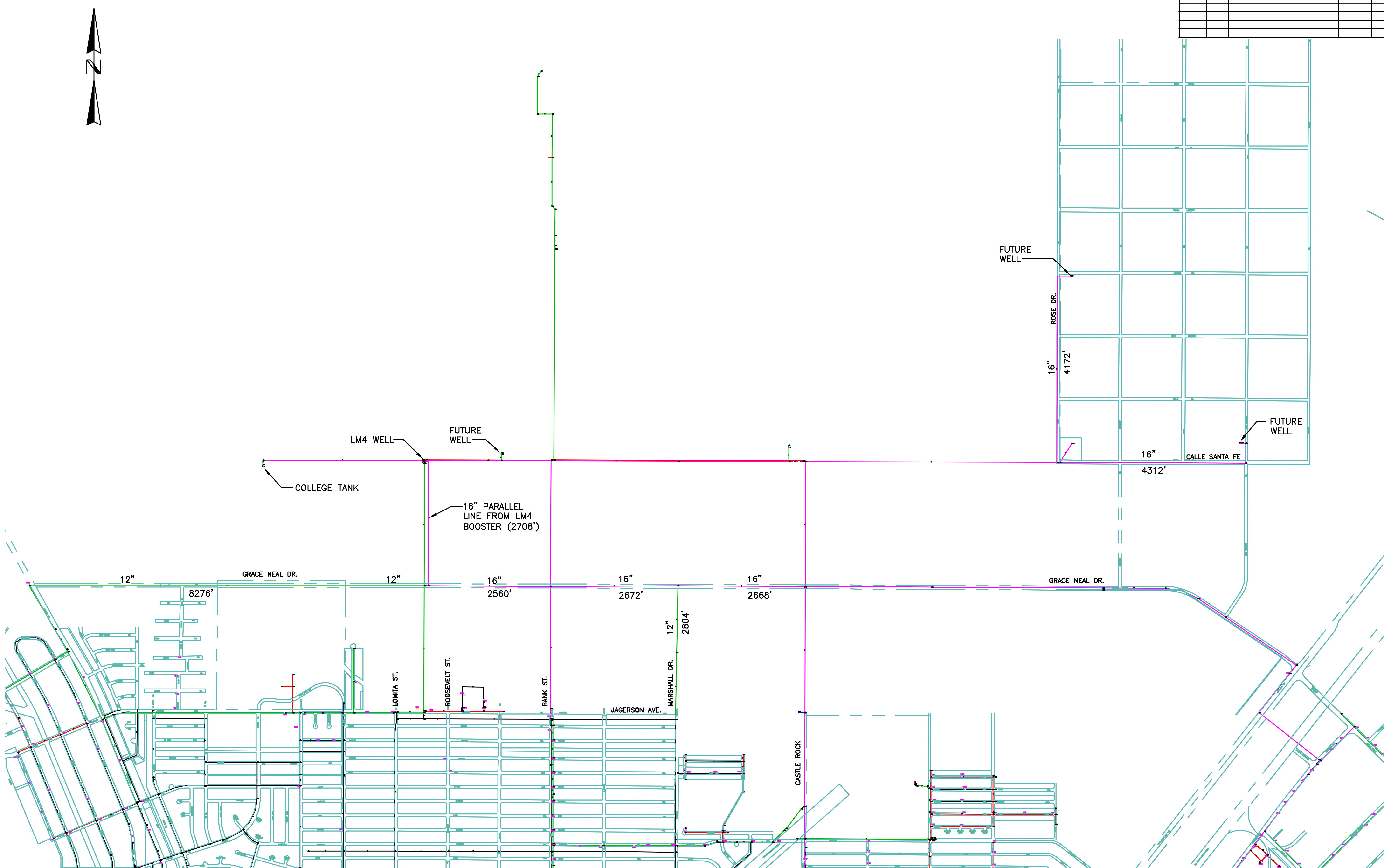
CITY OF KINGMAN
WATER SYSTEM MASTER PLAN

10 YEAR PLAN
RANCHO SANTA FE AREA

DRAWING NUMBER
SHEET

ZONE	REV	REVISIONS DESCRIPTION	DATE	APVD

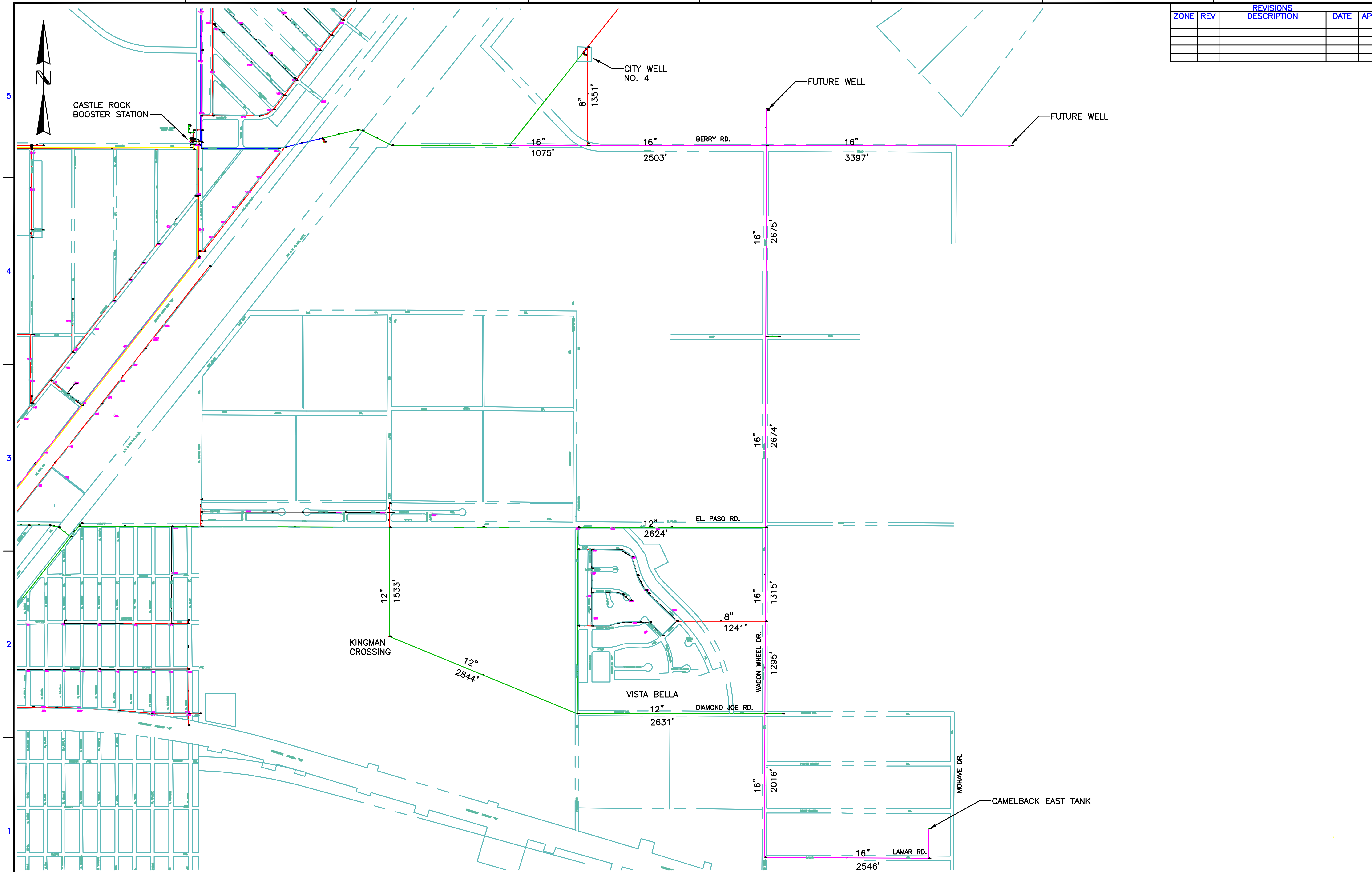


C5 Engineering, Inc. 7161 NORTH HIGHWAY 89 FLAGSTAFF, ARIZONA 86004 TEL:(928) 714-0251 FAX:(928) 714-0243	DESIGNED JFC CHECKED JHC DRAWN BY SOS	JOB No. KM 1062 DATE MAY 23, 2005	CITY OF KINGMAN WATER SYSTEM MASTER PLAN

20 YEAR PLAN
COLLEGE TANK AREA

DRAWING NUMBER

SHEET



REVISIONS

ZONE	REV	DESCRIPTION	DATE	APVD

C5 Engineering, Inc.
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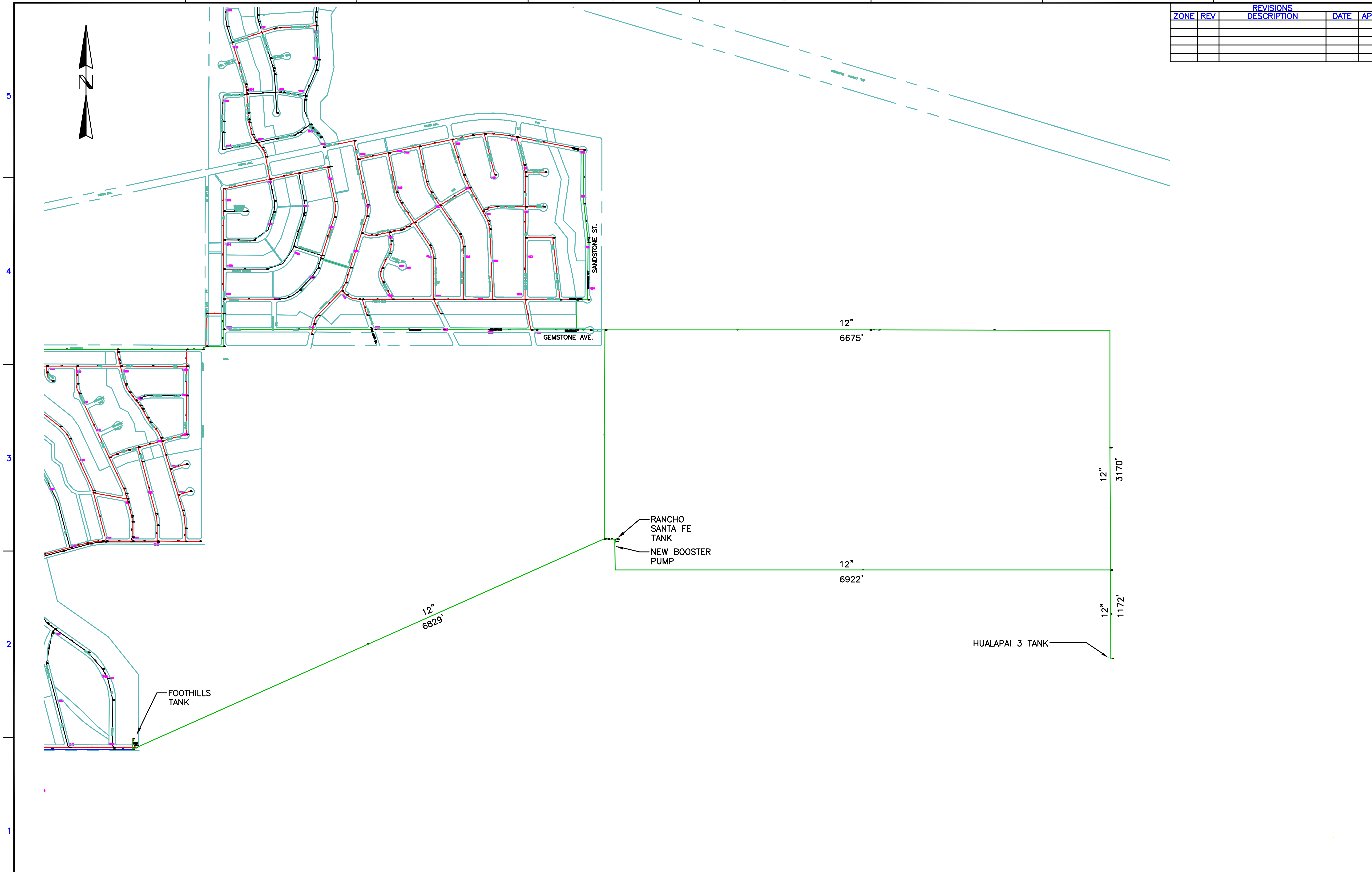
DATE MAY 23, 2005

CITY OF KINGMAN
WATER SYSTEM MASTER PLAN

20 YEAR PLAN
VISTA BELLA AREA

DRAWING NUMBER

SHEET



REVISIONS				
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C5 Engineering, Inc.
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CITY OF KINGMAN
WATER SYSTEM MASTER PLAN

20 YEAR PLAN
RANCHO SANTA FE AREA

DRAWING NUMBER

SHEET

combined discharge capacity of 9,950 gpm are needed to keep the College tank full.

Downtown Zone

No changes were made to the existing Downtown well scheme. The four Downtown wells are used to fill the Beale Street tank in conjunction with the water received from the Main Tanks/Hualapai zone via the two pressure reduction valves which control flow into the Downtown zone.

Results

The main objective in the development of these models is to ensure that the system can produce enough water to satisfy future demands and keep the tanks nearly full all of the time. The elements listed above were added and modified until the models achieved this objective.

Pressures in the mainline between Castle Rock and the Main and Hualapai tanks are too high for distribution. As is the case now, pressure reduction valves will be needed in some locations where water is taken directly from the main. This is true of the area West of Western Ave. and South of Beverly Ave. where pressures are between 95 and 110 psi and also near the junction of the 16" and 12" at Kingman and Hoover. Pressures in the Camelback East subdivision are between 40 and 50 psi and drop to the low 20 psi range during a 2 hour fire flow. Pressures closer to the Camelback East Tank at the new node East of Wagon Wheel Drive on Diamond Joe are even lower between 30 and 40 psi and decrease even further the closer to the tank. The city may want to consider a different location for this tank at a higher elevation or using an elevated tank to accommodate growth in this neighborhood.

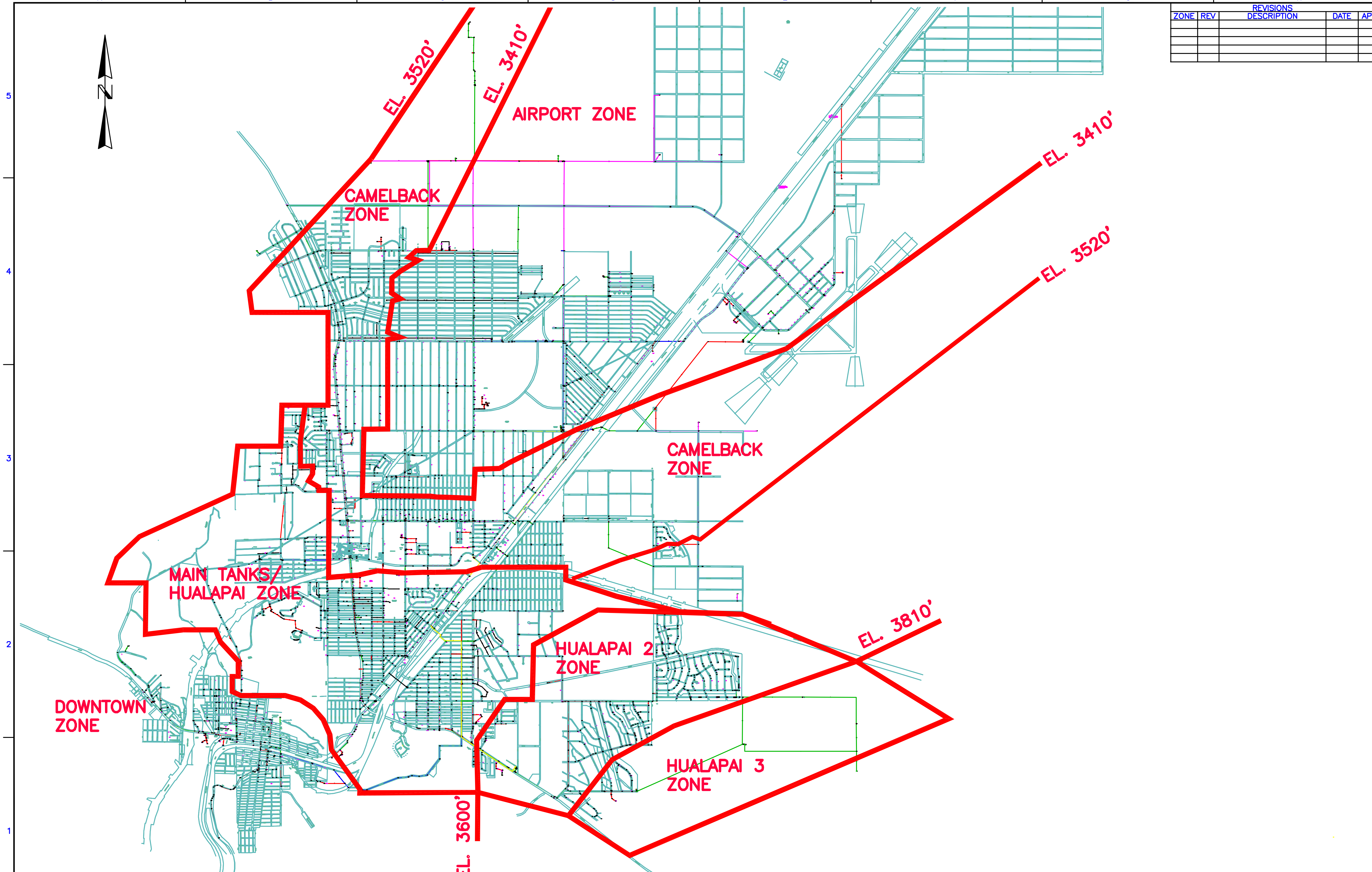
The future models suffer from the same problems that the existing model has and are described in chapter 5 and chapter 6 of this report. Even though we corrected as many errors as were discovered we cannot guaranty that all elements of the model are completely accurate and we cannot predict how many more problems may still exist or what impact they may have on the model. We think most of the major problems are corrected and that the models presented here are fair representations of the system, but city staff will have to continually study and correct and update the model.

In addition to those problems outlined in chapter 5 the city should also address the following problems:

Correct errors and update the system plumbing.

Update system demands. The system demands used are based on monthly consumption averages within a particular billing cycle which are distributed evenly to all the nodes within the cycle. This approach assumes that the demand is the same each day at each node throughout the month which is not an accurate representation of actual conditions. This problem was mitigated somewhat by establishing nodes at the locations of the top 50 users in the city and applying the actual monthly demand averages to these nodes. Further errors arise due to discrepancies between billing and production records, and due to corrections the city makes to consumption records. System demand is probably the area that the city could make the most improvements to the model by further refining actual system demands and more accurately allocating them within the model.

Conduct field calibration of the existing model to verify the accuracy of the model results.



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CITY OF KINGMAN
WATER SYSTEM MASTER PLAN

NEW TANK PRESSURE ZONE MAP

DRAWING NUMBER
SHEET

The construction cost estimate consists of 10 year and 20 year capital improvement plans. The estimates include only the major components of the recommended improvements including tanks, wells, booster pumps, and mainline piping. Distribution piping is not included in this report nor is maintenance or repair or upgrades to the existing system. The number of new wells required is based on the maximum day demand as shown in the Future water Demand Projection in chapter 7 of this report. The number of new tanks is based on the average day of the maximum month, which is July. The city will have to decide if they want to continue the interruptible power scenario and the report shows the costs with and without interruptible power.

10 Year Plan

Tanks

A total of 6 new storage tanks with a combined capacity of 6.5 mg are recommended to be added in the 10 year plan, along with the Castle Rock forebay tank.

College
A new 2.0 mg tank is recommended to be added at the College tank site.

Camelback
A new 2.0 mg tank is recommended to be added at the Camelback tank site, and a new 1.5 mg tank at the Camelback East site.

Hualapai 3
A new 1.0 mg tank is recommended to be added at the location shown in chapter 7.

Castle Rock booster
We are also recommending to increase the Castle Rock forebay tanks to a minimum of 1 mg.

Wells
The number of new wells required is based on an average production rate of 1,000 gallon per minute for each new well. The cost per well of $750,000 is what the city budgets for a new well at this time. If the city continues with the interruptible power option, 11 new wells will be needed in the 10 year plan. If the city discontinues the interruptible power option, 7 new wells will be needed.

Booster Pumps
To handle the larger demand in the expanded Camelback Tank zone, the Long Mountain 4 Booster pump was upsized from 1,100 gpm to 2,500 gpm.
A new booster station will be needed at the Rancho Santa Fe Tank to lift the water into the new Hualapai

3 Tank.

Water Main Piping

Approximately 111,000 feet of new mainline piping will be needed in the 10 year plan.

The following Tables summarize the plans

10 Year Plan (From 2004 to 2014)		
	Without Interruptible Power	**With Interruptible Power**
Tanks	**$2,276,000**	**$2,276,000**
Wells (1000 GPM)	**$5,250,000**	**$8,250,000**
Mainline Piping	**$5,709,580**	**$5,709,580**
10 Year Plan Total	**$13,235,580**	**$16,235,580**
20 Year Plan (From 2014 to 2024)		
Tanks	**$470,000**	**$470,000**
Wells (1000 GPM)	**$10,500,000**	**$12,750,000**
Mainline Piping	**$614,050**	**$614,050**
20 Year Plan Total	**$11,584,050**	**$13,834,050**
GRAND TOTAL (From 2004 to 2024)	**$24,819,630**	**$30,069,630**

10 Year Plan Tanks

Camelback East	Unit	Quantity	Cost
1.5 mg Tank	EA	1	$435,000
Foundation	EA	1	$35,000
		Total	**$470,000**
Rancho Santa Fe			
1 mg Tank	EA	1	$315,000
Foundation	EA	1	$35,000
		Total	**$350,000**
Camelback			
2.0 mg Tank	EA	1	$518,000
Foundation	EA	1	$35,000
		Total	**$553,000**
College			
2 mg Tank	EA	1	$518,000
Foundation	EA	1	$35,000
		Total	**$553,000**
Castle Rock			
1 mg Tank	EA	1	$315,000
Foundation	EA	1	$35,000
		Total	**$350,000**
TOTAL TANK COST 10 YEAR PLAN			**$2,276,000**

10 Year Plan Wells

	Without Interruptible Power	New Wells @ 1,000 gpm	**With Interruptible Power**	New Wells @ 1,000 gpm
Well Capacity 2004 (mgd)	22		22	
Well Capacity Requirement 2014(mgd)	28.12		32.95	
Extra Capacity Needed (mgd)	**6.12**	**7**	**10.95**	**11**
Cost of Wells @ $750,000/Well		$ 5,250,000		$ 8,250,000

10 Year Plan Mainline Piping					
ITEM	UNIT	QTY	UNIT PRICE		TOTAL
Camelback East					
16"	LF	16,099	$	50.00	$804,950
12"	LF	8,099	$	45.00	$364,455
				Total	**$1,169,405**
Rancho Santa Fe					
12"	LF	24,639	$	45.00	**$1,108,755**
RSF 500 gpm Booster	EA	1	$	15,000.00	**$15,000**
				Total	**$1,123,755**
College					
16"		10,608	$	50.00	$530,400
12"PVC	LF	2,804	$	45.00	$126,180
				Total	**$656,580**
Camelback					
12"	LF	8,276	$	45.00	**$372,420**
LM4 2,500 gpm BSTR	EA	1	$	40,000.00	**$40,000**
				Total	**$412,420**
Parallel Pipe					
18" Castle Rock to Jct.	LF	16,680	$	60.00	**$1,000,800**
18" Jct to HUA	LF	11,985	$	60.00	**$719,100**
14" Jct to Main Tanks	LF	12,554	$	50.00	**$627,700**
				Total Parallel Pipe	**$2,347,600**
				Total Cost Mainline Piping 10 Year Plan	**$5,709,760**

20 Year Plan

Tanks

A total of 1 new storage tanks with a combined capacity of 1.5 mg are recommended to be added in the 20 year plan.

College
A new 1.5 mg tank is recommended to be added at the College tank site.

Wells
Depending on whether the city chooses the interruptible or uninterruptible power option 14 to 17 new wells will be needed, based on 1,000 gpm wells being developed.

Booster Pumps
A new 1,000 gpm booster will be needed at the Castle Rock Booster Station.

Water Main Piping
Approximately 12,000 feet of new mainline piping will be needed in the 20 year plan.

The following Tables summarize the 20 year plan

20 Year Plan Tanks			
College			
1.5 mg Tank	EA	1	$435,000
Foundation	EA	1	$35,000
		Total	**$470,000**
Total Tank Cost 20 year Plan			**$470,000**

20 Year Plan Wells				
	Without Interruptible Power	New wells @ 1,000 gpm	**With Interruptible Power**	New wells @ 1,000 gpm
Well Capacity Requirement 2014(mg)	28.12		32.95	
Well Capacity Requirement 2024(mg)	42.01		49.23	
Extra Capacity Needed (mgd)	13.89	14	16.28	17
Well Cost @ $750,000/well		**$ 10,500,000**		**$ 12,750,000**

20 Year Plan Mainline Piping				
16" To Future Well #2	LF	3,397	$ 50.00	$169,850
			Total piping	**$169,850**
College				
16" to Future Well # 4	LF	4,172		
16" to Future Well # 5	LF	4312		
Total 16" in 20 Year Plan	LF	8,484	$ 50.00	**$424,200**
Castle Rock Booster Sta				
1,000 gpm pump	EA	1	$ 20,000.00	**$20,000**
			Total Mainline Piping Cost 20 Year Plan	**$614,050**

Chapter 10 - Operations

The city is generally satisfied with the water system as it now operates, and doesn't anticipate any major changes to the way the system is now operated. The system will remain a tank and well system for the foreseeable future. The SCADA system is now a major element in the operation of the system and allows the city more control of the system.

The following is a list of items that we noticed or were mentioned to us by city staff as areas which may need to be addressed

Tanks
The city currently operates the tanks within a narrow band so that they are nearly full all of the time. This may prevent the tank from experiencing an adequate amount of mixing and flushing and cause water to stagnate. We recommend to widen the set points on the pumps to allow the tank to empty more thus promoting more thorough mixing and turnover in the tanks.

Pressure Zones
The city wishes to reduce the number of pressure zones within the system. By expanding the Camelback tank zone South to I-40 the city may be able to eliminate the need for the following 6 prv's that regulate the North side of the City Shop Regulated District and the Hilltop Regulated District:
Airway & Bank St., Airway & Willow, Airway & Burbank, Airway & Stockton Hill Rd., Western & Sycamore, and Western & Beverly Ave.
Furthermore, the following four prv's that regulate the County Yard Regulated District, the La Senita Regulated District, and the City Shop Regulated District, and are on the 16" mainline will become zone valves and closed:
Sunshine Dr. & Castle Rock Rd., Horizon Blvd. & Highway 66, Bank St. & Armour Ave., and Bank St. & Townsend.

Pump Controls
Some pump controls are older and need to be updated. This is particularly true of the Downtown wells, but all pumps should be evaluated.

Electronic Data Collection
The city may want to consider upgrading the water meters to include electronic data collection which allows each water meter to be read remotely. Not only will this increase the efficiency of collecting water meter readings, it will allow the city the ability to more closely examine demand patterns and provide a more accurate picture of demand throughout the system. WaterGems also includes a feature to allow this information to be input directly into the water model thereby greatly increasing the accuracy of the model.