NORTH COAST RESOURCE PARTNERSHIP

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2018/19 IRWM Project Application

The North Coast Resource Partnership (NCRP) 2018/19 Project Application Instructions and additional information can be found at the NCRP 2018/19 Project Solicitation webpage (https://northcoastresourcepartnership.org/proposition-1-irwm-round-1-implementation-funding-solicitation/). Please fill out grey text boxes and select all the check boxes that apply to the project. Application responses should be clear, brief and succinct.

Project Applications will be accepted until 5:00 pm, ~~March 8, 2019~~ **March 15, 2019.** It is important to save the application file with a distinct file name that references the project name. When the application is complete, please email to kgledhill@westcoastwatershed.com

If you have questions, need additional information or proposal development assistance please contact:

- Katherine Gledhill at kgledhill@westcoastwatershed.com or 707.795.1235
- Tribal Projects: Sherri Norris, NCRP Tribal Coordinator at sherri@cieaweb.org or 510.848.2043

Project Name: Improving Willits Water Supply Reliability and Drought Resiliency with Groundwater and Conjunctive Use

A. ORGANIZATION INFORMATION

1. **Organization Name: City of Willits**

2. **Contact Name/Title**
   Name: Jim Robbins
   Title: Community Development Specialist
   Email: jrobbins@cityofwillits.org
   Phone Number (include area code): 707-459-7155

3. **Organization Address (City, County, State, Zip Code):**
   111 E. Commercial Street - Willits, CA 95490 - Mendocino County

4. **Organization Type**
☒ Public agency
☐ Non-profit organization
☐ Public utility
☐ Federally recognized Indian Tribe
☐ California State Indian Tribe listed on the Native American Heritage Commission's California Tribal Consultation List
☐ Mutual water company
☐ Other:

5. **Authorized Representative** (if different from the contact name)
Name: Stephanie Garrabrant-Sierra
Title: City Manager
Email: sgsierra@cityofwillits.org
Phone Number (include area code): 707-459-4601

6. **Has the organization implemented similar projects in the past?** ☒ yes ☐ no
Briefly describe these previous projects.
The Emergency Water Line Project (2014-15): Installed a production well (the Elias Replacement Well), built a groundwater treatment plant, and installed 8000' of new 8" C900 water pipe.
Long 20 Test Well Project: Installed an 8" test well 2500' south of the Elias Replacement Well. The City is considering converting this well into a regular use production well.

7. **List all projects the organization is submitting to the North Coast Resource Partnership for the 2018/19 Project Solicitation in order of priority.**
1 Project: "Improving Willits Water Supply Reliability and Drought Resiliency with Groundwater and Conjunctive Use"

8. **Organization Information Notes:**
The City of Willits is a severely disadvantaged community in Mendocino County.

B. ELIGIBILITY

1. **North Coast Resource Partnership and North Coast IRWM Objectives**

GOAL 1: INTRAREGIONAL COOPERATION & ADAPTIVE MANAGEMENT
☒ Objective 1 - Respect local autonomy and local knowledge in Plan and project development and implementation
☐ Objective 2 - Provide an ongoing framework for inclusive, efficient intraregional cooperation and effective, accountable NCIRWMP project implementation
☐ Objective 3 - Integrate Traditional Ecological Knowledge in collaboration with Tribes to incorporate these practices into North Coast Projects and Plans

GOAL 2: ECONOMIC VITALITY

☒ Objective 4 - Ensure that economically disadvantaged communities are supported and that project implementation enhances the economic vitality of disadvantaged communities by improving built and natural infrastructure systems and promoting adequate housing
☐ Objective 5 - Conserve and improve the economic benefits of North Coast Region working landscapes and natural areas

GOAL 3: ECOSYSTEM CONSERVATION AND ENHANCEMENT
☐ Objective 6 – Conserve, enhance, and restore watersheds and aquatic ecosystems, including functions, habitats, and elements that support biological diversity
☐ Objective 7 - Enhance salmonid populations by conserving, enhancing, and restoring required habitats and watershed processes

GOAL 4: BENEFICIAL USES OF WATER
☒ Objective 8 - Ensure water supply reliability and quality for municipal, domestic, agricultural, Tribal, and recreational uses while minimizing impacts to sensitive resources
☒ Objective 9 - Improve drinking water quality and water related infrastructure to protect public health, with a focus on economically disadvantaged communities
☐ Objective 10 - Protect groundwater resources from over-drafting and contamination

GOAL 5: CLIMATE ADAPTATION & ENERGY INDEPENDENCE
☒ Objective 11 - Address climate change effects, impacts, vulnerabilities, and strategies for local and regional sectors to improve air and water quality and promote public health
☒ Objective 12 - Promote local energy independence, water/ energy use efficiency, GHG emission reduction, and jobs creation

GOAL 6: PUBLIC SAFETY
☐ Objective 13 - Improve flood protection and reduce flood risk in support of public safety

2. **Does the project have a minimum 15-year useful life?**
   ☒ yes ☐ no
   If no, explain how it is consistent with Government Code 16727.

3. **Other Eligibility Requirements and Documentation**

   CALIFORNIA GROUNDWATER MANAGEMENT SUSTAINABILITY COMPLIANCE
   a) Does the project that directly affect groundwater levels or quality?
      ☒ yes ☐ no
   b) If Yes, will the organization be able to provide compliance documentation outlined in the instructions, to include in the NCRP Regional Project Application should the project be selected as a Priority Project?
      ☒ yes ☐ no

   CASGEM COMPLIANCE
   a) Does the project overlie a medium or high groundwater basin as prioritized by DWR?
      ☐ yes ☒ no
   b) If Yes, list the groundwater basin and CASGEM priority:
   c) If Yes, please specify the name of the organization that is the designated monitoring entity:

d) If there is no monitoring entity, please indicate whether the project is wholly located in an economically disadvantaged community.
☒ yes ☐ no

URBAN WATER MANAGEMENT PLAN

a) Is the organization required to file an Urban Water Management Plan (UWMP)?
☐ yes ☒ no
b) If Yes, list the date the UWMP was approved by DWR:
c) Is the UWMP in compliance with AB 1420 requirements?
☐ yes ☐ no
d) Does the urban water supplier meet the water meter requirements of CWC 525?
☐ yes ☐ no
c) If Yes, will the organization be able to provide compliance documentation outlined in the instructions, to include in the NCRP Regional Project Application should the project be selected as a Priority Project?
☐ yes ☐ no

AGRICULTURAL WATER MANAGEMENT PLAN

a) Is the organization – or any organization that will receive funding from the project – required to file an Agricultural Water Management Plan (AWMP)?
☐ yes ☒ no
b) If Yes, list date the AWMP was approved by DWR:
c) Does the agricultural water supplier(s) meet the requirements in CWC Part 2.55 Division 6?
☐ yes ☐ no

SURFACE WATER DIVERSION REPORTS

a) Is the organization required to file surface water diversion reports per the requirements in CWC Part 5.1 Division 2?
☒ yes ☐ no
d) If Yes, will the organization be able to provide SWRCB verification documentation outlined in the instructions, to include in the NCRP Regional Project Application should the project be selected as a Priority Project?
☒ yes ☐ no

STORM WATER MANAGEMENT PLAN

a) Is the project a stormwater and/or dry weather runoff capture project?
☐ yes ☒ no
b) If yes, does the project benefit a Disadvantaged Community with a population of 20,000 or less?
☐ yes ☐ no
e) If No, will the organization be able to provide documentation that the project is included in a Stormwater Resource Plan that has been incorporated into the North Coast IRWM Plan, should the project be selected as a Priority Project?
☐ yes ☒ no

C. GENERAL PROJECT INFORMATION

1. Project Name: Improving Willits Water Supply Reliability and Drought Resiliency with Groundwater and Conjunctive Use

2. Eligible Project Type under 2018/19 IRWM Grant Solicitation

- ☐ Water reuse and recycling for non-potable reuse and direct and indirect potable reuse
- ☐ Water-use efficiency and water conservation
- ☐ Local and regional surface and underground water storage, including groundwater aquifer cleanup or recharge projects
- ☐ Regional water conveyance facilities that improve integration of separate water systems
- ☒ Watershed protection, restoration, and management projects, including projects that reduce the risk of wildfire or improve water supply reliability
- ☐ Stormwater resource management projects to reduce, manage, treat, or capture rainwater or stormwater
- ☐ Stormwater resource management projects that provide multiple benefits such as water quality, water supply, flood control, or open space
- ☐ Decision support tools that evaluate the benefits and costs of multi-benefit stormwater projects
- ☐ Stormwater resource management projects to implement a stormwater resource plan
- ☒ Conjunctive use of surface and groundwater storage facilities
- ☐ Decision support tools to model regional water management strategies to account for climate change and other changes in regional demand and supply projections
- ☐ Improvement of water quality, including drinking water treatment and distribution, groundwater and aquifer remediation, matching water quality to water use, wastewater treatment, water pollution prevention, and management of urban and agricultural runoff
- ☐ Regional projects or programs as defined by the IRWM Planning Act (Water Code §10537)
- ☐ Other:

3. Project Abstract

Today, the Willits water system lacks the groundwater capacity to provide for the needs of the communities if surface water again becomes untenable. The proposed project seeks to expand both groundwater capacity, increasing system resiliency, and conjunctive use, increasing flexibility. This flexibility would increase options for managing water quality, aquifers, watersheds, and critcal habitats. Secure water also represents an economic benefit for a severely disadvantaged community.

4. Project Description

The Willits water system serves approximately 5,500 people in the City of Willits and adjacent communities, providing an average 890 thousand gallons per day (kgpd), with peak flows up to 1,400 kgpd in summer. Until recently, all drinking water flowed from Morris Reservoir. In 2014, the continuing drought led to a water crisis in Willits, restrictions on water use, and emergency funds. As a result, the Elias well system was developed, which now supplies and treats supplementary groundwater. Currently, that system can produce a maximum of 490 kgpd. However, the Elias system is inadequate to meet the community's needs in the event of severe or protracted drought, or if the surface water system or its single pipeline were damaged, especially if such events occur in summer months.

The proposed project would expand the initial groundwater capacity, allow for increased conjunctive use, and ensure a reliable water supply sufficient to meet community needs if surface water again becomes untenable. Specifically, the project would replace a 30 hp pump in the primary "Elias Replacement" well with a 70 hp pump, increasing capacity to 1,140 kgpd. A prior study showed that well and aquifer capable of sustaining 1,150 kgpd with adequate safety factors. The 30 hp pump and controls would then be installed in the secondary “Long 20” well. Both pumps would require upgraded power supplies. Increased flows also require upgrading a 3650 ft secton of 6" sch 40 PVC pipe connecting the wells to the treatment plant. Finally, we would perform pilot tests to confirm the arsenic detected in the secondary Long 20 well would be adequately removed by the treatment plant prior to integrating that source. The treatment plant was designed with excess capacity.

Increasing groundwater capacity creates system resilience and the flexibility to manage sources based on real-time considerations. The people of Willits see this effort as crucial and it has broad support in the City Council. Water security represents an economic benefit in an area almost entirely classified as severely disadvantaged. The area has experienced recent droughts, and climate change predictions suggest such conditions will only become more common.

5. Specific Project Goals/Objectives

Goal 1: Improve reliability of potable water supplies for the City of Willits and surrounding communities.
Goal 1 Objective: Increase capacity to provide potable water from groundwater sources, providing local self-reliance during dry periods, expected to become more common with climate change effects.
Goal 1 Objective: Develop groundwater sources sufficient to provide potable water in the event of catastrophic failure of the surface water system.
Goal 1 Objective:
Goal 1 Objective:

Goal 2: Increase flexibility in potable water source selection.
Goal 2 Objective: Increase conjunctive use of existing storage, preventing water quality issues resulting from low reservoir levels and providing options in the event of water quality issues from either source.
Goal 2 Objective: Allow for source-selection decision-making which considers economic concerns, energy efficiency, downstream flows and watersheds, salmonid populations, and aquifer health.
Goal 2 Objective:
Goal 2 Objective:

Goal 3: Support the City of Willits and surrounding communities.
Goal 3 Objective: Provide reliable water quality and water quantities required for development in an almost entirely severely economically disadvantaged area.
Goal 3 Objective:
Goal 3 Objective:

Additional Goals & Objectives (List)

6. Describe how the project addresses the North Coast Resource Partnership and North Coast IRWM Plan Goals and Objectives selected.

Additional groundwater capacity provides both increased reliability of water supply and flexibility to avoid and respond to water quality issues, addressing NCRP’s “ensure water supply reliability and quality” objective. That resulting flexibility also allows decision-making that supports healthy downstream surface-water flows, watersheds, salmonid habitat, and aquifers, addressing NCRP objectives “improve watersheds & salmonid populations” and “protect groundwater resources.” As it provides reliability for communities almost entirely classified as SDAC, it addresses the objective “Support disadvantaged communities” within NCRP’s "economic vitality” goal. Finally, this project helps the communities adapt to dry periods, likely to be increasingly common as consequences of climate change, addressing the NCRP goal of "climate adaptation & energy independence."

7. **Describe the need for the project**.
   Today, the Willits water supply faces numerous threats. Severe or protracted drought, like that experienced in 2014 and prior years, could reduce Morris Reservoir levels such that it cannot serve as an adequate source. Additionally, water is transported from the reservoir to the city via a single pipeline; there would be little recourse in the event of catastrophic failure. Further, reduced levels in the reservoir have led to increased temperatures, causing biological growth and water quality issues. Indeed, such organics overwhelmed the system following the 2014 drought, leading to violations for TTHM. Currently, the well can provide supplementary groundwater, but only a fraction of typical needs. Thus, water quantities and qualities remain vulnerable to extreme events or failures. The proposed project would build on the initial development of the existing improvement, creating a system that offers resilient and reliable supply of high-quality drinking water.

8. **List the impaired water bodies (303d listing) that the project benefits:**
   N/A

9. **Will this project mitigate an existing or potential Cease and Desist Order or other regulatory compliance enforcement action?** ☐ yes ☒ no
   If so, please describe?

10. **Describe the population served by this project.**
    This project serves roughly 5,500 people in the City of Willits and surrounding communities. The vast majority of this population (>95%) resides within severely economically disadvantaged communities (SDAC), as identified via the NCRP mapping data tool. The SDAC area includes census block groups with median HH incomes between $35,094 and $18,261 based on the DWR's DAC mapping tool. Less than 5% of the popluation lives outside this region, but within economically disadvantaged communities (DAC).

11. **Does the project provide direct water-related benefits to a project area comprised of Disadvantaged Communities or Economically Distressed Communities?**
    - ☐ Entirely
    - ☒ Partially
    - ☐ No

    List the Disadvantaged Community(s) (DAC)
    Less than 5%: Neigborhoods near Bray & Commercial (E of Willits), Locust Street (S of Willits), and Hill & Center Valley Rd (E of Willits).

12. **Does the project provide direct water-related benefits to a project area comprised of Severely Disadvantaged Communities (SDAC)?**
    - ☒ Entirely
    - ☒ Partially
    - ☐ No

    List the Severely Disadvantaged Community(s)
    Over 95%: City of Willits, Simerson (unincorporated, N of Willits); Upp (unincorporated, N of Willits); Fair Oaks (unincorporated, S of Willits); Meadowbrook (neighborhood, S of Willits).

13. **Does the project provide direct water-related benefits to a Tribe or Tribes**?
    - ☒ Entirely
    - ☐ Partially
    - ☐ No

    List the Tribal Community(s)
    Sherwood Valley Band of Pomo Indians, tribal lands adjacent to the City of Willits
    If yes, please provide evidence of support from each Tribe listed as receiving these benefits.

14. **If the project provides benefits to a DAC, EDA or Tribe, explain the water-related need of the DAC, EDA or Tribe and how the project will address the described need.**
    All of the City of Willits is a severly disadvantaged community. The City water system also serves the Sherwood Valley Rancheria. The City of Willits, Racheria, and other adjoining areas have similar needs for water that will be enhanced and made more secure by this project. As the project area includes only DAC and Tribal communities, all needs (C.7.) and benefits (F.2., F.6.) refer to communities so classified.

15. **Does the project address and/or adapt to the effects of climate change? Does the project address the climate change vulnerabilities in the North Coast region?** ☒ yes ☐ no
    If yes, please explain.
    The North Coast Regional Climate Adaptation Report describes the forecast for drought as the most concerning of regional climate impacts. This project would add resiliency to a system known to be vulnerable to such droughts, representing an adaptation to expected trends.

    Additionally, the Elias well system represents a more energy-efficient source of water, as the higher water quality requires fewer treatment steps and as the geographically closer source requires less energy for transport.

16. **Describe how the project contributes to regional water self-reliance.**
    In 2014, the City of Willits required outside assistance from the State of CA in response to emergency conditions. This project aims to build resilience in the water system such that response to similar scenarios could be handled locally.

17. **Describe how the project benefits salmonids, other endangered/threatened species and sensitive habitats.**
    Morris Reservoir, the current source for Willits surface water, empties into Davis Creek, which feeds Outlet Creek in the Eel River watershed. Davis Creek is classified as a critical habitat for both Chinook salmon and steelhead, based on the NCRP's mapping data tool. Expanding groundwater and conjunctive use for the city allows additional flexibility in managing the reservoir output during dry months, including consideration of requisite flows for salmonid species.

18. **Describe local and/or political support for this project.**
    Given the recent 2014 water emergency, there is broad local public support for projects that improve resilience and reliability of the local water supply. Additionally, this and similar projects have been discussed at numerous City Council meetings and Water and Wastewater Committee meetings. Current and past City Councils have strongly supported the development of groundwater because they recognize how vulnerable the City is to dry periods or pipeline failures.

19. **List all collaborating partners and agencies and nature of collaboration.**

To date, the city has not created partnerships for this project outside of the fact that the City provides water to the Sherwood Valley Rancheria, including their small casino and café on tribal land.

20. **Is this project part or a phase of a larger project?** ☒ yes ☐ no
Are there similar efforts being made by other groups? ☐ yes ☒ no
If so, please describe?
This project represents an informal second phase of the response to the 2014 water emergency. The improvements undertaken since the emergency have allowed the communities to get by. This phase would complete the effort, creating a conjunctive use system providing a resilient water supply with the flexibility to consider watersheds, aquifers, habitats, energy, and economic considerations.

21. **Describe the kind of notification, outreach and collaboration that has been done with the County(ies) and/or Tribes within the proposed project impact area, including the source and receiving watersheds, if applicable.**
The City of Willits has worked with the County to secure a permit for the well. The city provides water and wastewater services to the Sherwood Valley Band of Pomo Indians.

22. **Describe how the project provides a benefit that meets at least one of the Statewide Priorities as defined in the 2018 IRWM Grant Program Guidelines and Tribal priorities as defined by the NCRP?**
By completing a groundwater system capable of meeting the needs of these communities, this project will create a more resilient drinking water system, addressing the Statewide Priority to "provide safe water for all communities." By adding flexibility, it will allow decision-making that considers economic, watershed, ecosystem, and aquifer health, meeting the Statewide Priority to "ensure that there is a sustainability aspect to the project." Together, the added resiliency and flexibility address the Statewide Priority to "manage and prepare for dry periods."

23. **Project Information Notes:**

D. PROJECT LOCATION

1. **Describe the location of the project**
Geographical Information
All project-related land parcels are owned by the City of Willits and are adjacent to or near the city limits to the north and north-east in the Little Lake Valley.

2. **Site Address (if relevant):**

3. **Does the applicant have legal access rights, easements, or other access capabilities to the property to implement the project?**
☒ Yes If yes, please describe
☐ No If No, please provide a clear and concise narrative with a schedule, to obtain necessary access.
☐ NA If NA, please describe why physical access to a property is not needed.
The City of Willits owns all of the property at and surrounding the project site, has full access rights, and has full easements that are or might be necessary to implement and complete this project.

4. **Project Location Notes:**

E. PROJECT TASKS, BUDGET AND SCHEDULE

1. **Projected Project Start Date:** 1/1/20
   Anticipated Project End Date: 12/31/21

2. **Will CEQA be completed within 6 months of Final Award?**
   ☒ Yes State Clearinghouse Number: TBD
   ☐ NA, Project is exempt from CEQA
   ☐ NA, Not a Project under CEQA
   ☐ NA, Project benefits entirely to DAC, EDA or Tribe, or is a Tribal local sponsor. [Projects providing a water-related benefit entirely to DACs, EDAs, or Tribes, or projects implemented by Tribes are exempt from this requirement].
   ☐ No

3. **Please complete the CEQA Information Table below**
   Indicate which CEQA steps are currently complete and for those that are not complete, provide the estimated date for completion.

CEQA STEP	COMPLETE? (y/n)	ESTIMATED DATE TO COMPLETE
Initial Study	N	1/30/20
Notice & invitation to consult sent to Tribes per AB52	N	1/30/20
Notice of Preparation	N	1/30/20
Draft EIR/MND/ND	N	2/15/20
Public Review	N	3/15/20
Final EIR/MND/ND	N	3/30/20
Adoption of Final EIR/MND/ND	N	4/30/20
Notice of Determination	N	4/30/20
N/A - not a CEQA Project	N	

If additional explanation or justification of the timeline is needed or why the project does not require CEQA, please describe.

4. **Will all permits necessary to begin construction be acquired within 6 months of Final Award?**
   ☒ Yes
   ☐ NA, Project benefits entirely to DAC, EDA, Tribe, or is a Tribal local sponsor
   ☐ No

5. **PERMIT ACQUISITION PLAN**

Type of Permit	**Permitting Agency**	**Date Acquired or Anticipated**
404 Certification	U.S. Army Corps of Engineers	4/30/20
401 Certification	Regional Water Board	4/30/20

For permits not acquired: describe actions taken to date and issues that may delay acquisition of permit.
Although not anticpated to delay the acquisition of permits, the completion of a Wetland Delineation at the project site in tandem with the preparation of permit applications is recommended.

6. **Describe the financial need for the project**.
The City of Willits is a severly disadvantaged community that has significant need, but little capacity, to finance medium and large scale public works projects to address the water needs of the community with existing fund sources.

7. **Is the project budget scalable?** ☐ yes ☒ no
Describe how a scaled budget would impact the overall project.
From a budget standpoint, upgrading the pipeline from the wells to water treatment constitutes the largest single component, and there is no practical way to scale this element. That said, the project could likely be implemented in two phases. In the first phase, the pipeline would be upgraded to increase transfer capacity from the wells to the groundwater treatment plant. In the second phase, the wells would be upgraded to increase pumping capacity and arsenic pilot tests would be performed.

8. **Describe the basis for the costs used to derive the project budget according to each budget category.**
For cost estimates, this project relied heavily on the professional experience of the City's engineer. Specifically, estimates for the pipeline replacement were made based on a similar project in Round Valley, where final costs for installation of a 6" main were ~$140/ft. Costs for the 70 hp pump and pilot testing for arsenic removal were based on preliminary quotes. Most labor costs are based in prevailing wage, but there is a premium for specialized equipment given the City's remote location.

9. **Provide a narrative on cost considerations including alternative project costs.**
Considered alternatives included integrating water from the Park well, currently used for agriculture, but much higher arsenic levels necessitated additional treatment capital projects in excess of $350k (compare with $150k for the new pump). Increasing reservoir capacity was also considered but proved expensive and offered fewer benefits. Drilling of additional wells and alternative screening were both considered to reduce Long 20 arsenic levels but proved costlier than pilot testing.

10. **List the sources of non-state matching funds, amounts and indicate their status**.
N/A

11. **List the sources and amount of state matching funds.**

    N/A

12. **Cost Share Waiver Requested (DAC or EDA)?** ☒ yes ☐ no

    Cost Share Waiver Justification: Describe what percentage of the proposed project area encompasses a DAC/EDA, how the community meets the definition of a DAC/EDA, and the water-related need of the DAC/EDA that the project addresses. In order to receive a cost share waiver, the applicant must demonstrate that the project will provide benefits that address a water-related need of a DAC/EDA.

    The proposed project serves the City of Willits and surrounding communities. The vast majority of the service area falls within severely economically disadvantaged communities (SDAC), as identified in both the NCRP and DWR DAC mapping tools. This SDAC area includes census block groups with median HH incomes between $35,094 and $18,261 based on the DWR's DAC mapping tool. The remaining area, less than 5%, lies outside SDAC block groups but within economically disadvantaged communities (DAC).

    Currently, surface water from Morris reservior is the only source capable of meeting the community's needs. The system is vulnerable to drought, as experienced in 2014, as well as failure of the surface water source, treatment, or single pipeline. The proposed project would develop groundwater capacity to meet the community's need, providing both reliablility and the flexibility to optimize water quality, energy use, watershed and aquifer health, and critical habitat impacts.

13. **Major Tasks, Schedule and Budget for NCRP 2018 IRWM Project Solicitation**

    Please complete MS Excel table available at https://northcoastresourcepartnership.org/proposition-1-irwm-round-1-implementation-funding-solicitation/; see instructions for submitting the required excel document with the application materials.

14. **Project Tasks, Budget and Schedule Notes:**

F. PROJECT BENEFITS & JUSTIFICATION

1. **Does the proposed project provide physical benefits to multiple IRWM regions or funding area(s)?**

   ☐ yes ☒ no

   If Yes, provide a description of the impacts to the various regions.

2. **Provide a narrative for project justification. Include any other information that supports the justification for this project, including how the project can achieve the claimed level of benefits. List any studies, plans, designs or engineering reports completed for the project.** *Please see the instructions for more information about submitting these documents with the final application.*

   The City of Willits is classified as a severley disadvantaged community. In response to the extreme drought conditions of 2013-2014, the City completed an emergency project constructing a new water treatment plant and over 8000' of new water line to connect two existing wells to the distribution system. This initial phase of developing groundwater infrastructure set up the framework for creating a full system of redundency. In 2017, non-emergency use of this groundwater supply was approved; however, the current infrastructure is only able to supply 490,000 gallons per day, approximately 43% of the amount needed to supply peak demand.

The surface water pipeline represents an additional vulnerability. Currently, the City's primary water supply travels 2.5 miles via a single 16" transmission line. In the event that the transmission line is comprimised, the City would be solely reliant on groundwater. Completing the development of a secondary source of water that can supply the community's needs independent of surface water is critically important to the City's water security.

Improving water supply reliability is the primary purpose of this project; however, the added benefits of conjuctive use are numerous, including improved water quality, reduced operations and maintenance costs, greater operational flexibility, increased energy efficiency, reduced demands on staff time related to reporting and operations, as well as potentially increased water releases to Davis Creek, a critical salmonid habitat.
The City has received complaints regarding taste and odor during the summer months when reservoir water temperature rises and algae blooms. In contrast, groundwater developed to date produces colder, higher quality water, void of organics that occur in surface water and cause these issues. Blending groundwater with surface water would improve the overall water quality and temperature delivered to the consumers. Staff will have the ability to operate the Water Treatment Plant in conjunction with the Groundwater Treatment Plant to manage water quality, as well as reservoir levels.

The Groundwater Treatment Plant (GWTP) also requires less energy to operate than the surface Water Treatment Plant (WTP). As minimal treatment is required for this groundwater, the GWTP is simple in design, which makes it comparatively cost effective and energy efficient to run. Further, the Division of Drinking Water requires only minimal reporting and testing for groundwater, when compared with surface water.

Finally, a secondary supply of water creates operational flexibility to provide water if a critical system component for either supply needs to go offline for maintenance. Overall, use of groundwater as a supplement or replacement to surface water realizes the full investment into groundwater infrastructure to date. It provides the best quality water at a reduced operational cost with a negligible environmental impact.

3. **Does the project address a contaminant listed in AB 1249 (nitrate, arsenic, perchlorate, or hexavalent chromium)?** ☒ yes ☐ no
   If yes, provide a description of how the project helps address the contamination.
   The primary Elias Replacement well has negligible levels of arsenic (As), but the secondary Long 20 well water has levels above the maximum contaminant level (MCL). We believe the current groundwater treatment system can remove As aqeduately, but this has not been independently tested. The project includes pilot testing to confirm that the existing treatment plant will reduce As levels below MCLs, a prerequisite to integrating that source into the drinking water system.

4. **Does the project provide safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes consistent with AB 685?** ☒ yes ☐ no
   If Yes, please describe.
   This project further develops alternative groundwater supplies for integration into the City of Willits drinking water system. Water from the primary Elias Replacement well has been used previously and

has adequate treatment methods in place. Water from the secondary Long 20 well has been tested for various analytes, showing elevated iron, manganese, and arsenic. As part of the proposed effort, in-place treatment methods will be tested to ensure safety before the source is integrated.

5. **Does the project employ new or innovative technologies or practices, including decision support tools that support the integration of multiple jurisdictions, including, but not limited to, water supply, flood control, land use, and sanitation?** ☒ yes ☐ no
   If Yes, please describe.
   Once complete, this project will allow for flexibility in source selection for the system's drinking water. We have identified a recently-developed model which could help forecast demand and support decision-making to balance considerations around water quality, energy efficiency, watershed and habitat health, and aquifer management.

6. **For each of the Potential Benefits that the project claims complete the following table to describe an estimate of the benefits expected to result from the proposed project.** [*See the NCRP Project Application Instructions, Potential Project Benefits Worksheet and background information to help complete the table. The NCRP Project Application, Attachment B includes additional guidance, source materials and examples from North Coast projects*.]

PROJECT BENEFITS TABLE

Potential Benefits Description	Physical Amt of Benefit	Physical Units	Est. Economic Value per year	Economic Units
Water Supply				
1. Increased Instream Flow	70	acre-ft	$8,400	$/acre-ft/yr
2. Change in Timing and Volume of Instream Flows/ Fish Improvement			not monetized	
3. Increased Water Supply Reliability	2400	# households	$777,600	$/yr
4. Water supply purchases 5. Avoided Water Supply Projects 6. Avoided Electric Costs 7. Avoided Water Shortage Costs	4) 503 5) 1 6)36,000 7)15000 sq. ft.	4) acre-ft 5) facility 6)kwh 7)sq. ft.	4) 140,840 5) $750,000 6)$5,000 7)$15,000	4) $/acre-ft per year 5)$/facility 6)$/yr 7)$/yr
Water Quality				
8. Additional Water Quality Projects Avoided			Monetized above in #5 $750,000	$/facility
9. Chemical Treatment Reduction			$27,500	$/yr
Other Ecosystem Service Benefits				
Other Benefits				
10. Increased Water Supply for Wildfire Fighting Use			10) not monetized	10) none

Potential Benefits Description	Physical Amt of Benefit	Physical Units	Est. Economic Value per year	Economic Units
11. Decreased O&M Costs at Main Reservoir Plant				11. 7,000 $/year
12. Improved water quality			Not monetized	

7. **Project Justification & Technical Basis Notes:**
   The following notes correlate with the Project Benefits Table in F.6. above and provide assumptions for the calculations.
   1. Increased Instream Flow - Voluntary 10% increase of water released to Davis Creek based on 2017 creek flows
   2. Change in Timing and Volume of Instream Flow/Fish Improvement - Increased flows could have added benefit to Salmon and Steelhead populations
   3. Increased Water Supply Reliability - Approximate number of households (Barakat & Chamberlin, 1994), assuming consumers would be willing to pay $27 per month to avoid severe water rationing if an emergency cut off surface water supply.
   4. Water supply purchases - High value based on shipping costs, no canals ways or pipes for water transfer, assume 1/2 water will need to be trucked in and other from Park Well or other well source
   5. Avoided Water Supply Projects - Park Well may be improved to provide additional water supply if needed.
   6. Avoided Electric Costs - Scaled reduction in energy costs. Approximate reservoir water plant yearly costs minus current groundwater plant costs scaled up by a factor of 1.8. Scale factor is current use ~350 gpm to ~624 gpm, assuming $0.14 per kwh
   7. Avoided Water Shortage Costs - Having reliable water from parks and recreation areas will prevent them from having to be replaced
   8. Additional Water Quality Projects - Utilizing the Park Well would require treatment of arsenic
   9. Chemical Treatment Reduction - Assumed 50% reduction in chemical needs other than copper sulfate
   10. Increased Water Supply for wildfire Fighting Use - Having groundwater wells for domestic use means having more water for fore fighting use
   11. Decrease O&M Costs at main reservoir plant - 10% reduction in maintenance due to minimized use at reservoir water plant, less wear on pumps
   12. Improved water quality for the community is not monetized.

   Total calculation for the project benefit in dollars per year, not including the Park Well improvement avoided cost = $981,340

Major Tasks, Schedule and Budget for North Coast Resource Partnership 2018/19 IRWM Project Solicitation

Project Name: Improving Willits Water Supply Reliability and Drought Resiliency with Groundwater and Conjunctive Use
Organization Name: City of Willits

Task #	Major Tasks	Task Description	Major Deliverables	Current Stage of Completion	IRWM Task Budget	Non-State Match	Total Task Budget	Start Date	Completion Date
A	**Category (a): Direct Project Administration**								
1	Administration	In cooperation with the County of Humboldt sign a sub-grantee agreement for work to be completed on this project. Develop invoices with support documentation. Provide audited financial statements and other deliverables as required	Invoices, audited financial statements and other deliverables as required	0%	$1,600.00	$0.00	$1,600.00		
2	Monitoring Plan	Develop Monitoring Plan to include goals and measurable objectives	Final Monitoring Plan	0%	$3,000.00	$0.00	$3,000.00		
3	Labor Compliance Program	Execute service agreement with Labor Compliance Program company	Submission of Labor Compliance Program	0%	$9,500.00	$0.00	$9,500.00		
4	Reporting	Develop monthly reports describing work completed, challenges, and strategies for reaching remaining project objectives. Develop Final Report	Quarterly and Final Reports	0%	$2,000.00	$0.00	$2,000.00		
B	**Category (b): Land Purchase/Easement**								
1				0%	$0.00	$0.00	$0.00		
C	**Category (c): Planning/Design/Engineering/Environmental Documentation**								
1	Design / Plans	Perform preliminary calculations for pipeline requirements, power requirements	Preliminary power requirements	40%	$2,400.00	$0.00	$2,400.00	1/1/20	1/7/20
2	Design / Plans	Develop preliminar plans for pipeline replacement and connection to Long 20 well	Preliminary design plans	20%	$2,000.00	$0.00	$2,000.00	1/8/19	
3	Design / Plans	Develop 90% plans for pipeline replacement and connection to Long 20 well	90% design plans		$16,000.00	$0.00	$16,000.00	1/15/20	1/31/20
4	Environmental Documentation: CEQA *			0%	$10,000.00	$0.00	$10,000.00	1/1/20	4/30/20
5	Permit Development:	Obtain Regional Water Board: 401 Certification	Regional Water Board 401 Certification	0%	$1,600.00	$0.00	$1,600.00	2/1/20	5/31/20
6	Permit Development:	Obtain US Army Corps of Engineers: 404 Certification	US Army Corps of Engineers 404 Certification	0%	$1,600.00	$0.00	$1,600.00	2/1/20	5/31/20
7		Obtain PG&E service for Long 20 well and updgrade for Elias Replacement well		0%	$35,000.00	$0.00	$35,000.00	2/1/20	6/30/20
8	Design / Plans	Perform final calculations for pipeline requirements	Final expected water flows, power requirments	0%	$900.00	$0.00	$900.00	4/1/20	4/15/20
9	Design / Plans	Develop final plans for pipeline replacement and connection to Long 20 well	Final design plans	0%	$6,000.00	$0.00	$6,000.00	5/16/20	5/31/20
10	Design / Plans	Prepare bid packages for installation of pump, etc. for Elias Replacement well, moving Elias Replacement well pump, etc. to Long 20 well, replacement of 6" pipeline		0%	$5,000.00	$0.00	$5,000.00	4/1/20	5/31/20
D	**Category (d): Construction/Implementation**								
1	Construction/Implementation Contracting			0%	$3,200.00	$0.00	$3,200.00	5/1/20	5/30/20
2	Mobilization and Site Preparation			0%	$81,800.00	$0.00	$81,800.00	6/1/20	6/1/20
3	Project Construction/Implementation:	Install new pump in Elias Replacement well, with VFD and controls		0%	$150,000.00	$0.00	$150,000.00	7/1/20	9/30/20

Project Name: Improving Willits Water Supply Reliability and Drought Resiliency with Groundwater and Conjunctive Use
Organization Name: City of Willits

Task #	Major Tasks	Task Description	Major Deliverables	Current Stage of Completion	IRWM Task Budget	Non-State Match	Total Task Budget	Start Date	Completion Date
4	Project Construction/Implementation:	Move Elias Replacement well pump, VFD, controls and install in the Long 20 well. (removal, re-installation, security fencing, electrical and other miscellaneous ancillary facilities)		0%	$120,000.00	$0.00	$120,000.00	8/1/20	9/30/20
5	Project Construction/Implementation:	Install 8" replacement pipe from the Elias Replacement well to the junction with existing 8" pipeline. (Assuming 8" C900 PVC at $150/ft installed * 3650 ft)		0%	$548,000.00	$0.00	$548,000.00	7/1/20	9/30/20
6	Project Construction/Implementation:	Install PG&E service connection at Long 20 test well, and upgrade connection at Elias Replacement well.		0%	$50,000.00	$0.00	$50,000.00	7/1/20	8/31/20
7	Pilot Testing	Conduct pilot tests to determine the current groundwater treatments plant's capacity to remove arsenic from the Long 20 well.			$8,000.00		$8,000.00	4/1/21	6/1/21
8	Project Signage			0%	$500.00	$0.00	$500.00	6/1/20	6/30/20
9	Project Close Out, Inspection & Demobilization	Inspect project components and establish that work is complete. Verify that all project components have been installed and are functioning as specified will be conducted as part of construction inspection and project closeout. Conduct project completion photo monitoring. Prepare record drawings.	As-Built and Record Drawings; Project completion site photos	0%	$4,140.00	$0.00	$4,140.00	6/30/21	12/31/21
10	Project Performance Monitoring	The performance of the project will be monitored in accordance to the Monitoring Plan using the following measurement tools and methods:	The project objectives will be monitored in accordance with the Monitoring Plan using project milestones and target dates. Data will be incorporated in Quarterly and Final Reports.	0%	$4,080.00	$0.00	$4,080.00	6/1/20	11/30/21
11	Construction Administration	Complete tasks necessary to administer construction contract. Keep daily records of construction activities, inspection, and progress. Conduct project construction photo-monitoring.	Construction Management Logs; Completed construction administration tasks documented in monthly progress reports	0%	$35,992.00	$0.00	$35,992.00	5/1/20	12/31/21
	Total North Coast Resource Partnership 2018/19 IRWM Grant Request				**$1,102,312.00**	**$0.00**	**$1,102,312.00**		
	Is Requested Budget scalable by 25%? If yes, indicate scaled totals; if no delete budget amount provided.								
	Is Requested Budget scalable by 50%? If yes, indicate scaled totals; if no delete budget amount provided.								

Attachment A
City of Willits NCRP 2018/19 IRWM Project Application

WATER SUPPLY PLANNING STUDY

Prepared For

City of Willits

February 2006

WEST YOST & ASSOCIATES

Consulting Engineers

706-04-04-02

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EXECUTIVE SUMMARY

The City of Willits (City) owns and operates the public water system and supplies potable water to residential, commercial, industrial and institutional customers within and outside the City limits. While the current City population is just over 5,000, potable water is supplied by the City to a total population of about 6,500. The existing water supply is surface water from the Davis Creek watershed, impounded by the Centennial and Morris Dams, and treated in a filtration plant.

The City retained the engineering consultant team of West Yost & Associates and MBK Engineers to analyze the City water demands and existing water supply capacity and to determine any need for a supplemental water supply. The commissioned Water Supply Planning Study included the following scope of study:

- Determination of current water demands
- Projection of future water demands
- Analysis of existing water supply capacity
- Determination of supplemental supply requirements
- Evaluation of supplemental supply alternatives
- Conclusions and recommendations

Population and land use methodologies were used to project the 2025 and build-out water demands for the City. The land use methodology was considered more accurate, and the land use based demand projections were used as a basis of planning for the remainder of the study. Demand management measures were determined to have significant potential to reduce water demands in the future, and estimates of demand reductions with implementation of these measures were incorporated into the projected 2025 water supply requirements.

Hydrological analysis and modeling of the Morris/Centennial Reservoir system revealed a current worst-case water supply deficit of 650 acre-feet per year (AF/year) and a projected 2025 worst-case deficit of 1,300 AF/year in critically dry years. Enforcement of Ordinance 95-4 during critically dry years would reduce but not eliminate the worst-case deficits. The supplemental water supply requirements are summarized in Table ES-1 in terms of million gallons per day (mgd).

The supplemental water supply alternatives for the City include:

- Additional surface water supply
- Neighboring water system interconnection
- Recycled water supply
- Groundwater supply

Table ES-1. Supplemental Water Supply Requirements

	Without Enforcement of Ordinance 95-4	With Enforcement of Ordinance 95-4 Stage I	With Enforcement of Ordinance 95-4 Stage II
Current Demands, mgd	0.9	0.8	0.6
Projected 2025 Demands, mgd	1.8	1.5	1.3

Several of the alternatives were deemed inadequate to satisfy the City's need for a supplemental water supply or were otherwise not feasible. The three feasible alternatives are: 1) expanding the capacity of Morris Reservoir, 2) building another dam elsewhere in the Little Lake Valley to expand the surface water supply, and 3) implementing a groundwater supply. The capital cost estimate for a supplemental or expanded surface water supply is $18 to $20 million while the capital cost estimate for a groundwater supply is $7.0 million. In addition to the cost and other advantages of the groundwater supply alternative, it is feasible to implement the groundwater supply in phases to minimize the initial effect on rates. The principal downside of the groundwater supply alternative is that the long-term annual yield of the Little Lake Valley groundwater basin may limit the groundwater supply potential to accommodate City water system growth beyond 2025.

As a result of this Water Supply Planning Study, it is recommended that the City:

- Designate a Water Conservation Coordinator to develop, launch and manage a City water conservation program and oversee the implementation of demand management measures, as described in this report.
- Continue aggressively detecting and repairing leaks in the water distribution system and maintaining or replacing meters to reduce the unaccounted for water demand to 12 percent of the customer water demand.
- Determine whether to develop enough supplemental water supply capacity to avoid enforcement of Ordinance 95-4 in critically dry years.
- Continue to operate the lower outlet(s) of Morris Reservoir as necessary to scour the immediate bottom area and minimize future sedimentation, and work with the County to promote erosion control in the upper Davis Creek watershed.
- Pursue the use of Wente Lake as part of a water supply contingency plan, as described in this report.
- Provide treated wastewater to local area farmers to offset the agricultural demand for groundwater and increase the groundwater supply availability to the City.
- Incorporate the water supply needs of any future annexation into the capacity of a supplemental water supply project(s).
- Continue discussions with Brooktrails to determine the feasibility and potential advantages of participating in an expansion of the Brooktrails water supply capacity.

- Develop a groundwater supply as described in this report.
- Plan to expand Morris Reservoir and the surface water treatment plant in the future if annexations and growth projections require a greater water supply capacity than the existing surface water supply and proposed groundwater supply can support.

Implementation of the first phase of the groundwater supply project, as described in this report and depicted in Figure 5-2, will entail:

1. Evaluating environmental impacts, preparing necessary environmental documentation, and soliciting public comments for CEQA compliance.
2. Consulting with Department of Health Services (DHS), investigating potentially contaminating activities that might affect water quality, and adjusting proposed well locations and screening intervals as necessary.
3. Initiating detailed design of wells, pipelines and groundwater treatment plant, and securing easements as necessary.
4. Drilling wells, conducting pumping tests, collecting water quality data, and incorporating test results and water quality data into detailed design.
5. Finalizing design and amending domestic water supply permit from DHS.
6. Advertising project, evaluating and awarding construction contract, and administering contract through completion.
7. Commissioning facilities and training operators as regards groundwater supply operations and maintenance requirements.

The preliminary description of the groundwater supply project, found in this report, will serve as a rational foundation to pursue CEQA compliance and proceed into design.

1. INTRODUCTION

The City of Willits (City) is located in Mendocino County, about 140 miles north of San Francisco along Highway 101. The City owns and operates the public water system and supplies potable water to residential, commercial, industrial and institutional customers within and outside the City limits. While the current City population is just over 5,000, potable water is supplied by the City to a total population of about 6,500. Population growth is anticipated to increase the demand for potable water.

The primary source of supply is surface water from the Davis Creek watershed, impounded by the Centennial and Morris Dams and treated in a filtration plant that was built in the late 1980s. Raw water from Morris Reservoir is pumped into the filtration plant, and filtered water is delivered by gravity into a clearwell. Potable water from the clearwell is delivered by gravity through a transmission main into the City water distribution system, which comprises eight pressure zones at various elevations and includes four storage reservoirs.

The existing water supply and treatment system is not adequate to meet the City water system demands under all demand and hydrologic conditions. The Centennial and Morris Reservoirs periodically draw down to very low levels, and the distribution system storage capacity is frequently drafted to meet maximum day demands. In contrast, an adequate and reliable water supply system would have adequate capacity to meet average and maximum day demands under all anticipated demand and hydrologic conditions.

The City retained the engineering consultant team of West Yost & Associates and MBK Engineers to address the water supply needs. The commissioned Water Supply Planning Study included the following scope of study:

- Determination of current water demands
- Projection of future water demands
- Analysis of existing water supply capacity
- Determination of supplemental water supply requirements
- Evaluation of supplemental water supply alternatives
- Conclusions and recommendations

The purpose of this report is to document the analysis, findings and recommendations of the Water Supply Planning Study.

2. WATER DEMANDS

An analysis of the current water demands and a projection of the future water demands is a necessary first step in determining the water supply requirements for the City. Therefore, a metered water use and land use database was developed to characterize water uses inside and outside the City limits. The resultant database was analyzed to develop unit water demands for each customer classification and projections of future demands in 2025 and at build-out. The build-out projection integrated the City's updated General Plan for the remaining undeveloped areas. The water demand analysis and findings are documented in this section.

The City provided the following data for the water demand analysis:

- Annual water production and maximum day demand for 1994-2002
- Monthly customer metering data for August 2002-July 2004
- Monthly data from the production, system and customer meters for 1983-2003
- City of Willits 2003-2008 Housing Element
- Willits General Plan, Vision 2020, Adopted August 12, 1992
- City of Willits Zoning Map adopted January 1988 and corresponding electronic file dated September 4, 2003
- Aerial photograph of the City dated July 12, 1993

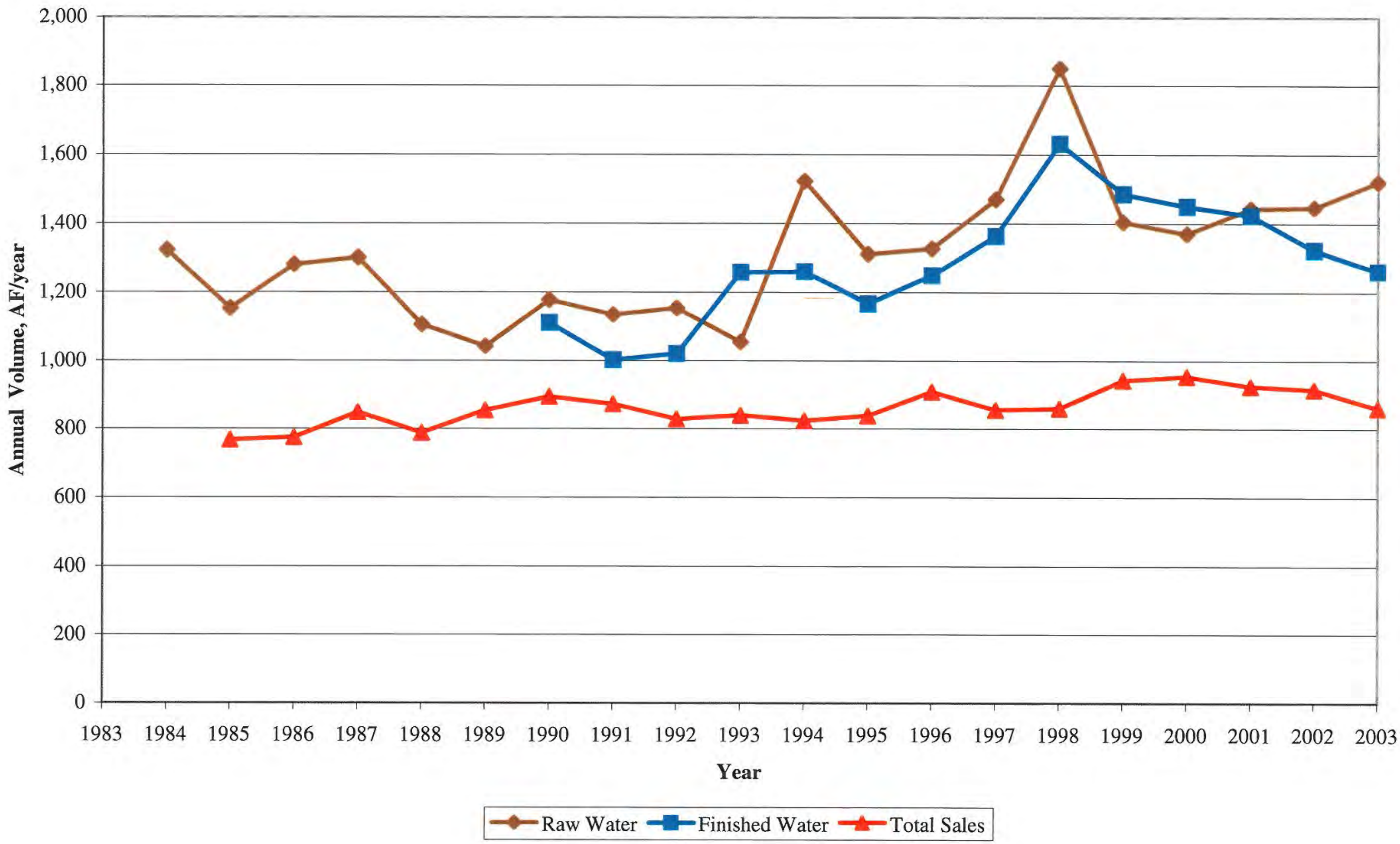
HISTORICAL WATER PRODUCTION

Annual metering data from the production (raw water), system (finished water), and customer (total sales) meters are summarized in Figure 2-1. The production meter measures the flow of raw water entering the water treatment plant from the pump station at Morris Dam. The finished water meter measures the flow downstream of the finished water storage tank (i.e., clearwell) at the plant. Total sales are determined by the customer meter readings taken at the service connections within the water distribution system inside and outside the City limits.

The finished water production volume is normally less than the raw water volume because some of the raw water is used to flush the clarifiers, and some of the finished water is used to backwash the filters, operate the chemical systems, and supply potable water for housekeeping and sanitary purposes within the plant. Total sales are typically lower than the finished water flow due to distribution system leakage and other components of unaccounted for (UAF) water demand. However, the recorded finished water flow was greater than the recorded raw water flow in three of the fourteen years, as presented in Figure 2-1. Because more water cannot leave the water treatment plant than enters the plant, these anomalies are likely due to metering errors. The City recognized this issue and replaced the raw and finished water flow meters in 2004. Further analysis of the UAF water demand is discussed later in this Section 2.

The total sales volume has increased by approximately 20 percent over the 15-year period from 1985 to 2000, averaging a 1.2 percent increase per year.

Figure 2-1. City of Willits
Historical Flow Measurements



The available finished water meter data were used to assess peaking factors, which are summarized in Table 2-1. The highest maximum day demand occurred on July 19, 1998 resulting in maximum month/average day and maximum day/average day peaking factors of 1.37 and 1.97, respectively. Maximum day peaking factors increased until 1998, declined through 2001, and then increased again in 2002.

Table 2-1. Historical Peaking Factors

	Average Day, mgd	Maximum Month, mgd	Maximum Day, mgd	Maximum Day, date	Peaking Factors[a]	
					Maximum Month	Maximum Day
1994	1.13	1.56	1.91	July 19	1.39	1.69
1995	1.04	1.41	1.76	August 16	1.36	1.69
1996	1.12	1.59	—	—	—	—
1997	1.22	1.57	1.82	August 6	1.29	1.49
1998	1.46	1.99	2.87	July 19	1.37	1.97
1999	1.33	1.80	2.55	July 15	1.36	1.92
2000	1.29	1.87	2.24	June 16	1.45	1.74
2001	1.27	1.68	1.98	August 17	1.32	1.56
2002	1.18	1.74	2.19	July 30	1.47	1.85
Average	1.22	1.69	2.16	—	1.38	1.74
Max	1.46	1.99	2.87	—	1.47	1.97
Min	1.04	1.41	1.76	—	1.29	1.49

[a] As a function of average day demand

Rounding the maximum factors in Table 2-1, 1.5 is the recommended maximum month peaking factor and 2.0 is the recommended maximum day peaking factor for the demand projections and other planning purposes. While these peaking factors are similar to experiences elsewhere in California, the City should reevaluate the peaking factors when more data are available from the new finished water meter.

CURRENT WATER DEMANDS

Current water demands are based on monthly customer metering data provided by the City from August 2002 through July 2004. The customer database includes meter readings inside and outside the City limits divided into the following customer types:

- Administrative Offices
- Commercial
    - Community Commercial
    - Heavy Commercial

- Industrial
  - Industrial Park
  - Heavy Industrial
  - Limited Industrial
- Public Facility
- Residential
  - Single Family Residence
  - Residential Medium Density
  - Multiple Residence
  - Residential Estate
- Unclassified (mostly rural residential)

Current monthly water demands by customer type inside and outside the City limits are presented graphically in Figure 2-2 and range from 46 to 113 acre-feet (AF) for the period of record. Minimum water demands typically occur in January or February, and maximum water demands typically occur in July and August, as is typical for municipal water systems.

Annual average water demand data are presented in Figure 2-3 by customer type inside and outside the City limits. Approximately 689 acre-feet per year (AF/year) or 78 percent of the current water demand occurs within the City limits. Over half of that is residential water use (368 AF/year) followed by commercial use (211 AF/year). Outside the City limits, the unclassified customers have the greatest water demand of approximately 162 AF/year, which is 82 percent of the total, followed by a residential water demand of 33 AF/year.

Significant Water Users

The total number of customer connections inside and outside the City limits is approximately 2,245, resulting in an annual average water demand of 886 AF/year. Data for the top 10 percent (225) and the top 10 water users inside and outside the City limits are highlighted in Table 2-2. The top 10 percent of water users inside and outside the City limits comprise approximately half of the City's metered demand. The top 10 connections (0.4 percent of total) comprise approximately 13 percent of the total metered demand.

The top 10 percent of water users are characterized in Table 2-3 by customer type. Of the top 10 percent, the largest are commercial water users at approximately 32 percent of the total water use. The next largest are residential water users at approximately 29 percent of the total water use. The largest users outside of the City limits are unclassified. Comparing the percentage of connections to the percentage of water use, a proportionate share of the water use by customer type is apparent for the top 10 percent of users, comprising 50 percent of the metered demand.

The top 10 water users, including a mobile home park, a high school, and a heavy industrial customer inside the City limits, comprised approximately 111 AF/year per year or 13 percent of the total metered demand. Four of the top 10 users are unclassified and located outside the City limits, and used approximately 41 AF/year or 37 percent of the top 10 user demand.

Figure 2-2. City of Willits Monthly Water Demands

Figure 2-3. City of Willits
Annual Water Demands

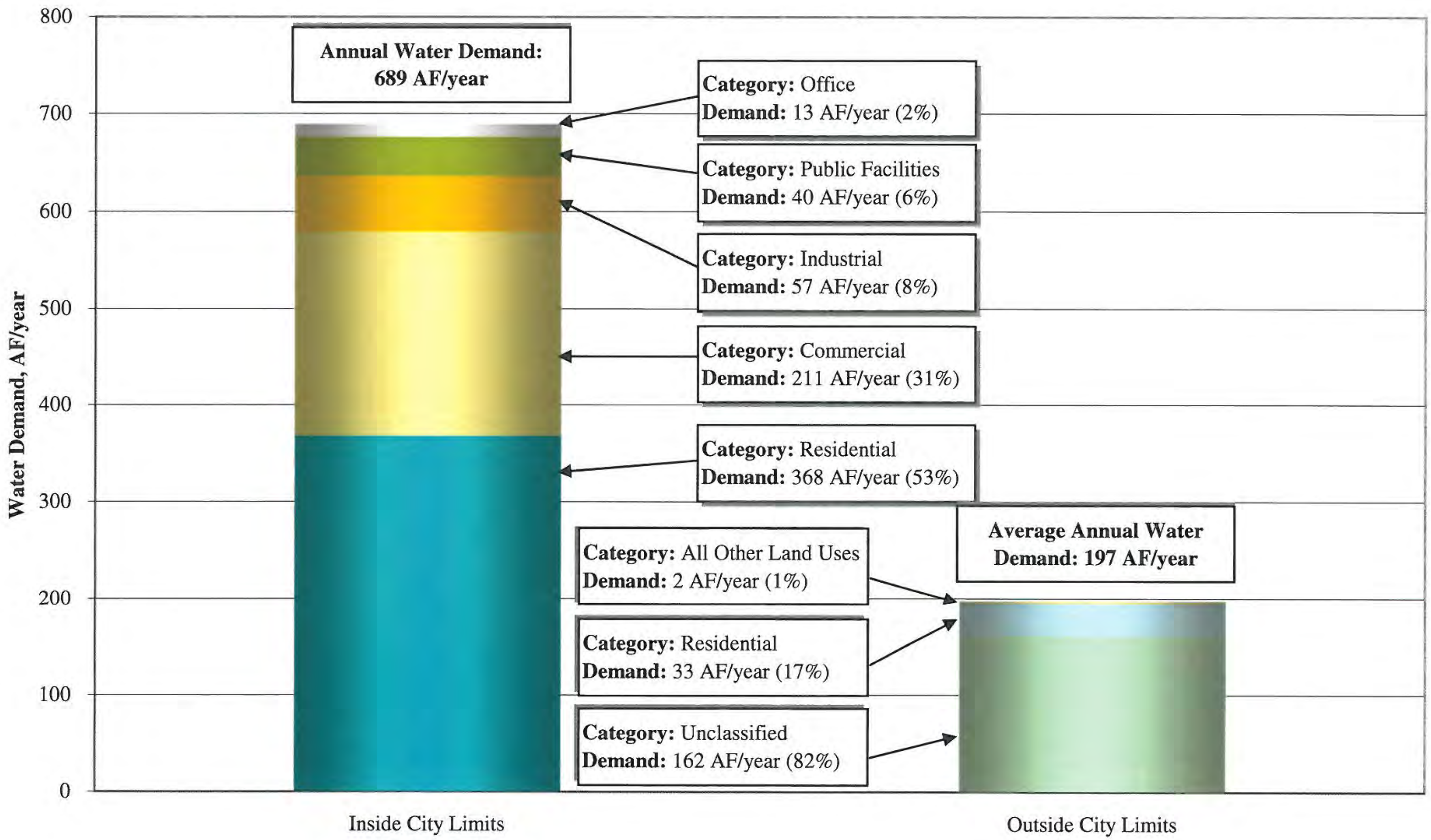


Table 2-2. Top Water Users

	All Connections	Top 10 Percent of Connections	Top 10 Connections
Number of Connections	2,245	225	10
Percent of Total Connections	100	10	0.4
Annual Water Use, AF/year	886	440	111
Percent of Total Annual Water Use	100	50	13
Quantity Delivered Inside City Limits, AF/year	689	354	70
Quantity Delivered Outside City Limits, AF/year	197	86	41

Table 2-3. Top 10 Percent of Water Customers

Customer Type	Number of Connections	Percentage of Number of Connections[a]	Average Annual Water Use, AF/year	Percentage of Water Use[a]
Administrative Office	6	3	7	2
Commercial	75	33	142	32
Industrial	16	7	39	9
Public Facilities	15	7	39	9
Residential	71	32	128	29
Outside, unclassified	42	19	86	19
Total	225	100	440	100

[a] Percentage of top 10 percent of customers

CURRENT LAND USE

Land use areas were calculated from the City zoning map that was adopted in January 1988, but using an electronic (AutoCAD) version of the zoning map dated September 4, 2003. The land use areas from the Vision 2020 Willits General Plan Revision and as calculated from the City zoning map are summarized in Table 2-4.

Some land use area discrepancies are apparent in Table 2-4, potentially resulting from land use adjustments by the City in preparing the General Plan and the zoning map at different times. The difference in total land use area may pertain to City-owned land located outside of the City zoning map such as the airport and water treatment plant. The land use areas in this report are based on the zoning map.

The approximate developed areas of administrative offices, commercial, industrial and public facilities were estimated by overlaying the land use map and the aerial photograph as shown in Figure 2-4. A significant amount of land is available for growth in all categories except commercial, which is 85 percent built out as presented in Table 2-4.

Table 2-4. Land Use Summary

Description	General Plan[a], acres	Zoning Map[b], acres	Difference, acres	Estimated Developed Area[c], acres	Estimated Developed Area, percent[d]
Inside City Limits					
Residential	650	688	38.4	323	47
Industrial	646	580	-66.4	172	30
Commercial	241	241	0.3	204	85
Public Facilities	174	150	-24.4	66	45
Open Space	35	33	-1.7	—	—
Total	1,746	1,692	-53.8	—	—

[a] From Vision 2020 Willits General Plan Revision
[b] As calculated using electronic version of City zoning map
[c] Estimated using overlay of land use map and aerial photograph
[d] Estimated developed area divided by zoning map area

POPULATION

Historical and projected populations for the City were obtained from the 2003-2008 Housing Element as summarized in Table 2-5. The Housing Element used census reports, the State Department of Finance, Mendocino Council of Governments, and various City documents to determine the historical population and to project the future population. From 1980 to 1990, the City experienced an average annual growth rate of 2.5 percent. From 1990 to 2000 the City experienced an average annual growth rate of 0.1 percent. The 2000 census reported a City population of 5,073 people with an average of 2.56 persons per residence.

According to the Housing Element, the annual growth rate from 2000 to 2020 is projected to range from 1.1 to 2.6 percent, with an average annual growth rate of 1.66 percent over the 20-year period. Since the Housing Element stopped at 2020, the average annual growth rate of 1.66 percent was applied to estimate the 2025 and build-out populations of the City.

Table 2-5. Historical and Projected Population

Year	Population[a]	Change	Percent Change	Annual Percent Change[b]
1980	4,008	—	—	—
1990	5,027	1,019	25.4	2.5
2000	5,073	46	0.9	0.1
2005	5,732	659	13.0	2.6
2008	5,930	198	3.5	1.2
2010	6,062	132	2.2	1.1
2020	7,050	988	16.3	1.6

[a] Population is projected after 2000
[b] Based on Housing Element population projections, and averaged in each 2 to 10-year increment

The build-out population was calculated using the residential areas in the zoning map, land use densities from the Housing Element, and the average occupancy of 2.56 persons per residence. The Housing Element reported both maximum allowable and typical land use densities. The resulting population projections for single family, medium density, multiple family, and residential estate residences are summarized in Table 2-6. The estimated total City population at build-out ranges from 13,058 to 16,019 people. Depending on actual density, build-out is estimated to occur between 2057 and 2070 as shown in Figure 2-5. The projected 2025 population is approximately 7,654 persons with an average annual growth rate of 1.66 percent.

UNIT WATER DEMANDS

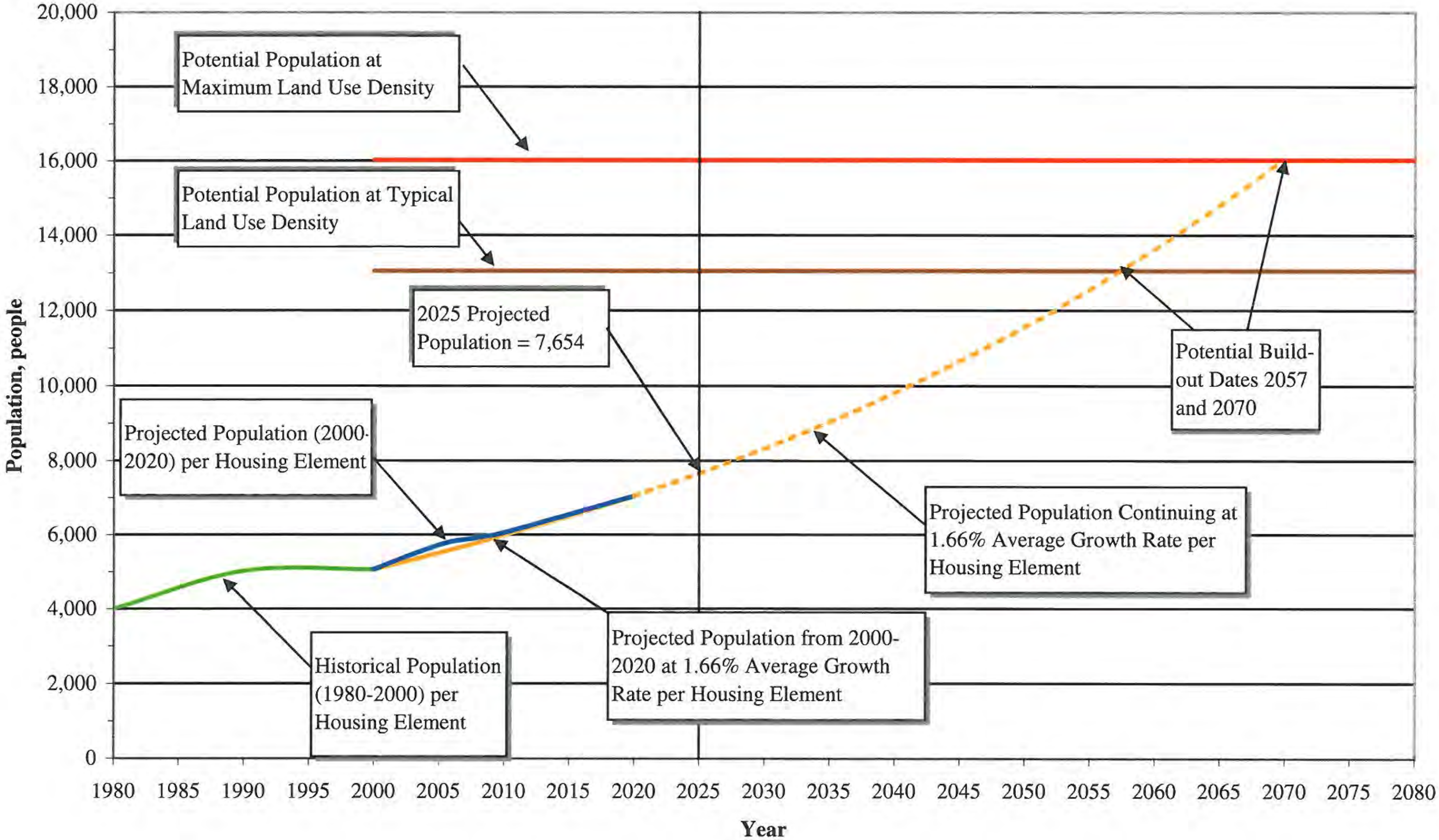
Unit water demands were calculated as a function of population and land use. To calculate the population based unit water demand, the total water demand was divided by the total population. Population based unit water demands are typically expressed in gallons per capita (person) per day (gpcd) or AF per person per year (AF/person/year). Projected water demands are calculated by multiplying the projected population by the estimated unit water demand, which is assumed to remain constant in the projection. Because development of the various land-use areas (residential and non-residential) could proceed at different rates and thereby change the unit water demands, projecting community water demands on a population basis carries an inherent risk of inaccuracy. Nevertheless, population based water demand projections can provide a reasonable comparison to land use based projections.

Table 2-6. Projected Build-Out Population

		Density, units per acre[a]			Projected Number of Units			Projected Population, persons	
Land Use Code	Description	Typical[b]	Maximum	Land Use Area[c], acres	Typical	Maximum	Persons per Household[d]	Typical	Maximum
R1	Single Family Residence	7	7.26	365	2,555	2,650	2.56	6,541	6,784
R2	Residential Medium Density	14	14.52	70	986	1,022	2.56	2,523	2,617
R3	Multiple Residence	18	29.04	77	1,384	2,233	2.56	3,544	5,717
RE	Residential Estate	1	2	176	176	352	2.56	451	902
Total		—	—	688	5,101	6,257	—	13,058	16,019

[a] Based on General Plan
[b] Based on historical densities
[c] Calculated/measured from land use map
[d] Average from 2000 Census

Figure 2-5. City of Willits
Historical and Projected Populations



The land use methodology takes into account the potential for the various land use areas to develop at different rates, and demands are calculated by dividing the current water demand by the developed area for each land use type to obtain a unit water demand, typically expressed in AF per year per acre (AF/year/acre), or AF per year per residential unit (AF/year/unit). Water demands are then projected by multiplying the total build-out area for each land use type by the estimated unit water demand in AF/year/acre or multiplying the number of residential units at build-out by the estimated unit water demand in AF/year/unit.

Both population and land use based projections were developed in this study, and the results were compared to formulate a water demand projection.

Population Based Water Demand

The population based water demands, as determined from total sales data and the reported population of the City, are summarized in Table 2-7. The annual per capita water demand from 1985 to 2000 ranged from 146 to 168 gpcd and averaged 154 gpcd. The annual average per capita water demand increased in 1999/2000 to approximately 168 gpcd or 0.19 AF/person/year using the actual 2000 census population.

Because the maximum unit water demand of 0.19 AF/person/year occurred in 2000, which was a census year, a unit demand of 0.19 AF/person/year or 170 gpcd was used to project future water demands in this study.

Land Use Based Water Demand

Historical and estimated unit water demands for each land use type inside and outside the City limits are presented in Table 2-8. Residential unit water demands are based on the annual customer meter readings divided by the number of services or connections. Commercial, industrial, and public facility unit water demands are based on the annual customer meter readings divided by the respective estimated developed areas from Table 2-4.

The current unit water demands were rounded up and used as the estimated future unit water demands as presented in Table 2-8.

PROJECTED WATER DEMANDS

Water demands were projected to 2025 and build-out using both the population and the land use methodologies. The build-out projections are based on the zoning map and General Plan, and not influenced by the water supply and other growth limitations.

Population Based Demand Projections

The population projections in 2025 and at build-out with typical and maximum residential land use densities were multiplied by the unit water demand as summarized in Table 2-9. The projected 2025 customer water demand of approximately 1,460 AF/year is 65 percent greater than the current customer water demand.

Table 2-7. Historical Per Capita Unit Water Demands

Year	Population[a]	Total Sales[b], AF/year	Unit Water Demand	
			AF/person/ year	gpcd
1980	4,008	—	—	—
1981	4,110	—	—	—
1982	4,212	—	—	—
1983	4,314	—	—	—
1984	4,416	—	—	—
1985	4,518	767	0.17	151
1986	4,619	774	0.17	150
1987	4,721	847	0.18	160
1988	4,823	788	0.16	146
1989	4,925	854	0.17	155
1990	5,027	894	0.18	159
1991	5,032	872	0.17	155
1992	5,036	829	0.16	147
1993	5,041	839	0.17	149
1994	5,045	824	0.16	146
1995	5,050	838	0.17	148
1996	5,055	909	0.18	160
1997	5,059	855	0.17	151
1998	5,064	860	0.17	151
1999	5,068	943	0.19	166
2000	5,073	954	0.19	168
Minimum	4,518	767	0.16	146
Maximum	5,073	954	0.19	168
Average	4,947	853	0.17	154

[a] Interpolated population from Housing Element
[b] From customer meter data

The projected customer water demand at build-out ranges from 2,490 to 3,050 AF/year depending on the residential land use density, which may continue at its historical value or reach the maximum allowable density. The build-out water demand is anticipated to occur between 2057 and 2070 and represents a significant increase from the City's current customer water demand of 886 AF/year. Such an increase in demand may appear unrealistic, but it is consistent with the General Plan, the Housing Element and other available planning documents.

Table 2-8. Land Use Water Demand Factors

						Current Unit Water Demands		Estimated Future Unit Water Demands[d]	
	Land Use Code	Description	Annual Demand, AF/year[a]	Number of Services[a]	Approximate Developed Area, acre[b][c]	AF/year /unit	AF/year /acre	AF/year /unit	AF/year /acre
Inside City Limits	C0	Administrative Offices	13	29	5	—	2.5	—	2.5
	C1	Community	134	345	115	—	1.2	—	1.5
	C2	Heavy Commercial	77	74	84	—	0.9	—	1.0
	IP	Industrial Park	3	9	—	—	—	—	1.0
	MH	Heavy Industrial	44	69	158	—	0.3	—	0.5
	ML	Limited Industrial	9	29	14	—	0.7	—	1.0
	PF	Public Facility	40	41	66	—	0.6	—	1.0
	R1	Single Family	226	848	—	0.27	—	0.28	—
	R2	Residential Medium	35	63	—	0.55	—	0.56	—
	R3	Multiple Residence	97	204	—	0.47	—	0.48	—
	RE	Residential Estate	10	33	—	0.32	—	0.34	—
	I	Inside City, unclassified	0	—	—	—	—	—	—
		Total Inside	689	1,744	—	0.40	—	—	—
Outside City Limits	C0	Administrative Offices	0.3	1	—	0.3	—	0.3	—
	C1	Community	2	2	—	1.0	—	1.0	—
	C2	Heavy Commercial	—	—	—	—	—	—	—
	IP	Industrial Park	—	—	—	—	—	—	—
	MH	Heavy Industrial	0.1	1	—	0.1	—	0.1	—
	ML	Limited Industrial	—	—	—	—	—	—	—
	PF	Public Facility	0.1	1	—	0.1	—	0.1	—
	R1	Single Family	31	136	—	0.2	—	0.2	—
	R2	Residential Medium	—	—	—	—	—	—	—
	R3	Multiple Residence	—	—	—	—	—	—	—
	RE	Residential Estate	2.3	5	—	0.5	—	0.5	—
	O	Outside City, unclassified	162	355	—	0.5	—	0.5	
		Total Outside	197	501	—	0.39		—	—
		Total Inside and Outside	886	2,245	—	—	—	—	—

(a) Based on August 2003 – July 2004 customer meter readings
(b) Estimated in City from aerial photo dated July 12, 1993 and zoning map dated January 1998
(c) Indeterminate outside City limits
(d) Current values rounded upward for conservative projections

Table 2-9. Population Based Demand Projections

	Population, people	Unit Water Demand, AF/person /year	Projected Water Demand, AF/year
2025	7,654	0.19	1,458
Build-out, Typical Density	13,058	0.19	2,488
Build-out, Maximum Density	16,019	0.19	3,052

Land Use Based Demand Projections

Residential water demands inside the City limits at build-out were projected at the typical and maximum allowable densities as defined in the Housing Element. The housing unit densities in Table 2-6 were multiplied by the number of acres in each residential zone to determine the maximum number of connections. As summarized in Table 2-10, the unit water demand was multiplied by the number of connections to estimate the residential water demand in the City of approximately 1,990 AF/year at typical density and 2,500 AF/year at maximum density.

Projected water demands for administrative offices, commercial, industrial, and public facilities were calculated by multiplying the unit water demand by the zoning map area for each land use. The total projected non-residential water demand is approximately 840 AF/year.

It was assumed that the City will continue to serve the current customers but will not add customers outside the City limits without an annexation(s). Since annexations are not planned at this time, the projected demand outside the City limits is the same as the current demand of approximately 200 AF/year. In considering any future annexation(s), the City should consider the additional water demand that will result from the annexation(s).

In round numbers, the build-out water demand ranges from 3,000 to 3,500 AF/year depending on the actual residential land use densities. Demand curves spanning from 2000 to the projected population build-out dates from Figure 2-5, assuming build-out for all land uses occur at the same time as residential build-out, are presented in Figure 2-6. Customer water demands in 2025 were interpolated from the curves and range from 1,525 to 1,580 AF/year for typical and maximum land use densities, respectively.

Comparison of Population and Land Use Based Demand Projections

The projected 2025 water demand is approximately 1,458 AF/year (Table 2-9) using the population method and between 1,525 and 1,580 AF/year using the land use method for typical and maximum residential land use densities, respectively (Figure 2-6). While the population and land use projections for 2025 are not very different, the land use projections are somewhat higher and therefore, are used as the basis for the remainder of this study. The current demand and land use based demand projections are summarized in Table 2-11.

Table 2-10. Land Use Based Demand Projections

Land Use Code	Description	2003-2008 Housing Element: Typical Density, units per acre	2003-2008 Housing Element: Maximum Density, units per acre	Zoning Map Area, acres	Typical No. of Connections	Max. No. of Connections	Estimated Future Unit Water Demands: AF/year /unit	Estimated Future Unit Water Demands: AF/year/acre	Water Demand at Build-Out: Based on Typical Density, AF/year	Water Demand at Build-Out: Based on Maximum Density, AF/year
C0	Administrative Offices	—	—	15	—	—	—	2.5	38	38
C1	Community Commercial	—	—	142	—	—	—	1.5	213	213
C2	Heavy Commercial	—	—	84	—	—	—	1.0	84	84
IP	Industrial Park	—	—	99	—	—	—	1.0	99	99
MH	Heavy Industrial	—	—	445	—	—	—	0.5	223	223
ML	Limited Industrial	—	—	35	—	—	—	1.0	35	35
PF	Public Facility	—	—	150	—	—	—	1.0	150	150
R1	Single Family Residence	7	7.26	365	2,555	2,650	0.28	—	716	743
R2	Residential Medium Density	14	14.52	70	986	1,022	0.56	—	552	573
R3	Multiple Residence	18	29.04	77	1,384	2,233	0.48	—	659	1,064
RE	Residential Estate	1	2	176	176	352	0.34	—	59	118
OS	Open Space	—	—	33	—	—	—	—	—	—
O	Outside city limits	—	—	—	—	—	—	—	197	197
Total		—	—	1,692	5,101	6,257	—	—	3,026	3,537

Figure 2-6. City of Willits
Land Use Based Water Demand Projections

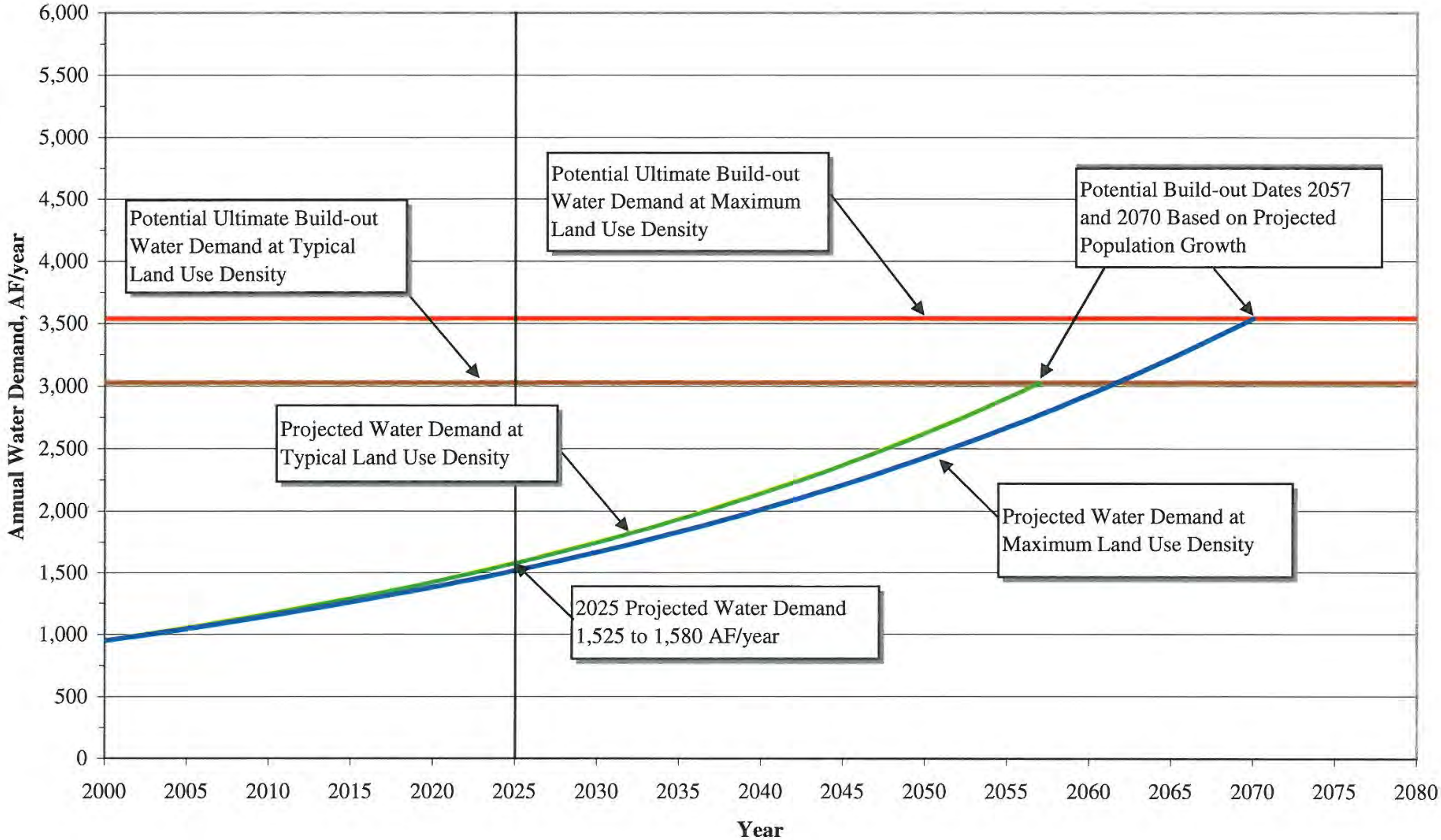


Table 2-11. Current and Projected Customer Water Demands(a)

	Current Density	Average Density	Maximum Density
Year	Annual Demand, AF/year	Annual Demand, AF/year	Annual Demand, AF/year
Current	886	—	—
2025	—	1,525	1,580
2057	—	3,030	—
2070	—	—	3,540

[a] Does not include UAF water demand

DEMAND MANAGEMENT MEASURES

The City already practices some degree of demand management (i.e. water conservation). Although the City is not a signatory to the California Urban Water Conservation Council (CUWCC) Memorandum of Understanding, the City has implemented some of the CUWCC Best Management Practices (BMPs), which are equivalent to the demand management measures (DMMs) in California Water code section 10631 subdivision (f). The City may consider implementing additional BMPs/DMMs, and the water supply savings potential of the additional BMPs/DMMs is estimated as a function of the projected 2025 customer water demand.

DMM 1 - Water Survey Program for Single and Multiple Family Residential Customers (CUWCC BMP 1)

A water survey program for single and multiple family residential customers would entail directly contacting at least 20 percent of the City's residential customers via letter or telephone in each annual reporting period, arranging indoor and outdoor water use surveys, and identifying the associated water savings potential. The indoor and outdoor water use surveys would include:

- Checking for leaks in plumbing fixtures, including toilets, faucets and meters
- Checking showerhead and faucet aerator flow rates, and offering to replace or recommending replacement if flow rates are excessive
- Checking toilet flow rates, offering to install or recommending installation of displacement device, replacing leaky flapper, and advising customer of any available ultra-low flush toilet (ULFT) replacement program if flow rates are excessive
- Checking irrigation system controllers and making or recommending program adjustments if irrigation rates are excessive

Potential water savings from DMM1 are discussed after the presentation of DMM 2.

DMM 2 - Residential Plumbing Retrofit (CUWCC BMP 2)

The City already requires the installation of water conserving fixtures in remodeled or newly constructed residential housing and applies credits to customer bills for customers who repair their own plumbing in the case of leaks. The CUWCC assumes the water savings indicated in Table 2-12 with implementation of residential plumbing retrofits.

The CUWCC also assumes that making or recommending adjustments to irrigation system controllers will result in a residential outdoor water use reduction of 10 percent.

Table 2-12. Water Savings via Plumbing Retrofits

	Pre-1980 Construction	Post-1980 Construction
Low-flow showerhead retrofit	7.2 gpcd	2.9 gpcd
Toilet retrofit (5-year life)	1.3 gpcd	0.0 gpcd
Leak repair	0.5 gpcd	0.5 gpcd
Total	9.0 gpcd	3.4 gpcd

DDM 1 and DDM 2 Water Savings Estimate

The City population was 4,008 in 1980, according to the Census Bureau, and the projected 2025 population is 7,654. The population outside the City limits that is served by City water is estimated as 1,270 based on the current 496 connections and an average of 2.56 people per connection. Assuming that 20 percent of the residential customers already have completed plumbing retrofits in the pre-1980 constructed houses and the resultant water savings were part of the customer water demand projections in Table 2-11, the additional water savings potential is approximately 53 AF/year in the remaining 80 percent of pre-1980 constructed houses. The estimated population increase from 1980 to 2025 is 3,646. Assuming the additional population currently lives or will live in post 1980 constructed houses with completed plumbing retrofits or equivalent, the additional water savings potential is approximately 14 AF/year.

The projected 2025 residential water demand is approximately 930 AF/year. Therefore, completing the outdoor water use surveys and making adjustments to irrigation system controllers equates to a water savings potential of 93 AF/year.

The total additional indoor and outdoor water savings potential with 100 percent implementation of DMMs 1 and 2, therefore, is approximately 160 AF/year. While 100 percent implementation is the ultimate goal for the City, the timeframe for implementation will depend on available funding and other factors. Therefore, the estimated additional water savings by 2025 are 48 AF/year assuming 30 percent additional participation over the course of 20 years, which is similar to the experience elsewhere in California.

DMM 3 - System Water Audits, Leak Detection and Repair (CUWCC BMP 3)

The original water system was constructed in the 1920s. Since acquiring the water system in 1984, the City has implemented an active leak detection and pipeline repair program, investing approximately $3.5 million in pipeline replacements. Through 2005, the City replaced about 26,400 feet of the approximately 170,000 feet of distribution system pipelines. Furthermore the City replaced about 6,200 feet of the 17,500-foot of transmission main in 1997 and another 4,000 feet in 2004-2005. The replaced segments of the original transmission main consisted of leak-prone riveted steel pipe.

Unaccounted for (UAF) water demand is the difference between the system meter data and the customer meter data. Initial estimates of UAF water demand were based on the system meter that was replaced in 2004 and suggested an UAF water demand of approximately 31 percent, meaning the volume measured at the customer meters was 69 percent of the volume measured at the system meter (i.e., exiting the clearwell). However, a reduced UAF water demand is evident since replacement of the system meter and more of the transmission main although not enough data are available at this time to conduct a statistical analysis. Consequently, an UAF water demand of approximately 24 percent of the customer demand, typical for older water systems, was assumed as the current condition.

A more accurate estimate of the UAF water demand is anticipated as more data are collected from the new finished water flow meter in the future. Through the City's leak detection, pipeline replacement, and customer meter replacement programs, the UAF water demand is anticipated to decline to 12 percent of the customer water demand by 2025. The volumetric reduction of UAF water demand by 2025 is estimated after factoring in the water savings from implementation of other DMMs.

DMM 4 - Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections (CUWCC BMP 4)

The CUWCC defines a commodity rate structure as a billing system in which water customers are charged by metered volume. The City already meters each customer account and applies commodity rates. The City bills monthly based on customer meter size and consumption using fixed and volumetric charges, respectively. For the volumetric charge, the City currently applies a uniform rate of $2.30 per 100 cubic feet.

Although the CUWCC assumes a water demand reduction with implementation of commodity rates, additional demand reduction is not anticipated in the City because DMM 4 is already in place and was factored into the demand projections.

DMM 5 - Large Landscape Conservation Programs (CUWCC BMP 5)

Typical large landscape conservation programs include installing separate irrigation meters, performing water use surveys, notifying customers of the start and end of the irrigation season, and promoting climate-appropriate landscapes. In some cases, financial incentives are offered to improve irrigation system efficiency including loans, rebates and grants for the purchase and/or installation of water efficient irrigation systems.

The CUWCC estimates a water savings of 15 percent with a large landscape conservation and incentive program for Commercial, Industrial and Institutional (CII) accounts. The CII accounts within the City are projected to use approximately 420 AF/year in 2025. Applying 15 percent, the water savings potential is approximately 63 AF/year. While 100 percent implementation is the ultimate goal for the City, the timeframe for implementation will depend on available funding and other factors. The estimated water savings by 2025 are 13 AF/year assuming 20 percent participation over the course of 20 years and recognizing that most of the CII customers in the City are industries without significant landscaping on their properties.

DMM 6 - High Efficiency Washing Machine Rebate Programs (CUWCC BMP 6)

The CUWCC estimates approximately 5,100 gallons per year of potential savings for each household that replaces a low efficiency clothes washer with a high efficiency clothes washer. For the projected 2025 population of 7,654 within the City and 1,270 outside the City limits and a density of 2.56 persons per household, the 3,486 residential customers could save 47 AF/year with 100 percent participation in DMM 6 assuming that all existing clothes washers are low efficiency. While 100 percent implementation is the ultimate goal for the City, the timeframe for implementation will depend on available funding and other factors. A water savings estimate of 5 AF/year is based on 10 percent participation by 2025 given the economic conditions in the City and the possibility that some existing clothes washers already are high efficiency.

Implementation of a light-wash commercial and multi-family housing coin-operated washing machine rebate program could provide additional savings potential, but insufficient data are available to estimate the benefits.

DMM 7- Public Information Programs (CUWCC BMP 7)

The CUWCC does not provide any particular water savings assumption for a public information program, but recommends implementation of such a program with the following elements:

- Promotion of water conservation and water conservation related benefits.
- Provision of a speaker(s) for employee and community groups and the media; paid and public service advertising; bill inserts; billing information that includes billing period usage compared to the previous year.
- Coordination with other government agencies, industry groups, public interest groups, and the media.

DMM 8 - School Education Programs (CUWCC BMP 8)

The CUWCC does not provide any particular water savings assumption for a school education programs, but recommends implementation of such a program with the following elements:

- Promotion of water conservation and water conservation related benefits.
- Coordination with the school district(s) and private schools in the water service area to provide instructional assistance, educational materials, and classroom presentations that identify urban, agricultural, and environmental issues and conditions in the local

watershed; distributed materials should meet state education requirements with grade-appropriate materials.

DMM 9 - Conservation Programs for Commercial, Industrial and Institutional Accounts (CUWCC BMP 9)

The first step of DMM 9 is to identify and rank the following Commercial, Industrial and Institutional (CII) accounts according to water use:

- Commercial Accounts: Any water user that provides or distributes a product or service, such as hotels, restaurants, office buildings, commercial businesses or other places of commerce. Does not include multiple family residences, agricultural users, and customers that fall within the industrial or institutional classifications.

- Industrial Accounts: Any water user that primarily manufactures or processes materials as defined by the Standard Industrial Classifications (SIC) Codes 2000 through 3999.
- Institutional Accounts: Any water using establishment dedicated to public service including schools, courts, churches, hospitals, and government facilities. All facilities serving these functions are considered institutions regardless of ownership.

The next steps of DMM 9 are to accelerate the replacement of existing toilets with ULFTs and execute one of the following programs:

CII Water Use Survey and Customer Incentives Program

- Implement a survey and incentives program similar to DMM 1 but tailored to CII water customers.
- Develop a customer targeting and marketing strategy to complete 10 percent of the CII water use surveys within 10 years of program commencement.
- Directly contact via letter, telephone or personal visit, and offer water use surveys and customer incentives to at least 10 percent of each CII account type on a recurring basis. Follow-up each customer survey, within one year, to review water use reductions and system improvements.

CII Conservation Performance Targets

- Implement a program(s) equaling or exceeding the CII Conservation Performance Target to achieve annual water use savings of 10 percent of the baseline use (1997 or alternative year) by CII customers in the agency's service area over a 10-year period.

Water savings assumptions by the CUWCC are 12 percent and 15 percent for commercial and industrial water users, respectively. The CUWCC has not made similar assumptions for institutional accounts. The projected 2025 commercial and industrial water demands are 257 AF/year and 164 AF/year, respectively. Therefore, the potential savings are approximately 31 AF/year and 25 AF/year, respectively, with 100 percent participation in DMM 9. While

100 percent implementation is the ultimate goal for the City, the timeframe for implementation will depend on available funding and other factors. Therefore, the estimated water savings by 2025 are 16 AF/year for commercial users and 12 AF/year for industrial users assuming 50 percent participation over the course of 20 years, similar to the experience elsewhere in California.

DMM 10 - Wholesale Agency Programs (CUWCC BMP 10)

The City is a water retailer rather than a wholesaler, and therefore, DMM 10 is not applicable to the City water system.

DMM 11 - Conservation Pricing (CUWCC BMP 11)

Conservation pricing gives customers an incentive to reduce their average and/or peak water use. The City already has implemented one type of conservation pricing as described under DMM 4. The City recovers the cost of providing water service through its rates, and bills the water and sewer customers partly based on the metered water use. Nevertheless, the City is planning to conduct a rate study in the near future including the consideration of conservation pricing alternatives, which may include:

- Tiered rates for increments of water use (i.e., increasing block rates).
- Seasonal rates or surcharges to reduce peak demands during summer months.
- Rates that are based on the long run marginal cost or the cost of adding the next increment of capacity to the water system.

The effect of conservation pricing is indefinite because the CUWCC does not provide a water savings assumption for implementation of DMM 11, and the resultant water savings are not estimated in this study. Nevertheless, it is recognized that conservation pricing is consistent with the overall objective of a water conservation program.

DMM 12 - Water Conservation Coordinator (CUWCC BMP 12)

The CUWCC recommends the following responsibilities for a water conservation coordinator position:

- Coordination and oversight of City water conservation programs.
- Preparation and submission of DMM Implementation Report.
- Communication and promotion of water conservation issues to agency senior management; coordination of agency conservation programs with operations and planning staff; preparation of annual conservation budget; participation in the City Council including regular attendance at City Council meetings; and preparation of the conservation elements of the Urban Water Management Plan, if applicable.

Because the CUWCC does not provide any particular water savings assumption for the implementation of DMM 12, the resultant water savings are not estimated in this study.

DMM - 13 Water Waste Prohibition (CUWCC BMP 13)

Water waste prohibitions under DMM 13 include:

- Gutter flooding.
- Single pass cooling systems in new connections.
- Non-recycling in new conveyer car wash and commercial laundry facilities.
- Non-recycling decorative water fountains.

In addition, DMM 13 includes the inspection of water softeners as part of a water audit program and the distribution of information about demand-initiated regenerating and exchange-type water softeners to promote replacement of timer models.

Because the CUWCC does not provide any particular water savings assumption for the implementation of DMM 13, the resultant water savings are not estimated in this study.

DMM - 14 Residential Ultra-Low Flush Toilet Replacement Programs (CUWCC BMP 14)

The CUWCC estimates that approximately 43 gallons per day of savings are possible if two pre-1980 toilets are replaced with two ULFTs in a typical household with an average of 2.5 persons. While 100 percent implementation is the ultimate goal for the City, the timeframe for implementation will depend on available funding and other factors. Therefore, the estimated additional water savings by 2025 are 14 AF/year assuming 10 percent of the pre-1980 toilets in City residences are replaced with ULFTs over the course of 20 years, which is similar to the experience elsewhere in California.

SUMMARY AND RESULTS OF DEMAND MANAGEMENT

Implementing DMMs 1, 2, 5 through 9, and 11 through 14 as described herein would result in an overall water savings of 108 AF/year by 2025. The City already has implemented DMMs 3 and 4, and DMM 10 is not applicable to the City. Additional savings are achievable as the City continues to pursue 100 percent participation in the DMMs in the future.

Subtracting the savings of 108 AF/year from the projected 2025 customer water demand of 1,580 AF/year results in a reduced demand of 1,472 AF/year. Then applying the UAF water demand goal of 12 percent to 1,472 AF/year results in a 2025 UAF water demand of 177 AF/year. Therefore, the continued implementation of DMM 3 will save an additional 177 AF/year compared to the 2025 condition with an UAF water demand of 24 percent. In other words, the UAF water demand will decline by 17 percent while the customer water demand increases by 78 percent from the current condition to 2025. The total water savings estimate of 285 AF/year by 2025, therefore, is almost 20 percent of the projected 2025 customer water demand.

MONTHLY WATER SUPPLY REQUIREMENTS

Current and projected monthly water demands are used in the existing water supply analysis. The average monthly water demands for the period of August 2002 through July 2004 were calculated as a percentage of the annual demand, as presented in Table 2-13. As is typical for most municipal water systems, the lowest customer water demand is experienced in February and the greatest customer water demand is experienced in July.

Table 2-13. Current Average Monthly Customer Water Demands

Month	Demand, AF	Percentage of Annual	Month	Demand, AF	Percentage of Annual
January	50.6	5.7	July	112.4	12.7
February	48.6	5.5	August	104.5	11.8
March	54.3	6.1	September	89.7	10.1
April	58.4	6.6	October	78.4	8.8
May	72.0	8.1	November	54.1	6.1
June	101.3	11.4	December	62.1	7.0
			Total	886.4	100.0

The monthly customer water demands are listed together with monthly estimates of UAF water demand and the resulting net monthly water demands in Table 2-14.

The net monthly water demands in Tables 2-14 and 2-15 represent the demands on the Morris/Centennial Reservoir system if the City does not develop a supplemental water supply. As described in Section 3, the Morris/Centennial Reservoir system capacity is analyzed in the absence of a supplemental water supply to determine the current and projected 2025 worst-case water supply deficits. Supplemental water supply requirements and alternatives to eliminate the deficits are evaluated in Sections 4 and 5, respectively.

The monthly percentages from Table 2-13 were applied to the projected annual customer water demand for 2025 in Table 2-15 along with monthly estimates of demand reduction via DMMs and monthly estimates of UAF water demand at an annual average of 12 percent.

Table 2-14. Current Water Supply Requirements

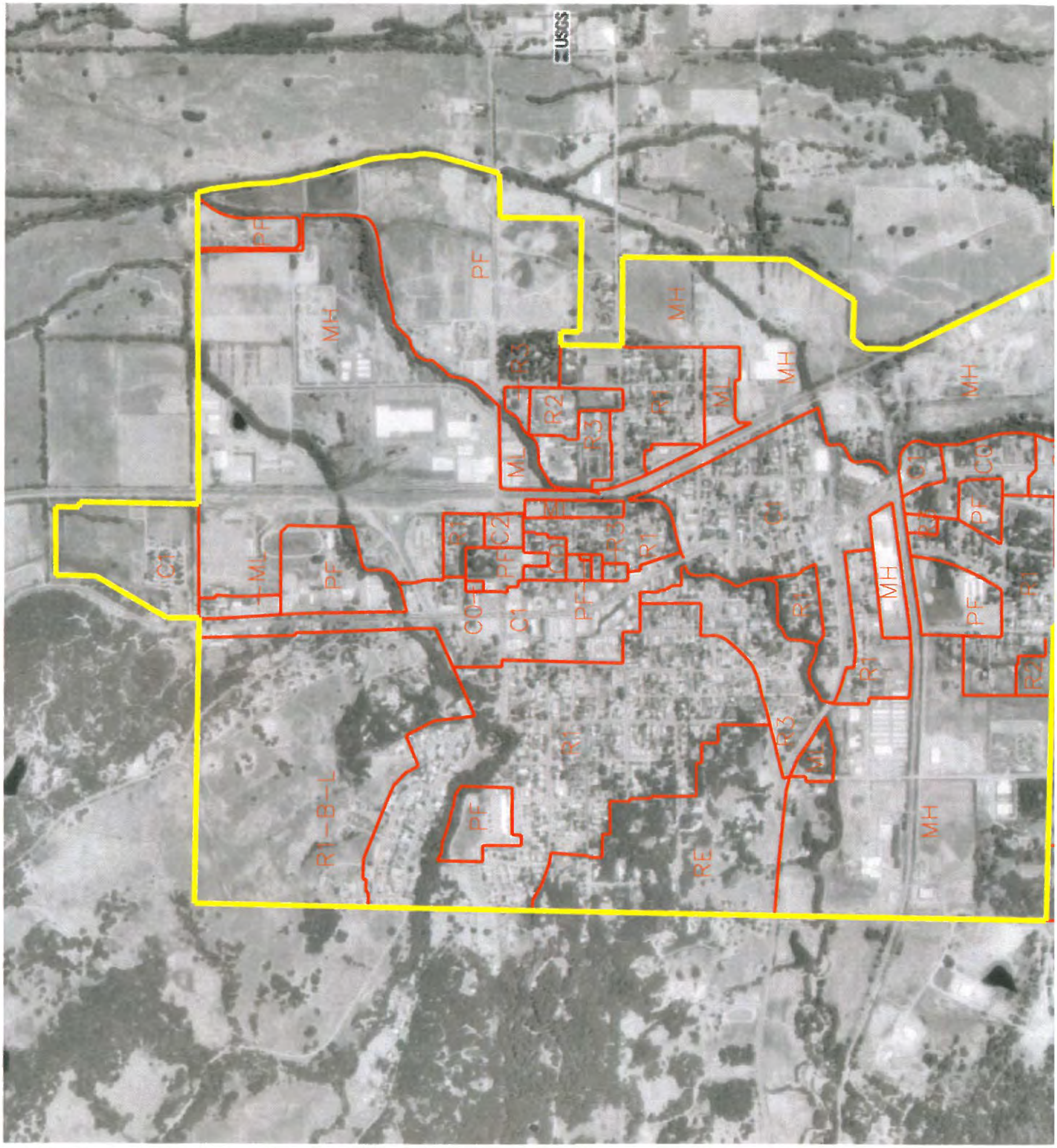
	Customer Water Demand, AF	Demand Reduction via DMMs, AF[a]	UAF Water Demand, AF[b]	Net Monthly Water Demand, AF
January	50.6	—	16.0	66.6
February	48.6	—	16.7	65.3
March	54.3	—	17.4	71.6
April	58.4	—	18.1	76.5
May	72.0	—	18.8	90.8
June	101.3	—	19.5	120.8
July	112.4	—	19.5	131.9
August	104.5	—	18.8	123.3
September	89.7	—	18.1	107.8
October	78.4	—	17.4	95.8
November	54.1	—	16.7	70.8
December	62.1	—	16.0	78.0
Total	886.4	—	212.7	1099.1

[a] With current savings via DMMs 3 and 4 not estimated but considered as baseline
[b] With current annual average of 24 percent of customer water demand

Table 2-15. Projected 2025 Water Supply Requirements

	Customer Water Demand, AF	Demand Reduction via DMMs, AF[a]	UAF Water Demand, AF[b]	Net Monthly Water Demand, AF
January	90.2	6.8	13.2	96.7
February	86.6	6.8	13.8	93.7
March	96.7	7.7	14.4	103.5
April	104.1	8.6	15.0	110.6
May	128.4	9.5	15.6	134.6
June	180.6	10.4	16.2	186.4
July	200.4	11.3	16.2	205.3
August	186.3	11.3	15.6	190.7
September	159.9	10.4	15.0	164.6
October	139.8	9.5	14.4	144.8
November	96.4	8.6	13.8	101.7
December	110.6	7.7	13.2	116.2
Total	1580.0	108.0	176.6	1648.6

[a] With current savings via DMMs 3 and 4 not estimated but considered as baseline
[b] With anticipated annual average of 12 percent of customer water demand



S:\Clients\706-04 Willits\04-02 Water Supply Planning Study\CAD\ZONING MAP 9-4-03.dwg 1-10-06 01:44:18 PM JSeebach

SOURCE: - CITY OF WILLITS, ADOPTED JANUARY, 1988
- AERIAL PHOTOGRAPHY DATED JULY, 1993

3. EXISTING WATER SUPPLY CAPACITY

The existing City water supply is surface water from the Davis Creek watershed, impounded in reservoirs by the Centennial and Morris Dams. Figure 3-1 is a graphical depiction of the watershed together with photographs of the Centennial and Morris Reservoir system.

Centennial Reservoir captures runoff from the upper portion of the Davis Creek watershed to a maximum storage capacity of 635 AF when the flashboards are installed along the spillway in the spring and summer months. Since construction of the dam in 1989, Centennial Reservoir has filled to capacity in all but two years. Water is released from Centennial Reservoir into Morris Reservoir during the summer months and in the event that Centennial Reservoir overfills at other times of the year.

Controlled releases from Centennial Reservoir are the only inflow to Morris Reservoir during the summer months. Morris Reservoir has a maximum storage capacity of 726 AF when the flashboards are installed along the spillway in the spring and summer months. Because the City has captured and retained its water supply further upstream since the construction of Centennial Reservoir, Morris Reservoir has filled to capacity in only eight of the past 15 years.

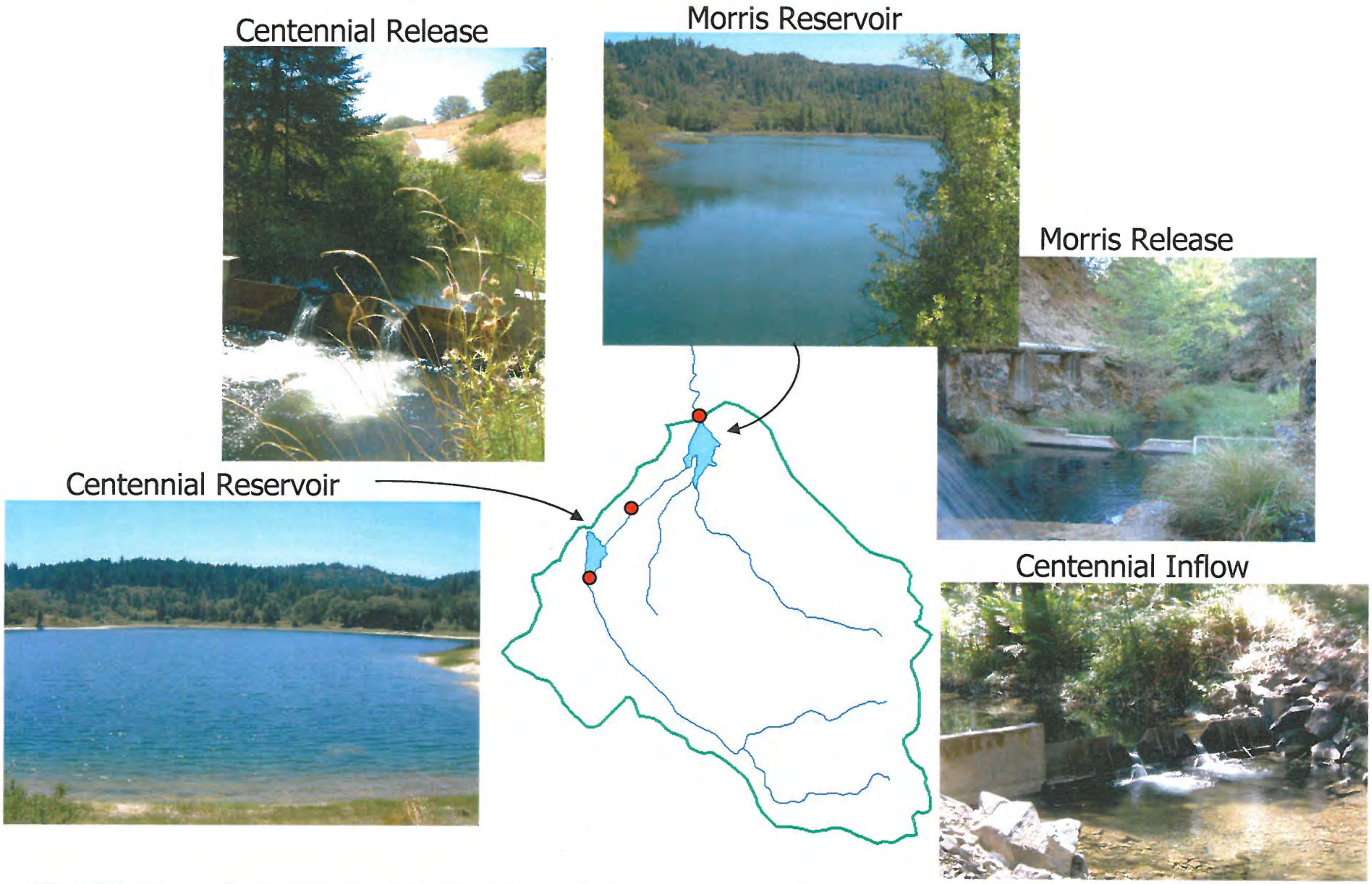
WATER SUPPLY SIMULATIONS

The current and projected 2025 net monthly water demands summarized in Tables 2-14 and 2-15, respectively, and a water supply simulation model described in Appendices A, B and C were used to analyze the delivery capacity of the Centennial and Morris Reservoir system. With current water demands and reservoir operations, the modeling forecasts water supply deficits in 10 of the 34 simulated years (almost 30 percent of the years). Figure 3-2 depicts the simulated deliveries and deficits graphically with each bar representing the current demand of 1,099 AF. The shaded portion of each bar represents the volume of water delivered in the simulated year, and the empty portion of some bars represents the anticipated water supply deficit. The average of the deficits (excluding years without shortages) is 275 AF. Based on the hydrologic conditions of an extremely dry year such as 1977, the maximum deficit is 650 AF with current demands.

Figure 3-3 presents the simulated deliveries and deficits with the projected 2025 demand of 1,649 AF. Deficits are anticipated in 29 of the 34 simulated years (85 percent of the years), with an average deficit of 458 AF and maximum deficit of 1,300 AF. The empty portion of some bars in Figure 3-3 represents the additional water supply capacity needed to avoid future deficits.

Figure 3-4 depicts the probability of meeting current and projected 2025 demands with the Centennial and Morris Reservoir system. The blue line, representing simulated deliveries with the current demand, is horizontal to a probability of 70 percent, meaning the demand will exceed the supply in 30 percent of the years. Only 449 AF of supply is available at the right end of the blue line, corresponding to the current maximum deficit of 650 AF.

Figure 3-1. Watershed and Reservoirs



The red line in Figure 3-4 represents simulated deliveries with the projected 2025 demand, and reveals that 1,649 AF is available for 15 percent of the simulated years. Only 349 AF of supply is available at the right end of the red line, corresponding to the projected 2025 maximum deficit of 1,300 AF.

Reservoir storage volumes and deficits with current and future demands, respectively, are presented in Figures 3-5 and 3-6. Deficits occur when reservoir storage falls to minimum operating pool, and further diversions are not possible. Monthly deficits are denoted by the red areas in Figures 3-5 and 3-6.

Figure 3-2. Annual Delivery and Deficit with Current Demands

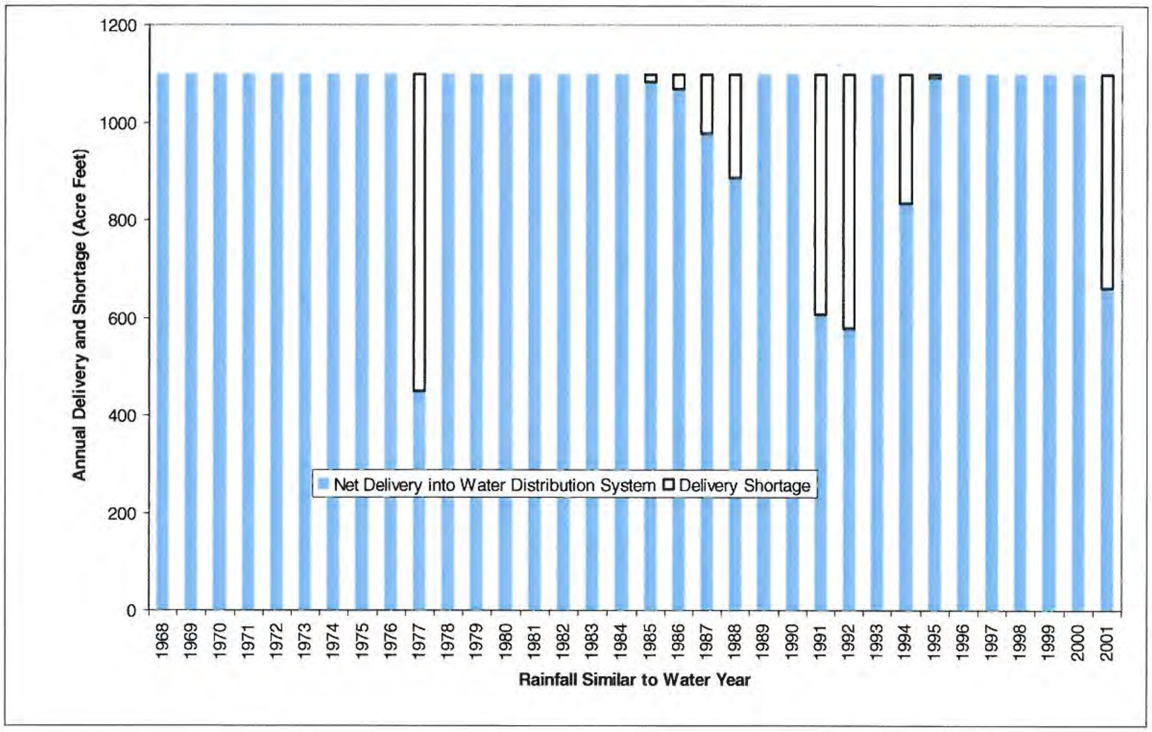


Figure 3-3. Annual Delivery and Deficit with Projected 2025 Demands

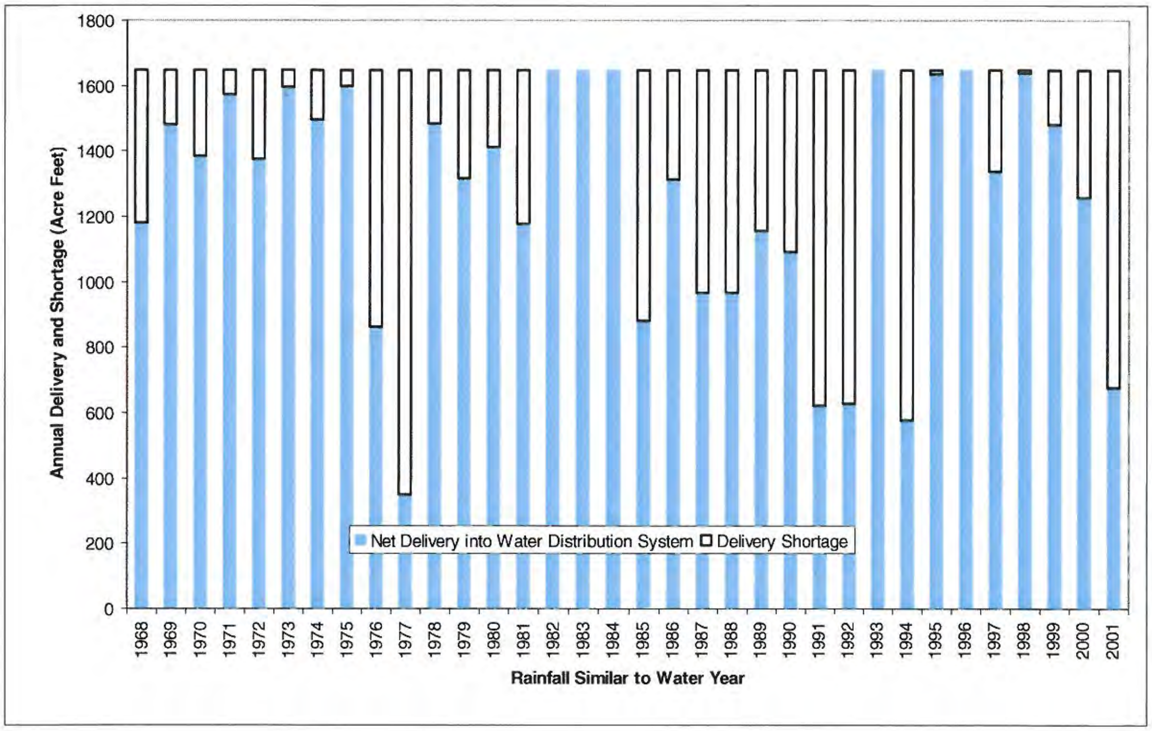


Figure 3-4. Probability of Delivery

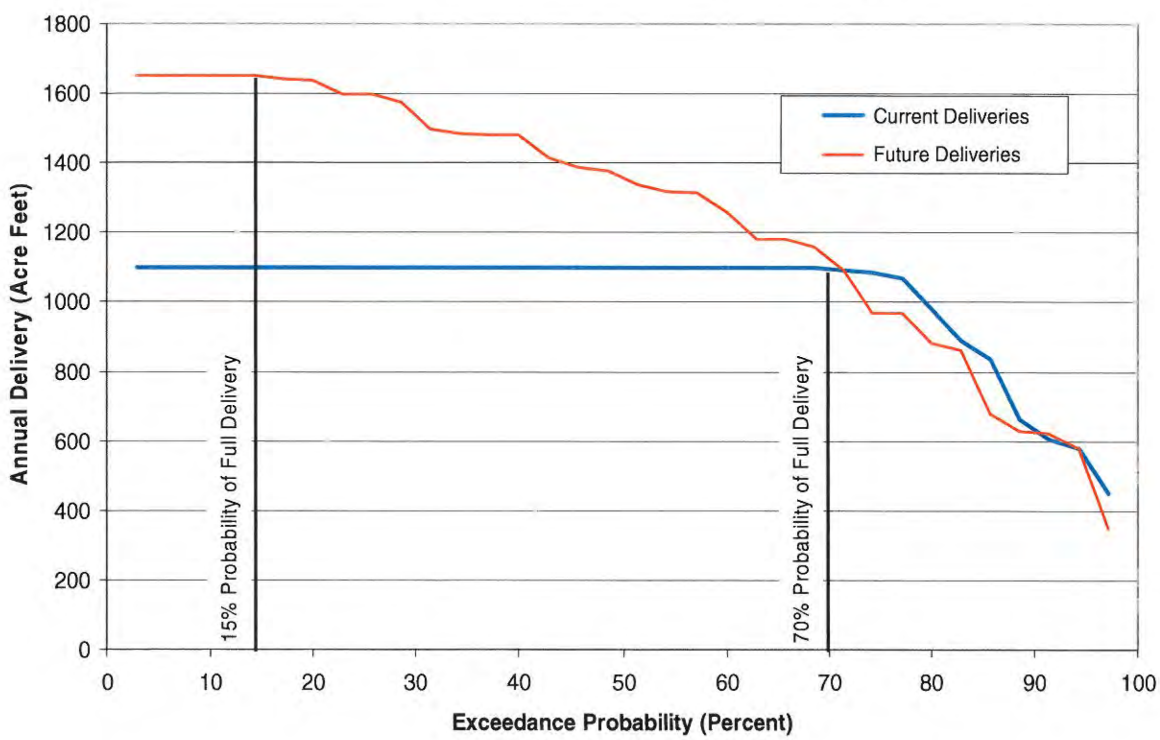


Figure 3-5. End-of-Month Storage and Deficit with Current Demands

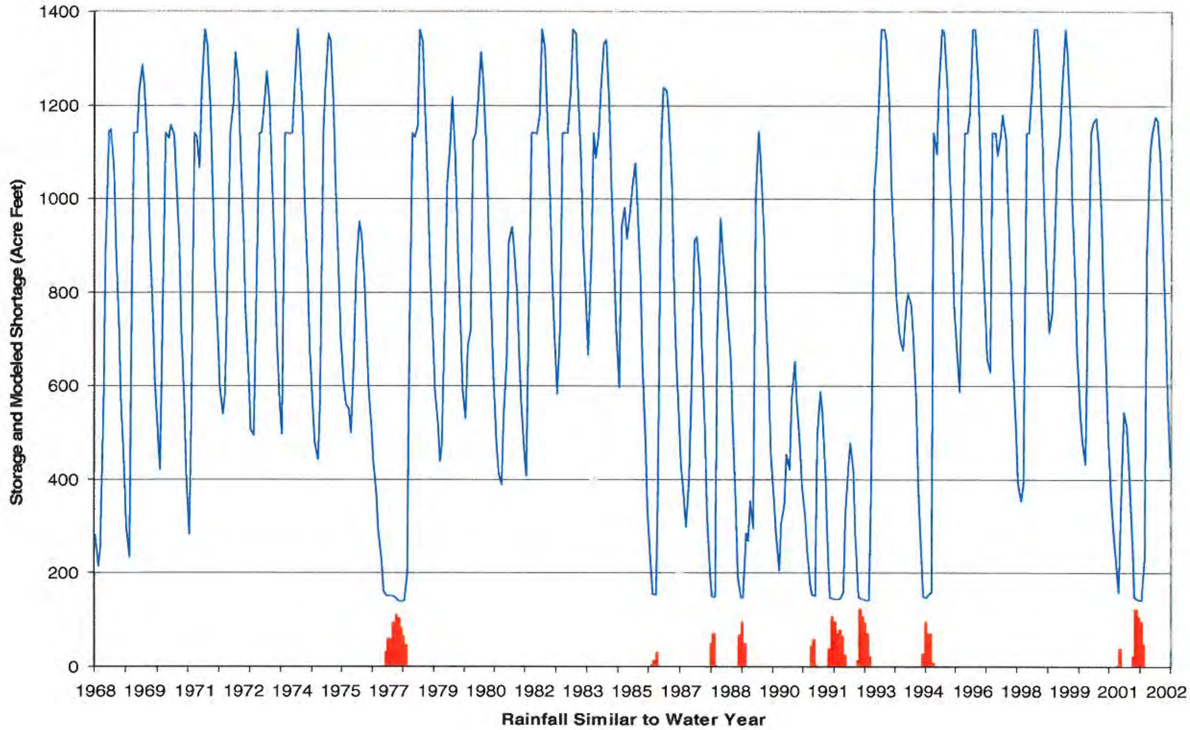
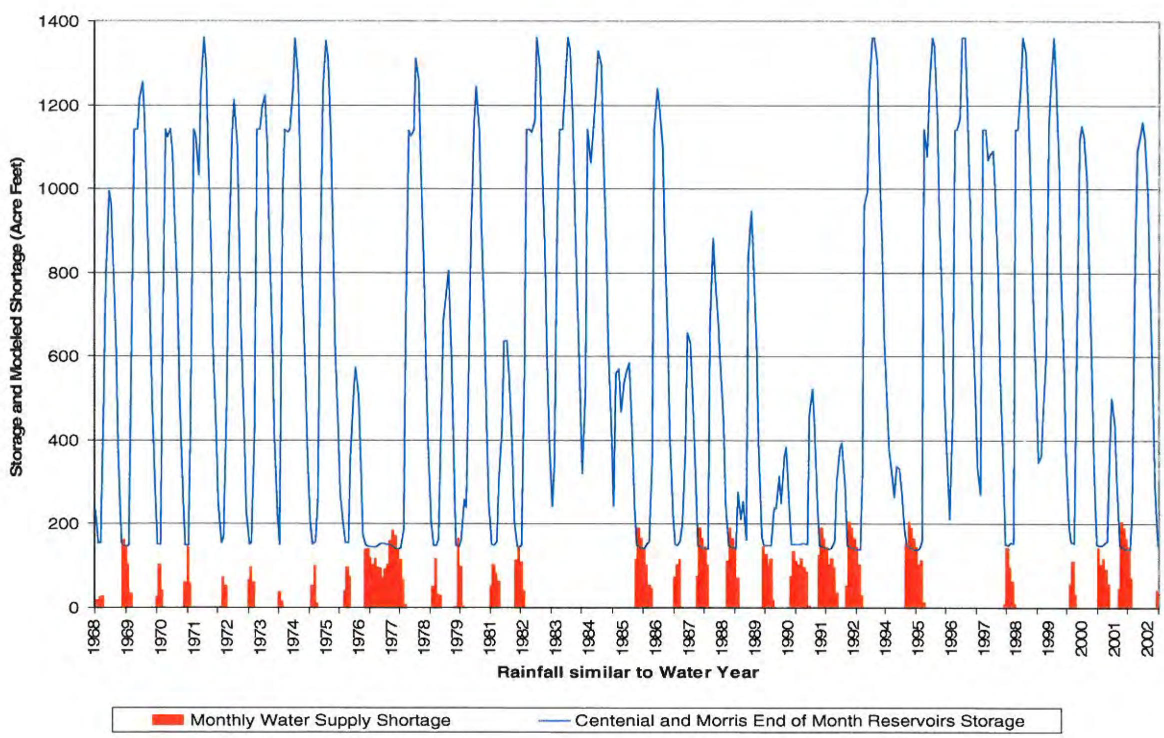


Figure 3-6. End-of-Month Storage and Deficit with Projected 2025 Demands



HYDROLOGY UPDATE

The initial hydrologic analyses and modeling were conducted using DWR stream flow measurements from 1986 to 1988. While only 27 measurements were reported by DWR, the resulting simulation compares well with the DWR data, and the simulated data correlate closely to the Elder Creek gage. Details of the initial hydrologic analyses and reservoir simulations are provided in Appendices A, B, C and D.

The City has collected Davis Creek stream flow data periodically since 1999 and recently upgraded the water level gages to record the data automatically. In 2005, the water levels were recorded every six hours and converted to stream flow data. These data were correlated to the Elder Creek gage, and the hydrologic dataset was updated in additional simulations as presented in Appendix D. The average annual inflow to Centennial Reservoir is approximately 400 AF greater with the updated hydrology, and the simulated deliveries to the City water system are 60 AF/year greater with current demands and 100 AF/year greater with the projected 2025 demands as compared to the initial simulations.

Figure 3-7 depicts the projected 2025 annual deliveries with deficits anticipated in six of the 34 simulated years (17 percent of the years) based on the updated hydrology. Figure 3-8 depicts the updated deficits and shortages, and Figure 3-9 reveals a reduced probability and severity of deficits. The red curve in Figure 3-9 represents the probability of deliveries with the updated hydrology while the blue curve represents the probability of deliveries with the original hydrology.

Hydrology modeling is influenced by climatic variations during data collection. The DWR measurements were taken from late 1986 to 1988, a slightly drier than average period, while the City measurements were taken in 2005 during a slightly wetter than average period. To provide a greater margin of safety in planning for the City water supply, the reservoir simulations based on DWR measurements are used in the analysis of supplemental supply requirements in Section 4 and the evaluation of supplemental supply alternatives in Section 5. Nevertheless, it is recommended that the City continue to record water levels every six hours and periodically update the reservoir simulations to refine the water supply planning criteria in the future.

Figure 3-7. Annual Delivery and Shortage with Projected 2025 Demands: Regression with City Measurements

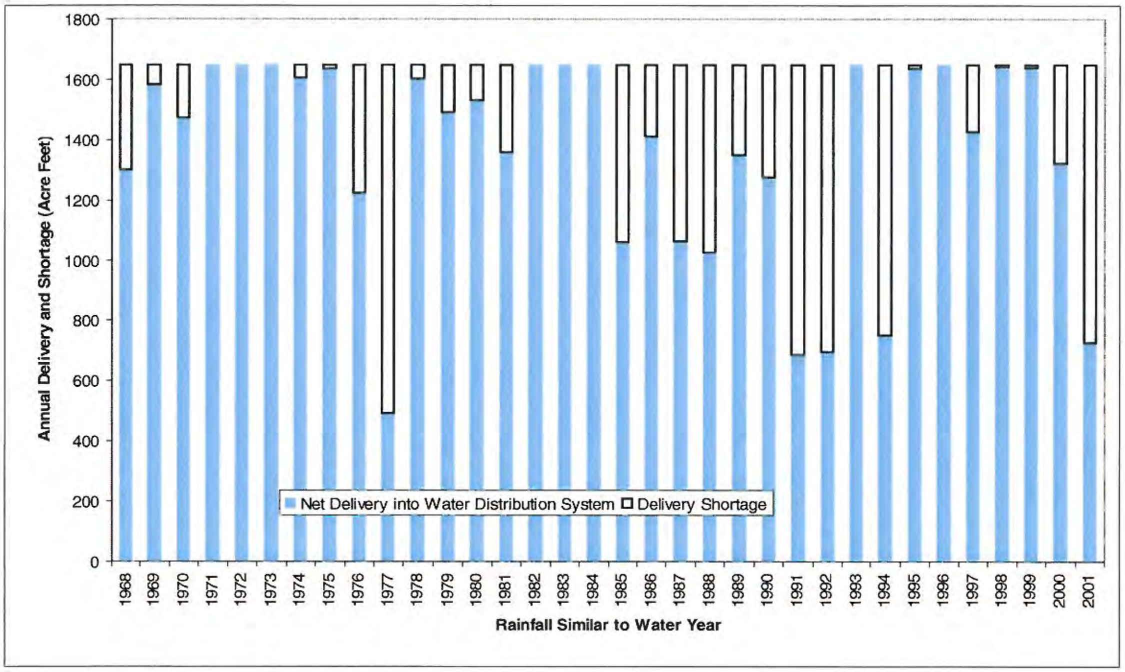


Figure 3-8. End-of-Month Storage and Shortage with Projected 2025 Demands: Regression with City Measurements

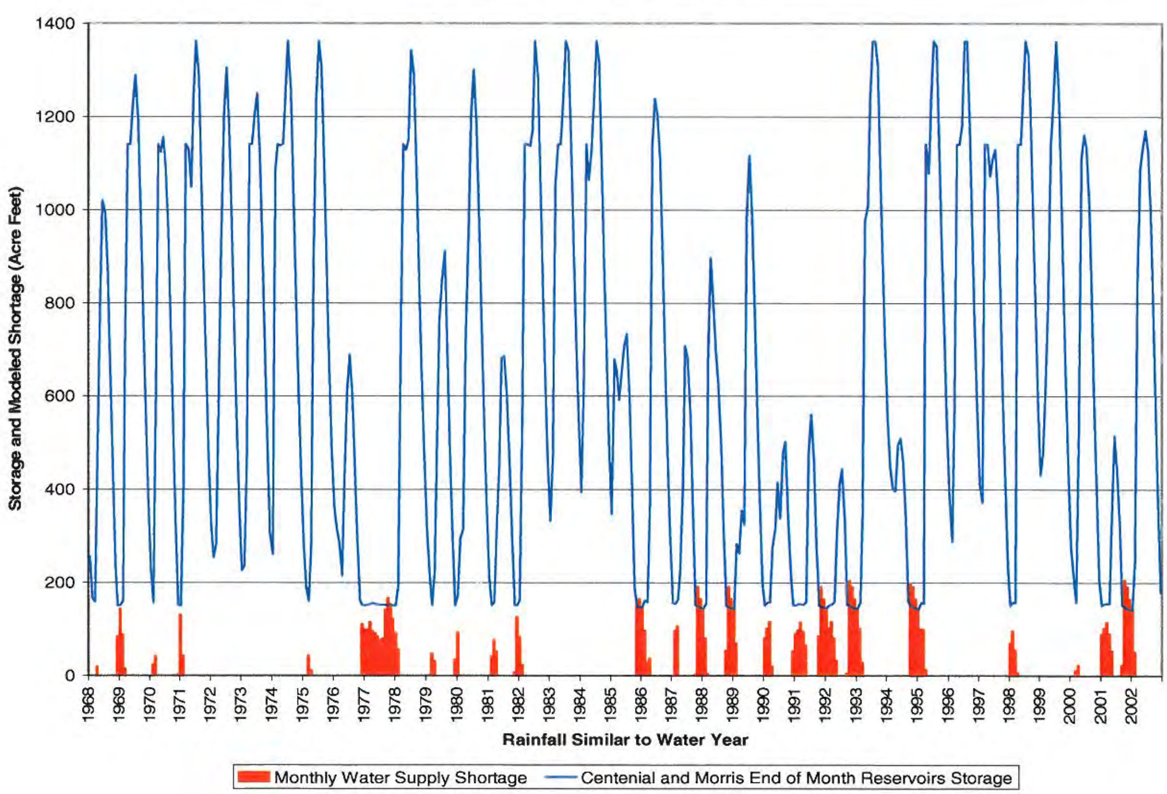
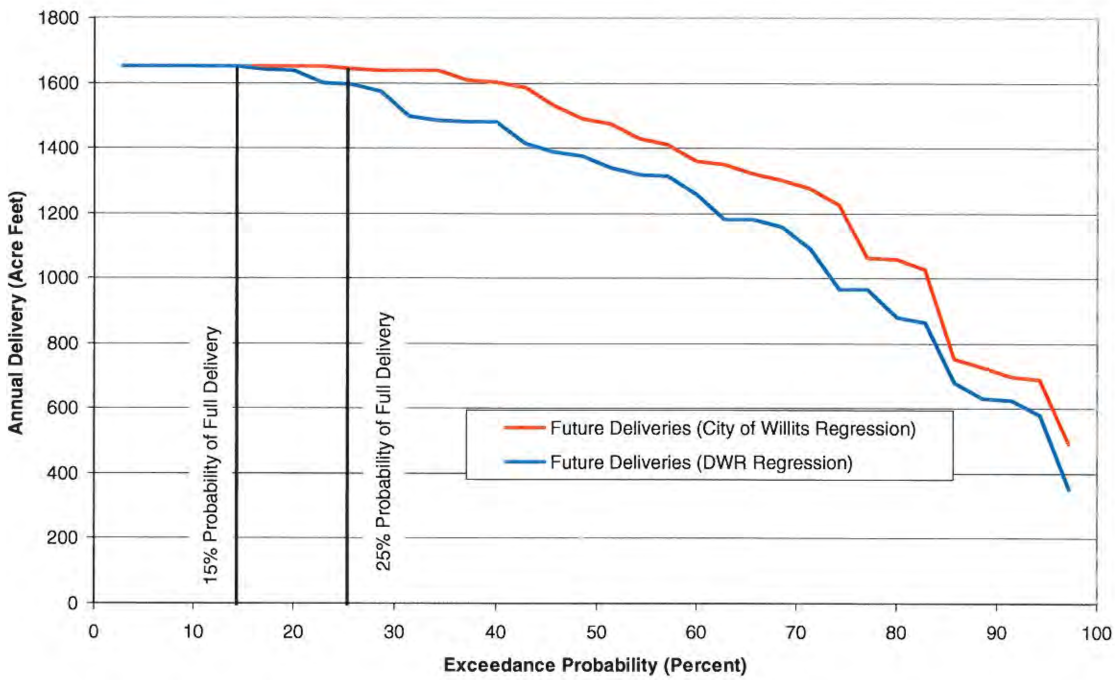


Figure 3-9. Probability of Delivery



4. SUPPLEMENTAL SUPPLY REQUIREMENTS

The current and projected City water demands, the existing water supply, and the current and projected 2025 worst-case water supply deficits are summarized in Table 4-1.

Table 4-1. Comparison of Water Demands and Existing Supply

	Current	Projected 2025
Water Demand, AF/year	1,099	1,649
Reservoir Supply in Critically Dry Year, AF/year [(a)]	449	349
Worst-Case Deficit, AF/year	650	1,300

(a) Reservoir supplies are projected to decline in future due to increased demands and correspondingly reduced reserves leading into critically dry years; actual 2025 reservoir supplies in critically dry years may approach current conditions with implementation of supplemental supply

The City adopted Ordinance 95-4, defining emergency restrictions for water use, after experiencing severe droughts in the 1980s and 1990s. The purpose of Ordinance 95-4 is to curtail nonessential water use and preserve the City's available water resources to maintain an adequate supply for human consumption, sanitation, and fire protection during water supply emergencies. While water supply forecasting is difficult and uncertain, the City could enforce Ordinance 95-4 during a critically dry year to reduce demand and correspondingly reduce the actual deficit.

Three stages of water emergency and related rationing measures are defined in Ordinance 95-4. Water emergency Stage I is a voluntary stage with an overall demand reduction goal of 15 percent for all customers. Water emergency Stage II is a mandatory stage that prohibits nonessential water use including outdoor use such as landscape irrigation. The Department of Water Resources estimates that 50 percent of all residential water use is outdoors. Therefore, it is estimated that enforcing water emergency Stage II would reduce residential water demands by 50 percent. For other customers, the assumed demand reductions are 15 percent. Water emergency Stage III is a mandatory stage that restricts single family residential customers to 50 gallons per capita per day (gpcd) and multiple family residential customers to 45 gpcd and requires 50 percent demand reductions by other customers.

The calculated effects of enforcing each stage of Ordinance 95-4 in 2004 and 2025 are summarized in Table 4-2.

Table 4-2. Effects of Enforcing Ordinance 95-4

Water Emergency Stage	Type of Rationing	Based on Current Customer Demands [a]	Based on Projected 2025 Customer Demands [b]
I	Voluntary	All customers = 15% reductions Estimated savings = 133 AF/year	All customers = 15% reductions Estimated savings = 221 AF/year
II	Mandatory	All residential customers = 50% reductions Other customers = 15% reductions Estimated savings = 331 AF/year	All residential customers = 50% reductions Other customers = 15% reductions Estimated savings = 528 AF/year
III	Mandatory	Single family residential customers = 50 gpcd limitation Multiple family residential customers = 45 gpcd limitation Other customers = 50% reductions Estimated savings = 545 AF/year	Single family residential customers = 50 gpcd limitation Multiple family residential customers = 45 gpcd limitation Other customers = 50% reductions Estimated savings = 922 AF/year

[a] Current customer demands = 886 AF/year; residential portion = 565 AF/year; other portion = 321 AF/year; single family residential demand = 468 AF/year at 154 gpcd; multiple family portion = 97 AF/year at 154 gpcd

[b] Projected 2025 customer demands = 1,472 AF/year; residential portion = 878 AF/year; other portion = 594 AF/year; single family residential demand = 699 AF/year at 170 gpcd; multiple family portion = 179 AF/year at 170 gpcd

Most water emergency ordinances in California align the rationing and demand reduction goals with defined water supply deficits. Normally, the first stage is voluntary with an overall demand reduction goal of 15 percent, similar to Stage I of Ordinance 95-4. Subsequent stages are mandatory but with three to four increments based on the potential water supply deficit and a maximum overall demand reduction goal of 50 percent. Stage III of Ordinance 95-4 is even more severe and potentially unrealistic because its enforcement would result in greater than 50 percent reduction of the overall demand. Stage II is realistic as its enforcement would result in about 30 percent reduction of the overall demand, and 30 percent is the maximum reasonable reduction after implementation of the DMMs, as described in Section 2. Therefore, only Stages I and II are considered in estimating the water supply deficit reductions in Table 4-3.

Table 4-3. Deficit Reductions by Enforcing Ordinance 95-4

	Current	Projected 2025
Water Demand, AF/year	1,099	1,649
Reservoir Supply in Critically Dry Year, AF/year	449	349
Worst-Case Deficit without Enforcing Ordinance 95-4, AF/year	650	1,300
Savings by Enforcing Ordinance 95-4 Stage I for 12 months, AF/year	133	221
Reduced Deficit, AF/year	517	1,079
Savings by Enforcing Ordinance 95-4 Stage II for 12 months, AF/year	331	528
Reduced Deficit, AF/year	319	772
Savings by Enforcing Ordinance 95-4 Stage I for 8 months, AF/year [(a)]	89	147
Reduced Deficit, AF/year	561	1,153
Savings by Enforcing Ordinance 95-4 Stage II for 8 months, AF/year [(a)]	221	352
Reduced Deficit, AF/year	429	948

[(a)] Considering potential for delayed enforcement in critically dry years

Table 4-3 demonstrates that enforcement of Ordinance 95-4 would reduce but not eliminate the current and projected 2025 worst-case water supply deficits. Therefore, the City will need a supplemental supply to eliminate the remaining deficits. Supplemental source capacity requirements are expressed in terms of million gallons per day (mgd) in Table 4-4 based on 8-month enforcement of Ordinance 95-4 and 8-month operation of the supplemental source. The 8-month assumption is reasonable because critically dry years are difficult to forecast, and a response during the early months of a critically dry year is unlikely.

5. SUPPLEMENTAL SUPPLY ALTERNATIVES

The following supplemental supply alternatives were evaluated to determine the most feasible means to satisfy the City's requirements:

- Additional surface water supply
- Neighboring water system interconnection
- Recycled water supply
- Groundwater supply

The implementation of DMMs was addressed and incorporated into the water demand projections in Section 2, and therefore, not considered as a supplemental supply alternative.

The evaluation addresses the feasibility and cost of the identified water supply alternatives. Recommendations are made to ensure that the supplemental supply, in combination with the existing surface water supply, is of sufficient capacity to satisfy the current and projected water demands. The supplemental source and production capacity requirements in Table 4-6 are used to determine the adequacy or capacity needs of each supplemental supply alternative.

ADDITIONAL SURFACE WATER SUPPLY

The development of additional surface water supply capacity is achievable by raising or replacing Morris Dam, raising the Morris Dam flashboards, dredging Morris Reservoir and deepening the raw water pump station, building another dam, or gaining access to Wente Lake. Raising Centennial Dam is not feasible because an increase in Centennial Reservoir's maximum water surface elevation would cause flooding of Highway 101 and the Northwestern Pacific railroad tracks to the west.

Raising or Replacing Morris Dam

The 1985 Water System Master Plan for the City indicated that raising Morris Dam by 50 feet would provide 2,000 to 3,000 AF of additional storage capacity. However, the Master Plan recommended against raising Morris Dam because at the time, Morris Reservoir was the sole source of water supply for the City, and raising the dam would have required taking Morris Reservoir out of service for an extended period of time.

Since the City constructed Centennial Dam, it is now possible to provide a temporary connection from Centennial Reservoir to the water treatment plant, drain Morris Reservoir, and raise Morris Dam while maintaining the production and delivery of potable water to the City. Extrapolation of the Morris Reservoir elevation-capacity curve confirms that a 50-foot height increase would provide 2,000 to 3,000 AF of additional storage capacity. Increasing the Morris Dam crest height and maximum water surface elevation would require thickening or otherwise increasing the structural capacity of the existing dam to support the additional hydrostatic pressure. The taller Morris Dam would have a crest length of about 500 feet. However, raising Morris Dam is complicated by the presence of Centennial Dam upstream, which may limit the Morris Reservoir water surface to prevent saturation of the outside toe of Centennial Dam.

Expanding Morris Reservoir would increase the surface water supply capacity. However, determining the source capacity would require surveying the watershed to a higher elevation, additional modeling of the reservoir system, and consulting with the State Water Resources Control Board and the DWR Division of Safety of Dams. The environmental review and permitting process would add to the cost and schedule of the project, considering the federal Clean Water and Endangered Species Acts, the California Environmental Quality Act (CEQA) and the other permitting requirements.

The construction phase would require dewatering Morris Reservoir and keeping it out of service for at least eight months during the dry season. Using the entire volume of Centennial Reservoir for eight months would provide approximately 1.0 mgd, which is less than the average water demand during the dry season. Furthermore, because Centennial Reservoir would empty toward the end of the dry season, the risk of not finishing the work in time to refill Morris Reservoir during the following wet season is significant.

Alternatively, the City could construct a taller dam just downstream of the existing Morris Dam and then remove or submerge the existing dam in an expanded Morris Reservoir. Although the 1985 Water System Master Plan indicated that Davis Creek downstream of Morris Dam is geologically unstable, additional research may reveal that constructing a dam just downstream from the Morris Dam is costly yet feasible. It would entail similar environmental permitting requirements as raising Morris Dam but would allow Morris Reservoir to remain in service during construction of the downstream dam.

Increasing the height of Morris Dam or building a taller dam just downstream would expand the surface water supply capacity only. To increase the potable water production capacity, the City would also need to replace the raw water pump station and expand the water treatment plant, adding significant cost to this alternative. A very preliminary estimate of the capital cost of raising Morris Dam or building a taller dam just downstream and expanding the water treatment plant is $20 million, as itemized in Appendix E.

Increasing Height of Morris Dam Flashboards

The 1985 Water System Master Plan indicated that increasing the Morris Dam flashboard height to 3.7 feet would provide 60 AF of additional storage capacity, and extrapolation of the Morris Reservoir elevation-capacity curve confirms that estimate. While increasing the flashboard height is not as costly as raising Morris Dam, it would encompass many of the same environmental permitting and logistical hurdles, including the potential need to strengthen the existing dam to support the additional hydrostatic pressure. The 60 AF increase in the reservoir storage capacity is small compared to the water supply needs of the City. Consequently, increasing the Morris Dam flashboard height is not considered a feasible alternative to satisfy the City's need for a supplemental water supply.

Dredging Morris Reservoir

Previous estimates of sedimentation in Morris Reservoir have ranged from 50 to 100 AF. The 1987 Limnological Investigation of Morris Reservoir by DWR determined a sedimentation volume of 99 AF. While the current sediment volume in Morris Reservoir is unknown, the City water system operators have reported noticeable increases in vegetative growth over the past several years. A bathymetric survey is required to determine the current elevation-capacity curve for Morris Reservoir. However, even a bathymetric survey would not quantify the volume of sediment because the soundings would indicate the water depth to sediment, not the water depth to the original bottom of the reservoir.

Dredging to remove 100 AF of sediment would cost approximately $3.2 million at a unit cost of $20 per cubic yard for dredging and disposal. Furthermore, the City would need to deepen the lowest outlet and suction well of the raw water pump station to reduce the minimum pool and conduct maintenance dredging routinely to maintain the reduced minimum pool.

The environmental review and permitting process for such a project would add to the cost and schedule, considering the federal Clean Water and Endangered Species Acts, CEQA and other permitting requirements. The reservoir storage capacity increase by dredging and deepening is relatively small, the benefit-to-cost ratio is very low, and the environmental review and permitting requirements are significant. Consequently, dredging of Morris Reservoir is not considered a feasible alternative to satisfy the City's need for a supplemental water supply.

Nevertheless, it is recommended that the City continue to operate the existing lower outlet(s) of Morris Reservoir as necessary to scour the immediate bottom area and minimize future sedimentation within Morris Reservoir, and work with the County to promote erosion control in the upper Davis Creek watershed.

Building another Dam

The City could augment its surface water supply by constructing another dam in the Davis Creek watershed or in a separate watershed of the Little Lake Valley.

Preliminary analysis indicates that constructing another dam upstream of Morris Reservoir, on a tributary to Davis Creek but separate from Centennial Reservoir, would provide limited storage capacity due to the relatively steep terrain and narrow gullies. Constructing another dam on Davis Creek but far enough downstream of Morris Dam to create a separate reservoir would provide limited storage capacity due to the steep terrain and narrow gullies leading to the Little Lake Valley floor.

Constructing another dam in a separate watershed of the Little Lake Valley is feasible but costly. A very preliminary estimate of the capital cost for a fixed dam to create a 600 to 800 AF storage reservoir, a water treatment plant with a capacity of 1.8 mgd, and a pipeline connecting to the existing transmission main or distribution system is $18 million, as itemized in Appendix E. Such a project would involve significant environmental permitting requirements, potentially reducing its feasibility.

If construction of a concrete dam is not permitted due to environmental constraints, an alternative is to use an inflatable dam to retain stream flow during the dry seasons, and deflate the dam to accommodate fish passage during the migration seasons. However, this alternative would not provide as much storage capacity as a fixed dam due to the height limitations of an inflatable dam compared to the generally steep terrain surrounding the Little Lake Valley. The significant cost of a water treatment plant and pipeline connecting to the City water distribution system would remain the same whether a fixed or inflatable dam is used to impound the supplemental surface water supply.

Gaining Access to Wente Lake

Wente Lake is an 800 AF reservoir located four miles east of the City in the Finney Valley as depicted in Figure 5-1. It was constructed by the San Francisco Bay Area Council of the Boy Scouts of America (Boy Scouts), and is used by the Boy Scouts for recreational activities. The Boy Scouts also used the reservoir as a potable water supply until they converted to groundwater in the late 1990s. The City gained emergency access to Wente Lake from November 1987 through May 1988 during a severe drought. Approximately 75 AF was diverted from Wente Lake via creek channels and a temporary overland pipeline to the original water treatment plant, which was located downstream from Morris Dam. (The existing plant is located uphill and adjacent to Morris Dam.)

Recent discussions with the Boy Scouts revealed a willingness to explore the possibility of using Wente Lake as an emergency or permanent water supply component for the City. The Boy Scouts hold water rights License 8042 (Application 19415) and License 8043 (Application 19755) for a combined 800 AF/year from a Berry Creek tributary to replace water lost from Wente Lake through evaporation and seepage. City use of Wente Lake as a water supply would require a reservoir capacity analysis, further discussions with the Boy Scouts, and resolution of water right issues. However, the projected 2025 worst-case water supply deficit for the City is potentially greater than the Boy Scouts' entire licensed diversion to Wente Lake even with enforcement of Ordinance 95-4 Stage II (Table 4-3). Because such a diversion would impede the Boy Scouts' use of Wente Lake, accessing Wente Lake is not considered a feasible alternative to satisfy the City's need for a supplemental water supply.

Nevertheless, the City could make Wente Lake part of a water supply contingency plan. Using Wente Lake only in emergencies would entail fewer permitting requirements. A gravity diversion from Wente Lake to Morris Reservoir is achievable with a closed conduit connection, comprising about 4.4 miles of cross-country pipeline together with flow and pressure control facilities.

Another potential approach for emergency use of Wente Lake is to:

- Divert water from Wente Lake into creek channels for open channel flow to a temporary impoundment about 1.4 miles downstream
- Pump water from the impoundment into a nearby portable water treatment plant
- Deliver finished water from the portable water treatment plant to the existing transmission main at East Hill and East Side Roads via 7,700 lineal feet (LF) of temporary pipeline

To minimize cost, the City could rent rather than purchase the portable water treatment plant and temporary pipeline only as needed during a water supply deficit, or obtain the temporary components through the Office of Emergency Services. Portable water treatment plants are commercially available at capacities approaching 1.0 mgd per trailer. The stream channel approach is illustrated in Figure 5-1.

Depending on the selected supplemental supply alternative and the timeframe for implementation, the City should consider further developing a water supply contingency plan, potentially involving Wente Lake.

NEIGHBORING WATER SYSTEM INTERCONNECTION

The City obtained 70 AF through a temporary 8-inch diameter overland pipeline connection to the Brooktrails water system during the 1970s drought. Brooktrails relies on a relatively small surface water supply but is considering a project to expand the reservoir storage capacity, and the City is in discussions with Brooktrails regarding possible participation in the project. While the project is conceptual and the water supply capacity from Brooktrails to the City is unknown at this time, the City is encouraged to take advantage of any cost effective opportunity to supplement the City water supply by participating in the Brooktrails project.

The next closest sizeable community, the City of Ukiah, is greater than 20 miles from the City of Willits. The City of Ukiah uses both groundwater and riverbank filtered surface water from a collector well at the Russian River. The riverbank filtered surface water is treated in a conventional filtration plant. The Director of Public Utilities indicated that the City of Ukiah has emergency interconnections with two neighboring small water systems, but does not have sufficient water supply capacity to share on a regular basis. In fact, the City of Ukiah is exploring the development of additional groundwater supply capacity to meet its own needs.

Furthermore, this alternative would entail significant cost and permitting requirements, including the need to address interbasin transfer issues. Considering the water supply, cost, and environmental permitting issues, interconnecting with the City of Ukiah is not considered as a feasible alternative to satisfy the City's need for a supplemental water supply.

RECYCLED WATER SUPPLY

Many water systems in California have developed or are pursuing the development of recycled water supplies to offset the demand for potable water. Most recycled water supply systems entail advanced treatment of wastewater to generate a non-potable water supply that is compliant with the terms and conditions of California Code of Regulations Title 22, distribution of the recycled water supply through a dedicated distribution system, and in some cases, storage in dedicated reservoirs. The recycled water supply is typically used to irrigate crops, turf and landscapes.

The City is in the process of designing a major upgrade of its wastewater treatment facilities. The project includes an effluent storage pond and a dedicated irrigation field, and several farmers have expressed interest in receiving effluent for irrigation of their crops. However, those farmers do not currently use City water, so irrigating the crops with treated wastewater will not offset potable water demand from the City.

The current wastewater treatment facilities upgrade project is not intended to generate recycled water that complies with Title 22. The City previously explored providing recycled water to offset potable water demands within the City, but the large customers that were interested in receiving recycled water have since gone out of business. The City does not anticipate a significant demand for recycled water, and therefore, the development of a recycled water supply to offset some of the potable water demand is not considered a feasible alternative to satisfy the City's need for a supplemental water supply.

Nevertheless, irrigating nearby crops with treated wastewater will offset some of the groundwater supply needs of the local area farmers and indirectly benefit the City if groundwater is developed as a potable water supply for the City water system.

GROUNDWATER SUPPLY

The feasibility of implementing a groundwater supply for the City to supplement the existing surface water supply depends on the groundwater quality and treatment requirements, the location and yield of proposed wells, and the effect of City pumping on local area agricultural and domestic wells. References for the groundwater supply analysis include:

- Weeks Drilling and Pump Company. 1984. Water Well Drillers Report. (Weeks 1984)
- Weeks Drilling and Pump Company. 1984. Test Pump Log. (Weeks 1984)
- Alpha Analytical Laboratories, Inc. 1984. Chemical Examination Report. (Alpha 1984)
- Farrar, C.D. 1986. Ground-Water Resources in Mendocino County, California. USGS Water-Resources Investigations Report 85-4258. (USGS 1986)
- State of California – Resources Agency, Department of Water Resources, Northern District. 1987. City of Willits – Department of Water Resources Ground Water Study. (DWR 1987)
- State of California – Resources Agency, Department of Water Resources, Northern District. 1988. Letter to City of Willits. (DWR 1988)
- Alpha Analytical Laboratories, Inc. 2000. Chemical Examination Report. (Alpha 2000)
- Willits Environmental Remediation Trust. 2002. Former Remco Hydraulics, Inc. Site, Willits, California, Final Remedial Investigation Report Summary. (WERT 2002)
- California Department of Water Resources. 2004. California's Ground Water Bulletin 118. Little Lake Valley Groundwater Basin. (DWR 2004)
- California State Water Resources Control Board. 2005. www.Geotracker.com. (SWRCB 2005)

Little Lake Valley Groundwater Basin

The Little Lake Valley groundwater basin is an irregularly shaped basin in the Coast Range within central Mendocino County (DWR 2004). The basin is approximately seven miles long and as much as three miles wide near the centerline of the valley and likely was formed by faulting along its margins. The City is located in the west-central portion of the basin. The Little Lake Valley is drained to the north by several streams including Baechtel, Broaddus, Davis, Haehl and Willits Creeks and then to the northwest through Outlet Creek.

Water-bearing formations in the basin consist of the Quaternary alluvial deposits and older Pliocene to Pleistocene continental basin deposits. Groundwater is locally available in fractures in the underlying and surrounding consolidated bedrock of the Jurassic-Cretaceous Franciscan Complex. The alluvial deposits are Holocene in age and cover most of the flat portions of the valley, an area of approximately 12 square miles. The alluvium, which consists of uncemented gravel, sand, silt and clay, is the most productive aquifer in the valley, and properly constructed wells in favorable areas of the alluvium can yield several hundred gallons per minute. Most of the groundwater in the alluvium is either confined or semiconfined beneath extensive sheets of fine-grained sediments, or unconfined along the valley margins and in the shallow alluvium along creek channels. Specific yield for the alluvium is estimated at about eight percent, which is reasonable for water supply wells. Most recharge to the alluvium occurs at the southern margin of the alluvial plain. Hydrographs of groundwater levels from the late 1950s to present show typical seasonal water level fluctuations without any significant long-term trends.

Park Well

The City constructed a groundwater well known as the Park Well east of Lenore Avenue and just south of Commercial Street in 1984. The Park Well was drilled to a depth of 240 feet below ground surface, and it has a 50-foot deep sanitary seal, an 8 5/8-inch diameter steel casing of 0.188-inch wall thickness, a high capacity wire wrapped screen with 0.07-inch slot openings, and a packing of fine pea gravel (Weeks 1984). The steel casing is not corrosion resistant, the casing wall is relatively thin, and the packing is not sized or graded to maximize yield and prevent sand production from the well.

Pumping tests in the 1980s revealed that the Park Well can support a pumping rate of approximately 225 gallons per minute (gpm) for 180 consecutive days per year (i.e. 360 AF/year), causing a maximum drawdown of about 7.5 feet in neighboring wells within a 1,000 feet radius (DWR 1987 and 1988). However, the existing pump in the Park Well has a greater capacity than 225 gpm and causes more significant drawdown of neighboring wells. The Park Well was not connected to the City water system, but is used seasonally to irrigate athletic fields in the vicinity of the wellhead.

Groundwater Quality

Groundwater in the Little Lake Valley is characterized as calcium-magnesium bicarbonate and magnesium-calcium bicarbonate, with a few exceptions characterized by sodium bicarbonate and sodium chloride (DWR 2004). Total dissolved solids concentrations from 17 wells in the Little Lake Valley range from 97 to 1,710 mg/L and average 340 mg/L (USGS 1986) while some local area wells contain significant concentrations of arsenic, boron, iron and manganese (DWR 2004). Arsenic is a health concern in drinking water, and the federal maximum contaminant level (MCL) was reduced to 0.010 mg/L in January 2006. Significant concentrations of boron in a water supply can restrict crop yield and adversely affect landscaping and house plants. Iron and manganese are the cause of aesthetic concerns but not health effects in drinking water, and are subject to secondary MCLs.

Pertinent water quality data for the Park Well are summarized in comparison to the respective drinking water MCLs in Table 5-1 (Alpha 1984 and 2000 and DWR 1987).

Table 5-1. Park Well Water Quality

	Sample Collection Date			
	May 8, 1984	September 4, 1986	March 21, 2000	MCL[a]
Alkalinity, mg/L as $CaCO_3$	382	344	357	None
Apparent Color, PCU	—	—	7	10[b]
Arsenic, mg/L	—	0.122	0.150	0.010[c]
Boron, mg/L	BDL[d]	0.2	—	3[e]
Chloride, mg/L	12	8	7.9	250[b]
Fluoride, mg/L	0.4	—	0.23	2[c]
Hardness, mg/L as $CaCO_3$	330	—	298	250[b]
Iron, mg/L	0.9	1.1	2.0	0.3[b]
Manganese, mg/L	2.7	3.2	3.5	0.05[b]
Nitrate, mg/L	BDL	—	BDL	45[c]
Odor, TON	—	—	BDL	3[b]
pH	7.4	—	7.1	6.5 to 8.5[b]
Specific Conductance, umhos/cm	910	—	667	None
Sulfate, mg/L	BDL	4	BDL	250[b]
Total Dissolved Solids, mg/L	395	—	384	500[b]
Turbidity, NTU	7.8	—	18	0.3[c][f]

[a] Maximum contaminant level
[b] Secondary (aesthetic based) MCL
[c] Primary (health based) MCL; listed arsenic value is federal MCL
[d] Below detection limit
[e] Threshold for agriculture and landscape irrigation rather than state or federal MCL
[f] Value applicable to filtered surface water supplies

The water quality parameters of concern in the Park Well are arsenic, hardness, iron, manganese and turbidity. The removal of these undesirable constituents from a water supply is readily achievable via oxidation-filtration enhanced by coagulant addition. However, the relatively high turbidity of the groundwater from the Park Well is indicative of sand production from the well, which can cause excessive wear of the wellhead equipment. Hardness is a cause of aesthetic concerns but not health effects in drinking water. City water customers who are accustomed to the existing surface water supply with a hardness of 120 mg/L may experience more scaling in plumbing fixtures and appliances with the 300 to 330 mg/L of hardness in the groundwater supply. The customers also may use more soap to generate lather and more water for rinsing with the groundwater supply. Hardness reduction is achievable via softening but the cost of centralized softening is generally greater than the benefit. Alternatively, individual water customers can install point-of-entry softeners at their discretion.

The most publicized groundwater contamination in the City is the former Remco Hydraulics facility, located southwest of the intersection of Highways 20 and 101, where leaky chrome plating tanks introduced volatile organic chemicals (VOCs) and hexavalent chromium into the groundwater beneath the site. The remedial investigation has determined the horizontal extent of contamination is widespread only near the ground surface, the contamination is mostly contained within the site, the contamination has not migrated far from the source, and interim remedial actions have removed the contamination sources and limited the routes of migration (WERT 2002). Nevertheless, continued monitoring of the groundwater quality in the vicinity of the Remco Hydraulics site is advisable to confirm the adequacy of remediation.

Several leaky underground storage tanks (LUSTs) were identified in the northeast quadrant of the City, but the identified leaks were relatively minor (SWRCB 2005). Nevertheless, investigation of the case files containing more detailed information about the LUST sites is recommended prior to final site selection for a City well(s).

Proposed Groundwater Supply

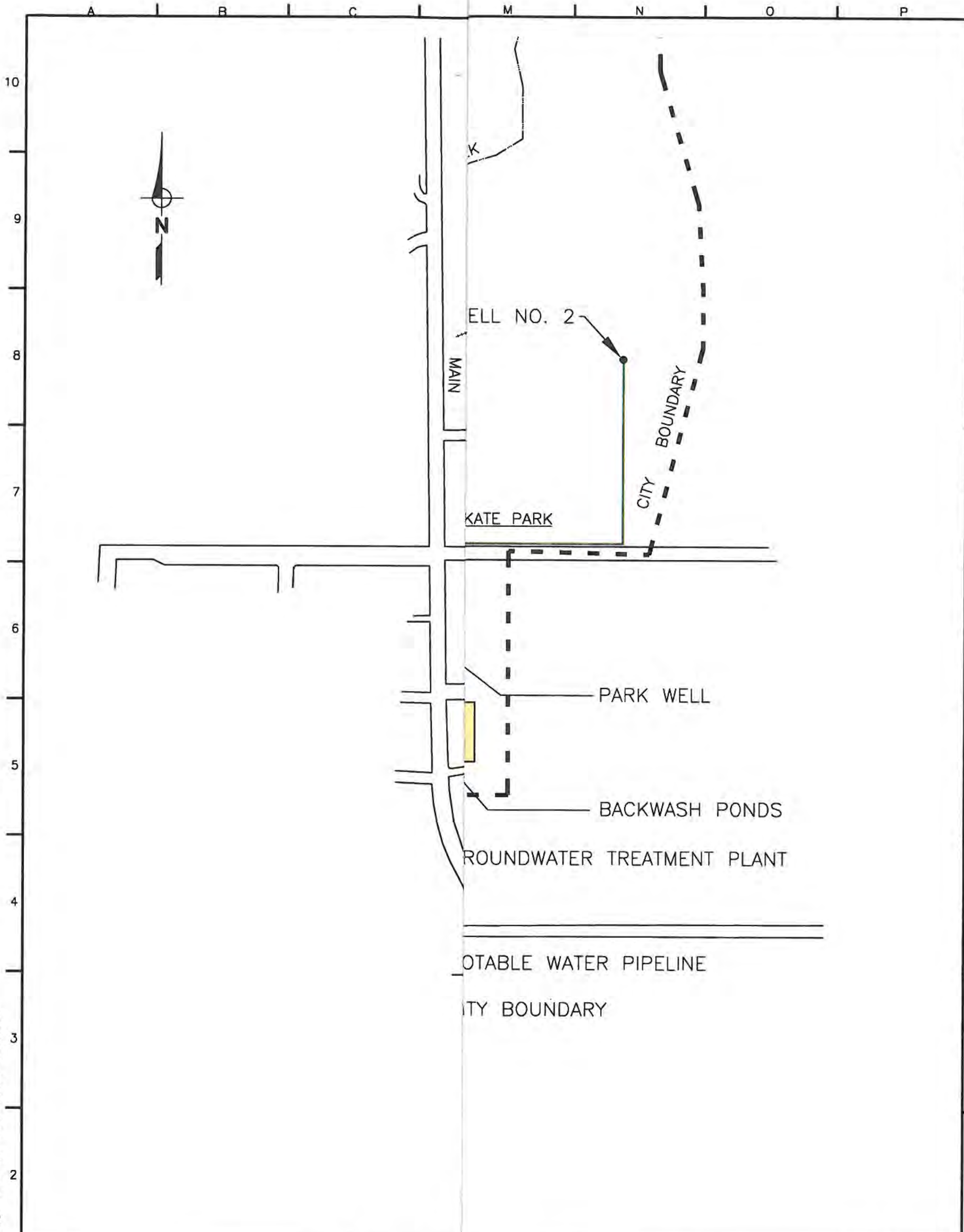
The City will need about 1.8 mgd of supplemental water supply by 2025 without enforcing Ordinance 95-4 during critically dry periods (Table 4-6). It is assumed herein that the maximum reliable pumping capacity of the proposed wells is 330 gpm per well. Therefore, delivering 1.8 mgd of groundwater into the distribution system would require the development of four wells with a pumping capacity of 330 gpm each. The combined pumping capacity of the proposed wells is somewhat greater than 1.8 mgd because a portion of the groundwater flow is needed to backwash filters and for other non-potable purposes in a typical groundwater treatment plant.

Alternatively, the City could redevelop and re-equip the Park Well as a 225 gpm potable water supply well after video logging and an additional pumping test to evaluate the well condition, identify needed repairs, determine the severity of sand production, and confirm the groundwater quality. However, because the current condition and longevity of the Park Well are questionable, and at best, conversion of the Park Well into a potable water supply well would defer the need for one of the proposed wells, it is recommended that the City retain the Park Well for non-potable use (i.e. irrigation) only.

Under current demand conditions, the City will need about 0.6 mgd of supplemental water supply in critically dry periods while enforcing Ordinance 95-4 Stage II, and 0.9 mgd to avoid enforcement of Ordinance 95-4 (Table 4-6). Whether the City is willing to enforce Ordinance 95-4 to survive critically dry periods in the long-term is a policy decision that may entail significant deliberation by the City. Consequently, phased implementation of the groundwater supply project is recommended to allow time for such deliberations and to minimize the immediate capital investment.

The phasing plan would entail:

> <u>Phase 1</u> – Developing two 330 gpm wells, and constructing a centralized 0.9 mgd groundwater treatment plant to eliminate the current water supply deficit
>
> <u>Phase 2</u> – Developing an additional well to pump 330 gpm, and expanding the groundwater treatment plant to a capacity of 1.35 mgd by 2015 or as dictated by increasing demands



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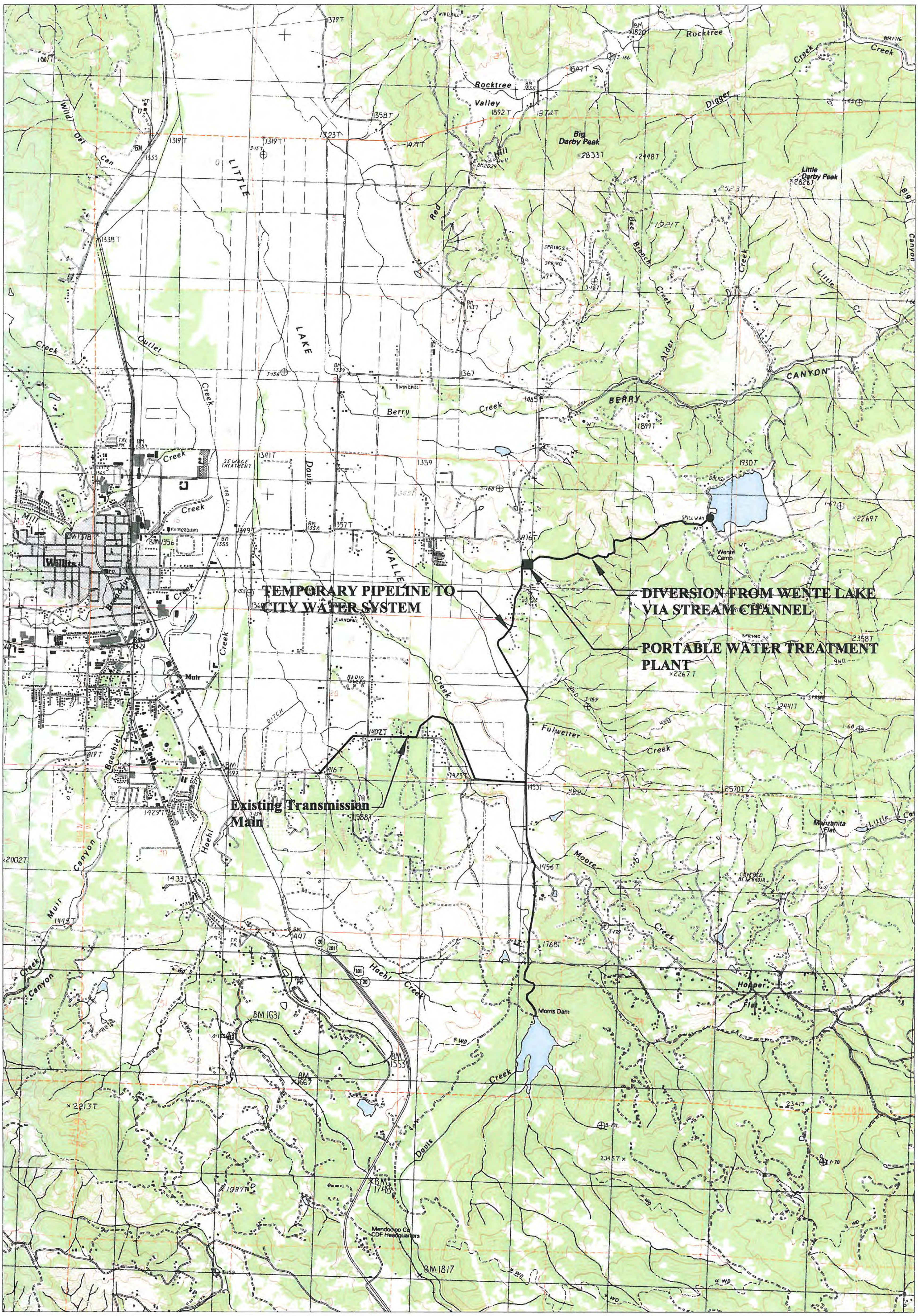

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Figure 5-1

City Of Willits
Water Supply Planning Study
Proposed Water Supply Contingency Plan

WEST YOST & ASSOCIATES

Phase 3 – Developing an additional well to pump 330 gpm, and expanding the groundwater treatment plant to a capacity of 1.8 mgd by 2025 or as dictated by increasing demands

The approximate locations of the Phase 1 groundwater supply facilities are depicted in Figure 5-2. Approximately 2,500 LF of 8-inch diameter pipeline would connect the proposed wells to the groundwater treatment plant, and approximately 500 LF of 12-inch diameter pipeline would connect the groundwater treatment plant to an existing 8-inch diameter pipeline in Valley Street. It is assumed that each of the Phase 2 and Phase 3 wells will require about 1,000 LF of 8-inch diameter pipeline to connect to the centralized groundwater treatment plant. An additional 1,100 LF of pipeline, from the groundwater treatment plant connection in Valley Street to Lenore Avenue, may prove necessary in the future depending on the final groundwater supply capacity. A side benefit of the proposed groundwater supply location is that the treated groundwater would enter the distribution system in the northern sector of the City while the treated surface water would continue to enter at the south end, potentially reducing the need for future distribution system improvements in other areas of the City water system.

Locating the groundwater supply and treatment facilities as depicted in Figure 5-2 would place the wells in a 100-year flood plain and potentially in a floodway. Nevertheless, this general location is recommended to maximize the groundwater quality and yield. Locating the wells further to the east and closer to the centerline of the Little Lake Valley would help to maximize the groundwater quality and yield, but would entail property acquisition and extend the time requirements for project implementation. The Department of Health Services (DHS) prohibits the construction of water supply wells in a 100-year floodplain unless there are no viable alternatives, and consultation with DHS is a recommended early step in the groundwater supply project. It is anticipated that DHS will accept the proposed locations of the groundwater supply and treatment facilities, providing that the wellheads and treatment facilities are high enough in elevation to prevent surface water from contaminating the groundwater supply and to protect the pumping and treatment facilities from potential flood damage.

To achieve 330 gpm per well, the preliminary recommendation is to drill the proposed wells to a similar depth as the Park Well but with a larger diameter to achieve greater yield and efficiency. Other recommendations to provide greater efficiency, strength and durability in the proposed wells as compared to the Park Well include:

- Casing wall thickness of at least 0.32 inches
- Casing and screen construction with corrosion resistant materials such as copper-bearing steel, high-strength low alloy steel, or type 304 stainless steel
- Packing composed of durable and appropriately sized and graded gravel to maximize yield and minimize sand production for site-specific conditions

Screening intervals are typically determined as part of the drilling operation. Nevertheless, screening intervals generally similar to the Park Well are anticipated in the proposed wells.

The groundwater treatment facilities would remove arsenic, iron, manganese, turbidity and other undesirable constituents as necessary, depending on the actual groundwater quality, to produce potable water in compliance with the drinking water regulations. Constructing the Phase 1 treatment facilities and then incrementally expanding the plant capacity would cost more, even in current dollars, than initially constructing 1.8 mgd of treatment facilities due to economies of scale. However, incremental expansion of the plant together with phased implementation of the other project components would minimize the initial effect on rates.

The groundwater treatment plant would include an oxidation-filtration system, chemical storage and feed facilities, and waste handling facilities as well as instrumentation and controls to accommodate remote control of the well pumps and treatment facilities from the existing plant at Morris Reservoir. The use of backwash ponds is assumed in the costs estimates and Figure 5-2 although discharging the waste streams to the City sewer system, if feasible, could reduce the cost and footprint of the groundwater supply project. Softening to reduce hardness is not included in the cost estimates. Standby power is not needed at the wells or groundwater treatment plant because a concurrent electrical power supply interruption at the groundwater treatment plant and the surface water treatment plant is very unlikely, and after implementation of Phase 2 of the groundwater supply project, either plant could supply the average demands. The development of more specific design criteria for the groundwater treatment plant will depend on the groundwater quality from the proposed wells as determined after pumping tests.

The preliminary estimated capital cost of Phases 1, 2 and 3 combined is $7.0 million as itemized in Appendix E. Lower capital costs are potentially achievable by:

- Discharging the groundwater treatment plant waste streams to the City sewer system instead of providing on-site treatment
- Reducing the capacity of the groundwater supply facilities and enforcing Ordinance 95-4 Stage II to survive critically dry periods in the long-term
- Reducing the capacity of the groundwater treatment facilities and using additional groundwater as a non-potable water supply

Determining the feasibility of discharging the waste streams to the City sewer system and other sub-alternatives to reduce the cost of the groundwater supply project is appropriate for the preliminary design phase of the project.

COMPARISON OF ALTERNATIVES

The following water supply alternatives were deemed inadequate to satisfy the City's need for a supplemental water supply or were otherwise not feasible:

- Raising Morris Dam
- Increasing height of Morris Dam flashboards
- Dredging Morris Reservoir
- Gaining access to Wente Lake

- Interconnecting with neighboring water system
- Implementing recycled water supply

While gaining access to Wente Lake is not considered a feasible alternative to satisfy the City's need for a supplemental water supply, the City could make Wente Lake part of a water supply contingency plan, as described in this report.

The three feasible alternatives to augment the City water supply and a matrix comparison of critical evaluation criteria are provided in Table 5-2.

Table 5-2. Comparison of Water Supply Alternatives

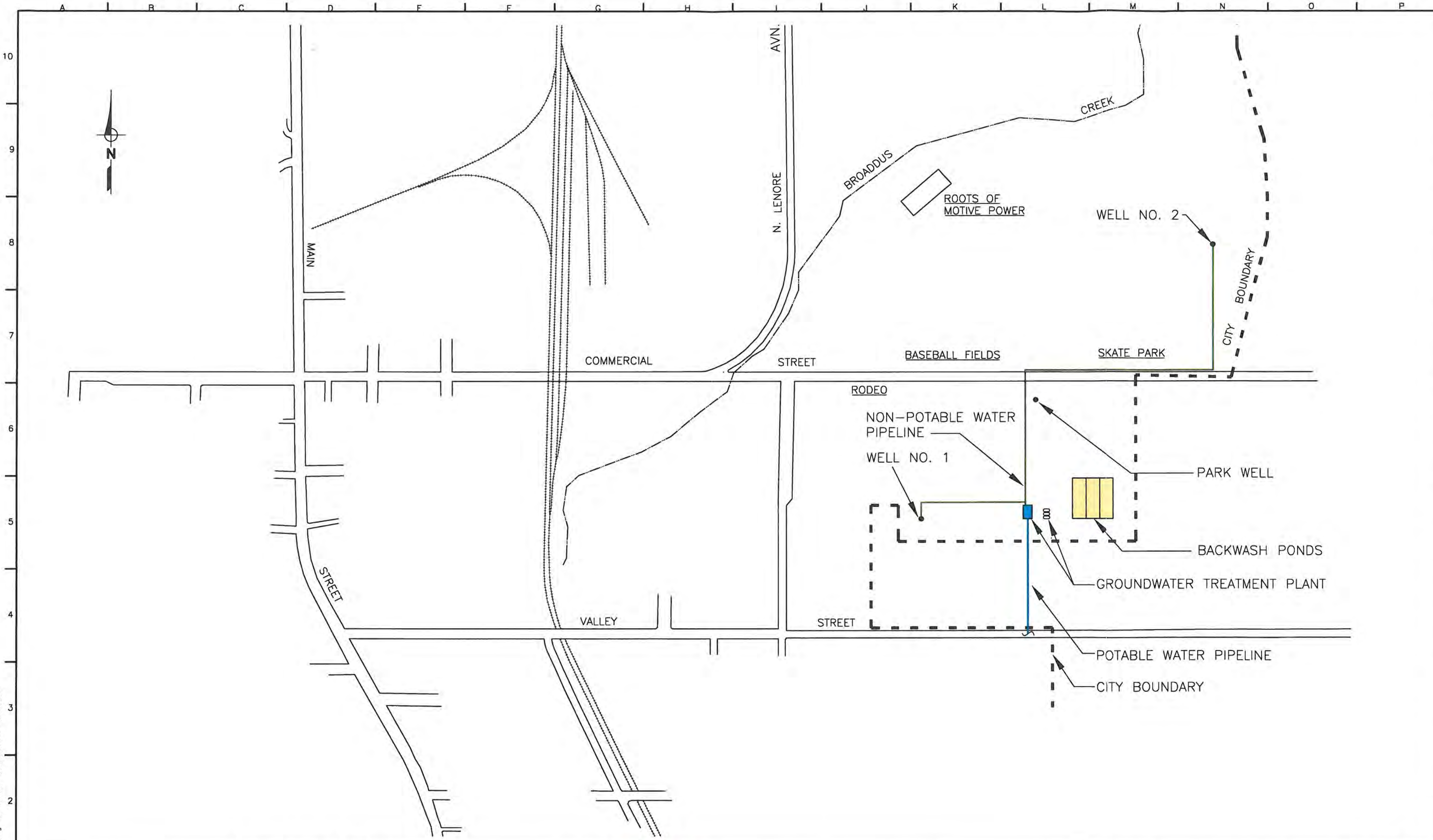
Alternative	Expanded Morris Reservoir[a]	Supplemental Surface Water Supply[b]	Groundwater Supply
Capacity through 2025	High	High	High
Capacity to accommodate growth beyond 2025	High	Uncertain[c]	Uncertain[d]
Water quality perception	Positive	Positive	Potentially negative[e]
Benefit to distribution system	Low	Uncertain[c]	High
Relative cost	High	High	Moderate
Environmental permitting requirements	Major	Major	Moderate
Land purchase requirements	Minor[f]	Major	Minor[g]
Phasing potential	None	None	High
Implementation timeframe	10 years	10 years	2 years

[a] Raising or replacing Morris Dam
[b] Building another dam elsewhere in Little Lake Valley
[c] Depends on capacity and location of additional dam and reservoir
[d] Potentially limited by groundwater basin capacity
[e] Greater hardness of groundwater supply may cause aesthetic concerns for some customers
[f] Potentially none
[g] Potentially none in Phase 1

Developing a supplemental surface water supply would entail a similar cost and timeframe as expanding Morris Reservoir, but would require a much greater land purchase and may not provide as much capacity to accommodate growth beyond 2025. Consequently, expanding Morris Reservoir and developing a groundwater supply are the more feasible alternatives to satisfy the

City's need for an additional water supply. The primary benefits of a groundwater supply are its lower cost and more rapid implementation compared to an expanded surface water supply and its phasing potential. The capital cost estimate for all three phases of a groundwater supply is $7.0 million, which is less than half of the capital cost estimate for an expanded surface water supply. Because the groundwater supply would require treatment, the operations and maintenance (O&M) cost for a groundwater supply is similar to the O&M cost for an expanded surface water supply, and the capital cost is the primary differentiator. Furthermore, phasing the implementation of the groundwater supply can minimize the initial effect on rates, which is not the case for an expanded surface water supply. The principal downside of a groundwater supply is its uncertain capacity to accommodate growth beyond 2025.

Given the cost and other advantages, the development of a groundwater supply is the recommended alternative for the City to provide an adequate water supply through 2025. Nevertheless, it is recommended that the City plan to expand Morris Reservoir and the surface water treatment plant in the future if annexations and growth projections require a greater water supply capacity than the existing surface water supply and proposed groundwater supply can support.



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WEST YOST & ASSOCIATES
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FAX (530) 756-5991

CITY OF WILLITS
WATER SUPPLY PLANNING STUDY

GROUNDWATER SUPPLY PROJECT
PHASE 1

CONCEPTUAL VICINITY MAP

JOB NUMBER
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FIGURE 5-2
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6. CONCLUSIONS AND RECOMMENDATIONS

Population and land use methodologies were used to project the 2025 and build-out water demands for the City. The land use methodology was considered more accurate, and the land use based demand projections were used as a basis of planning for the remainder of the study. Demand management measures were determined to have significant potential to reduce water demands in the future, and estimates of demand reduction were incorporated into the projected 2025 water supply requirements.

Hydrological analysis and modeling of the Centennial and Morris Reservoir system revealed a current worst-case water supply deficit of 650 AF/year and a projected 2025 worst-case deficit of 1,300 AF/year in critically dry years. Enforcement of Ordinance 95-4 during critically dry years would reduce but not eliminate the worst-case deficits. The supplemental water supply requirements for the City are summarized in Table 6-1.

Table 6-1. Supplemental Water Supply Requirements

	Without Enforcement of Ordinance 95-4	With Enforcement of Ordinance 95-4 Stage I	With Enforcement of Ordinance 95-4 Stage II
Current Demands, mgd	0.9	0.8	0.6
Projected 2025 Demands, mgd	1.8	1.5	1.3

The supplemental water supply alternatives for the City include:

- Additional surface water supply
- Neighboring water system interconnection
- Recycled water supply
- Groundwater supply

Several of the alternatives were deemed inadequate to satisfy the City's need for a supplemental water supply or were otherwise not feasible. The three feasible alternatives are: 1) expanding the capacity of Morris Reservoir, 2) building another dam elsewhere in the Little Lake Valley to expand the surface water supply, and 3) developing a groundwater supply. The capital cost estimate for a supplemental or expanded surface water supply is $18 to $20 million while the capital cost estimate for a groundwater supply is $7.0 million (Appendix E). In addition to the cost and other advantages of the groundwater supply alternative, it is feasible to implement the groundwater supply project in phases and minimize the initial effect on rates, which is not the case for an expanded surface water supply. The principal downside of the groundwater supply alternative is that the long-term annual yield of the Little Lake Valley groundwater basin may limit the groundwater supply potential to accommodate City water system growth beyond 2025.

As a result of this Water Supply Planning Study, it is recommended that the City:

- Designate a Water Conservation Coordinator to develop, launch and manage a City water conservation program and oversee the implementation of demand management measures, as described in this report.
- Continue aggressively detecting and repairing leaks in the water distribution system and maintaining or replacing meters to reduce the UAF water demand to 12 percent of the customer water demand.
- Determine whether to develop enough supplemental water supply capacity to avoid enforcement of Ordinance 95-4 in critically dry years.
- Continue to operate the lower outlet(s) of Morris Reservoir as necessary to scour the immediate bottom area and minimize future sedimentation, and work with the County to promote erosion control in the upper Davis Creek watershed.
- Pursue the use of Wente Lake as part of a water supply contingency plan, as described in this report.
- Provide treated wastewater to local area farmers to offset the agricultural demand for groundwater and increase the groundwater supply availability to the City.
- Incorporate the water supply needs of any future annexation into the capacity of a supplemental water supply project(s).
- Continue discussions with Brooktrails to determine the feasibility and potential advantages of participating in an expansion of the Brooktrails water supply capacity.
- Develop a groundwater supply as described in this report.
- Plan to expand Morris Reservoir and the surface water treatment plant in the future if annexations and growth projections require a greater water supply capacity than the existing surface water supply and proposed groundwater supply can support.

Implementation of the first phase of the groundwater supply project, as described in this report and depicted in Figure 5-2, will entail:

1. Evaluating environmental impacts, preparing necessary environmental documentation, and soliciting public comments for CEQA compliance.
2. Consulting with DHS, investigating potentially contaminating activities that may affect water quality, and adjusting proposed well locations and screening intervals as necessary.
3. Initiating detailed design of wells, pipelines and groundwater treatment plant, and securing easements as necessary.
4. Drilling wells, conducting pumping tests, collecting water quality data, and incorporating test results and water quality data into detailed design.
5. Finalizing design and amending domestic water supply permit from DHS.
6. Advertising project, evaluating and awarding construction contract, and administering contract through completion.

7. Commissioning facilities and training operators as regards groundwater supply operations and maintenance requirements.

The preliminary description of the groundwater supply project, found in this report, will serve as a rational foundation to pursue CEQA compliance and proceed into design.

APPENDIX A

Detailed Model Description

APPENDIX A - Detailed Model Description

GENERAL MODEL DESCRIPTION

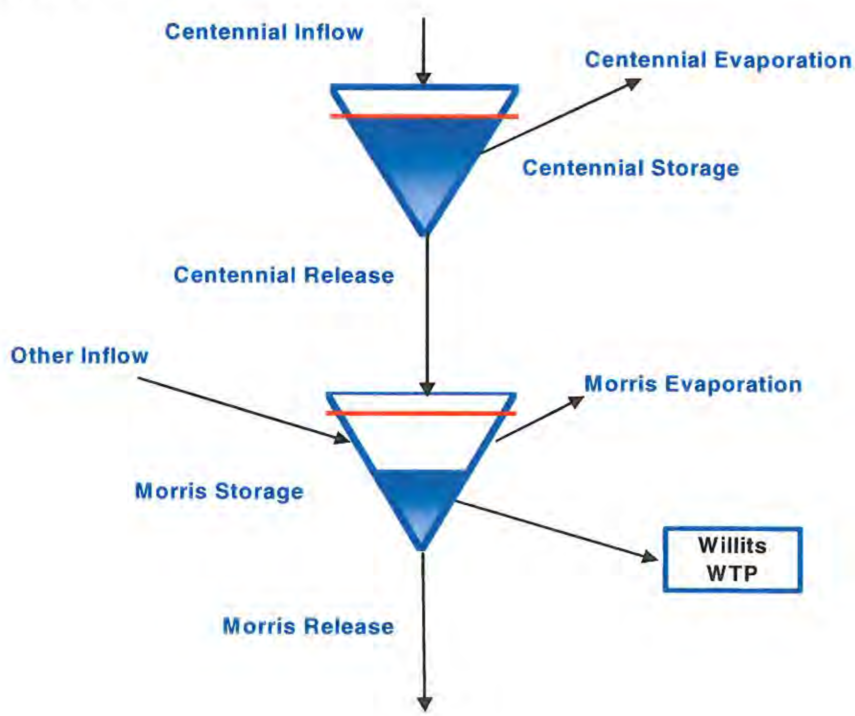
The Willits water supply model was developed as a spreadsheet. System conditions (e.g., beginning reservoir storage and water demands) are initialized for a given date, with subsequent operations determined by a series of rules and constraints. Each day's operation is dependent upon the state of the system at the end of the previous day. The model is used to simulate continuous operation of the system, day-to-day, month-to-month and year-to-year, over a time period of 36 years. The effects of a set of operating rules can be evaluated by running a simulation over the long-term hydrologic record that includes periods of flood and prolonged drought. Appendix A contains a detailed description of the model.

This type of model can be used to evaluate a given set of demands or operational rules over a long sequence of months and years. Starting with the historical hydrology (watershed inflows), the model stores or moves water based on a given set of rules and constraints such as demands, bypass requirements, flood control or spillway requirements. The results indicate what water is expected to be available for various purposes under the specified operational rules.

SYSTEM DEPICTION

Figure 1-A is the model representation of the City's reservoir system. Daily inflows are input, along with evaporation rates, reservoir operating parameters, flow requirements, and water demands. Operations of the reservoir system were designed, based on discussions with system operators, to mimic actual operations.

Figure 1-A Model Schematic



BASIC MODEL ASSUMPTIONS

Operations

The primary purpose of Centennial and Morris Reservoirs is water supply; these reservoirs are not operated to provide flood protection. Safety of Dams criteria dictates operation of flashboards at Centennial and Morris Dams, these flashboards increase storage capacity when they are in place.

In the winter, water is held upstream in Centennial Reservoir until it is required for water supply or spills into Morris. Morris is filled during the winter from Centennial spills and from local area runoff.

In the summer, water released from Centennial at a constant rate so that Centennial will reach its minimum pool by October 31. The algorithm used does not "look ahead", so increases in inflow or additional water required by Morris can alter summertime operations.

State Water Resources Control Board License 11311, Permit 17613 and Permit 20352 govern reservoir operations. Permit 20352 specifies Davis Creek bypass flow requirements for both reservoirs. These bypass requirements are implemented using two lookup tables: one table for the normal year bypasses (as defined in the Permit); and a second table for the drought year bypasses (as defined in the Permit). These tables match the seasonal bypass requirements specified in Permit 20352, paragraphs 18 and 19. The model looks up the value for the condition and the month, and bypasses the minimum of this value or the actual reservoir inflow, whichever if less. This same bypass procedure is used for each reservoir.

Hydrologic Data Development

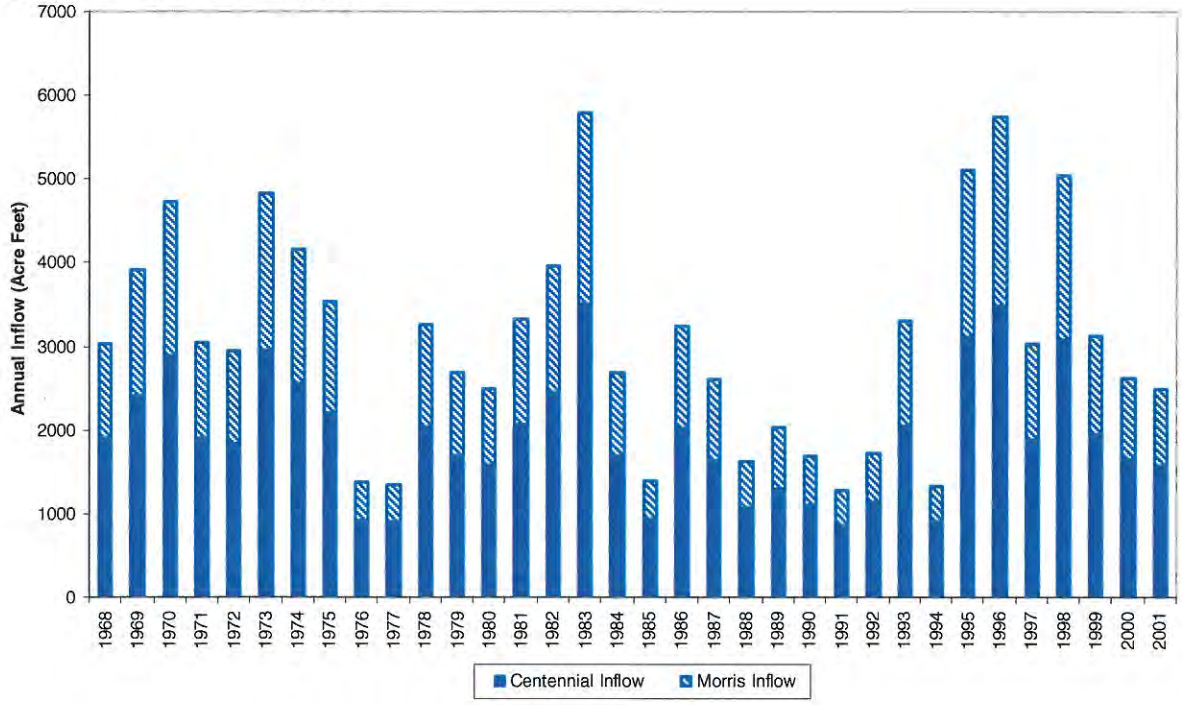
The volume and timing of runoff into the reservoir system significantly influences water supply results. Therefore, it is important to use the best inflow data available. Because there are no long-term stream gage records for the inflow into Centennial and Morris Reservoirs, inflows were estimated based on data provided by the State of California Department of Water Resources, data provided by the City of Willits, and USGS streamflow reports. The inflow and evaporation data are described in detail in Appendix B.

Figure 2-A contains a chart showing annual inflows to both Centennial and Morris Reservoirs; the average total inflow to both the reservoirs is 3,100 acre feet.

Calibration / Validation

To verify the accuracy of the model and the conclusions that are based on model results, modeled storage was compared with historical storage. Actual water deliveries and dates of flashboard use were used as inputs to the model and the reservoir storage levels were compared with historic data. This comparison and discussions with system operators confirm that the model is an acceptable tool for this water supply analysis. Appendix C contains a detailed comparison of the modeled results and historical data.

Figure 2-A Reservoir Inflows



User Interfaces

Inflows, storage and outflows from Centennial and Morris Reservoirs are graphically depicted in Figure 3-A. These modeled parameters show the month-by-month results of each simulation.

Several sheets within the model provide additional graphic and tabled information regarding the results of each simulation. These sheets are described later in this report.

Model Layout

The model is coded by several worksheets within a single Excel workbook. The individual worksheets group common functions or purposes. Several of the worksheets are further organized into sections to provide the user with logically grouped information.

The Excel workbook contains the following worksheets:

- System schematic
- Control
- Daily Model
- Monthly Charts
- Operations Chart
- Annual Charts
- Period of Record Charts
- Lookup
- License and Permits
- Centennial Area-Capacity
- Morris Area-Capacity

Each of these worksheets is described here:

System Schematic Worksheet

This worksheet contains a schematic representation (Figure 3-A) of the major components in the water system that are simulated by the model. The flowchart reports an end of month "snapshot" of reservoir storage and modeled flows. The user can specify the month to display by typing the year and month in the control box located in the worksheet. The user may also step through the simulation one month at a time or one year at a time by clicking on the forward and backward arrows in the control boxes.

Control Worksheet

The control worksheet contains parameters used to control the simulation of the water system. The control worksheet is shown in Figure 4-A.

The *control worksheet* is divided into the following sections:

- Demand Data
  Current and future water demand requirements are entered into this monthly table.

- Reservoir Operations
  The physical operations criteria for the system are defined in this section. For each reservoir, the minimum pool, maximum storage, and flashboard installation dates may be entered. The minimum pool is the lowest level that water can be drawn out of a reservoir. The outflow could be limited by the elevation of the gates or sediment filling the bottom of the reservoir. Installing flashboards across the spillway of each reservoir increases the maximum storage capacity. The dates that flashboards are installed and the new maximum capacities are entered in this table.

- System Losses
  The only losses considered this model are evaporative losses; storage losses due to seepage and sedimentation are not modeled. These losses are entered separately for each month for each reservoir. The procedure for estimating the evaporative losses is described in Appendix B.

- License and Permit Requirements
  Requirements for various licenses and permits are specified in this section.
    - License 11311 restricts direct diversions, diversions to storage, the sum of the direct diversions and diversions to storage, and the sum of the direct diversions and withdrawals from storage.
    - Permit 17613 adds an additional 280 acre-feet that may be collected to storage in Morris Reservoir.
    - Permit 20352 allows up to 767 acre-feet to be diverted and put to beneficial use. This permit also specifies Normal and Drought year minimum bypass requirements for both reservoirs.

Daily Model Worksheet

The actual simulation is performed in this worksheet. Details of the model logic are contained in Figure 5-A. This chart includes the equations that are embedded in the model and their descriptions.

The *Daily Model Worksheet* is visually grouped into four sections:

- Inflows
  Two series of inflow were analyzed. Both sets of inflow data were developed by regression with a similar basin with a USGS gage. The first inflow series was based on data taken by the Department of Water Resources from 1986 – 1988; the second series was based on the 2005 Centennial inflow records kept by the City of Willits. There are more details on development of the inflow series in Appendix B. The simulated data for Centennial and Morris and the entire watershed is an input to the model in this section.

- Centennial Reservoir
  This section of the model simulates Centennial reservoir operations.

- Morris Reservoir
  This section of the model simulates Morris reservoir operations.

Monthly Charts Worksheet
This worksheet can be used to step through and view water supply system information for each month. Controls allow stepping through simulation one month or one year at a time or jumping to a specific month and year.

Operations Chart 1 Worksheet
This chart graphically depicts the monthly shortages and end-of-month storages for the entire simulation.

Operations Chart 2 Worksheet
This chart graphically depicts the daily shortages and storages for the entire simulation.

Annual Charts Worksheet
This worksheet totals daily data from the simulation into monthly tables. Charts allow stepping through and viewing simulation data for a single year.

Period of Record Charts Worksheet
This worksheet totals daily data from the simulation into a yearly table. Charts summarize simulation results in various formats.

Lookup Worksheet
This worksheet contains data for looking up year type (Normal or Drought). The year type is estimated twice a year, on March 1 and on April 30. Figure 4-A shows the historical year types. This information is used to determine bypass flow requirements for the coming year.

License and Permits Worksheet

This worksheet contains water supply limits and bypass requirements from the license and permits.

Centennial Area-Capacity Worksheet

This worksheet contains elevation, capacity and area data for Centennial Reservoir. This table is used to determine surface area of the reservoir for evaporation calculations. Area-Capacity is discussed further in Appendix B, and the curves are in Figure 5-B.

Morris Area-Capacity Worksheet

This worksheet contains elevation, capacity and area data for Morris Reservoir. This table is used to determine surface area of the reservoir for evaporation calculations. Area-Capacity is discussed further in Appendix B, and the curves are in Figure 5-B.

Figure 3-A

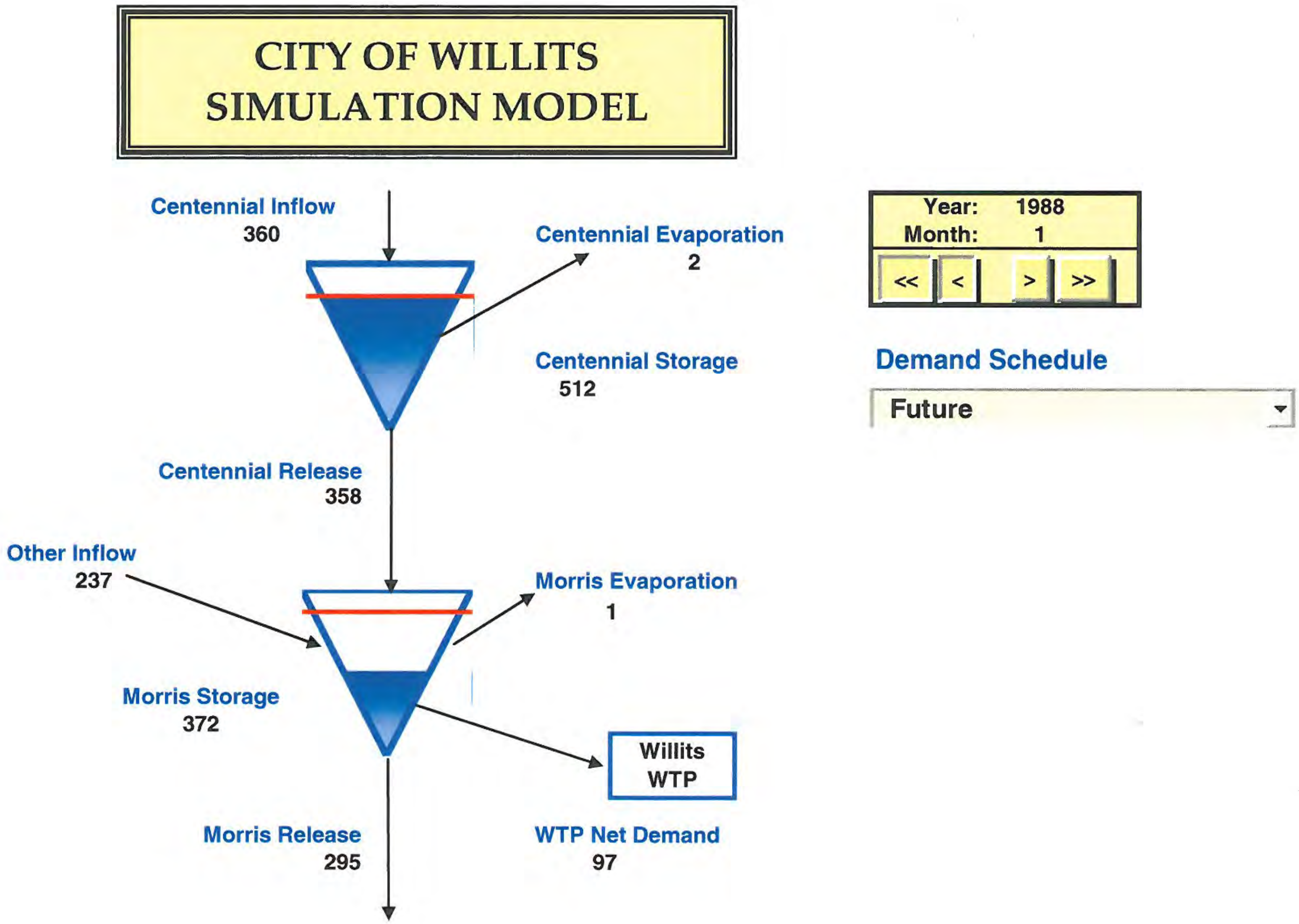

CITY OF WILLITS
SIMULATION MODEL
Centennial Inflow
360
Centennial Evaporation
2
Centennial Storage
512
Centennial Release
358
Other Inflow
237
Morris Evaporation
1
Morris Storage
372
Willits
WTP
Morris Release
295
WTP Net Demand
97
Year: 1988
Month: 1
<<
<
>
>>
Demand Schedule
Future

Figure 4-A

CONTROL DATA

NOTE This is a listing of all the variables for the simulation model.
The values in the yellow cells are the values that may be changed.

Demand Data

Monthly Demand Pattern (less backwash) - acre feet

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total (af)	Total (mg)
Current (2003)	95.8	70.8	78.0	66.6	65.3	71.6	76.5	90.8	120.8	131.9	123.3	107.8	1099	358
Future	144.8	101.7	116.2	96.7	93.7	103.5	110.6	134.6	186.4	205.3	190.7	164.6	1649	537

Reservoir Operations

	Flashboard Date	Min Pool	Max Storage with FB	Max Storage w/o FB
Centennial	Apr 2	50	635	512
Morris	Mar 16	100	726	628

System Losses

Reservoir Evaporation (in)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
Centennial	2.52	1.07	0.66	0.83	1.21	2.55	3.88	5.77	6.53	7.91	6.97	4.67	44.59
Morris	2.52	1.07	0.66	0.83	1.21	2.55	3.88	5.77	6.53	7.91	6.97	4.67	44.59

License and Permit Requirements

Max Direct Diversion (cfs)	Max Morris Storage (af)	Max Centennial Storage (af)	Max Diversion plus Morris Storage	Max Diversion plus Morris Withdrawals (af)
2.00	915	767	1888	2491

Permit 17613 addition 280

Minimum Bypass (cfs) - Normal Year

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Centennial	1	1	1	1	1	1	1	1	1	1	1	1
Morris	1	5	5	5	5	1.5	0.5	0.75	1	1	1	1

Minimum Bypass (cfs) - Drought Year

Centennial	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Morris	0.1	1.5	3.5	3.5	3.5	1	0.5	0.1	0.1	0.1	0.1	0.1

Figure 5-A
List of Columns in Daily Model

Heading	Title	Units	Column	Equation	Description
Dates	Month - Year		A	=DATE(YEAR(B16),MONTH(B16),1)	Used for creating monthly totals and graphics
	Date		B		
	Year Type		C	=VLOOKUP(IF(MONTH(B16)<3,YEAR(B16)-1,YEAR(B16)),Year_Type,IF(MONTH(B16)=OR(3,4),2,3),FALSE)	Normal or Drought as defined in Permit 20352, used to determine bypass requirements
Inflows	Centennial	CFS	D	Model input developed separately	Simulated daily inflow based on regression with Elder Creek near Branscomb
	Morris+ Cent	CFS	E	Model input developed separately	Simulated daily inflow based on regression with Elder Creek near Branscomb
	Morris	CFS	F	Model input developed separately	Total basin flow less Centennial inflow
Centennial	Inflow	ACRE-FEET	H	=D16*1.983	Centennial inflow converted to acre-feet
	Evaporation	ACRE-FEET	I	=HLOOKUP(MONTH(B16),Control!$C$25:$N$28,3,FALSE)/IF(DAY(B16)=31,31,EDATE(B16,1)-B16)*VLOOKUP(T15,'Centennial Area-Capacity'!$C$7:$D$34,2,TRUE)/12	Multiplies the evaporation rate on control page times the reservoir area. Area is looked up based on beginning of month storage.
	Bypass Release	ACRE-FEET	J	=MIN(H16,HLOOKUP(MONTH(B16),Control!$C$39:$N$46,IF(C16="Normal",3,7),FALSE)*1.983)	This value is minimum of bypass flow and Centennial inflow
	Max Storage		K	=IF(AND(B16>DATE(YEAR(B16),MONTH(Control!$C$18),DAY(Control!$C$18)),B16<DATE(YEAR(B16),10,1)),Control!$E$18,Control!$F$18)	Maximum capacity of Centennial. This value changes when the flashboards are installed
	Number of days left of summer drawdown to Morris	ACRE-FEET	L	=IF(AND(MONTH(B16)>4,MONTH(B16)<11),DATE(1967,11,1)-DATE(1967,MONTH(B16),DAY(B16)),0)	Number of days until November 1, if date is after April 30

Heading	Title	Units	Column	Equation	Description
Centennial	Standard summer drawdown to Morris	ACRE-FEET	M	=IF(L16>0,MAX(0,(T15-Control!$D$18)/L16+H16-I16),0)	Useable water left in Centennial divided by the number of days left of summer drawdown
	Extra Summer release when Morris is low	ACRE-FEET	N	=IF(AG15<Control!$D$19+75,MAX(0,MIN(T15-Control!$D$18,AB15+AA15)),0)	If Morris has less than 75 acre-feet of useable water left, release the amount of water used by Morris from Centennial if the water is available
	Extra winter release when Morris is low	ACRE-FEET	O	=IF(OR(AND(AG15<Control!$D$19+75,AA15>=Z15),AND(AG15<Control!$D$19+10,(T15-Control!$D$18)>(Z15-V15))),T15-Control!$D$18,0)	If Morris has less than 75 acre-feet of useable water left and the full bypass is already being released from Morris, or if Morris has less than 10 acre-feet, release whatever water Centennial has available
	Extra Releases to Morris	ACRE-FEET	P	=IF(AG15>Y16-100,0,IF(L16>0,MAX(M16,N16),MAX(0,O16)))	If Morris is within 100af of full don't make extra release. If making summer drawdowns, release the greater of regular drawdown or extra summer release. During the winter make extra winter releases if needed.
	Spill	ACRE-FEET	Q	=MAX(T15+H16-I16-MAX(J16,P16)-K16,0)	Amount of water that is over the spillway (>max storage)
	Release to Davis Creek	ACRE-FEET	R	=MAX(T15+H16-I16-K16,MAX(J16,P16+Q16),0)	Sum of Bypass release, extra releases to Morris and Spills
	Max Change - Release to Davis Creek	ACRE-FEET	S	=IF(Q16=0,MIN(R16,IF(C16="Normal",'License and Permits'!$D$33,'License and Permits'!$D$37)+S15),R16)	Permit 20352 paragraphs 19A and 19B limit increases or decreases in bypass flows to prevent stranding of fish and damage to aquatic invertebrates. When the reservoir isn't spilling, the releases to Davis Creek may be limited by these requirements.
	End of Day Storage	ACRE-FEET	T	=T15+H16-I16-S16	End of day storage in Centennial.

Heading	Title	Units	Column	Equation	Description
Morris	Local Inflow	ACRE-FEET	V	=F16*1.983	Morris local inflow converted to acre-feet
	Actual Inflow	ACRE-FEET	W	=S16+V16	Total release from Centennial plus local Morris inflow
	Evaporation	ACRE-FEET	X	=HLOOKUP(MONTH(B16),Control!$C$25:$N$28,4,FALSE)/IF(DAY(B16)=31,31,EDATE(B16,1)-B16)*VLOOKUP(AG15,'Morris Area-Capacity'!$C$8:$D$407,2,TRUE)/12	Multiplies the evaporation rate on control page times the reservoir area. Area is looked up based on beginning of month storage.
	Max Storage	ACRE-FEET	Y	=IF(AND(B16>DATE(YEAR(B16),MONTH(Control!$C$19),DAY(Control!$C$19)),B16<DATE(YEAR(B16),10,1)),Control!$E$19,Control!$F$19)	Maximum capacity of Morris. This value changes when the flashboards are installed
	Max bypass requirement	ACRE-FEET	Z	=HLOOKUP(MONTH(B16),Control!$C$39:$N$46,IF(C16="Normal",4,8),FALSE)*1.983	The Morris bypass requirement specified in Permit 20352 for the month
	Bypass Release to Davis Ck	ACRE-FEET	AA	=MIN(W16,Z16)	Minimum of the total Morris inflow or the bypass requirement specified in Permit 20352
	Scheduled Delivery to WTP	ACRE-FEET	AB	=HLOOKUP(MONTH(B16),Control!$C$9:$N$12,MATCH($AB$1,Control!$B$11:$B$12,0)+2,FALSE)/IF(DAY(B16)=31,31,EDATE(B16,1)-B16)	Monthly value looked up based on demand schedule selected on schematic page
	Spill	ACRE-FEET	AC	=MAX(AG15+W16-X16-AA16-AB16-Y16,0)	Amount of water that is over the spillway (>max storage)
	Net Delivery to WTP	ACRE-FEET	AD	=MAX(MIN(AG15-Control!$D$19+W16-X16-AA16,AB16),0)	Minimum of scheduled delivery and water available in Morris
	Total Release to Davis Creek	ACRE-FEET	AE	=MAX(MIN(AG15-Control!$D$19+W16-X16,AA16)+AC16+MAX(IF(MONTH(B16)=OR(7,8,9),W16-X16-AA16-AC16-AD16,0),0),0)	Sum of bypass release from Morris and spills
	Total Release and Delivery	ACRE-FEET	ACRE-FEET	=AD16+AE16	Sum of delivery to water treatment plant and releases to Davis Creek
	End of Day Storage	ACRE-FEET	AG	=AG15+W16-X16-AF16	End of day storage in Morris
	Shortage	ACRE-FEET	AH	=MAX(AB16-AD16,0)	Shortage in deliveries to the water treatment plant

Figure 6-A
Year Type Lookup Table

	Year Type	
	Calculated Mar1	Calculated Apr 30
1961	Normal	Normal
1962	Normal	Normal
1963	Normal	Normal
1964	Normal	Normal
1965	Normal	Normal
1966	Normal	Normal
1967	Normal	Normal
1968	Normal	Normal
1969	Normal	Normal
1970	Normal	Normal
1971	Normal	Normal
1972	Normal	Normal
1973	Normal	Normal
1974	Normal	Normal
1975	Normal	Normal
1976	Drought	Drought
1977	Drought	Drought
1978	Normal	Normal
1979	Normal	Normal
1980	Normal	Normal
1981	Drought	Drought
1982	Normal	Normal
1983	Normal	Normal
1984	Normal	Normal
1985	Normal	Normal
1986	Normal	Normal
1987	Normal	Normal
1988	Normal	Normal

	Year Type	
	Calculated Mar1	Calculated Apr 30
1989	Normal	Normal
1990	Drought	Drought
1991	Normal	Normal
1992	Normal	Normal
1993	Normal	Normal
1994	Normal	Normal
1995	Normal	Normal
1996	Normal	Normal
1997	Normal	Normal
1998	Normal	Normal
1999	Normal	Normal
2000	Normal	Normal
2001	Normal	Normal
2002	Normal	Normal

APPENDIX B

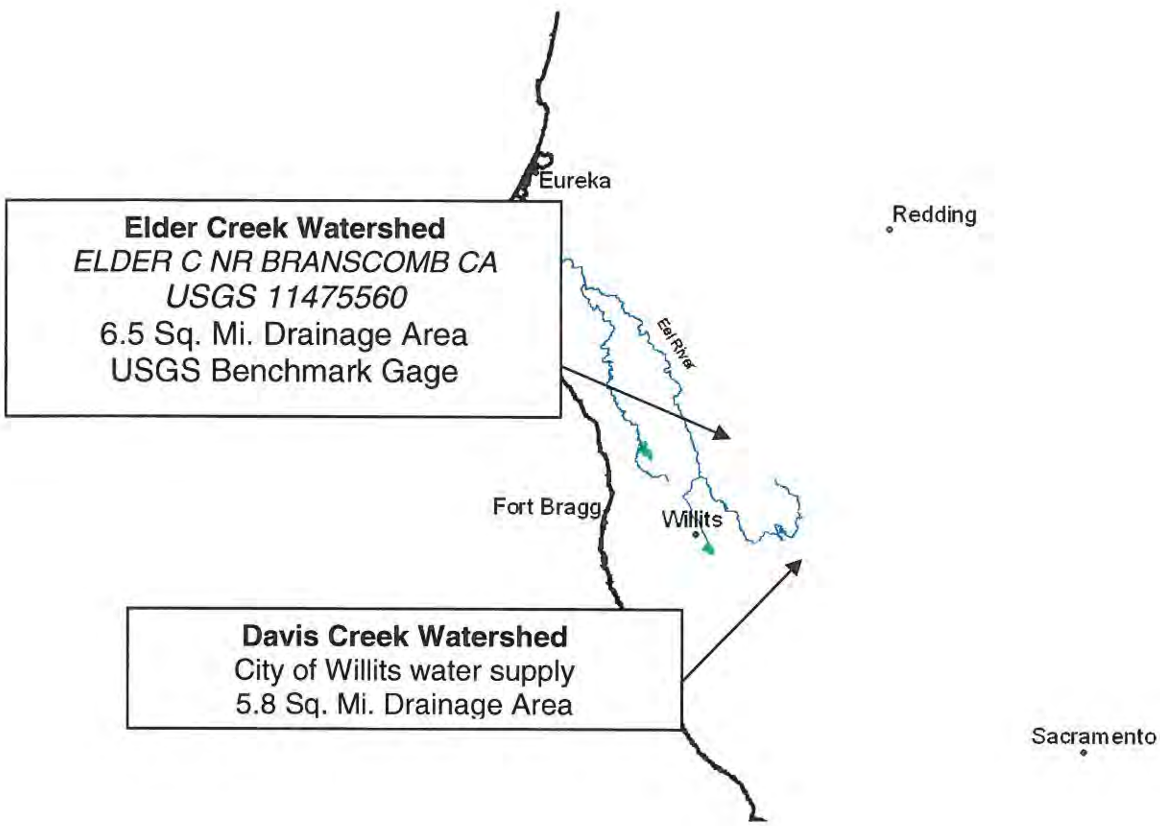
Development of Hydrology

APPENDIX B
Development of Hydrology

This appendix describes the development of the hydrologic data that are used in the simulation model. Estimates of reservoir inflow were developed by relating the Davis Creek watershed to the Elder Creek watershed. Development of evaporation data is also presented in this Appendix.

Selection of similar basin

The Centennial-Morris watershed drains 5.8 square miles. The region can experience heavy rainfall in the winter with little or no rain through the summer. The watershed has a small spring which flows throughout the summer, providing a small amount of inflow to Centennial reservoir.



Centennial Reservoir (from DWR Bulletin 17-93):
Mendocino County, California
Hydrologic Unit Code 18010106
Latitude 39°21'30", Longitude 123°18'42" NAD27
Crest of Dam 1,682 feet above sea level NGVD29

Morris Reservoir (from DWR Bulletin 17-93):
Mendocino County, California
Hydrologic Unit Code 18010106
Latitude 39°22'12", Longitude 123°17'54" NAD27
Crest of Dam 1,552 feet above sea level NGVD29

Branscomb Gage on Elder Creek

USGS 11475560 ELDER C NR BRANSCOMB CA
Mendocino County, California
Hydrologic Unit Code 18010106
Latitude 39°43'47", Longitude 123°38'34" NAD27
Drainage area 6.50 square miles
Gage datum 1,391.08 feet above sea level NGVD29

The USGS has compiled daily streamflow data from this gage since October 1, 1967.

Hydrologic Benchmark Network

The following abstract is from "Hydrologic Benchmark Network Stations in the U.S. 1963-95 (USGS Circular 1173)". The full text of the report can be found at http://ny.cf.er.usgs.gov/hbn/report.cfm

"The Hydrologic Benchmark Network was established in 1963 to provide long-term measurements of streamflow and water quality in areas that are minimally affected by human activities. These data were to be used to study time trends and to serve as controls for separating natural from artificial changes in other streams. The network has consisted of as many as 58 drainage basins in 39 States. This report describes the environmental characteristics and water quality at 56 benchmark basins including 16 in the Eastern United States, 14 in the Midwestern United States, 14 in the West-Central United States, and 12 in the Western United States. The information in this report was compiled to aid in the application and interpretation of historical water-quality data collected as part of the U.S. Geological Survey Hydrologic Benchmark Network program.

"The site characteristics vary amount the stations in the Hydrologic Benchmark Network. Land-use activities range from recreational use and timber harvesting on publicly owned land to agriculture and residential development on privately owned land. The streams drain a variety of physiographic, geologic, and ecologic settings that range from low-elevation coastal plain environments to high-elevation alpine environments. The streamflow characteristics of the stations are variable. Some of the sites are dominated by steady ground-water flows, and others have snow-dominated hydrographs where a large part of the flow results from the melting of the annual snowpack.

" Stream-water chemistry at most Hydrologic Benchmark Network stations appears to be controlled by the interaction of acidic precipitation with underlying soils and bedrock. Land use has a minimal effect on stream-water chemistry except for a few stations in the Eastern and Midwestern regions of the United States. Temporal trends in water-quality constituents were observed at several of the stations and were attributed either to environmental or to method-related factors. Environmental factors that may have caused water-quality trends include increases in residential population, trends in atmospheric deposition, agricultural activities, landscape disturbance, and extended periods of drought. A few common trends were observed among stations, including downward trends in sulfate and upward trends in pH at several stations, which were attributed to changes in field instrumentation and analytical techniques rather than environmental change."

Development of Streamflow Regression Equations

California Department of Water Resources Centennial and Morris Inflow Data
From 1986 through 1988 (before construction of Centennial Reservoir), the California Department of Water Resources (DWR) took flow measurements of the tributaries that discharged into Morris Reservoir. Measurements for Davis Creek, the un-named middle tributary and the un-named east tributary are included in Figure 1-B.

City of Willits Centennial Inflow Data
Since 1999, the City of Willits has been collecting periodic inflow data for Centennial and Morris reservoirs. Recently, automatic recorders have been added to the weirs and data is currently being collected every six hours. Hydrology was developed using the 2005 inflow data.

Elder Creek (Branscomb Gage) Data
Elder Creek flow records for the same dates at the DWR measurements are included in Figure 2-B

Regression Equations
Two sets of regression equations were developed:
1 - Regression of Elder Creek with Davis Creek using 27 DWR measurements:

Centennial inflow = 0.0888 x Elder Creek flow + 0.5930
Correlation coefficient (R^2) = 0.8579

Total Morris and Centennial inflow = 0.1513 x Elder Creek flow + 0.3757
Correlation coefficient (R^2) = 0.9163

Morris local inflow was calculated by subtracting the Centennial inflow from the Total inflow.

Figure 3-B is a graphical representation of these regressions with the DWR measurements.

2 - Regression of Elder Creek with Davis Creek using City of Willits 2005 measurements:

Centennial low inflow (Elder Creek flow < 3.5 cfs) = 0.017 x Elder Creek flow + 0.07
Correlation coefficient (R^2) = 0.96

Centennial mid inflow (3.5 cfs < Elder Creek flow < 10 cfs) = 0.03 x Elder Creek flow + 1.07
Correlation coefficient (R^2) = 0.92

Centennial high inflow (Elder Creek flow > 10 cfs) = 0.09 x Elder Creek flow + 0.98
Correlation coefficient (R^2) = 0.62

When Centennial inflow is low (<2 cfs) it was assumed that Morris would have no additional local inflow. When Centennial inflow was higher (>2 cfs) Morris additional local inflow was assumed to be 38% of the basins inflow.

Figure 4-B, 5-B, and 6-B are graphical representations of these regressions with the City of Willits 2005 measurements.

Estimate of Reservoir Evaporation

DWR Bulletin 73-79 was used to estimate the monthly evaporation from each reservoir. The Fullerton Pan A coefficient was multiplied by the average pan evaporation recorded at Covello 1E, Lake Pillsbury, and Coyote Dam. Figure 7-B shows these calculations.

Inches of evaporation are converted to acre-feet in the simulation model by multiplying by the surface area of each reservoir. Surface area was estimated using the volume of storage at the beginning of the month and the reservoir area capacity graphs in Figure 8-B.

Figure 1-B
Department of Water Resources
Davis Creek Streamflow Measurements

OF CALIFORNIA—RESOURCES AGENCY GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT
0 MAIN STREET
. BOX 607
D BLUFF 96080
(916) 527-6530

MORRIS RESERVOIR TRIBUTARY DISCHARGE (cfs)

Date	Davis Creek	Middle Tributary	East Tributary
4-24-86	2.69	Pooled	
5-21-86	1.27	-	0.17
6-05-86	1.76	-	0.08
6-18-86	1.37	-	0.04
7-09-86	0.89	-	-
7-24-86	0.12	-	-
8-07-86	0.54	-	-
8-21-86	0.58	-	-
9-11-86	0.61	-	-
9-25-86	1.03	-	-
10-10-86	0.80	-	-
10-24-86	-	-	-
11-06-86	0.52	-	-
11-21-86	0.88	-	-
12-11-86	0.53	-	-
12-23-86	1.65	0.31	0.77
1-09-87	1.87	0.35	0.66
1-22-87	0.99	0.02	0.13
2-05-87	4.41	0.80	2.04
2-18-87	5.42	1.01	2.34
3-04-87	1.79	0.24	0.81
3-17-87	8.54	1.36	3.53
4-03-87	3.03	0.24	0.74
4-13-87	1.70	-	-
5-07-87	1.07	-	-
6-05-87	0.99	-	Pooled
6-25-87	0.76	-	-
7-01-87	0.75	-	-
8-07-87	0.26	No data	No data
9-03-87	-	"	"
10-08-87	0.30	"	"
11-03-87	0.50	"	"
12-03-87	10.03	"	"
1-08-88	10.47	"	"
2-09-88	2.23	"	"
3-09-88	1.81	"	"
4-07-88	1.08	"	"
5-03-88	3.67	"	"
6-10-88	1.46	"	"

Figure 2-B
Elder Creek Gage Data Compared with Department of Water Resources Data

Date	Elder Creek (Branscomb) Gage	Centennial Inflow (Davis Creek) DWR Data	Total Inflow (Davis Creek + Middle Tributary + East Tributary DWR Data
	cfs	cfs	cfs
4/24/1986	7	2.69	2.69
5/21/1986	6.6	1.27	1.44
6/5/1986	4.4	1.76	1.84
6/18/1986	3.4	1.37	1.41
7/9/1986	1.8	0.89	0.89
7/24/1986	1.3	0.12	0.12
8/7/1986	1	0.54	0.54
8/21/1986	0.85	0.58	0.58
9/11/1986	0.7	0.61	0.61
9/25/1986	2.5	1.03	1.03
10/10/1986	1.6	0.8	0.8
11/6/1986	4	0.52	0.52
11/21/1986	4.6	0.88	0.88
12/11/1986	5.1	0.53	0.53
12/23/1986	15	1.65	2.73
1/9/1987	25	1.87	2.88
1/22/1987	8.8	0.99	1.14
2/5/1987	57	4.41	7.25
2/18/1987	62	5.42	8.77
3/4/1987	22	1.79	2.84
3/17/1987	67	8.54	13.43
4/3/1987	19	3.03	4.01
4/13/1987	11	1.7	1.7
5/7/1987	5.7	1.07	1.07
6/5/1987	3	0.99	0.99
6/25/1987	2	0.76	0.76
7/1/1987	1.7	0.75	0.75

Figure 3-B

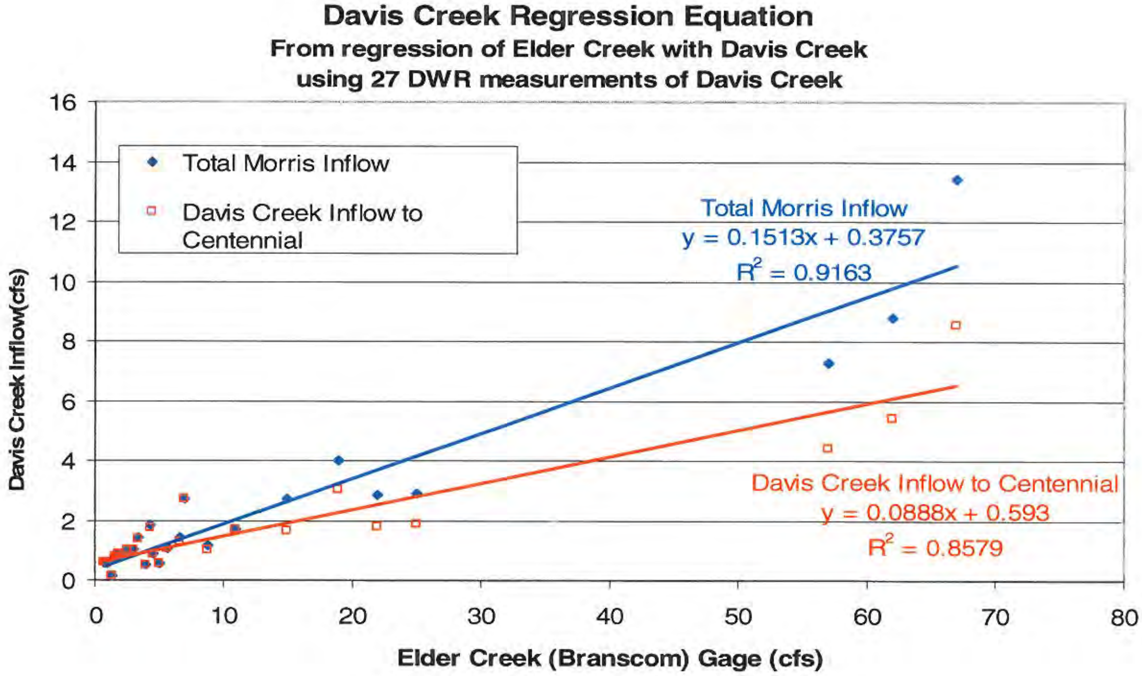


Figure 4-B

Davis Creek Low Flow Regression Equation
From regression of Elder Creek with Davis Creek
Using City of Willits 2005 measurements

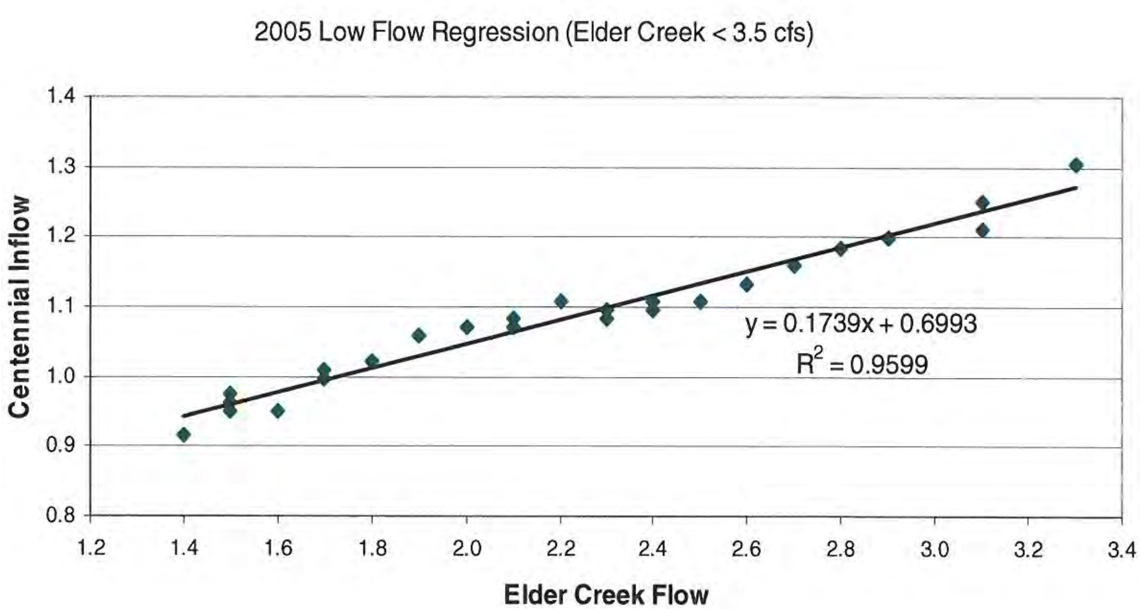


Figure 5-B

Davis Creek Mid Range Flow Regression Equation
From regression of Elder Creek with Davis Creek
Using City of Willits 2005 measurements

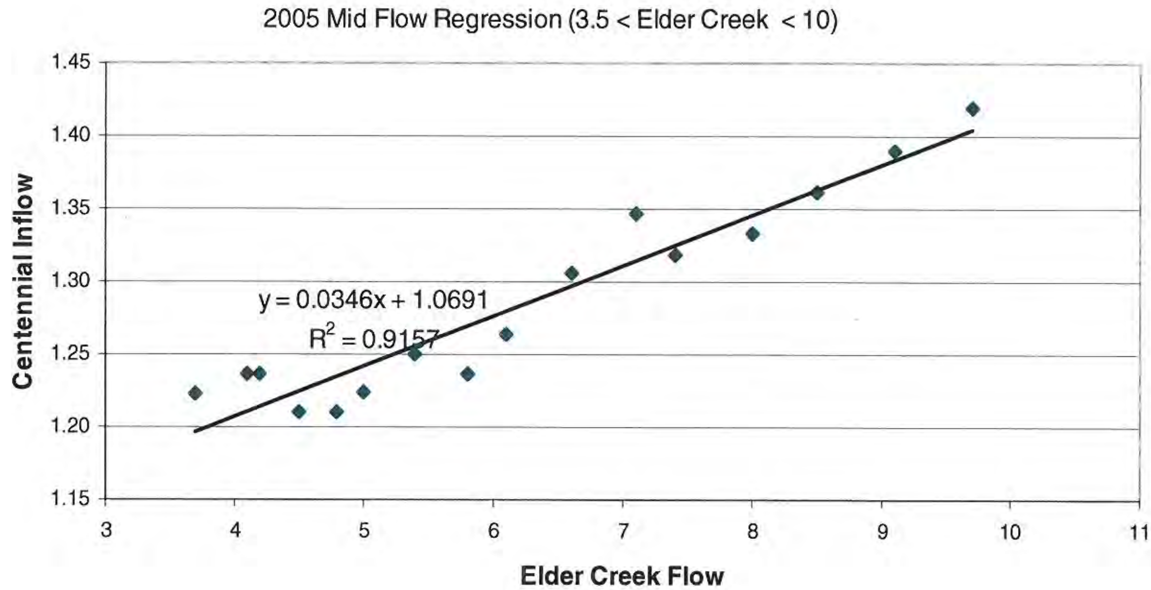


Figure 6-B

Davis Creek High Flow Regression Equation
From regression of Elder Creek with Davis Creek
Using City of Willits 2005 measurements

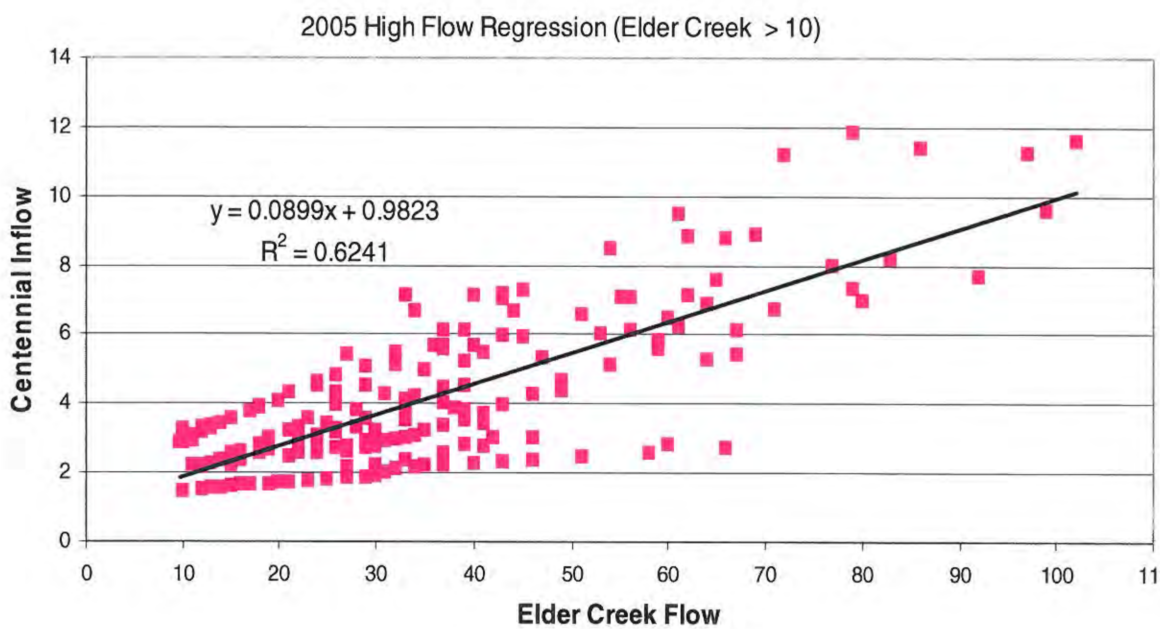
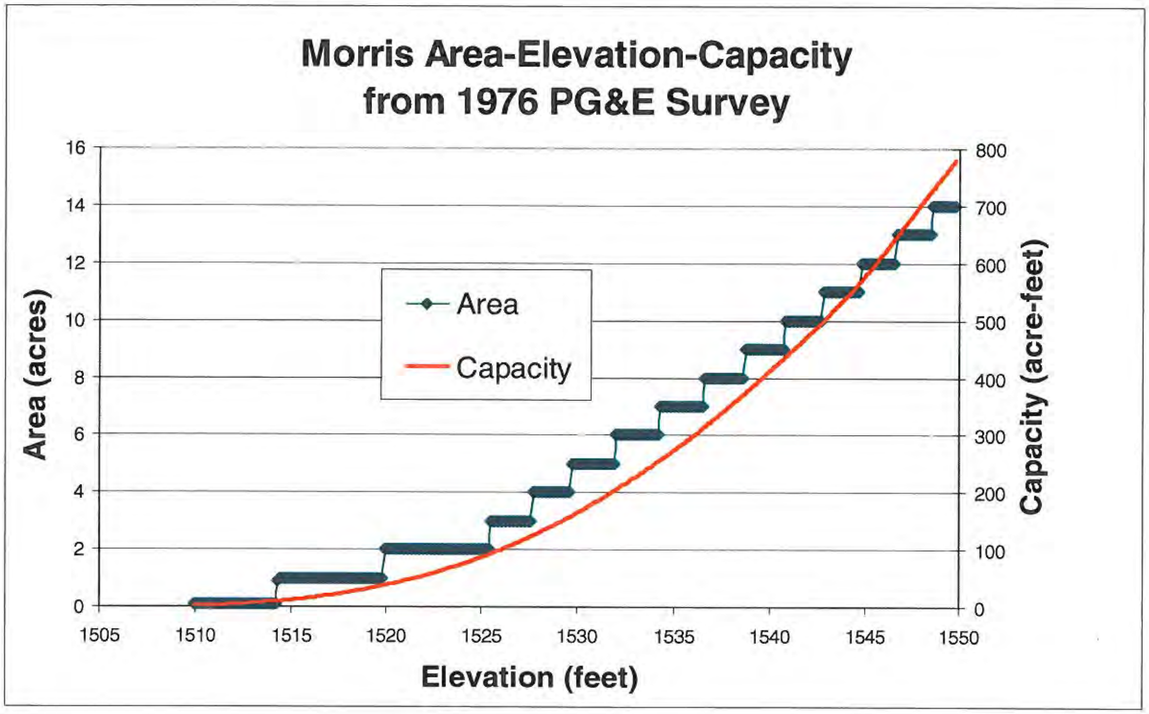
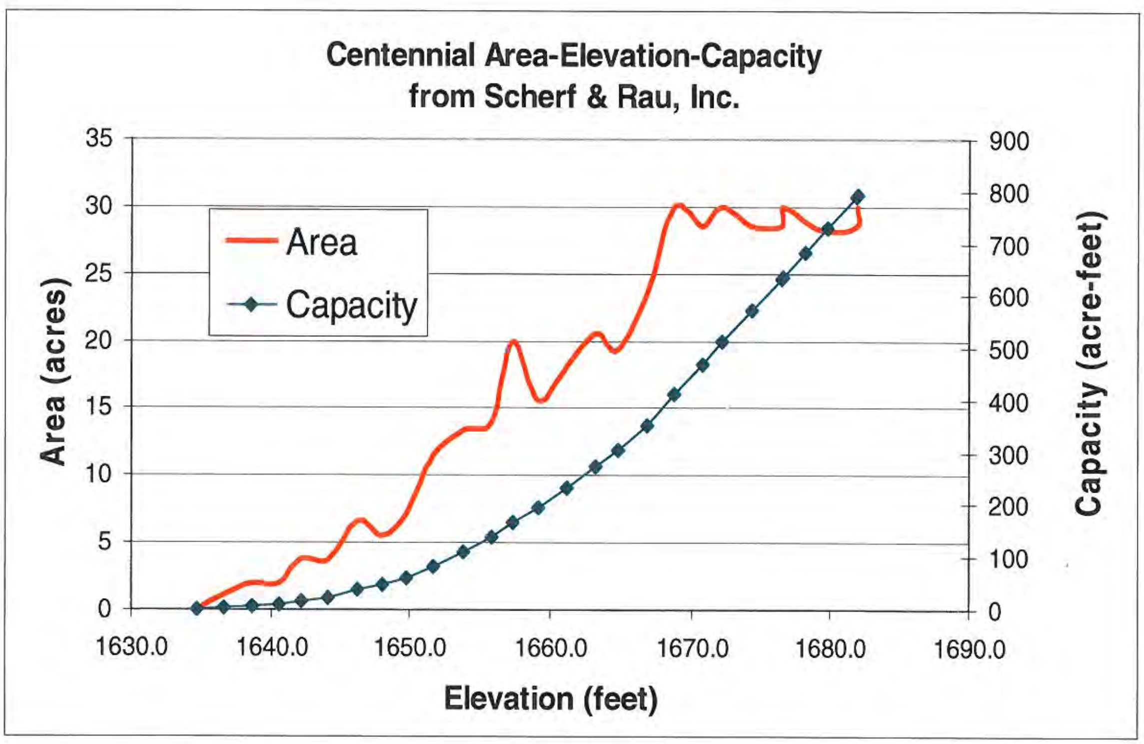


Figure 7-B
Estimate of Monthly Evaporation

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
DWR Bulletin 73-79 Pan A Coefficient													
Fullerton	0.65	0.77	0.76	0.8	0.81	0.82	0.81	0.81	0.76	0.75	0.72	0.66	0.76
DWR Bulletin 73-79 Pan data (mm)													
Covelo 1E	92	28	15	27	30	77	111	165	193	240	231	163	1372
Lake Pillsbury	87	30	22	16	36	76	117	188	211	265	238	176	1462
Coyote Dam	117	48	29	36	48	84	137	190	251	299	269	200	1708
Ave Cov-Pills-Coy	99	35	22	26	38	79	122	181	218	268	246	180	1514
Centennial/Morris (mm)	64	27	17	21	31	65	99	147	166	201	177	119	1132
Centennial/Morris (inches)	**2.52**	**1.07**	**0.66**	**0.83**	**1.21**	**2.55**	**3.88**	**5.77**	**6.53**	**7.91**	**6.97**	**4.67**	**44.59**

Figure 8-B
Area Capacity Charts





APPENDIX C
Model Validation

APPENDIX C
Model Validation

The water supply simulation model was validated by comparing the model's predicted water storage with historical periodic measured storage. For this comparison, a simulation was run that used historical water treatment plant deliveries and flashboard installation dates. Because Centennial Reservoir is a fairly new reservoir, comparison was only performed from October 1993 through September 2002 (after Centennial had filled and stabilized).

Historical Operations Data Used for Validation

City of Willits Water Treatment Plant Production Data

The City of Willits provided data on withdrawals from Morris Reservoir ("Production") and water delivered from the treatment plant into the City's water system ("System"). The difference between these values is the water used for backwashing filters that was returned to Morris reservoir. Water treatment plant data provided is included as Figure 1-C.

For the simulation model, this data was converted from monthly to daily values and used in place of the demand data.

Flashboard Installation Dates

DWR Division of Safety of Dams (DSOD) has approved the use of flashboards across the spillways, which increases the storage capacity of each reservoir. On March 7, 1978, DSOD authorized the installation of flashboards across the Morris spillway from March 16 through October 31. And on January 5, 1990, DSOD authorized the installation of flashboards across the Centennial spillway from April 2 through September 30.

Because the reservoirs fill quickly during the spring runoff, available water supply is very sensitive to the exact date of installation of the flashboards. The historical installation dates, shown in Figure 2-C, were used to validate the simulation model's operations.

Reservoir Storage and Lake Level Data

Figure 3-C shows historical weekly reservoir storage data provided by the City of Willits. These data were compared with the simulated storage data to validate the model.

Comparison of Modeled and Historical Total System Storage

For validation of the simulation model, the water stored in Centennial was added to water stored in Morris and total system storage was compared with historical storage data. Comparison of these values is shown graphically in Figure 4-C and Figure 5-C. Overall, the model does a good job of predicting system operations and water supply both with the DWR inflow series and with the City of Willits inflow series.

The DWR inflow series was based on measurements taken from 1986 – 1988. This was a fairly dry period with annual precipitation slightly below average. The City of Willits inflow series was based on measurements taken in 2005. 2005 was fairly wet with annual precipitation somewhat higher than average. The summer periods for the City of Willits validation shows the reservoirs being drawn down faster than predicted. It is possible that the regression predicts higher inflow than actually occurs during dry periods.

The filling of Centennial and Morris Reservoirs is sensitive to the exact timing of storm runoff and exact installation date of the flashboards in the spring. In many years the Reservoirs will spill before the flashboards are installed, giving the graphs the stepped rise in the spring. If a storm's runoff estimated by the model is a few days different than historical, or if the modeled flashboards installation is a few days different than historical, there can be significant differences in predicted and actual water stored during the spring. This extra water could cause validation differences in the spring, through the summer, and possibly into the following year.

Differences in validation could also be due to historic surcharging of the reservoirs. Reservoirs often hold more water than their capacity for a short period during storms events or periods of high runoff. The model does not allow the reservoirs to overfill, and so does not predict the capture of the extra surcharged water.

In 1998 and in 2000, the model does not capture as much runoff in the spring as was historically captured. In 1998, the reservoirs were spilling and the surcharge effect increased the historical storage above the modeled storage. This extra water would make a difference throughout the summer. In 2000, the reservoirs were spilling on the flashboard installation date. The surcharge effect, timing of storm and flashboard installation date have all reduced the modeled storage.

Figure 1-C

Water Treatment Plant Production Data

Month	Production (mg)	Sales (mg)	System (mg)	Month	Production (mg)	Sales (mg)	System (mg)
Jan-90	24.52	18.60	21.21	Sep-93	35.90	30.15	43.03
Feb-90	20.75	20.32	21.16	Oct-93	28.60	28.13	35.85
Mar-90	27.09	17.91	25.87	Nov-93	25.29	18.55	33.88
Apr-90	27.72	18.62	27.87	Dec-93	26.71	19.38	30.00
May-90	30.66	25.28	31.00	Jan-94	33.78	18.42	26.02
Jun-90	39.00	26.74	31.60	Feb-94	33.26	25.68	23.15
Jul-90	49.18	28.54	44.50	Mar-94	41.66	17.98	30.46
Aug-90	52.45	36.59	43.71	Apr-94	39.89	20.35	28.58
Sep-90	30.63	32.42	31.75	May-94	38.27	18.80	32.00
Oct-90	29.83	23.33	29.52	Jun-94	44.96		40.15
Nov-90	21.36	23.78	23.30	Jul-94	50.68	34.12	48.44
Dec-90	30.70	19.09	30.75	Aug-94	54.24	34.71	46.67
Jan-91	29.46	16.95	24.68	Sep-94	49.51	31.91	42.24
Feb-91	23.09	19.07	18.46	Oct-94	46.48	26.60	38.16
Mar-91	29.26	16.95	21.11	Nov-94	33.93	21.45	27.48
Apr-91	23.84	16.67	21.10	Dec-94	29.64	18.39	27.68
May-91	26.37	19.65	24.31	Jan-95	34.08	20.66	28.64
Jun-91	43.09	27.10	33.30	Feb-95	35.17	13.51	24.75
Jul-91	38.64	28.20	38.57	Mar-95	41.14	16.97	27.01
Aug-91	38.70	35.59	36.80	Apr-95	30.91	16.48	26.57
Sep-91	38.86	31.45	35.35	May-95	33.01	18.29	29.00
Oct-91	33.57	31.58	28.37	Jun-95	39.56	23.60	35.71
Nov-91	25.02	23.93	23.22	Jul-95	39.36	28.80	41.25
Dec-91	20.10	17.10	21.48	Aug-95	39.93	36.12	43.86
Jan-92	26.36	18.51	21.95	Sep-95	36.17	31.01	37.07
Feb-92	24.48	15.05	19.20	Oct-95	33.33	26.36	33.00
Mar-92	19.53	14.84	21.20	Nov-95	29.82	21.10	27.88
Apr-92	18.01	18.21	21.40	Dec-95	34.75	20.12	25.75
May-92	24.56	21.26	29.60	Jan-96	33.07	20.59	25.70
Jun-92	41.00	27.18	34.52	Feb-96	33.31	15.14	25.80
Jul-92	43.46	30.01	36.33	Mar-96	37.70	19.31	29.69
Aug-92	48.61	33.66	38.84	Apr-96	31.70	18.72	28.15
Sep-92	38.41	28.41	32.14	May-96	32.36	19.14	29.66
Oct-92	33.98	24.64	28.07	Jun-96	39.96	25.77	38.59
Nov-92	27.20	21.81	24.15	Jul-96	45.54	31.42	49.33
Dec-92	30.61	16.40	25.42	Aug-96	49.38	38.67	49.39
Jan-93	23.90	17.96	31.99	Sep-96	38.54	38.97	41.00
Feb-93	21.49	14.10	28.30	Oct-96	33.07	32.00	34.10
Mar-93	23.46	16.29	28.62	Nov-96	29.02	19.03	28.03
Apr-93	24.11	19.96	28.26	Dec-96	28.80	17.51	28.05
May-93	24.95	18.94	32.03	Jan-97	35.32	20.16	31.04
Jun-93	29.50	19.36	31.29	Feb-97	34.19	16.63	28.58
Jul-93	39.41	39.33	42.76	Mar-97	38.56	16.86	32.40
Aug-93	40.54	31.28	43.93	Apr-97	39.11	18.89	33.65

Month	Production (mg)	Sales (mg)	System (mg)
May-97	44.96	23.47	39.28
Jun-97	47.01	24.90	39.79
Jul-97	48.34	30.16	48.72
Aug-97	42.15	35.70	46.36
Sep-97	35.55	31.11	36.51
Oct-97	33.44	21.25	35.11
Nov-97	36.84	18.25	34.17
Dec-97	43.38	21.25	38.81
Jan-98	45.76	18.98	39.64
Feb-98	43.18	16.77	37.71
Mar-98	48.72	15.69	40.92
Apr-98	46.74	18.81	39.87
May-98	47.49	18.43	41.85
Jun-98	57.85	21.61	47.03
Jul-98	65.80	29.99	60.49
Aug-98	66.56	37.68	61.76
Sep-98	57.52	36.53	53.33
Oct-98	45.65	27.14	40.24
Nov-98	36.53	19.83	32.69
Dec-98	40.89	18.63	36.07
Jan-99	40.10	21.57	33.09
Feb-99	35.68	18.51	27.45
Mar-99	41.98	16.13	32.87
Apr-99	31.40	19.46	31.25
May-99	37.29	20.91	41.95
Jun-99	46.17	29.55	50.69
Jul-99	51.06	35.62	55.91
Aug-99	45.66	35.79	50.69
Sep-99	39.35	36.66	48.47
Oct-99	40.09	32.41	47.41
Nov-99	25.04	22.19	32.10
Dec-99	23.69	18.41	32.20
Jan-00	30.00	20.64	32.26
Feb-00	27.34	22.57	28.57
Mar-00	39.10	20.68	32.38
Apr-00	37.61	21.14	34.44
May-00	44.05	22.87	44.04
Jun-00	52.34	29.02	53.70
Jul-00	49.59	31.67	56.16
Aug-00	45.67	40.17	54.29
Sep-00	37.28	33.21	41.12
Oct-00	31.93	27.44	34.67
Nov-00	26.09	22.08	30.10
Dec-00	25.40	19.22	30.69
Jan-01	30.43	20.92	30.50
Feb-01	25.57	18.45	26.67
Mar-01	36.73	17.63	39.69

Month	Production (mg)	Sales (mg)	System (mg)
Apr-01	32.45	19.08	28.65
May-01	46.49	20.94	42.44
Jun-01	48.35	37.13	47.28
Jul-01	50.48	30.44	51.95
Aug-01	47.43	35.67	50.46
Sep-01	43.42	34.13	45.10
Oct-01	42.63	24.71	40.52
Nov-01	34.67	22.58	31.08
Dec-01	31.62	19.56	29.49
Jan-02	32.29	19.18	26.29
Feb-02	28.28	21.91	26.76
Mar-02	29.00	16.11	28.40
Apr-02	30.43	18.28	29.57
May-02	42.23	20.53	36.94
Jun-02	50.01	28.59	44.56
Jul-02	50.91	33.26	53.86
Aug-02	52.40	38.13	50.74
Sep-02	46.90	32.68	43.00
Oct-02	40.59	27.39	37.40
Nov-02	32.57	22.65	28.27
Dec-02	35.53	19.32	25.44
Jan-03	35.80	16.83	24.11
Feb-03	31.59	15.83	22.99
Mar-03	37.44	15.75	26.33
Apr-03	37.29	18.23	26.38
May-03	46.74	17.20	29.86
Jun-03	53.35	26.17	46.42
Jul-03	54.43	37.00	52.69
Aug-03	51.17	34.83	47.49

Figure 2-C

Historical Flashboard Installation Dates

MORRIS AND CENTENNIAL DAM BOARDS INSTALLATION DATES		
YEAR	CENTENNIAL	MORRIS
2004	1-Apr	24-Mar
2003	1-Apr	14-Mar
2002	3-Apr	15-Mar
2001	29-Mar	15-Mar
2000	31-Mar	16-Mar
1999	7-Apr	29-Mar
1998	10-Apr	17-Mar
1997	4-Apr	19-Mar
1996	3-Apr	21-Mar
1995	13-Apr	20-Mar
1994	1-Apr	17-Mar
1993	13-Apr	29-Mar
1992	17-Apr	31-Mar
1991	1-Mar	25-Mar
1990	30-Mar	16-Mar
1989	N/A	1-Mar
1988	N/A	16-Mar
1987	N/A	N/A

Figure 3-C
Historical Lake Storage Levels

Date	Morris (acre-feet)	Board/I.O.	Centennial (acre-feet)	Board/I.O	Date	Morris (acre-feet)	Board/I.O.	Centennial (acre-feet)	Board/I.O
1/23/99	575	o	512	o	10/23/99	535	o	275	o
2/6/99	575	o	512	o	11/4/04	532	o	268	o
2/20/99	575	o	512	o	11/6/99	529	o	193	o
2/27/99	575	o	512	o	11/13/99	546	o	294	o
3/6/99	575	o	512	o	11/20/99	542	o	318	o
3/13/99	575	o	512	o	11/26/99	539	o	340	o
3/20/99	575	o	512	o	12/4/99	571	o	384	o
4/1/99	575	o	502.1	o	12/11/99	575	o	455	o
4/3/99	575	o	492.2	o	12/18/99	575	o	448	o
4/4/99	575	o	482.3	o	12/24/99	560	o	456	o
4/6/99	575	o	496.1	o	12/31/99	542	o	458	o
4/7/99	575	o	608.2	i	1/1/00	542	o	458	o
4/10/99	575	o	635	i	1/8/00	529	o	465	o
4/17/99	575	o	635	i	1/16/00	590	o	536	o
4/29/99	575	i	635	i	1/22/00	582	o	552	o
5/1/99	672	i	635	i	1/29/00	578	o	528	o
5/8/99	640	i	635	i	2/5/00	590	o	560	o
5/15/99	621	i	635	i	2/12/00	590	o	532	o
5/22/99	621	i	635	i	2/20/00	582	o	528	o
5/29/99	617	i	635	i	2/26/00	590	o	540	o
6/5/99	613	i	635	i	3/4/00	590	o	540	o
6/12/99	601	i	635	i	3/11/00	586	o	540	o
6/15/99	590	i	635	i	3/18/00	609	i	526	o
6/19/99	575	i	635	i	3/25/00	645	i	526	o
6/23/99	575	o	635	i	4/1/00	650	i	429	i
6/26/99	575	o	635	i	4/8/00	609	i	500	i
7/6/99	546	o	635	i	4/15/00	590	i	558	i
7/7/99	549	o	613	i	4/22/00	663	i	622	i
7/10/99	549	o	613	i	4/29/00	637	i	655	i
7/17/99	553	o	613	i	5/6/00	629	i	645	i
7/24/99	553	o	572	i	5/20/00	654	i	655	i
7/31/99	553	o	548	i	5/28/00	625	i	645	i
8/7/99	553	o	504.1	i	6/10/00	597	i	645	i
8/14/99	553	o	484.2	i	6/17/00	578	o	645	i
8/21/99	553	o	467.1	i	7/1/00	549	o	627	i
8/28/99	553	o	458.3	i	7/8/00	557	o	622.5	i
9/1/99	553	o	455	i	7/14/00	525	o	625	i
9/4/99	557	o	452.5	o	7/22/00	564	o	548	i
9/18/99	557	o	370.3	o	7/29/00	549	o	538	i
9/25/99	557	o	336	o	8/19/00	539	o	408	i
10/2/99	557	o	302	o	8/27/00	564	o	405.9	i
10/16/99	557	o	288	o	9/2/00	514	o	401.1	o
10/16/99	549	o	280	o	9/9/00	529	o	377.4	o

Date	Morris (acre-feet)	Board/I.O.	Centennial (acre-feet)	Board/I.O	Date	Morris (acre-feet)	Board/I.O.	Centennial (acre-feet)	Board/I.O
9/23/00	546	o	298.3	o	8/25/01	529		168.9	
10/7/00	529	o	270.2	o	9/1/01	539		121.3	
10/21/00	525	o	225.5	o	9/8/01	529		121.3	
11/4/00	546	o	255.6	o	9/15/01	493		102	
11/18/00	549	o	250.8	o	9/19/01	486		108	
11/26/00	549	o	268.5	o	9/22/01	472		96	
12/2/00	567	o	255.6	o	9/28/01			110	
12/9/00	567	o	266.9	o	9/29/01	452		116	
12/16/00	578	o	268.5	o	9/30/01	441			
1/13/01	578	o	389.3	o	10/2/01	431		104.7	
1/27/01	578	o	467.1	o	10/7/01	414		104.7	
2/3/01	578	o	504.1	o	10/13/01	424		90	
2/18/01	586	o	536.3	o	10/20/01	428		104	
2/24/01	590	o	560.1	o	10/27/01	356		104.7	
3/11/01	578	i	560.1	o	11/3/01	338		121.3	
3/16/01	590	i		o	11/10/01	323		121.3	
3/24/01	629	i		o	11/13/01	323		148.6	
3/31/01	629	i	484.2	i	11/14/01	323		153.7	
4/7/01	609	i	504.1	i	11/16/01	323		160.2	
4/11/01	601	i		i	11/17/01	326		160.2	
4/15/01	590	i	538.5	i	11/18/01	335		155	
4/17/01					11/19/01	338		148.6	
4/21/01	590		544.2		11/20/01	344		136.3	
4/28/01	582		564.1		11/21/01	353		131.3	
5/6/01	567		570		11/22/01	472		208.4	
5/12/01	553				11/24/01	529		271.8	
5/17/01	539		579.9		11/23/01	574		300.5	
5/19/01	532				12/9/01	570		538.3	
5/23/01	518		579.9		12/15/01	586		544.2	
5/26/01	525		568		12/25/01	582		542.3	
6/2/01	518		556.1		12/29/01	582		544.2	
6/9/01	525		542.1		1/5/02	582	o	544.2	o
6/17/01	536		482.3		1/20/02	574	o	536.3	o
6/23/01	536		456.9		1/26/02	582	o	542.3	o
6/26/01	536		445.2		2/2/02	574	o	538.3	o
6/30/01	542		445.2		2/10/02	582	o	544.2	o
7/2/01	539				2/15/02	578	o		o
7/4/01	539				2/17/02	578	o	536.3	o
7/8/01	536				2/24/02	582	o	538.3	o
7/14/01	529		389.3		3/1/02	578	o		o
7/22/01	521		330		3/3/02	575	o	536.3	o
7/27/01	529				3/9/02	578	o	538.3	o
7/28/01					3/13/02	578	o	538.3	o
8/4/01	542		254		3/17/02	601	i	536.3	o
8/11/01	535				3/24/02	650	i	536.3	o
8/19/01	518		208.4		3/29/02		i	504.1	o

Date	Morris (acre-feet)	Board/I.O.	Centennial (acre-feet)	Board/I.O
4/6/02	650	i	536.3	i
4/12/02	650	i	542.3	i
4/13/02	648	i	546.2	i
4/20/02	633	i	570	i
4/27/02	621	i	593.9	i
5/4/02	613	i	605.8	i
5/11/02	600	i	617.7	i
5/18/02	579	i	624.9	i
5/26/02	570	i	645.5	i
6/1/02	564	i	647.9	i
6/8/02	546	i	645.5	i
6/16/02	532	i	643.1	i
6/22/02	518	i	629.6	i
6/27/02	49.4	i	629.6	i
6/29/02	497	i	624.9	i
7/6/02	501	i	596.3	i
7/13/02	514	o	566	i
7/20/02	518	o	536.3	i
7/28/02	542	o	465.6	i
8/4/02	546	o	451	i
8/10/02	546	o	398.8	i
8/15/02	539	o	375	o
8/17/02	529	o	372.6	o
8/24/02	497	o	372.6	o
8/31/02	479	o	367.9	o
9/7/02	452	o	363.1	o
9/15/02	414	o	353.6	o
9/22/02	391	o	353.6	o
9/28/02	375	o	348	o
10/6/02	435	o	263.7	o
10/13/02	441	o	222	o
10/26/02	416	o	213.5	o
11/3/02	414	o	209.4	
11/9/02	418	o	230.6	
11/17/02	416	o	223.8	
11/28/02	418	o	223.8	
12/7/02	401	o	222	
12/16/02	654	o	218.6	
12/22/02	654	o	542.3	
12/28/02	654	o	546.2	
1/4/03	654	o	546.2	o
1/11/03	654	o	546.2	o
1/18/03	579	o	537.3	o
1/25/03	579	o	537.3	o
2/1/03	579	o	537.3	o
2/8/03	571	o	464.2	o
2/16/03	654	o	546.2	o
2/22/03	579	o	546.2	o
3/2/03	578	o	542.3	o
3/9/03	557	o	566	o
3/15/03	641	i	566	o
3/29/03	676	i	482.3	o
4/5/03	676	i	546.2	i
4/12/03	676	i	576	i
4/19/03	676	i	647.9	i
4/26/03	676	i	659.9	i
5/3/03	676	i	647.9	i
5/12/03	676	i	647.9	i
5/19/03	676	i	647.9	i
5/26/03	672	i	647.9	i
6/2/03	667	i	647.9	i
6/8/03	667	i	645.5	i
6/15/03	667	i	645.5	i
6/22/03	654	i	645.5	i
6/29/03	633	i	645.5	i
7/6/03	593	i	645.5	i
7/13/03	564	o	645.5	i
7/20/03	553	o	627.2	i
7/27/03	553	o	584.4	i
8/3/03	553	o	558.1	o
8/10/03	553	o	448.8	o
8/17/03	557	o	448.8	o
8/24/03	553	o	448.8	o
8/30/03	546	o	448.8	o
9/3/03	542	o	372.6	o

Figure 4-C

Morris Plus Centennial End of Month Storage

Inflow based on regression with DWR measurements

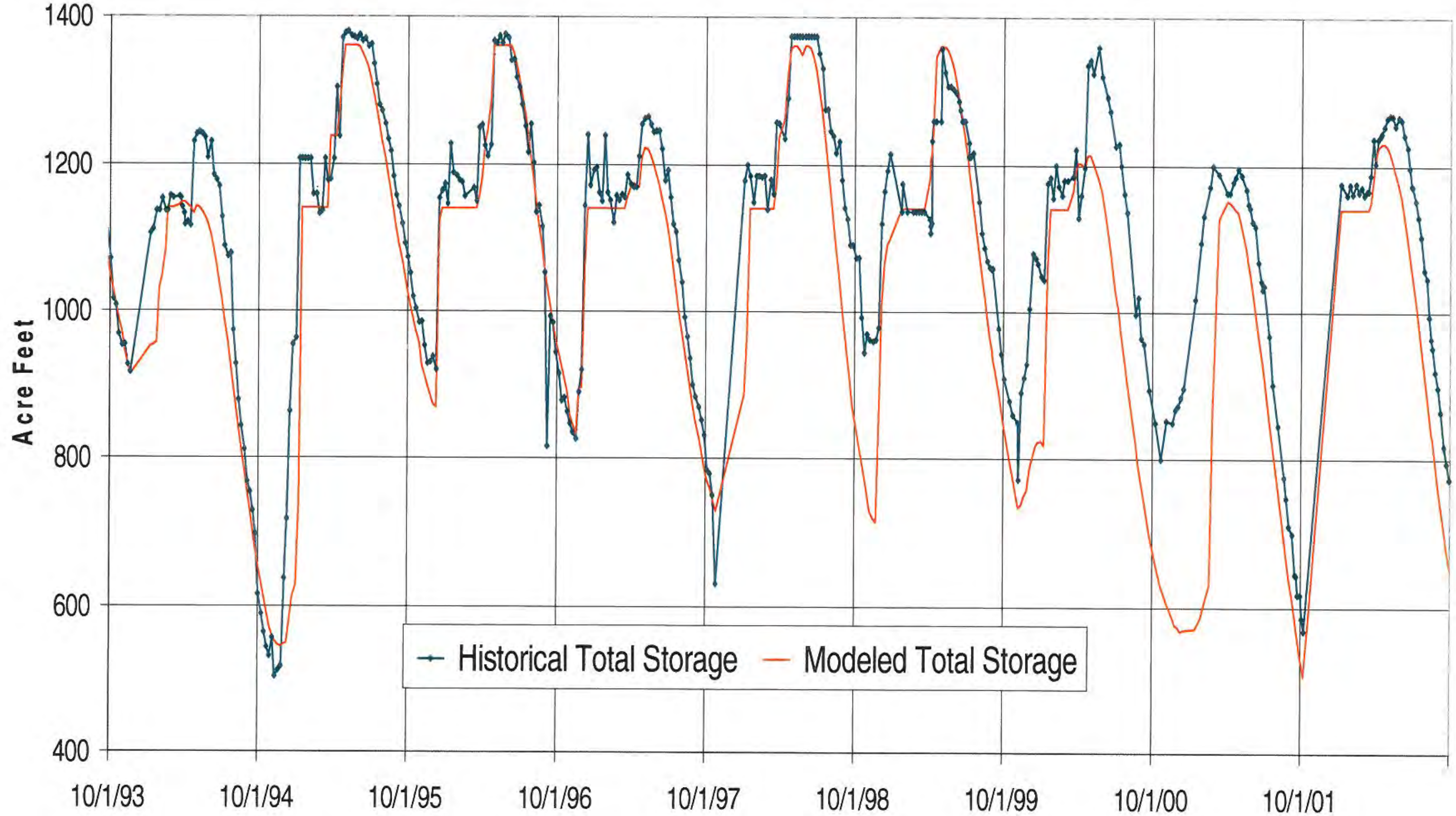
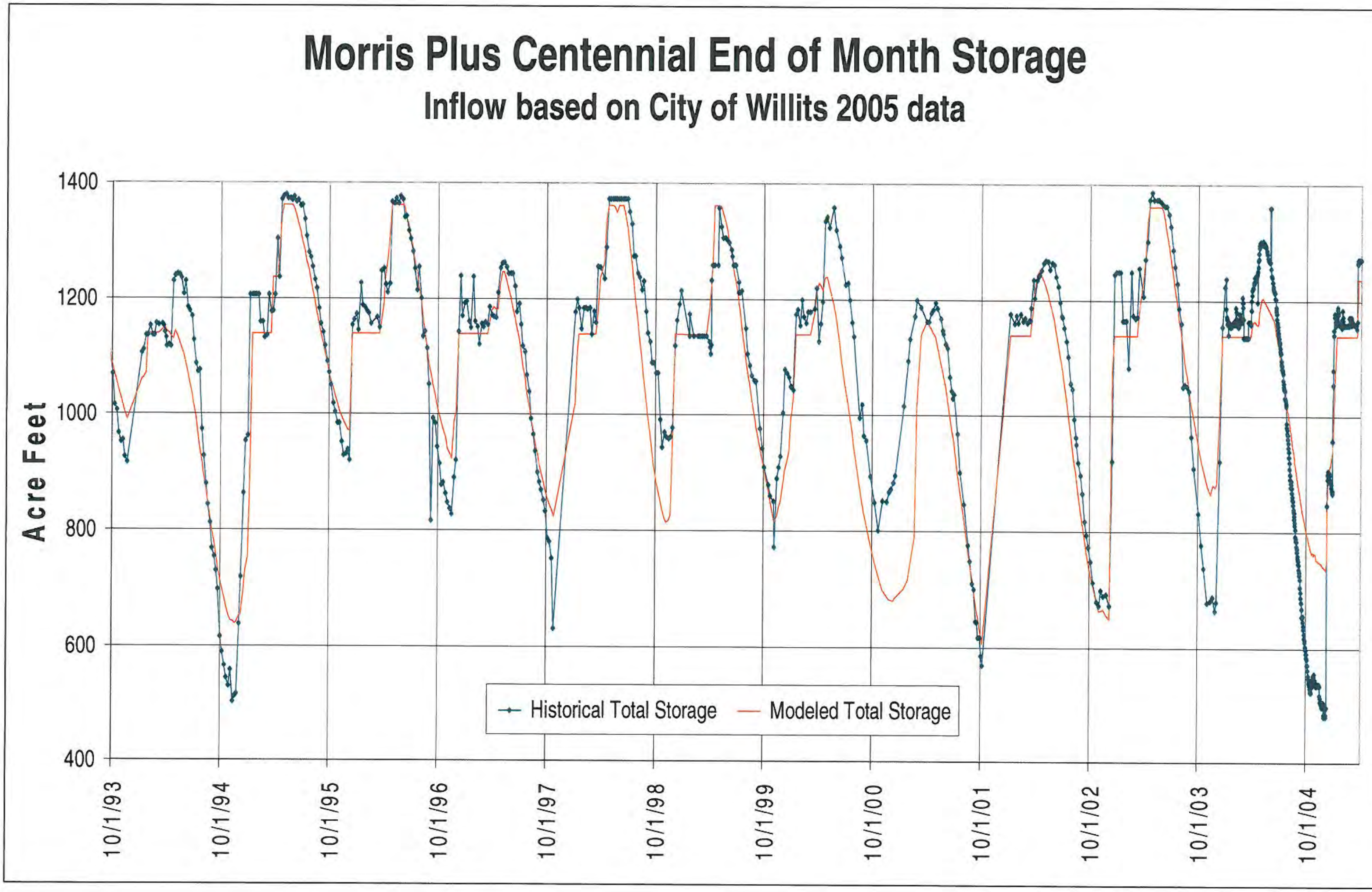


Figure 5-C


Morris Plus Centennial End of Month Storage
Inflow based on City of Willits 2005 data
Acre Feet
1400
1200
1000
800
600
400
10/1/93
10/1/94
10/1/95
10/1/96
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/1/03
10/1/04
Historical Total Storage
Modeled Total Storage

APPENDIX D

Detailed Model Results

APPENDIX D
Detailed model results

Current Level of Demand with DWR Inflow

Table 1-D Current Annual Operations Summary - Calendar Year

	Centennial					Morris						
max	3508	102	3409	512		5687	46	1099	4542	628		651
ave	1913	83	1820	276		2975	36	1018	1913	348		81
Year	Inflow	Evap	Release	End of Dec Storage		Inflow	Evap	Net Delivery to WTP	Release to Davis Creek	End of Dec Storage		Delivery Shortage
1968	1889	82	1428	512		2565	37	1099	1262	292		0
1969	2405	93	2391	432		3892	43	1099	2605	437		0
1970	2886	83	2723	512		4563	38	1099	3235	628		0
1971	1895	95	2118	194		3260	44	1099	2359	385		0
1972	1839	92	1585	356		2687	43	1099	1550	381		0
1973	2940	93	2691	512		4569	42	1099	3180	628		0
1974	2548	94	2875	91		4477	44	1099	3612	350		0
1975	2185	94	2012	170		3359	44	1099	2185	380		0
1976	920	85	955	51		1410	32	1099	421	238		0
1977	896	23	469	455		908	12	449	433	252		651
1978	2023	95	2334	49		3567	44	1099	2286	389		0
1979	1683	90	1269	373		2262	40	1099	1168	344		0
1980	1576	92	1763	94		2680	43	1099	1588	294		0
1981	2056	84	1554	512		2809	31	1099	1345	628		0
1982	2440	96	2344	512		3870	44	1099	2726	628		0
1983	3508	99	3409	512		5687	46	1099	4542	628		0
1984	1688	97	1591	512		2586	45	1099	1601	469		0
1985	926	84	1302	53		1763	33	1084	1016	100		16
1986	2012	87	1911	66		3135	41	1069	1893	233		30
1987	1641	78	1181	448		2145	25	978	1107	268		122
1988	1062	71	1360	79		1916	20	888	1088	189		211
1989	1299	82	1247	49		1970	35	1099	869	155		0
1990	1099	55	1040	54		1623	28	1099	528	122		0
1991	858	47	819	46		1231	18	606	629	100		493
1992	1122	40	956	171		1554	16	579	888	172		520
1993	2051	102	1813	307		3065	45	1099	1710	382		0
1994	892	73	1068	58		1504	21	834	931	100		265
1995	3111	98	2678	394		4676	45	1091	3144	495		8
1996	3485	99	3268	512		5529	45	1099	4251	628		0
1997	1885	87	2119	190		3254	40	1099	2547	196		0
1998	3069	100	2702	457		4671	45	1099	3267	455		0
1999	1950	94	2219	94		3400	43	1099	2373	339		0
2000	1648	85	1603	54		2571	39	1099	1612	159		0
2001	1570	43	1068	512		1982	16	661	1083	381		439

Future Level of Demand with DWR Inflow

Table 2-D Future Annual Operations Summary - Calendar Year

	Centennial				Morris					
Year	Inflow	Evap	Release	End of Dec Storage	Inflow	Evap	Net Delivery to WTP	Release to Davis Creek	End of Dec Storage	Delivery Shortage
max	3508	97	3412	512	5689	43	1649	3804	628	1299
ave	1913	72	1828	229	2983	28	1258	1690	226	391
1968	1889	71	1421	452	2559	23	1180	1192	263	469
1969	2405	88	2431	337	3931	35	1481	2425	254	168
1970	2886	77	2634	512	4474	30	1386	2684	628	263
1971	1895	93	2254	60	3396	38	1574	2305	108	75
1972	1839	82	1576	241	2678	32	1376	1197	180	273
1973	2940	87	2582	512	4460	34	1597	2381	628	52
1974	2548	92	2913	55	4515	37	1497	3506	103	153
1975	2185	92	2094	54	3441	37	1598	1809	100	51
1976	920	48	882	45	1337	16	862	459	100	787
1977	896	23	488	430	927	11	350	442	223	1299
1978	2023	92	2312	49	3544	36	1483	2148	100	166
1979	1683	67	1543	121	2537	20	1318	1180	118	331
1980	1576	85	1554	58	2471	33	1414	1042	100	235
1981	2056	58	1544	512	2800	17	1180	1075	628	469
1982	2440	94	2346	512	3872	38	1649	2381	432	0
1983	3508	96	3412	512	5689	40	1649	3804	628	0
1984	1688	95	1703	401	2699	38	1649	1471	169	0
1985	926	47	1224	56	1685	15	881	858	100	768
1986	2012	82	1928	58	3152	33	1313	1807	100	336
1987	1641	51	1200	448	2164	16	967	1058	223	682
1988	1062	52	1359	99	1915	16	967	1042	114	682
1989	1299	68	1282	48	2005	21	1157	840	100	493
1990	1099	26	1068	54	1651	19	1091	541	100	558
1991	858	40	830	41	1242	15	622	605	100	1027
1992	1122	35	957	171	1555	14	629	873	140	1020
1993	2051	97	2028	97	3280	43	1649	1514	214	0
1994	892	29	901	58	1337	13	577	860	100	1072
1995	3111	95	2812	263	4810	40	1637	3020	213	12
1996	3485	96	3140	512	5401	40	1649	3296	628	0
1997	1885	80	2264	53	3399	30	1339	2558	100	310
1998	3069	95	2691	335	4660	41	1640	2935	145	9
1999	1950	92	2142	52	3323	36	1480	1852	100	169
2000	1648	78	1569	53	2537	31	1258	1249	100	391
2001	1570	37	1073	512	1987	14	678	1063	332	971

Current Level of Demand with City of Willits Inflow

Table 3-D Current Annual Operations Summary - Calendar Year

	Centennial				Morris					
Year	Inflow	Evap	Release	End of Dec Storage	Inflow	Evap	Net Delivery into Water Distribution System	Release to Davis Creek	End of Dec Storage	Delivery Shortage
max	3960	104	3861	512	5728	46	1099	4583	628	284
ave	2332	90	2233	342	3137	40	1078	2012	406	122
1968	2384	89	1978	512	2865	41	1099	1254	607	
1969	2790	94	2720	488	3923	44	1099	2886	500	
1970	3315	84	3207	512	4699	40	1099	3432	628	
1971	2417	97	2528	304	3419	45	1099	2507	396	
1972	2288	94	1986	512	2842	44	1099	1660	435	
1973	3407	94	3314	512	4837	43	1099	3502	628	
1974	2977	96	3173	221	4457	45	1099	3550	390	
1975	2581	97	2407	298	3470	45	1099	2315	400	
1976	1336	96	1233	305	1533	43	1099	391	399	
1977	1264	61	997	512	1286	18	1040	385	242	59
1978	2398	97	2694	119	3678	45	1099	2376	399	
1979	2189	97	1699	512	2492	45	1099	1303	445	
1980	1939	94	2216	141	2918	44	1099	1835	384	
1981	2488	89	2028	512	3032	43	1099	1646	628	
1982	2854	97	2757	512	3990	45	1099	2845	628	
1983	3960	100	3861	512	5728	46	1099	4583	628	
1984	2100	99	2001	512	2785	45	1099	1737	532	
1985	1345	86	1530	241	1832	39	1099	1014	212	
1986	2435	90	2457	129	3404	42	1099	2141	333	
1987	2061	84	1594	512	2349	36	1099	1220	327	
1988	1426	81	1724	133	2105	26	1054	1165	187	45
1989	1703	88	1683	66	2205	41	1099	861	389	
1990	1479	85	1229	230	1627	38	1099	477	402	
1991	1248	85	1317	76	1576	35	1099	672	172	
1992	1549	58	1347	220	1772	17	816	963	148	284
1993	2449	104	2199	366	3205	45	1099	1828	381	
1994	1242	82	1472	55	1726	25	985	996	100	114
1995	3519	99	2978	497	4612	45	1091	3118	458	8
1996	3911	99	3796	512	5661	46	1099	4346	628	
1997	2265	89	2436	251	3313	42	1099	2491	309	
1998	3497	101	3135	512	4736	46	1099	3464	436	
1999	2431	95	2613	234	3536	44	1099	2424	404	
2000	2035	85	2110	73	2832	41	1099	1850	245	
2001	2016	65	1512	512	2207	17	879	1161	395	220

uture Level of Demand with City of Willits Inflow

Table 4-D Future Annual Operations Summary - Calendar Year

max	3960	98	3864	512	5731	44	1649	3955	628	1157
ave	2332	76	2243	252	3146	29	1359	1751	233	379

	Centennial				Morris					
Year	Inflow	Evap	Release	End of Dec Storage	Inflow	Evap	Net Delivery into Water Distribution System	Release to Davis Creek	End of Dec Storage	Delivery Shortage
1968	2384	76	1881	481	2768	24	1301	1307	239	348
1969	2790	91	2825	356	4028	37	1584	2415	231	65
1970	3315	80	3079	512	4571	30	1475	2669	628	174
1971	2417	94	2691	144	3582	39	1649	2384	138	0
1972	2288	89	2043	300	2899	35	1649	1181	171	0
1973	3407	90	3106	512	4630	36	1649	2489	628	0
1974	2977	93	3341	56	4624	38	1607	3504	104	42
1975	2581	93	2429	115	3492	38	1638	1751	168	11
1976	1336	63	1334	53	1634	17	1225	461	100	424
1977	1264	21	825	471	1114	11	492	492	218	1157
1978	2398	93	2725	51	3709	39	1602	2186	100	47
1979	2189	78	1978	184	2770	22	1491	1230	128	158
1980	1939	89	1978	55	2680	35	1532	1141	100	117
1981	2488	65	1966	512	2970	17	1358	1067	628	291
1982	2854	95	2760	512	3992	39	1649	2390	542	0
1983	3960	96	3864	512	5731	41	1649	3955	628	0
1984	2100	96	2004	512	2788	40	1649	1586	142	0
1985	1345	63	1736	57	2038	16	1059	1004	100	590
1986	2435	85	2346	62	3293	34	1410	1849	100	239
1987	2061	56	1580	487	2335	16	1063	1160	196	586
1988	1426	56	1723	133	2105	16	1026	1129	129	623
1989	1703	81	1699	57	2221	26	1351	873	100	298
1990	1479	44	1439	53	1838	21	1275	541	100	374
1991	1248	42	1206	52	1465	15	687	763	100	963
1992	1549	35	1369	197	1794	14	697	1039	143	952
1993	2449	98	2428	120	3434	44	1649	1604	281	0
1994	1242	39	1268	55	1522	14	752	937	100	897
1995	3519	95	3117	363	4750	41	1636	2972	202	13
1996	3911	97	3665	512	5529	41	1649	3413	628	0
1997	2265	84	2637	56	3514	31	1428	2582	100	221
1998	3497	96	3042	414	4644	42	1643	2852	207	6
1999	2431	93	2695	58	3617	37	1638	2049	100	11
2000	2035	80	1958	54	2679	31	1321	1327	100	328
2001	2016	38	1520	512	2216	14	727	1236	338	922

References

Mast, M.A., and Clow, David W., 2000, Environmental characteristics and water-quality of Hydrologic Benchmark Network stations in the Western United States, U.S. Geological Survey Circular 1173-D, 115 p. http://ny.cf.er.usgs.gov/hbn/report.cfm

State of California Department of Water Resources. Dams Within Jurisdiction of the State of California, Bulletin 17-93, 12 p. and 49 p.

State of California Department of Water Resources. Evaporation from Water Surfaces in California, Bulletin 73-9-79, 13 p., 78 p. and 79 p.

APPENDIX E
Cost Estimates

The intention of estimating costs in the Water Supply Planning Study is to provide reasonably accurate cost estimates for comparison of alternatives, not to anticipate every possible contingency. The capital cost estimates herein, particularly for the dams, are not sufficient to budget the design and construction phases because the scope definition is preliminary, and the necessary equipment, construction materials and labor are subject to price volatility and influenced by economic conditions and competition. If the City chooses to expand Morris Reservoir or develop a supplemental surface water supply, a more detailed study of sub-alternatives and costs is recommended to develop a basis for decision making and design.

While the groundwater supply alternative is less complex, updating the cost estimate is advisable during design of each phase of the groundwater supply project.

Table E-1. Estimated Cost of Expanding Morris Reservoir

Component	Estimated Cost, dollars[a]
Concrete dam (assumed dimensions: 100-foot height and 500-foot length at crest)	6,400,000
Spillway and fish ladder	1,800,000
Fish screen, pump station, and pipeline	600,000
Water treatment plant expansion	4,400,000
Subtotal	13,200,000
Construction contingency (25 percent)	3,300,000
Subtotal	16,500,000
Engineering and project administration (15 percent)	2,500,000
Environmental documentation and permits	800,000
Land purchase[b]	0
Total	19,800,000
Round-off	**$20 million**

[a] Based on ENR Construction Cost Index of 7518 (September 2005)
[b] Assuming current land owned by City is adequate

Table E-2. Estimated Cost of Supplemental Surface Water Supply[a]

Component	Estimated Cost, dollars[b]
Concrete dam (assumed dimensions: 60 feet high by 200 feet long)	2,600,000
Spillway and fish ladder	800,000
Fish screen, pump station, and pipeline	600,000
Water treatment plant	4,400,000
Pipeline (assumed 4 miles @ $100/lineal foot)	2,100,000
Subtotal	10,500,000
Construction contingency (25 percent)	2,625,000
Subtotal	13,125,000
Engineering and project administration (15 percent)	1,970,000
Environmental documentation and permits	800,000
Land (60 acres including buffer @ $30,000/acre)	1,800,000
Total	17,695,000
Round-off	**$18 million**

(a) Assuming another dam in separate watershed of Little Lake Valley
(b) Based on ENR Construction Cost Index of 7518 (September 2005)

Table E-3. Estimated Cost of Groundwater Supply – Phase 1

Component	Estimated Cost, dollars[a]
Wells No. 1 and No. 2 (develop and equip)	780,000
Groundwater treatment plant	1,250,000
Pipelines from Wells No. 1 and No. 2 to centralized plant (2,500 LF @ $75/LF)	188,000
Pipeline from plant to distribution system (500 LF @ $120/LF)	60,000
Subtotal	2,278,000
Construction contingency (25 percent)	570,000
Subtotal	2,848,000
Engineering and project administration (15 percent)	427,000
Environmental documentation and permits	120,000
Land purchase[b]	0
Total	3,395,000
Round-off	**$3.4 million**

[a] Based on ENR Construction Cost Index of 7518 (September 2005)
[b] Assuming use of City property (Figure 5-2)

Table E-4. Estimated Cost of Groundwater Supply – Phase 2

Component	Estimated Cost, dollars[a]
Well No. 3 (develop and equip)	390,000
Groundwater treatment plant expansion	750,000
Pipeline from Well No. 3 to centralized plant (1,000 LF @ $75/LF)	75,000
Subtotal	1,215,000
Construction contingency (25 percent)	304,000
Subtotal	1,519,000
Engineering and project administration (15 percent)	228,000
Land (0.5 acres including buffer @ $30,000/acre)	15,000
Total	1,762,000
Round-off	**$1.8 million**

[a] Based on ENR Construction Cost Index of 7518 (September 2005)

Table E-5. Estimated Cost of Groundwater Supply – Phase 3

Component	Estimated Cost, dollars[a]
Well No. 4 (develop and equip)	390,000
Groundwater treatment plant expansion	750,000
Pipeline from Well No. 4 to centralized plant (1,000 LF @ $75/LF)	75,000
Subtotal	1,215,000
Construction contingency (25 percent)	304,000
Subtotal	1,519,000
Engineering and project administration (15 percent)	228,000
Land (0.5 acres including buffer @ $30,000/acre)	15,000
Total	1,762,000
Round-off	**$1.8 million**

[a] Based on ENR Construction Cost Index of 7518 (September 2005)