Final Report
Water Distribution Study

City of Bondurant

February 1995

STANLEY CONSULTANTS

STANLEY CONSULTANTS, INC.

100 Court Avenue, Suite 300 • Des Moines, IA 50309 Tel: 515/246-8585 • Fax: 515/246-8617

February 16, 1995

The Honorable Mayor and City Council
City of Bondurant
City Hall
Bondurant, IA 50035

Dear Mayor and City Council:

We are pleased to submit this "**Final Report - Water Distribution Study**" for the City of Bondurant prepared in accordance with our agreement for professional services which was authorized by the City Council.

It was a pleasure working with City staff during the study. We appreciate the opportunity to work on this important project and are looking forward to providing further assistance to you during implementation of the recommended plan for improvements.

Sincerely,

STANLEY CONSULTANTS, INC.

Edwin R. Slattery

Edwin R. Slattery, P.E.
Project Manager

Enclosure

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I hereby certify that this report was prepared by me or under my direct personal supervision and that I am a duly Registered Professional Engineer under the laws of the State of Iowa.		
Edwin R. Slattery name		Edwin R. Slattery signature
2/16/95 date	10698 reg. no.	12/31/96 exp. date

February 1995

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Section 1

Introduction and Project Scope

General

The existing Bondurant water supply system serves the domestic, commercial, and industrial water demands of approximately 1800 people within the city limits. Water service is also provided to approximately 60 households outside the city limits between the water plant and the ground storage reservoir.

Raw water is provided by four relatively shallow wells located near the Skunk River approximately three miles northeast of the city. The water undergoes aeration, filtration, and chlorination treatment at the well site before potable water is pumped to a 0.5 MG ground storage reservoir located approximately one mile north of the city limits. A single 8-inch water line connects the water plant with the ground storage reservoir. This pipe, which is located on N.E. 80th Street and N.E. 94th Avenue, provides water service to homes located along this route. Two high service pumps in the treatment plant supply water to the ground storage reservoir. Three high service pumps at the ground storage reservoir supply water to Bondurant and the residences between the water plant and reservoir when the water plant is not operating.

The water system is intended to satisfy all normal and peak demand conditions. These demands have increased over the years. Recent major residential development, proximity of major transportation routes, Bondurant's presence in a fast growing metropolitan area, and the city's commitment to attract new business suggest that significant growth in the community appears likely in the future and expansion of the water system will be required. This should result in increases in average day, maximum day, and peak hour water demands into the next century. The water system including storage, pumping facilities, and distribution network must have adequate capacity and reliability to deliver the required flow with adequate pressures to all portions of the service area. In addition, the water system must provide fire flows to both existing and expected areas of development.

The comprehensive approach to water system evaluation and planning contained in this report is especially significant since this is the first time a complete assessment of all distribution system facilities has been undertaken. An organized approach to integrating all system components into an efficient operation is crucial to providing quality service to all of Bondurant's water customers.

Stanley Consultants, Inc. (SCI) has completed a comprehensive evaluation of the water distribution system based on site visits, discussions with city staff, field testing, and data from past operating data. In addition, SCI has developed a computer model of the existing Bondurant water distribution system to evaluate its performance under existing and projected demand conditions. The adequacy of the pipe network, storage, and pumping system was evaluated by the model under average, peak, and fire demand and storage refilling conditions. The results, conclusions, and recommendations of the study are presented in this report.

Approach to Project

This project includes a detailed analysis of the Bondurant water pipe network and pumping and storage facilities. A review of water source and treatment facilities is not part of the scope of services.

The approach to the project is presented in a letter proposal from SCI dated August 3, 1993, and approved by action of the Bondurant City Council. The approach to the project included in the proposal follows:

- Project Kick-off and Data Collection: Meet with city fire department and water system personnel to discuss the specific goals of the project. During this meeting, Stanley Consultants will learn of specific deficiencies in system performance. An overview of system maintenance procedures will be provided. As part of the meeting, data will be collected including maps, pump curves, water use records, maintenance records, fire flow test results and any other data that may be relevant to the project.
- Land Use Planning: Stanley Consultants will meet with appropriate city officials involved in planning issues. This session will be used to establish general guidelines for future development in the community. Prime residential, commercial and industrial development areas will be identified through this effort.
- Develop Design Water Use Projections: Water pumpage and metered use data will be analyzed to establish current water use characteristics. Future development plans will be considered for establishing projected water use into the future.
- Develop and Calibrate Computer Model: All components of the water system including pipes, pumps, and storage facilities will be represented mathematically and entered into the "KYPIPE" computer model. The model will be calibrated against hydrant flow test data to make sure that it simulates actual field conditions. Existing hydrant flow test data will be reviewed to determine if it can be used for model calibration purposes. If not, Stanley Consultants will develop testing protocol for acquiring flow data for model calibration. This scope of services assumes City of Bondurant personnel will conduct any new hydrant flow tests needed for this study.
- Water System Analysis: Water system analysis will be conducted that evaluates current and future water needs. Several operational alternatives will be developed including continued service with the existing system, adding new pipelines to service deficient areas, adding new elevated storage, adding a new ground storage and booster pumping station, and connection with the Des Moines Water Works distribution

system. A recommended plan for improvements will focus on adequate fire flow and reliable water service.

- Control System Evaluation: The city has identified a long standing problem with lack of adequate controls on the elevated tank and main booster pumping station. The problem will be investigated by a Stanley Consultants control system specialist and a plan for improved control on these facilities will be recommended.
- Cost Estimate: Estimated construction costs will be developed for all components of the recommended plan for improvements.
- Funding Sources: It is recognized that funding improvements with any significant cost will place a burden on limited Bondurant finances. This portion of the study will investigate the possibility of tapping outside resources including state and federal grants and loans. An assessment will be made regarding those funding sources, if any, that may be appropriate for funding water system improvements.
- Write Report: A report will be written that will summarize the findings of the study. The report will present existing system operations, alternatives considered, details of the recommended improvement plan, cost estimate and possible funding scenarios. The report will be formatted for use as part of, or an addendum to, the City's Comprehensive Plan Update.

In addition to the overall system evaluation, a number of specific operating problems were identified for study. Each has been analyzed in detail.

Summary

The performance of the Bondurant water distribution system was evaluated using current Iowa Department of Natural Resources (IDNR) and public works design standards. The evaluation showed that the distribution system is characterized by a number of serious weaknesses including:

- Deficient storage.
- Long dead-end water mains.
- Deficient fire flow.
- Lack of reliability.
- Small diameter mains.

A number of water system improvements are identified to meet current design standards. As new business and industry locates in Bondurant, this report provides recommendations for orderly development of the water system to meet future needs.

Each component of the distribution system has been evaluated. A recommended plan for improvements includes scheduled routine preventive maintenance, new pipelines, pump station improvements, new elevated storage, and other improvements. Implementing plan components will permit greater operational flexibility of pumping and storage facilities and promote reliable performance.

Total estimated project cost for all recommended near-term storage and pump and pipe improvements is approximately $1,892,340. A breakdown of recommended plan improvements is presented below:

Water Mains	$ 700,950
Elevated Storage	625,000
Controls	95,000
Miscellaneous Improvements	156,000
Subtotal	**1,576,950**
Engineering, Legal, and Administration	315,390
TOTAL PROJECT COST	**$1,892,340**

A detailed listing of individual near-term plan components is presented in Table 7-1.

The entire plan is likely not to be implemented at one time due to City of Bondurant budget constraints. Realistically, the plan could be implemented over a seven year period. Each year's capital improvement project will be packaged through consultation between city officials and Stanley Consultants based on such factors as available funding, coordination with other infrastructure projects, coordination with private development projects, availability of easements, and other factors. Table 7-2 presents a proposed seven year implementation schedule that allows for continuous construction of consecutive individual improvement packages. Detailed design of a major portion of the improvement program should occur initially to allow flexibility in selecting each year's package. Preparation of final detailed bid documents, easement acquisition, commitment of funds, and legal and administrative work should occur each year after that year's package is selected.

The improvements are identified according to the type of problem each is intended to correct. The seven year construction program identifies an implementation scenario to solve near-term deficiencies and plans for anticipated future development in the water system. The plan for recommended improvements is discussed in detail in Section 7.

Section 2

Design Criteria

General

The performance of existing water supply systems and the evaluation and design of new water system components in the State of Iowa is governed by the Iowa Water Supply Facilities Design Standards. These standards are administered by the Iowa Department of Natural Resources (IDNR). All water supply projects except minor water main extensions must be submitted to the IDNR for review and approval. The Recommended Standards for Water Works (10 States' Standards) and fire flow requirements established by the Insurance Services Office are also used in evaluating portions of existing water supply systems.

Iowa Water Supply Facilities Design Standards

The Iowa Water Supply Facilities Design Standards are divided into sections, each addressing requirements for the major components of the water system. Important requirements as they relate to the Bondurant water system are reproduced below:

"Chapter 7 - Finished Water Storage and High Service Pumping Facilities

7.1 General

7.1.1 Design Period

Finished water storage facilities shall be designed to meet system demands for a period of at least 20 years or be designed in accordance with a phased construction schedule contained in an approved engineering report covering at least a 20 year design period.

7.1.2 Selection of Distribution Storage Facilities

Ground level storage facilities located at a high elevation or elevated storage facilities that can provide the design flow and pressure directly to the system by gravity are preferred for distribution storage.

7.1.3 Minimum Storage Requirements

Each water supply system shall have sufficient pumping and effective finished water storage capacity, as determined from engineering studies, to meet system demands and, where fire protection is provided, fire flow demands.

a. Each system should be provided with an effective storage capacity equal to the peak day demand.

c. For systems designed to provide fire protection, the minimum effective storage shall be based on the desired fire flow plus the domestic water requirements for the duration of the fire, or the average day water requirements, whichever is greater. Effective storage equivalent to the larger of the following shall be provided as follows:

Effective Storage = $Q_f T_f + 0.8 Q_i T_f$

or

Effective Storage = Average day system water demand

Where Q_i = instantaneous peak flow rate (gpm)
Q_f = fire flow demand rate (gpm) (250 gpm minimum)
T_f = fire flow duration (min) (120 min minimum)

To meet the minimum fire flow requirements (Q_f = 250 gpm, T_f = 120 minutes) the above equations become:

Effective Storage = (250)(120) + 0.8 Q_i 250 gpm (120)
or
Effective Storage = Average day system water demands

Fire flow recommendations established by the Insurance Services Office of Iowa should be considered where practical.

The above calculated volumes may be reduced if additional source and high service pumping capacity as required by Sections 3.1.3c and 7.1.4b and emergency power as required in Section 7.1.3d are provided.

d. If the source, treatment and pumping facilities are equipped with adequate standby emergency power facilities, the minimum effective storage capacity may be reduced to the following:

Effective Storage = $Q_f T_f$ + 0.2 x peak day demand (gallons)

d. Additional net storage shall be provided for water treatment plant needs such as filter backwash, ion exchange regeneration, etc.

7.1.4 High Service Pumping Requirements

When ground storage facilities must be equipped with high service pumps:

a. Each ground storage facility shall be equipped with at least two high service pumps capable of supplying the peak day rate when the largest pump is out of service.

7.1.5 Distribution System Pressures

Finished water storage and pumping facilities shall be sized to maintain the minimum pressure requirements of Chapter 8, Iowa Standards for Water Supply Distribution Systems. The minimum working pressure in the distribution system should be 35 psi and the normal working pressure should be approximately 60 psi. The absolute minimum working pressure under fire flow conditions is 20 psi.

Chapter 8 - Iowa Standards for Water Supply Distribution Systems

8.1 Design Period

Water mains shall have a minimum size based on a hydraulic analysis utilizing 20 year design high flow demands.

8.2 Minimum Basis of Design

8.2.1 Minimum Water Main Size

Water mains shall be at least two inches in diameter. The minimum size for providing water for fire protection and for serving fire hydrants shall be six inches in diameter. Larger mains shall be required if necessary to allow the withdrawal of the required fire flow while maintaining a minimum residual pressure of 20 psi within the main. The minimum flow requirement for water mains serving fire hydrants is 500 gpm at 20 psi residual pressure.

8.3 Details of Design

8.3.1 Dead-End Mains

Dead-ends shall be minimized by looping mains whenever possible. Dead-ends shall terminate with an approved flushing device. They may terminate with an approved fire hydrant when adequate pressure is available at required flows. No hydrant, blowoff or flushing device shall be directly connected to any sewer.

8.3.2 Valving

Sufficient valves shall be provided on water mains so that inconvenience or sanitary hazards to water users will be minimized during maintenance and construction. Valves shall be located so that four or less city blocks can be isolated. Valves should be placed at intervals of one block in high density areas. Valves in rural areas shall be located at intervals of not more than 2.5 miles."

Recommended Standards for Water Works (10 State Standards)

Certain details of water system design are not specifically covered by the Iowa Design Standards. IDNR acknowledges the use of "10 State Standards" as a supplement to the Iowa Design Standards. "Ten State Standards" are used primarily for water treatment criteria which are not specifically covered by the Iowa Design Standards. However, some criteria presented in "10 State Standards" that supplements the Iowa Design Standards include the following:

"8.2 Valves

Sufficient valves shall be provided on water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more than 500 foot intervals in commercial districts and at not more than one block or 800 foot intervals in other districts. Where systems serve widely scattered customers and where future development is not expected, the valve spacing should not exceed one mile.

8.3 Hydrants

8.3.1 Location and Spacing

Hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the state Insurance Services Office. Generally, hydrant spacing may range from 350 to 600 feet depending on the area being served.

8.3.2 Valves and Nozzles

Fire hydrants should have a bottom valve size of at least five inches, one 4½ inch pumper nozzle and two 2½ inch nozzles.

8.3.3 Hydrant Leads

The hydrant lead shall be a minimum of six inches in diameter. Auxiliary valves shall be installed in all hydrant leads."

Insurance Services Office (ISO)

Both the Iowa Design Standards and "10 State Standards" recommend that fire flow requirements established by the Insurance Services Office should be satisfied when sizing facilities where fire protection is provided. Needed fire flows determined by ISO are based on the guidelines found in ISO's 1980 Fire Suppression Rating Schedule. Fire demands for individual building sites have been completed by the Bondurant fire chief utilizing ISO criteria. Individual fire demands are presented in Part 4.

Planning Period

A twenty year planning period has been selected for this study. The planning period extends from 1995 through the year 2015.

Section 3

Analysis of Water Demand

Background

The magnitude of demand for water is measured by four criteria:

- Average Day Demand
- Maximum Day Demand
- Peak Hour Demand
- Fire Demand

Average day demand is the annual average daily water use. It is not a significant design criteria for evaluation of the adequacy of a distribution or treatment system since it includes all seasonal water demand variations, thereby leveling out the high water use periods. Average day demand is used to estimate annual operating costs and energy usage.

Maximum day demand is the peak water use day during the year. It usually occurs during an extreme warm weather period. Daily demands that nearly equal the maximum day demand frequently occur during several consecutive days of the period. This demand usually establishes the capacity of the water supply and treatment facilities. Maximum day demand can be determined using historical water use data.

Peak hour demand occurs over a period of hours during the maximum demand day and is usually associated with an extreme warm weather period. This demand governs on-line water storage capacity, distribution system capacity, and performance and related high service pumping. The demand is normally equalized over a 24 hour period by on-line storage. Peak hour demand can be projected from average day demand using empirical factors derived from historical water use data.

Fire demand is the amount of water that is needed to fight a fire at selected building sites within the community. The amount and duration of the fire flow is estimated with information supplied by fire insurance personnel and community officials. Evaluation of the distribution system under a fire demand condition is performed when maximum day demand is occurring. The fire demand condition is typically the most rigorous test of distribution system performance and effects the capacity of high service pumping, storage and piping facilities.

Population and Development Plans

An estimate of the study area population and development plans through the year 2015 was made to estimate water requirements through the planning period.

Population Projections

Table 3-1 shows historical and projected population for the City of Bondurant. The 1990 census resulted in a population of 1584. This is an increase of 301 people since the 1980 census and 1122 people since the 1970 census. Historical data shows that the city's growth has been steady over the last 20 years.

Table 3-1 Population Trends
City of Bondurant

Year	Population
1960	389
1970	462
1980	1283
1990	1584
2000	2184 (1)
2010	2784 (1)
2015	3084 (1)

(1) Projections assume straight line increase in population.

Source: Des Moines Metropolitan Planning Organization Population and Employment Projections for the Year 2020, Des Moines Area Transportation Planning and Committee March 1992 and Stanley Consultants, Inc.

Significant residential and industrial growth has occurred in the city over the last few years with Meadowbrook and the Industrial Park being the most recent developments. With the prospects of major new residential, commercial, and industrial development occurring during the next 20 years, water use is expected to show a significant increase over current levels. Based on expected development plans, Bondurant's population could nearly double by the year 2015 and reach 3084 according to Metropolitan Planning Organization (MPO) figures. It is difficult to assess the pattern of growth during the study period since it depends on the timing of certain major developments. For purposes of this water study, straight line or linear growth is assumed throughout the study period.

Development Plans

Discussions with community officials indicate that prospects for future development in areas currently undeveloped are excellent. Bondurant's close proximity to the Des Moines metro area, the new eastern bypass around Des Moines, Highway 65, and I-80 make the area a prime location for new residential, commercial, and industrial development. City officials recognize the potential for a sizeable increase in development and are committed to utility upgrades to satisfy development needs as they arise.

Figure 3-1 is a map showing existing and projected land use for the city. This map, developed with input from city officials, shows a number of major land areas expected to show significant growth during the study period. Residential growth should occur on the north side of the city both east and west of Grant Street, and on the eastern side of the city on the east and west side of Highway 65. The corridor along Highway 65 and the area in the vicinity of Union 76 Truckstop is expected to be developed with commercial and industrial projects. Other areas are marked as agricultural districts within the city limits. These areas may become developed sometime in the future but are not expected to develop within the 20 year study period.

Water Use Data

SCI reviewed yearly water use records from 1980 to present. This data was used to develop patterns of water use and the amount of water pumped from the water treatment plant as shown on Table 3-2.

A record of water pumped is not consistently kept on a daily basis so a detailed evaluation of water use patterns is generally limited to yearly and monthly data. An evaluation of how water is used during peak water demand periods requires the application of typical water use patterns for similar communities and generally accepted peaking factors.

Average Day Demand

Table 3-2 shows the total yearly volume of water pumped from the water treatment plant. On an average day basis, water pumped has fluctuated between 0.118 mgd and 0.168 mgd since 1980. Based on a per capita water usage rate of 90 gpcpd, average day demand is expected to increase to 0.278 mgd by 2015.

Maximum Day Demand

Limited records for daily water pumpage were available for examination to determine the maximum day demand. An examination of available data shows that a maximum day to average day ratio of 2.11 and 2.42 occurred in 1981 and 1980, respectively. These values are somewhat higher than the peaking factor of 2.0 listed in Iowa Water Supply Facilities Design Standards for distribution system serving more than 500 people. A ratio of 4.3 occurred in 1989; however, this value is suspected to have been caused by an unusual event such as a water main break and does not represent normal conditions in the water system. Therefore, it will not be used.

A maximum day to average day ratio of 2.5 was utilized as a design value for this study. Based on a peaking factor of 2.5, the maximum day demand is expected to increase to 0.69 mgd in 2015.

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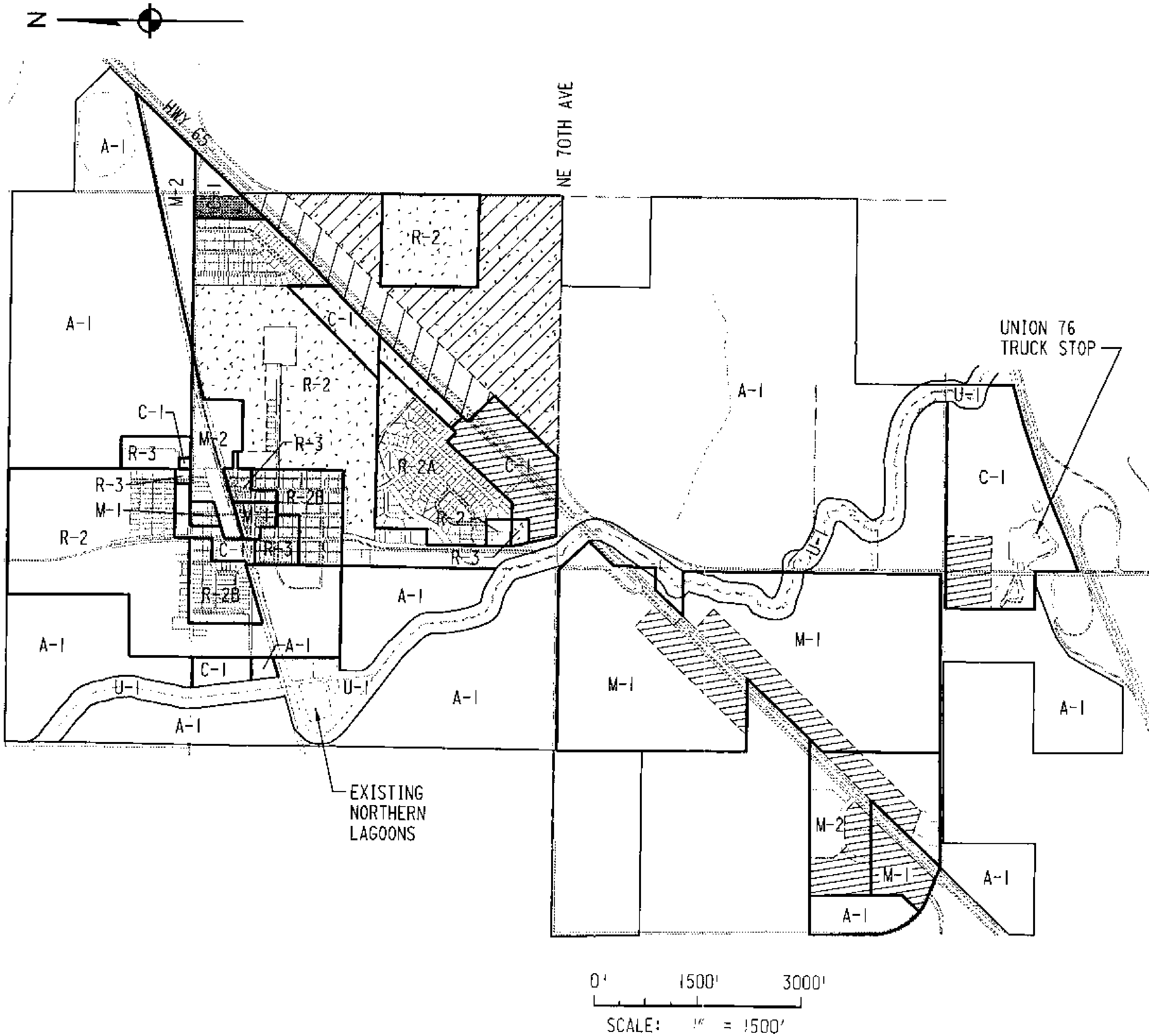


LEGEND

PROJECTED LAND USE:

- RESIDENTIAL
- RESIDENTIAL; ZONE CHANGE ANTICIPATED
- COMMERCIAL AND INDUSTRIAL
- COMMERCIAL; ZONE CHANGE ANTICIPATED
- COMMERCIAL

ZONING

U-1	CONSERVANCY DISTRICT
A-1	AGRICULTURAL DISTRICT
R-1	SINGLE FAMILY RESIDENTIAL DISTRICT
R-2 R-2A R-2B	ONE- AND TWO- FAMILY RESIDENTIAL DISTRICT
R-3	MULTI-FAMILY RESIDENTIAL DISTRICT
R-4	MOBILE HOME PARK RESIDENTIAL DISTRICT
R-5	PLANNED UNIT DEVELOPMENT
C-1	COMMUNITY COMMERCIAL DISTRICT
C-2	CENTRAL BUSINESS DISTRICT
C-3	PLANNED COMMERCIAL DISTRICT
M-1	LIMITED INDUSTRIAL DISTRICT
M-2	GENERAL INDUSTRIAL DISTRICT

PROJECTED GROWTH

FIGURE 3-1

CADD B2-R1

Table 3-2 Historical and Projected Water Use

Year	Population	Total Pumpage[1] (gals x 1000)	Average Day Pumpage[2] mgd	Per Capita Pumpage (gpcpd)	Ratio of Maximum Day to Average Day	Peak Hour Demand (mgd)	Total Billed (gals x 1000)	Percent Unbilled
1970	462	----	---	--	----	----	----	----
1980	1283	53,392	0.144	112	2.42	----	----	----
1981	1313	43,020	0.118	90	2.11	----	----	----
1982	1343	----	---	--	----	----	----	----
1983	1373	----	---	--	----	----	----	----
1984	1403	50,408	0.138	98	----	----	----	----
1985	1434	50,043	0.137	96	----	----	----	----
1986	1464	----	---	--	----	----	----	----
1987	1494	53,215	0.141	94	----	----	----	----
1988	1524	53,166	0.143	94	----	----	----	----
1989	1554	50,258	0.135	87	4.30	----	39,468	21.5
1990	1584	50,696	0.136	86	----	0.884	40,732	19.7
1991	1644	50,915	0.137	83	----	----	42,843	15.8
1992	1704	52,502	0.142	83	----	----	----	----
1993	1764	51,572	0.143	81	----	----	----	----
1994	1824	61,666	0.168	92	----	----	----	----
1995	1884	----	0.170	90	2.5	1.07	----	----
2015	3084	----	0.278	90	2.5	1.61	----	----

(1) Includes water pumped for filter backwash.
(2) Represents water delivered to distribution system. Excludes filter backwash water.

Source: City of Bondurant and Stanley Consultants, Inc.

Peak Hour Demand

The source of supply and treatment plant must have sufficient capacity to satisfy the maximum day demand. The difference between the rate of maximum day water production and peak hour water use will be satisfied from storage and pumping. A municipal water system will experience a near peak hour demand period lasting typically about three to four hours during the evening when lawn watering, bathing, dishwashing, and recreational activities predominate.

The accepted method for determining peak hour demand is to multiply average daily demand by a instantaneous peaking factor. The guidelines from Iowa Water Supply Facilities Design Standards were followed to provide a reasonable instantaneous peaking factor for Bondurant. This reference provides the following equation for calculating the instantaneous peaking factor:

Instantaneous Peaking Factor = $7/p^{(0.167)}$
Where p = population in thousands

For Bondurant, the calculated instantaneous peaking factor is 6.5 for 1990 and 5.8 for 2015. It is assumed that the instantaneous peak is equivalent to peak hour demand. Therefore, the peaking factors result in a peak hour demand of 1.07 mgd in 1995 and increases to 1.61 mgd in 2015.

Fire Demands

The Bondurant fire chief provided SCI with calculated fire demand for nine locations throughout the community. These fire demands are presented in Table 3-3. Table 3-3 also shows how much fire flow is available at 20 psi at or near these fire demand locations based on hydrant flow tests conducted by city personnel over the last several years and data provided by computer analysis (see Section 6). The information presented in Table 3-3 show that the needed fire flow at six of nine locations are inadequate and, in some cases, seriously deficient.

Unbilled and Unaccounted-For Water

A comparison between the total metered water use (water billed) and the pumping records (see Table 3-2) indicates the quantity of water that is produced but not metered or billed in the system. Unbilled water occurs as a result of such activities as hydrant flushing, leaks in pipes, water used for municipal parks and buildings, construction, and under registration of meters. Only limited data is available; however, it shows that unbilled water was 21.5 percent in 1989, 19.7 percent in 1990, and 15.8 percent in 1991. Since unbilled water represents lost revenue and higher facility operating costs for pumping and treatment, the city should attempt to minimize this percentage.

Unaccounted-for water represents that portion of unbilled water lost from the system that has not been metered or quantified. Unaccounted-for water results primarily from leaks in the pipe system, fire fighting, and under registration of meters. The city should track how much of the unbilled water is actually unaccounted-for by estimating water used for municipal purposes. Typical rates for unaccounted-for water are 10 to 15 percent in systems with an average level of maintenance.

Table 3-3 Fire Flow Requirements

Location	Name	Flow at 20 psi			Duration
		Needed[1] gpm	Available		hr
			Measured[2] gpm	Computer[3] gpm	
80th St. NE/2nd St. NE	Diamond Crystal	1500	---	1100	2
1500 S. Garfield	Central Printing	1000	---	805	2
1008 2nd St. NE	Lewis Tool & Die	600	720 [4]	---	2
102 Lincoln St. NE	Farmers Elevator	2000	1331	1740 [5]	2
108 Main N.	Accurate Automotive	550	750 [6]	---	2
250 Prairie Dr.	D&J Transfer	1500	475	330	2
4th & Garfield SW	Bondurant-Farrar H.S.	1900	411	340	2
6600 62nd Ave. NE	Hulcher Complex	750	---	390	2
396 2nd St. NW	American Legion	250	---	<250	2
NE 72nd St.	Union 76 Truckstop	1400	410 [1]	415	2

(1) Calculated by Bondurant fire chief.
(2) Field measured in February 1994.
(3) Determined by computer analysis. See Section 6.
(4) Hydrant flow tests conducted in 1987.
(5) Existing elevated tank releasing 1300 gpm. Tank will drain in 23 minutes.
(6) Flow from nearest fire hydrant located at 1st Street and Main Street.

Source: City of Bondurant and Stanley Consultants, Inc.

Section 4

Existing Facilities

General

The City of Bondurant receives its raw water from four alluvial wells located in the Skunk River valley approximately three miles from the city. Raw water passes through aeration, filtration, and chlorination treatment before two high service pumps direct the water to a 0.5 mg ground storage reservoir located on N.E. 86th Avenue north of the city limits. Three high service pumps located at the reservoir deliver water to the distribution system. The pipeline located between the water plant and the ground storage reservoir is pressurized by high service pumps located at either the water plant or the ground storage reservoir. An elevated tank located in the center of the city is used to equalize system pressure.

The distribution system consists of a network of pipelines ranging in size from 3" to 8", one ground storage reservoir, one elevated tank, two booster pumping stations, and a number of valves, fire hydrants, and other appurtenances. The city is located on relatively flat ground resulting in a single pressure zone. A large variation in ground elevation occurs between the water plant and the ground reservoir; however, this area is still served by the same pressure zone.

A unique feature of this water system is that the service area is extremely long and narrow from north to south. While the main portion of the water system downtown is about one-half mile wide, water service extends for over 2½ miles in the north-south direction.

A description of individual system components is presented in the following paragraphs.

Pressure Zone

System pressure is established by the operating head developed by the high service pumps and the elevated tank. In the city ground elevation ranges from approximately 930 feet along Mud Creek to approximately 980 feet near the intersection of Patterson and Paine Streets. Between the water plant and the ground reservoir ground elevation varies from approximately 830 feet to approximately 970 feet. With a potential system operating head of about 1090 feet at the elevated tank, static pressure in the city ranges from 47 psi to 69 psi. However, pressures significantly lower than these are recorded from hydrant tests during normal flow conditions. System pressure ranges from about 60 psi to about 120 psi between the water plant and the ground reservoir.

Storage

There are two storage reservoirs in the Bondurant water system. One reservoir is a ground tank located on N.E. 86th Avenue just west of S.E. 80th Street. An elevated tank is located in downtown Bondurant on First Street S.E. between Lincoln and Main Streets. Information concerning these tanks is summarized in Table 4-1.

Table 4-1 Water Storage Facilities

Type	Location	Year Constructed	Overflow Elevation ft	Head Range ft	Gross Volume gals
Ground Steel	86th Ave. N.E.	1972	1003	37	500,000
Elevated Steel	First St. S.E.	1952	1090 ±	—	30,000

Source: City of Bondurant

Ground Storage Reservoir

This reservoir is the main storage facility in the system. The tank has an overflow level of 1003 feet and is 37 feet deep. With a capacity of 0.5 mg this tank can supply the system for over a day under maximum demand conditions and over three days during average day demand conditions. The tank, which was constructed relatively recently, appears to be in good condition.

The tank is connected directly to the 8" water main coming from the water plant high service pumps which fills this reservoir. Water is pumped out of the reservoir with three high service pumps that deliver water directly into the distribution system through a single 8" water main more than one mile in length.

Elevated Tank

This 30,000 gallon steel elevated tank was constructed in about 1952. The tank exterior is generally in very good condition. It was last painted in 1990.

There are no records on the overflow level of the tank. However, it is believed to be approximately 120 feet above ground level or approximately at elevation 1090 feet. Head range is unknown.

There is no level control located on the elevated tank and no altitude valve exists. Therefore, the high service pumps must turn off when the tank is full, based on system pressure monitored at the base of the tank, to keep the tank from overflowing. Based on gauge readings taken at the base of the elevated tank and remote readings at the pump station control panel, it appears that the telemetry is not calibrated properly and is giving false readings. The booster pumps are set to maintain a water depth of 16 feet or a near full condition in the elevated tank. However, at the time pressure readings at the base of the tank were taken, only 42 psi was read indicating that the water depth in the tank was down by as much as 23 feet from the overflow level.

High Service Pumps

There are two booster pumps located at the water plant and three booster pumps located at the ground storage reservoir. The pumps at the water plant deliver water to the ground reservoir and supply water customers located between the water plant and the ground reservoir. The pumps located at the ground reservoir deliver water to the city and back to the water plant when the water plant pumps are not operating. The water plant pumps are constant speed with a rated capacity of 350 gpm each. Only one pump operates at a time with the second pump used for standby. The three pumps at the ground reservoir are variable speed. Typically, only one needs to be operating at a time to maintain pressure in the system. Each pump has a optimum design capacity of 350 gpm.

Water Distribution System

A water system must have a piping network capable of supplying water throughout the service area at required flows and pressures. The system must provide reliable service under normal and peak demand conditions and provide an adequate water supply to any location where fire fighting is required.

The pipe network in Bondurant consists of pipes ranging in size from 8" to 3" in diameter. Information provided by the city indicates that nearly 15 miles of water mains are in the system. Approximately 76 fire hydrants and more than 70 valves are present in the water system. Much of the pipe installed in recent years is plastic. This includes long runs of 8" installed in the southern portion of the system and in the Meadowbrook subdivision. Much of the pipe installed in the original town is asbestos cement. Cast iron pipe is used in newer development areas of the distribution system and in the transmission line between the water plant and the city.

The Bondurant water system, including location of water mains, fire hydrants, valves, storage, and pumping facilities is shown on Figure 4-1 (see pocket in back).

Current design standards (see Section 2) require that a 6" minimum water main size be used for providing fire protection and serving fire hydrants. This main size is required to allow withdrawal of required fire flow while maintaining minimum residual pressure of 20 psi. The Bondurant water system contains some hydrants located on 4" mains. Large pressure losses and small hydrant flows can be expected from hydrants on 4" mains. The City of Bondurant should be aware of flow limitations at these hydrants and either limit their use to supplement fire protection or provide adequate water main capacity to these hydrants to make them effective for fire fighting.

The Bondurant water system is characterized by numerous dead-end water mains. Many of these mains are very long. Dead-end water mains are an undesirable feature of a pipe network for four reasons including:

- A break or repair on a dead-end line that requires taking the pipe out of service means all customers downstream of the closure will be without water. Therefore, dead-end pipes significantly effect the reliability of water service to customers.

- Dead-end pipes have half the flow capacity to a given location than a looped pipeline to the same location. Therefore, a much higher level of fire protection can be provided on a looped system than a dead-end pipe.
- Water in dead-end pipes tends to stagnate when water use is low. Chlorine residual may lower to undesirable levels in stagnate water.
- A higher level of maintenance is required on dead-end pipes than on pipes that are looped. Frequent flushing of dead-end pipes should occur to remove accumulated debris and dirt deposits. Flushing also removes red water where iron pipes are located and low chlorine residual water from dead-end lines.

Extremely long dead-end lines are located in the following areas:
- 13,800 feet of 8" pipe on Grant Street from 10th Street S.E. to the industrial park on Prairie Drive S.W. and an additional 1200 feet to Union 76 Truckstop.
- 1600 feet of 6" pipe on Lincoln Street N.E., 3rd Street N.E., and 4th Street N.E.
- 1800 feet of 4" pipe to the cemetery.
- 1900 feet of 8" pipe on Brick Street S.E.

The approximately 26,500 feet of 8" transmission line from the water plant to the city is a single pipeline that exhibits some of the same characteristics as a dead-end line. Since only one pipe is present along this route, a major break in the line could disrupt service, particularly if the break occurs between the ground storage reservoir and the city. The reliability of water service to the entire city is compromised anytime a break in the line occurs.

Many other dead-end pipes are present but involve short lengths of pipe or serve less critical areas.

Fire Hydrants

There are 76 fire hydrants in the Bondurant distribution system. Twenty-four of the older hydrants are two-way, i.e. have two 2½" nozzles. The remaining hydrants are three-way, and feature a 4" nozzle along with two 2½" nozzles. The three-way hydrants are typically the newer hydrants in the system.

Valves

There are more than 70 valves that have been identified in the distribution system excluding valves on fire hydrant leads.

Section 5

Water System Modeling

General

A detailed hydraulic analysis of the existing Bondurant water distribution system was conducted using a computerized simulation technique to analyze pressure and flow in the pipe network. This simulation technique provides a means of determining the adequacy of the water distribution system to meet both present and future needs. The analysis was performed using the University of Kentucky "Computer Program for the Analysis of Pressure and Flow in Pipe Distribution Systems," or "KYPIPE" developed by Don J. Wood. This model has been widely used and accepted by consulting engineers and utilities nation-wide as a valuable tool for pipe network analysis.

The characteristics of the Bondurant water system were used as input to the computer model. They include length and diameter of water mains, pipe roughness coefficients, ground surface elevations, and sources of supply and demand. The location of water demands throughout the system were determined from city billing records. Projected water use was added to new development areas as identified on the development plan. These data, in combination with the generalized computer program constitute a mathematical model of the Bondurant water system.

The performance and adequacy of the distribution system were evaluated by modeling maximum day demand, peak hour demand, maximum day plus fire demand at various points in the system, and storage refilling. As deficiencies in the system were identified, the model was used to evaluate possible modifications to the system. These included adding booster pumps, storage tanks, and water mains that will be required to serve the Bondurant water system during peak water demand periods. Numerous computer iterations were required to assemble and collectively test the various modifications. The results of these evaluations are presented in Section 6 of this report.

Data Requirements

SCI gathered and analyzed available information to conduct the distribution system study. A number of items are presented below as assumptions, data sources or techniques of analysis that were incorporated into the model and used as the basis for the modeling effort.

Water Distribution System Mapping

A 1″ = 200′ scale water distribution system map was provided by the City of Bondurant. This map was supplemented with water system information shown on design drawings for new developments in the city. Together, this information shows the location and size of all pipes and the location of all valves, fire hydrants, storage and treatment/pumping facilities in the system. All water system information was transcribed by SCI to CADD generated base maps which can be made to any scale.

Topographic Mapping

USGS 7.5 minute quadrangle topographic mapping with 10′ elevation contours was utilized for the area serviced by the Bondurant water system. Limited topographic data was available from design drawings of various utility projects throughout the city to supplement information on the USGS map. These maps provided ground surface elevations required for this study.

Water Use Data

Allocation of water demand throughout the community was accomplished with information supplied from the City of Bondurant billing records. Billed water use for 1993 was allocated on an average daily use basis according to customer account address. This allocation permitted actual water use to be assigned to specific distribution system locations in the computer model.

The allocation of water demands was used to analyze the existing distribution system's response to the current average day demand conditions. The analysis provides a baseline of expected system pressures under average operating conditions. The magnitude and significance of lowered system pressures under design operating conditions can more easily be assessed when compared to this baseline condition.

All existing system demands were "scaled up" to account for unaccounted-for water and to represent existing maximum day and peak hour demand, conditions, respectively. Fire demands were located in the model at their actual locations. The response of the distribution system under the influence of individual fire events when the system was experiencing a maximum day demand condition was evaluated.

Another form of water demand is the flow rate required to fill storage tanks. As one of the most stringent tests of the distribution system, the storage refilling analysis imposes a large localized demand on the distribution system at the elevated and ground tanks as these tanks are being filled after a maximum demand day during which a major fire has occurred. It is assumed that the tanks are filled during the nighttime hours when normal demands have decreased. The tanks are filled with water pumped by the high service pumps.

The anticipated growth in water demand through the design period was allocated on the model to areas of new development. The total quantity of unaccounted-for water was assumed to remain constant through the design year. The future system was then evaluated under projected peak hour demand and maximum day plus individual fire events.

Storage

The operating level of the elevated storage tank varies rapidly with varying demand and pump operating conditions due to its small capacity. For both average and peak operating conditions, the elevated tank water level was assumed to be maintained at about 10′ below overflow. For a maximum day plus fire condition, the elevated tank water level was set near the bottom of the tank to simulate a depleted storage condition during the fire. Water level in the ground reservoir was maintained at a nearly full condition due to its large volume.

Pump Operating Conditions

Operating curves for the three high service pumps located on N.E. 86th Avenue are not available from the city. These pumps were simulated in the computer model as constant pressure points of input. In this way, flow from the variable frequency drives on the pumps is simulated by maintaining a constant head selected as typical for the modeled operating conditions while flow varies in response to demand. Pumps at the water plant are single speed and are modeled according to operating curves provided by the city.

Pipe Roughness Coefficients

The Hazen-Williams "C" factor is a coefficient used as a measure of internal pipe roughness. The "C" factor can vary depending on the age, material, and condition of each pipe. Variable "C" factors can be input to the computer when basic characteristics such as age and pipe material are known. These values are then adjusted through model calibration procedures once flow and pressure data from field survey are known.

Literature "C" values are used as initial data values input to the computer model. Table 5-1 presents typical "C" values that can be expected in a system for various materials and ages of pipe. Values of "C" greater than those shown on Table 5-1 should not be encountered in a pipe system due to the inherent deterioration of pipe with age. The average trend "C" values are representative of average results from actual "C" determinations conducted on numerous distribution systems over a 25 year period as reported in the literature.

Pipe roughness factors representing the average trend values shown on Table 5-1 were input to the computer model prior to calibration. Generally, asbestos cement, ductile iron, and plastic pipe has been installed in the system. The policy in recent years is to install plastic pipe exclusively in newly developed areas.

Model Calibration

Numerous checks were made to calibrate and verify the model by comparing computer output data with actual hydrant flow measurements that were conducted throughout the Bondurant water system on February 17, 1994, and general flow test data provided by the city (see Table 5-2). The exact conditions at the time of each test; i.e., water level elevations, pump operation, and demand conditions, were supplied as input to the model. Close agreement between the field conditions and the computer modeling results were achieved in most cases. The computer model was considered calibrated when an

Table 5-1 Hazen-Williams "C" Factor

Pipe Material	"C" Factor	
	Maximum	Average Trend
Cement Lined Cast or Ductile Iron	130	115
Plastic	150	120
Asbestos Cement	140	---
Cast Iron, Unlined		
10 years old	110	95
15 years old	105	87
20 years old	100	80
30 years old	90	68
40 years old	80	60
>40 years old	70	55

Source: Stanley Consultants, Inc.

adjustment to pipe friction factors resulted in close agreement between the field data and computer output.

One location where good correlation between test and model results could not be achieved initially was along Fourth Street N.E. between Grant Street and Lincoln Street N.E. Actual hydrant flow test results were input into the computer model generating extreme negative pressure conditions. It was determined through this calibration effort that the map showing 4"diameter pipes on Lincoln Street, Third Street N.E., and Fourth Street N.E. was incorrect. Excellent correlation occurred when these 4" diameter pipes were changed to the correct size of 6".

Table 5-2 Hydrant Flow Data[1]

Test No.	Hydrant Location	Pressure Before Test psi	Pressure During Test psi	Hydrant Flow gpm	Tank Levels Elevated ft	Tank Levels Ground ft	Booster Pump Operation	Discharge Pressure psi
1	4th & Lincoln	39	27	--	14-18	33	#2 & #3 Full, #1 Variable	70
	4th & Grant	--	--	681	14-18	33		
2	Paine & Patterson	38	12	--	12-18	32.5	#2 & #3 Full, #1 Variable	70
	Paine (SW end)	--	--	605	12-18	32.5		
3	Blaine & 2nd	40	9	--	12-18	32	#2 &#3 Full, #1 Variable	70
	Alpha & Blaine	--	--	400	12-18	32		
4	80th & 94th[2]	50	0	--	14-18	33	#2 & #3 Full, #1 Variable	65
	94th west of Hwy 65	--	--	813	14-18	33		
5	Grant N. of 10th	50	26	--	14-20	32	#2 & #3 Full, #1 Variable	68
	Grant & 10th	--	--	621	14-20	32		
6	Oleson & 11th	48	28	--	---	32	#2 & #3 Full, #1 Variable	67
	Oleson near Hwy 65	--	--	830	---	32		
7	At Central Printing N. of Hwy 65	52	42	--	16-20	31	#2 Full, #3 Variable	60
	Prairie @ Trucking Co.	40	13	--	16-20	31		
	Prairie @ Hwy 65	--	--	475	16-20	31		

(1) Hydrant flow tests conducted 2/17/94.
(2) Variable and unsteady readings during test.

Source: Stanley Consultants, Inc.

Section 6

Distribution System Analysis

General

The present study evaluates the performance of the distribution system from the high service pumps out into the pipe network. Storage, high service pumping and the pipe network are included. An evaluation of the well system and water treatment facilities was not conducted as part of this study.

A detailed analysis of the Bondurant water distribution system was performed using the computer simulation technique described in Section 5. Characteristics of the existing system were input to the model that describe the existing pipe network, pumping and storage facilities, and water demands.

The distribution system evaluation was completed by first identifying distribution system appurtenances (fire hydrants, valves, etc.) that are not functioning properly and thus inhibit routine operation and maintenance of the system. This was followed by simulation of maximum day demand, peak hour demand, and storage refilling conditions for the existing system to identify potential weaknesses in the piping network under current and design demand conditions. This phase of the analysis also included eliminating major existing dead-end pipelines by locating new pipelines to close loops.

Additional analysis included simulation of nine fire events at individual buildings occurring on the design maximum demand day. This allowed quantifying available fire flow and identified areas not meeting established design criteria. As system improvements were identified, they were added to the model cumulatively.

Once the near term improvements to the existing system were identified, the analysis was repeated for future development conditions to design year 2015. These analyses incorporated projected water demands and additional fire demands in those areas where new development is expected. A future water system development plan can then be prepared that outlines major distribution system improvements needed as development progresses.

Near Term Distribution System Improvements Evaluation Criteria

Figure 6-1 (see pocket in back) shows the type and location of all recommended near term distribution system improvements. Near term improvements are necessary to bring the entire system up to State and industry standards and satisfy the design criteria established for this analysis. It should be recognized that individual near term improvements have been recommended to correct specific deficiencies in the system. A number of improvements are recommended to provide satisfactory service under normal peak operating conditions and to increase the water supply to certain areas of the distribution system under very localized and severe demand conditions (fire demand). Other improvements are recommended to maintain integrity and allow basic operation and maintenance of the distribution system.

Near term distribution system improvements are recommended to satisfy certain operating standards or criteria as follows:

System Integrity

Improvements necessary to improve the basic integrity of the distribution system, achieve a satisfactory level of operation and maintenance, and promote public health. These improvements normally consist of installing new hydrants and valves, repairing malfunctioning hydrants, valves, and other appurtenances. Repairs on deteriorated storage reservoirs and pumping stations, when required, are considered System Integrity improvements. No attempt to directly increase water supply within the service area is intended with these improvements. They are typically improvements that correct deteriorated conditions on existing facilities or correct unacceptable operating conditions such as extreme levels of pressure.

Normal Service

Water system improvements required to maintain a minimum level of service during maximum day and peak hour demand conditions. The water system serving areas experiencing diminished water pressure during normal demand conditions is greatly improved by installing Normal Service improvements.

Fire Flow

Water system improvements (and associated appurtenances) needed to provide sufficient water supply to specific locations during a design fire event. Although these improvements were not necessary to meet existing or design maximum day or peak hour demand conditions, the overall hydraulic characteristics of the distribution system will be greatly improved once Fire Flow improvements are installed.

Storage Refilling

Water mains and associated appurtenances needed to refill the storage reservoirs quickly after their volumes have been depleted from unusually high demands. Storage refilling normally occurs during the night time hours when demand is lowest.

Close Loop

Water main improvements (and associated appurtenances) needed to close significant existing dead-end lines and provide satisfactory water service to all customers under normal and peak demand conditions. These improvements are important for increasing reliability to areas of the system that currently have a high risk for interrupted service due to breaks or excessively low pressure if an unusual demand is placed on the system.

Near Term Distribution System Analysis

Near term improvements for the distribution system are discussed according to their type in the following paragraphs. Figure 6-1 shows the location of recommended improvements.

System Integrity

City personnel indicate that the fire hydrants and valves in the system are in generally good repair. There are no known deteriorated fire hydrants in the system. All valves were exercised two to three years ago. Only a couple of deteriorated valves are reported in the system.

It is important that the city develop a routine program of flushing fire hydrants and exercising valves. Hydrant flushing should occur every year. Flushing serves two functions. The first is to flush dirt, debris, mineral deposits, and other sources of potential water quality problems from the pipes. Opening or "exercising" fire hydrants provides city personnel with valuable information on their physical condition. Any hydrant found defective can be identified and repaired.

Exercising valves on a routine basis is a vital maintenance function. This task should be conducted on a yearly or every other year basis. Valves found to be inoperable or to be malfunctioning should be identified and repaired. Without properly operating valves, it becomes extremely difficult to isolate a section of water main while repairs are being made.

Of the approximately 76 fire hydrants in the system about 24 representing 32 percent are of the two-way variety with 2 - 2½" outlets. They are typically the older hydrants located in the central portion of the city. These hydrants lack a pumper outlet (4") that allows a pumper truck to connect directly to the hydrant. It is good practice to phase out these old two-way fire hydrants and replace them with new three-way hydrants.

According to "Ten States Standards," hydrant spacing may range from 350 to 600 feet depending on the area being served but a hydrant should be located at each street intersection. It is recommended that hydrants not be spaced further apart than this in built up areas so mains can be adequately flushed and to provide appropriate fire protection. Pipelines in undeveloped areas must have fire hydrants added once development occurs in the area as long as there are currently adequate fire hydrants for flushing. It is recommended that new fire hydrants be installed at the nine locations shown on Figure 6-1 to eliminate long pipe runs without fire hydrants.

Field inspection of the elevated tank and the ground storage reservoir show that they are in generally good condition. The elevated tank was last painted in 1990 and shows no signs of deterioration. The ground reservoir was last painted about 1988 and is showing some deterioration in places. The interior condition of these tanks is reported to be good based upon recent inspections. City officials should monitor the internal and external condition of these tanks on a routine basis (once per year) and make repairs or repaint as necessary.

The Bondurant water system is comprised of a single pressure zone. The service area south of N.E. 86th Avenue is relatively flat with an approximate 50' elevation difference between the highest (980 feet) and lowest (930 feet) elevations. This results in a maximum pressure differential of 22 psi during static conditions.

The pipeline between the water plant and the ground reservoir traverses some relatively hilly terrain. There is an approximately 140 foot difference in elevation between the lowest (830 feet) and highest (970 feet) ground along the pipeline route. Services located on this pipeline are subject to excessive pressure in the low areas since these areas are considerably lower than the rest of the service area within the city limits. Damage to homeowners' water heaters and other fixtures have been reported due to pressure in excess of 100 psi. It has also been reported that some homeowners have purchased and installed pressure reducing valves on service lines to reduce problems associated with high pressure.

High pressure can lead to an increased incidence of leaks and breaks in the distribution pipelines and can be difficult to deal with at the tap. Ways to reduce this pressure to a more desirable level of under 70 to 80 psi should be considered. There are three alternatives that the city may consider for dealing with the high pressure.

- The city may do nothing to decrease the high pressure in the system. Current operating conditions are maintained with this option. This option accepts the problems associated with excessive pressure. No capital costs are associated with this option but high maintenance and customer complaints can be anticipated when compared with a low pressure condition.
- Offer pressure reducing valves or suggest their use to individual customers who would like to have lower service pressure and do not currently have pressure reducing valves. This option takes no action to reduce water pressure in the distribution mains.
- Install pressure reducing valves on the branch pipelines that serve customers that experience excessive pressure. Implementing this option would not reduce pressure in the main 8" diameter pipeline between the water plant and the ground reservoir, but it would improve the pressure situation for the majority of customers experiencing excessive pressure in the area. For those customers whose service line is connected directly to the 8" water main, the city may offer pressure reducing valves to individual customers who would like lower pressure in their homes.

It is recommended that the city implement the third option and install pressure reducing valves on each branch pipeline and at individual services where requested.

Many of the pipelines in the older portion of the city are 4" diameter. A number of these water mains have fire hydrants installed on them. According to IDNR standards pipelines smaller than 6" in diameter cannot be used for fire protection. There are at least eight fire hydrants fed by 4" diameter pipes that do not meet this criteria, including adjacent to the high school. The city should consider phasing out 4" diameter pipes on main streets by replacing them with larger pipes, preferably 8" diameter pipes. Since the presence of 4" diameter pipes causes serious fire flow deficiencies, many of these pipes and fire hydrants will be replaced with larger diameter pipes as part of the near term plan for improvements to meet normal and fire flow conditions, described later in this report.

Two problems related to the integrity of the system exist with the pump control system that was identified by city personnel and investigated by SCI. The first problem is related to pump operation at the ground reservoir. A single booster pump operates when the two valve assembly is positioned to allow water from the ground reservoir booster pumps to flow to the city and back towards the water plant. Two and even three pumps turn on when the two valve assembly is positioned to allow water to flow to the city only. This should be a lower flow condition and require a smaller pump output than the other two valve assembly position. This situation has occurred for approximately 1½ years according to city personnel.

During the evaluation of the control relay logic diagrams, it was noticed that there were panel lights at the booster station control panel to indicate the flow direction of the two valve assembly. Neither of these lights were lit. City personnel indicated that cams within the valve actuator were not positioned correctly, causing the invalid indication. Since the valve actuator is driven electrically, the end of travel has to be monitored in order to interrupt the open or close signal to the motor. If the valve indicator limit switches are not properly positioned, it may be possible that the end of travel limit switches are likewise not set properly. If the limit switches are set past end of travel the actuator motor could burn out. If they are set before the valve disc is fully seated the valve will not close completely and there would exist another path for water flow. Recirculation into the ground reservoir through the partially open valve would occur.

With the information that was available as a troubleshooting aid, it would appear that this is likely the problem. The valve assembly linkage should be disconnected and the valve manually moved to end of travel. The end of travel and open/close limit switches should be set for both diversion positions and the pump operation tested to see if the problem is corrected.

The second control problem relates to the outdated Autocon and relay logic control system. According to city personnel the control system is old and replacement parts and service are difficult to get. The system should be replaced with a Programmable Logic Controller (PLC) at both the ground reservoir station and the water plant.

The existing variable speed pumps at the booster station are adjusted via a potentiometer on the end of a camshaft that is positioned by pulse output from the Autocon system. If more than one pump is required to operate, the existing system causes one pump to operate at full speed and throttles the remaining pump. This is not the recommended mode of operation for variable speed pumps. When two or more pumps are in operation at reduced speeds, they should all operate at the same reduced speed in order to equally contribute to header pressure and flow for the same size pumps.

City personnel stated that if variable speed pumps are kept, then replacing the existing variable speed controllers with modern solid state units is desired. These new units would be incorporated into the PLC controller system via a standard 4-20 mA signal loop.

Because the water treatment pumping system is not manned and since there are existing control panels with control and monitoring devices that are still operational, this equipment should remain as is. Therefore, all existing devices would be incorporated into the new control logic system.

A single 8" diameter pipeline is located between the ground reservoir and the main portion of the distribution system at Lincoln Street N.E. and Second Street N.E. This pipeline is nearly 8800 feet long and is the city's only link to significant storage. Anytime this pipe would break or be out of service for any reason, the city is cut off from its source of supply. From a reliability and system integrity perspective this is an undesirable situation. There are two alternatives to correcting this situation. The first is to provide new large capacity effective storage in the system, preferably in the form of a new elevated tank in the city. The second is to install a second transmission line between the ground reservoir and the distribution system parallel to the existing 8" diameter pipeline. Either of these improvements would provide needed reliability for the system. Since new elevated storage is required in the system for other reasons, this improvement is recommended as a near term solution for increased reliability as well.

Historical pressure readings throughout the community shows that normal pressure under low flow conditions are typically low. IDNR standards require system pressure to be maintained above 35 psi under all normal and peak flow conditions except for fire flow conditions. Pressure readings taken at fire hydrants by city personnel and Stanley Consultants show normal pressure as low as 35 psi. Most normal pressures in the city are between 40 and 50 psi with some areas near Mud Creek experiencing pressure up to about 55 psi.

Since the desirable normal working pressure of a system should be around 60 psi according to IDNR design standards, the Bondurant water system is experiencing a deficit of approximately 15 to 20 psi during normal operating conditions. The lower than desirable pressure is caused by the hydraulic grade line being established at too low a level. There is no information on the exact overflow level of the elevated tank. However results of past pressure tests taken throughout the system indicate that the water level in the elevated tank is maintained at elevation 1060± feet. This level is considerably lower than what is believed to be an overflow elevation of approximately 1090 feet. To raise the hydraulic grade line by 15 to 20 psi, which is a more desirable operating level, the water level in the elevated tank needs to be 35 to 45 feet higher. This action requires the existing elevated tank to be replaced with a taller tank with an overflow level of approximately 1105 feet.

Once a taller elevated tank is constructed, the high service pump head must be increased to produce a sufficient hydraulic grade to fill the tank. According to nameplate information, the existing pumps at the ground reservoir currently produce 102 feet of head at an optimum output of 350 gpm. Since the pumps are located at approximate ground elevation of 967 feet, the total optimum hydraulic grade line established by these pumps is approximately 1069 feet or 44 psi. Considerably higher pressure is experienced at the pump station as the pumps run up on their operating curves, pump less water and run inefficiently. The likely solution is to replace the three existing pumps with three new pumps sized for the increased hydraulic head. With a new large capacity elevated tank in the system, new pumps can be constant speed instead of the variable speed pumps that are currently being used. The pumps would operate off the water level in a new elevated tank. However, the existing pumps should be examined to see if the impellers can be replaced to allow for the higher pump head conditions to be achieved.

Normal Service

The existing distribution system was tested under maximum day and peak hour demand conditions. Under these demand conditions system performance is marginally acceptable. Considerable pressure is lost (23 psi) between the high service pumps and the elevated tank during peak demand conditions. Computer analysis shows that the elevated tank contributes a flow of approximately 175 to 200 gpm during peak hour conditions. Since near peak conditions can persist for two or three hours, most of the volume of the elevated tank can be drained during this period. This situation underscores the problem of the small volume of this tank and the need to replace the tank with a larger tank or add a second elevated tank to the system.

Fire Flow

The ability to meet required fire demand most anywhere in the city is severely deficient. Two basic problems exist that prevent the system from delivering adequate fire flow.

There is a seriously undersized elevated tank and numerous water mains are too small to carry fire flow and do not meet the IDNR criteria.

The elevated tank, with a capacity of 30,000 gallons, will be completely drained by a design fire event in under 23 minutes, even with two booster pumps operating at full speed. Since a design fire event lasts for two hours, the elevated tank has enough capacity to contribute flow for fire fighting purposes for only 19 percent of the duration of the fire. This best case scenario assumes that the elevated tank is full at the beginning of the fire and the booster pumps are operating at their full rated capacity. The small elevated tank is clearly an unacceptable situation from a fire fighting perspective. Additional effective storage is required in the system and is best provided with new elevated storage. Location and size of a new elevated tank is dependent on several factors including:

- Location near major fire demands.
- Location where stabilizing hydraulic grade line is required.
- Location near future growth and where large fire demands are anticipated.
- Location where flow into the main portion of the system can be accomplished efficiently.
- Size determined by factoring volume needed for operating storage, storage to meet required fire flow, volume needed in reserve to insure reliability during an emergency, and volume needed to meet future development needs.

The fire flow analysis incorporated the location and size criteria into the decision making process. It was determined that two good locations exist for the new elevated tank. One is located on high ground along Highway 65 near Lincoln Street S.E. An alternate site is on high ground along Highway 65 near the industrial park. For either location to work a major transmission main (12"Ø) is necessary to interconnect the elevated tank with the existing pipeline on Grant Street. Other pipelines are necessary to meet specific fire flow conditions and are discussed individually below.

The Bondurant-Farrar High School currently has 4" and 6" diameter water mains located adjacent to the front of the building on Garfield Street. With a required fire demand of 1900 gpm, the computer analysis shows that 340 gpm can reach the fire hydrants at the high school. This represents 18 percent of the fire flow required at this site. It is essential that major pipeline improvements be located from a major source of water to the high school. This requires that the 12" diameter pipeline that is recommended between the site of the new elevated tank and Grant Street be extended north on Grant Street to S.W. Fourth Street and west to the high school. A 12" interconnection between Grant Street and Oleson Drive S.E. and a 12" pipeline between Lincoln Street S.E. and Grant Street is recommended to improve overall flow distribution to the older portion of the city including the high school during fire flow conditions. Under existing hydraulic grade conditions approximately 2100 gpm can be provided to the high school when these pipeline improvements are in place. Approximately 1750 gpm is contributed from the new elevated tank with the remainder from the high service pumps and existing elevated tank if the existing elevated tank remains in place. As a practical matter, the volume in the existing elevated tank would drain quickly during the early stage of the fire forcing all the water to flow from the new elevated tank and booster pumps as the fire event continues. With an increased hydraulic grade line by installing a new elevated tank and abandoning the existing elevated tank, even higher fire flows to the high school can be expected.

The farmer's elevator with a required fire flow of 2000 gpm is the largest fire demand in the city. Computer analysis shows that 1740 gpm can reach the area of the elevator. However, approximately 1300 gpm would be contributed from the existing elevated tank which would drain in 23 minutes. With all the pipeline improvements described above for providing fire flow to the high school, plus an extension of the 12" diameter pipe from the high school to Grant Street and north to Second Street then east on Second Street N.E. to Lincoln Street N.E., marginally acceptable fire flow can be provided at this location if the present hydraulic grade line is maintained. Over 1800 gpm can be provided to this location under existing head conditions when the existing elevated tank is removed from service as it would be after it is drained during the initial period of the fire. It is anticipated that the fire demand can be met when increased head conditions are provided by the new elevated tank.

Required fire flow at Diamond Crystal located at 80th Street N.E. and Second Street N.E. is 1500 gpm. The location is between the ground reservoir/booster pump station and the existing elevated tank. Flow to this location is influenced by the ability of the water system to deliver water through pipes located on 80th Street N.E. and Second Street N.E. from these sources of supply. Marginally acceptable fire flow can be achieved during existing hydraulic grade conditions at Diamond Crystal with two booster pumps operating at full speed and either the existing or new elevated tanks in operation and a new 12" diameter pipe in place from the site of the new elevated tank to Second Street N.E. and Lincoln Street N.E.. However, improved hydraulics to Diamond Crystal will occur with an increase in hydraulic grade line created by the new elevated tank, a new pipeline on Paine Street S.E. (extended), and with recommended future system improvements discussed later in the report.

Fire flow to the American Legion building is severely limited by the 4" water main located west of Grant Street on First and Second Streets N.W. This new building would be better served if a new 8" pipeline is installed along Second Street N.W. from Grant Street to Blaine Street N.W. where it can connect to an existing 8" pipeline.

The remaining required fire flows in downtown Bondurant can be met once the 12" pipeline and elevated tank described above are in place. This includes the 600 gpm demand at Lewis Tool & Die located at 1008 Second Street N.E. and the 550 gpm demand at Accurate Auto located at 108 N. Main.

Fire flow at Central Printing located at 1500 S. Garfield can reach approximately 800 gpm with no improvements in place. Once the new 12" diameter pipeline and elevated tank improvements are in place, fire flow to this location will exceed 3500 gpm.

Fire flow to the industrial park on Prairie Drive and nearby Hulcher Complex on 62nd Avenue N.E. is currently seriously deficient. Available flow is approximately 400 gpm at the industrial park and a little higher at Hulcher with the existing system. Since required fire flow at D&J Transfer is 1500 gpm and 750 gpm at Hulcher, there is a 1100 gpm and 300+ gpm deficit, respectively. By installing a new 12" pipeline between the industrial park and Grant Street and locating the proposed elevated tank along Highway 65 at either of the proposed locations the problem with deficient flows will be eliminated.

Computer analysis shows that available flow to Union 76 is a little more than 400 gpm with the existing system. An increase in available flow to over 900 gpm can be anticipated with the new elevated tank in place and the 12"Ø pipe in place between the elevated tank and Grant Street and using the existing hydraulic grade line. With an anticipated fire demand of 1400 gpm, the available fire flow is still deficient by approximately 500 gpm with these improvements in place.

The addition of a 10" pipeline parallel to the existing 8" pipeline to Union 76 from 62nd Avenue N.E. increases flow to a marginally acceptable level of approximately 1300 gpm. If greater fire flow is needed at Union 76 or by new development that may occur near Union 76, additional pipeline improvements should be considered including a new 12" pipeline on Grant Street between Highway 65 and 62nd Avenue N.E. or along an alternate route.

Storage Refilling

Computer analysis shows that the process of refilling the proposed elevated storage tank is significantly improved when an 8" pipeline is installed between the ends of two dead-end pipes on Paine Street. This new pipeline is also needed to increase reliability by providing a second route for water to flow into the city from 80th Street N.E.

Eliminate Dead-End Mains

According to IDNR design standards, dead-end mains shall be minimized by looping mains whenever possible. The Bondurant water system is characterized by some extremely long dead-end pipes which are identified in Section 4. It is important that these dead-end lines are eliminated by forming loops to improve reliability and flow to these areas. Each of the long dead-end pipelines except for the pipeline to the cemetery will be eliminated by installing improvements described above. The dead-end pipeline to the cemetery will be looped as part of internal Meadowbrook development sometime in the future.

Sizing of New Elevated Tank

The size of a new elevated tank is dependent on several factors including requirements for operating storage, fire storage, and reserve storage. Operating storage is considered as the amount of water in the upper portion of the tank that fluctuates with changing demand and pumping conditions. The level of water in operating storage is used to provide the normal hydraulic grade line and control operation of the pumps. It is recommended that up to 10 percent of the total capacity of the tank or 25,000 to 50,000 gallons be allocated. The amount of fire storage was determined by computer analysis with 210,000 gallons being the maximum amount required to existing fire demands. Higher fire storage quantities could be required when future development occurs, particularly when industrial-type businesses locate in Bondurant. Because of the long distance and single pipeline between the source of supply and the distribution system, it is good planning to provide a base level of storage equivalent to one average day demand. This will provide reliable water service to the community in a situation where the ground storage reservoir is taken out of service for any reason for up to one day. According to Table 3-2, storage volume equivalent to one average day demand in 2015 is 277,000 gallons. It is recommended that a 500,000 gallon elevated tank be installed to accommodate current and future storage needs.

Future System Analysis

The City of Bondurant is expected to grow to over 3000 people by the year 2015. Along with this growth in population, commercial and industrial development is expected. New improvements will be required to provide reliable water service to all developing areas. These improvements are shown on Figure 6-1 and are discussed in the following paragraphs.

Water supply is currently pumped from the water plant to the ground storage reservoir located on N.E. 86th Avenue. Although the pipeline has adequate capacity, reliability of this service between the water plant and the ground reservoir is greatly improved by installing a second pipeline. This pipeline can be installed along one of two possible routes. It can be installed parallel to the existing 8" pipeline on N.E. 94th Avenue and 80th Street N.E. or along Highway 65 and N.E. 86th Avenue. It is recommended that the pipeline be 10" in diameter to handle increased flows, faster ground reservoir filling times, and reduced head loss between the water plant and the ground reservoir.

Another location where reliable service to the community is being compromised is between the ground storage reservoir and the distribution system at Second Street N.E. and 80th Street N.E. There is currently a single 8" diameter pipeline that feeds the city from the pump station. Although the recommended near term improvements plan calls for a large capacity elevated storage reservoir to increase reliability to the city, the single pipeline from the ground storage reservoir provides no redundancy for supplying water to the city from the ground reservoir. Additionally, high head losses due to friction are currently being experienced in the 8" diameter pipeline that limits the flow of water through this pipeline during a fire flow event and causes the high service pumps to pump high on their operating curves. It is recommended that a new 12" diameter pipe be installed between the ground storage reservoir and the distribution system.

Other pipeline improvements shown on Figure 6-1 are needed to bring water service to anticipated development areas. They include 12" diameter pipes on N.E. 80th Street and N.E. 70th Avenue to provide a source of supply to anticipated residential development in the area. Twelve inch diameter pipes are planned west of Highway 65 on N.E. 70th Avenue and south of N.E. 70th Avenue to provide water service to future industrial development. A 10" loop is planned for residential development east of Grant Street and north of Fourth Street N.E.

The future system pipeline improvements shown on Figure 6-1 represent trunk lines required to form major loops in the anticipated development areas. Other smaller size pipelines may be necessary to distribute water and provide water service to specific locations in the development areas. These pipelines are not shown on Figure 6-1. Their exact size and location will need to be determined as development takes place.

The Southeast Polk Rural Water District has made some preliminary inquiries regarding purchasing water from the city or sharing water system facilities such as an elevated tank for the mutual benefit of both systems. No definite time frame for implementing these proposals has been developed at this time. However, the city should encourage further discussions with the Southeast Polk Rural Water District to determine if the proposals are feasible and can provide benefit to the citizens of Bondurant.

The City should recognize capacity limitations of the existing water plant when considering selling water to Southeast Polk Rural Water District or as development continues in Bondurant. The water plant, which is designed to produce a maximum of 0.5 mg could reach its capacity when a significant number of new water users are added to the system. It is recommended that the City conduct a study to evaluate treatment plant capacity within the next five years or prior to any major increases in water demand during that period. The study should focus on expanding the capacity of the water plant and feasibility of a connection to the Des Moines Water Works and abandoning the City's water plant.

The recommended near term improvements plan discussed in this water distribution system report would be compatible with a Des Moines Water Works connection, if such a connection were recommended as the desired water source sometime in the future.

Section 7

Recommended Water System Improvement Plan

General

This part summarizes the results and conclusions from the analysis of the Bondurant water system and presents a recommended plan and cost for upgrading the system. The development plan has been prepared for the design year 2015. The hydraulic performance of the water distribution system was analyzed using the "KYPIPE" computer model. Individual recommended improvements were evaluated using this modeling tool. Each is categorized by the type of problem the recommended improvement is intended to correct. In this way, a program to implement specific capital improvement packages can be considered according to need and the financial resources of the City of Bondurant. Figure 6-1 presents an overall plan of new water system facilities to be constructed through 2015.

Section 2 of this report presents an overview of the design criteria used to evaluate the Bondurant water system. Most of the criteria are provided by Iowa Department of Natural Resources design standards supplemented with criteria from other sources.

An evaluation of the water system based on IDNR design criteria and other operational factors indicate that many serious deficiencies exist. They include:

- Extremely long dead-end mains occur diminishing reliability and service to customers located on those lines.
- The city itself is located on the end of an extremely long single transmission line from the ground storage reservoir. Little effective storage volume is present in the city which subjects the city to lost water service if the transmission line is taken out of service for any length of time.
- Extremely poor fire flow to several locations including the high school, the industrial park, Hulcher, Union 76 Truckstop, and other locations currently exists.
- The existing elevated tank with a capacity of only 30,000 gallons does not have sufficient capacity to provide much more than a minimal contribution during a fire and poor operational control during normal service.

- Many of the pipelines in the older, central portion of the city are 4" in diameter. These pipes are too small to meet IDNR criteria for carrying fire flow and their presence in the Bondurant water system seriously diminishes the ability of the system to convey water during peak and fire demand conditions.
- The relay logic control system is old and outdated. Water system personnel indicate that replacement parts and service are difficult to get. The reliability and integrity of the entire water system is jeopardized by equipment that is difficult to maintain.
- There are currently many locations in the older, central portion of the city that do not have coverage by fire hydrants. According to IDNR fire hydrants should be provided at each street intersection with spacing ranging from 350 to 600 feet depending on the area being served. In downtown areas it is good practice to provide hydrants at each street intersection.
- Many fire hydrants in the older, central portion of the city are two-way variety with two 2½" outlets. Accepted practice is to provide fire hydrants with a 4" outlet in addition to the 2½" outlets to allow for a pumper truck connection.

Section 6 described all improvements to the distribution system that are necessary to upgrade the system and satisfy normal and fire demands and improve system integrity through the design period. The improvements are grouped into near term improvements to serve existing development and future improvements to serve the projected development plan. The recommended plan for improvements is shown on Figure 6-1. The near term improvements are discussed separately based on the type of deficiency the improvement is intended to correct.

System integrity improvements are needed to improve the basic integrity of the distribution system and achieve a satisfactory level of operation and maintenance. These improvements consist of a new 0.5 mg elevated tank, upgrade and replace the control system, add fire hydrants and replace obsolete fire hydrants, and conduct a routine program for flushing fire hydrants and exercising valves. Except for the new elevated tank, system integrity improvements do not necessarily increase water supply within the service area.

Normal service improvements are needed to provide adequate water service to all parts of the distribution system during normal and peak demand conditions. Although the computer analysis showed that the existing distribution system can provide marginally acceptable service, the addition of the new elevated tank and booster pumps will increase pressure and provide reliable service during normal demand periods.

Implementing fire flow improvements will allow design fire demands to be satisfied at specific locations through the distribution system. Many pipelines needed as normal service, storage refilling and loop improvements are also needed to meet specific fire demands.

Recommended Improvement Plan

The total estimated project cost for all recommended near term storage, pumping, and distribution piping improvements is approximately $1,892,340. The plan of near term recommended improvements identifies a program to bring the water system up to accepted IDNR and industry standards. Different types of deficiencies are discussed and evaluated in the report. Measures to correct deficiencies are itemized in Table 7-1 and shown on Figure 6-1. They comprise the components of the recommended improvement plan.

Implementing plan components depends on the city's budgeting process. The entire plan is not likely to be implemented at one time, but portions of the plan constructed each year for a number of years as money becomes available. Order for plan implementation is dependent on a number of factors. They can include the need to coordinate a water system improvement with other public infrastructure projects, i.e., street or sewer construction, coordination with private development projects, availability of easements or other factors. Each year's capital water improvement project should be packaged through consultation between city officials and Stanley Consultants based on these factors. In this way, program implementation will be tailored to meet funding in force at the time and can address specific needs to provide maximum benefit from available funds.

Improvements required to meet future development are presented in concept on Figure 6-1. Only major pipelines are shown. When developers' plans are known, then the exact location of these pipelines and the size and location of smaller service pipelines will be determined. The timing and cost for implementing long term improvements depends on when this development occurs.

Schedule

Project implementation is crucial to successfully bring the water system up to acceptable standards. A methodical approach to project scheduling is needed that combines such elements as engineering, easement acquisition, permit applications, commitment of funds, bid assistance, and construction/construction management on a yearly cycle to permit continuous progress. Table 7-2 shows a tentative seven year schedule that would obligate yearly expenditures shown. Construction would progress continuously over the seven year period while the process of preparing a new construction package for bidding would take place each year. Table 7-2 generally reflects a timetable for project funding based on when significant bonding capacity becomes available to the City. This schedule could be accelerated if alternative funding sources become available for water system improvements.

Financing Options

The city may consider several options for financing near term water system improvements. The first option utilizes available funds in the current water utility budget. With this option, implementation of each year's program for new improvements will occur only as cash reserves are replenished and the required level of funding for a project becomes available. Realistically, cash generated from the sale of water will be sufficient to finance only a portion of each year's capital improvements program.

The second financing option available to the city is long term borrowing. Financing can be accomplished by issuing either general obligation (G.O.) bonds or revenue bonds. Both G.O. and revenue bonds are tax exempt to the holders of these bonds. Therefore, these instruments offer the lowest possible interest rates of any financing option.

G.O. bonds are secured by the full faith, credit, and taxing power of the city. Water system improvements qualify as an "essential corporate purpose" per Section 384.24 of the Code of Iowa. Therefore, G.O. bond financing can be accomplished without voter approval. G.O. bond financing offers the advantage of lower interest rate and less restrictions and reserve fund requirements than revenue bond financing. G.O. bonds can be issued for a period not to exceed 20 years.

Table 7-1 Recommended Near Term Water System Improvement Plan

Item	Improvement	Purpose					Cost[1] $
		System Integrity	Normal Service	Fire Flow	Storage Refilling	Eliminate Dead-Ends	
	Miscellaneous						
A	Hydrant Replacement (24)	*	--	--	--	--	$48,000.00
B	Add 9 Hydrants to System	*	--	--	--	--	18,000.00
C	Install Pressure Reducing Valves	*	--	--	--	--	15,000.00
D	Hydrant Flushing Program	*	--	--	--	--	---[2]
E	Valve Maintenance Program	*	--	--	--	--	---[2]
	Storage						
F	0.5 mg Elevated Tank	*	*	*	--	--	625,000.00
G	Remove Existing Elevated Tank	--	--	--	--	--	45,000.00
	Pumping						
H	Replace Booster Pumps	*	*	*	*	--	30,000.00
	Controls						
I	Upgrade and Replace Control System	*	--	--	--	--	95,000.00
	Water Mains						
J	4800′ of 12″ on Hwy 65 between Prairie & Grant	--	--	*	--	*	158,400.00
K	2000′ of 12″ on Hwy 65 between Grant & Oleson	--	--	*	--	*	66,000.00
L	3800′ of 12″ on Grant between Hwy 65 & Fourth	--	--	*	--	--	138,600.00
M	350′ of 12″ on Fourth between Grant & Garfield	--	--	*	--	--	11,500.00
N	700′ of 12″ on Garfield between Fourth & Second	--	--	*	--	--	23,100.00
O	350′ of 12″ on Second between Garfield & Grant	--	--	*	--	--	11,550.00
P	1200′ of 12″ on Grant between Second SE & Second NW	--	--	*	--	--	39,600.00
Q	700′ of 12″ on Second NE between Grant & Lincoln	--	--	*	--	--	23,100.00

Table 7-1 Recommended Near Term Water System Improvement Plan (Continued)

Item	Improvement	Purpose: System Integrity	Normal Service	Fire Flow	Storage Refilling	Eliminate Dead-Ends	Cost[(1)] $
R	1200′ of 8″ on Second NW between Grant & Blaine	--	--	*	--	--	33,600.00
S	800′ of 8″ on Grant between Second NE & Fourth NE	--	--	--	--	*	22,400.00
T	1150′ of 8″ on Paine between Washington & Snyder	--	--	*	*	*	31,600.00
U	1300′ of 12″ on Hwy 65 between Oleson & Lincoln	--	--	*	--	*	42,900.00
V	400′ of 12″ between Elevated Tank and Lincoln	*	*	*	*	--	41,300.00
W	1150′ of 10″ on Grant between 62nd & Union 76′	--	--	*	--	*	34,200.00
X	700′ of 12″ on Fourth between Grant & Lincoln	--	--	*	--	--	23,100.00
	Subtotal Construction						$1,576,950.00
	Engineering, Legal, Administration at 20%						315,390.00
	TOTAL PROJECT						**$1,892,340.00**

(1) Cost based on 1995 prices.
(2) Hydrant and valve maintenance requires no capital expenditures.

Source: Stanley Consultants, Inc.

Revenue bonds are secured solely by the revenue producing capability of the water utility. Revenue bonds are entirely self-liquidating with debt service (principal and interest) payable entirely from net revenues. Revenue bonds can be issued without voter approval. Revenue bond issues typically include terms and conditions for creating and maintaining reserve funds and the issuance of additional revenue bonds ranking on a parity with the issued bonds. There are no term limitations for revenue bonds. However, interest rates for longer term revenue bonds are higher than shorter term bonds.

Other financing options include combined G.O. and revenue bond financing and special assessment bonds. Special assessment bonds are not suggested because of the costs to administer financing by this means and problems of equitable cost recovery from water utility customers.

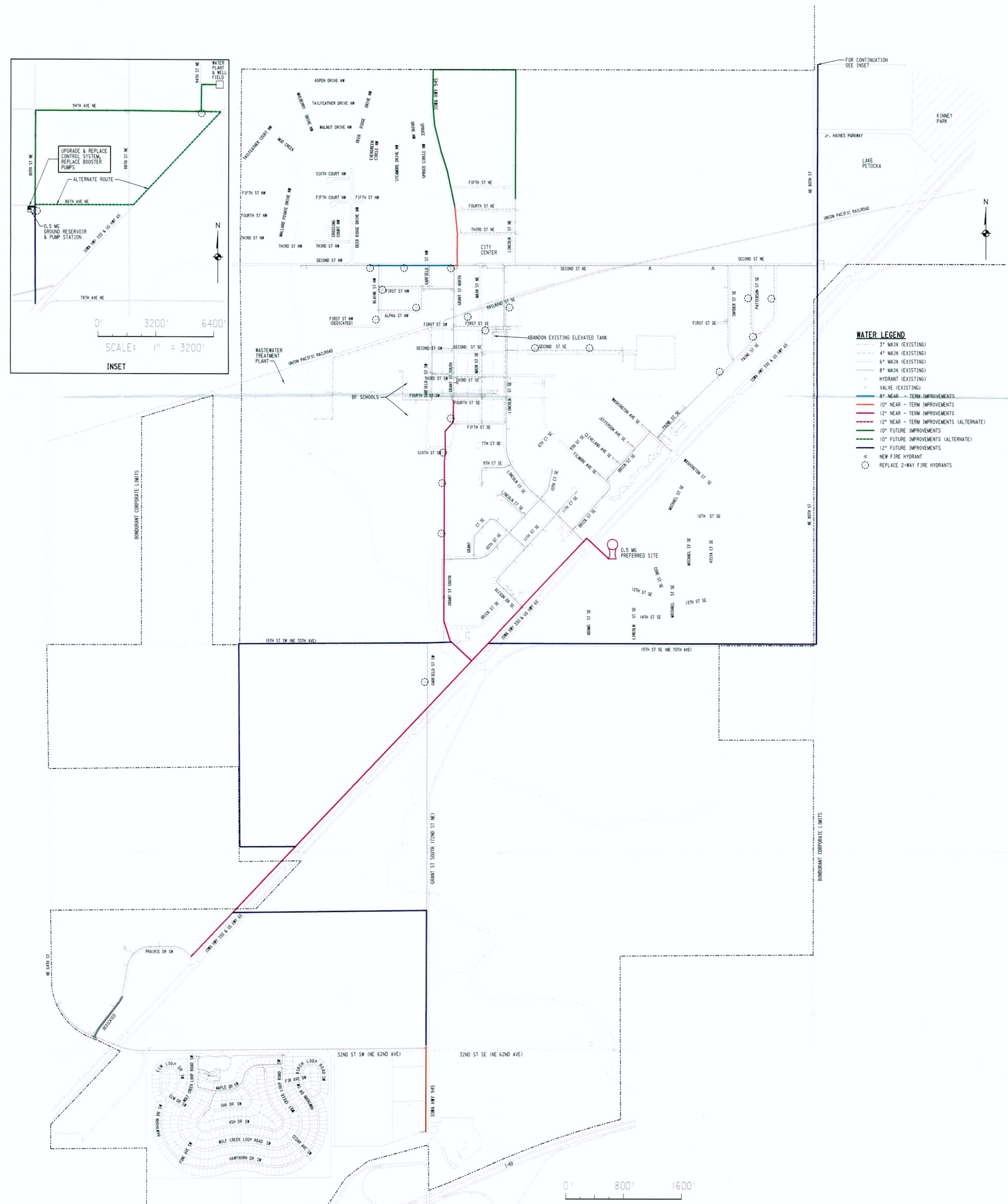
The Community Development Block Grant (CDBG) program provides low interest 40 year loans administered by the Farmers Home Administration (FmHA) for capital improvement projects. Water system improvements are eligible under this program. However, a community must show that at least 51 percent of its population is categorized in the low to moderate income (LMI) range to qualify. In Bondurant, current figures show that only 40.25 percent of its population falls into the LMI category. Therefore, Bondurant may not qualify for CDBG assistance unless specific LMI neighborhoods become the focus of specific water system improvements.

Table 7-2 Implementation Schedule

Work Task	1995 Quarter 1 2 3 4	1996 Quarter 1 2 3 4	1997 Quarter 1 2 3 4	1998 Quarter 1 2 3 4	1999 Quarter 1 2 3 4	2000 Quarter 1 2 3 4	2001 Quarter 1 2 3 4	2002 Quarter 1 2 3 4
Project Design								
Legal/Administration								
Bidding/Contracting								
Acquisition of Right-of-way								
Construction/Construction Administration[1]		Project: M,N,T,W	Project: B,O,P,Q	Project: E,V	Project: H,I	Project: K,L,G	Project: J	Project: A,C,G,R,S,W
Cash Flow Required[2]		$107,160	$110,700	$799,560	$150,000	$297,000	$190,080	$237,840

(1) See Table 7-1 for description of each project.
(2) Includes engineering, legal and administration at 20%.

Source: Stanley Consultants, Inc.



PLAN OF RECOMMENDED IMPROVEMENTS
FIGURE 6-1