

Citizens Helping Citizens

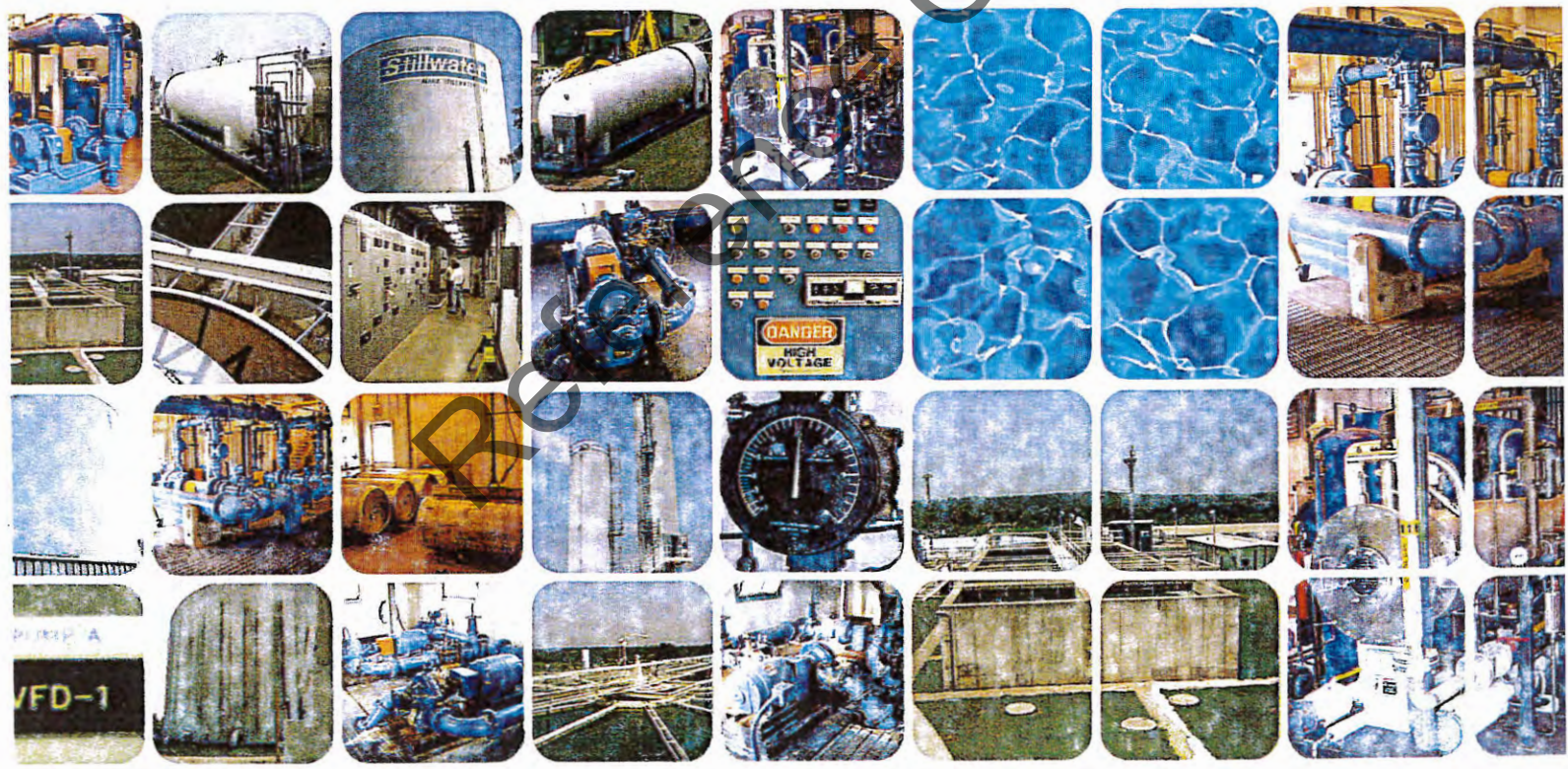
Stillwater

Make Stillwater Run

Water Resources Master & Infrastructure Assets Management Plan

January 2009

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Final Report

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Section 1

Population and Water Demand Forecast

1.1 Introduction

In order to plan for the long-term water supply needs for the City of Stillwater, Oklahoma, Stillwater Utilities Authority (SUA) retained Camp Dresser & McKee Inc. (CDM) to develop a 50-year water resources master plan. This section addresses population and water demand forecast for SUA's service area. The region is served by the Stillwater Water Treatment Plant (WTP) that currently has a treatment capacity of 18 million gallons per day (mgd).

In 2004, the average water production from the Stillwater WTP was 7.7 mgd and the maximum day production was 12.8 mgd. The top five water users in 2004 were:

- Oklahoma State University
- 51 East Water
- Rural Water Corporation #3
- National Standard
- Mercury Marine

This Section describes the methodology used in projecting the future service area population and developing the corresponding long-range water demand forecast. In developing the forecasts, a planning horizon of 2060 was used which represents the projected water needs for 55 years into future.

1.2 Definitions

The technical terminology used in this section is defined below;

Net annual average production (mgd) – The annual average of the daily production from the City of Stillwater WTP corrected for backwash water and cooling water flow (mgd). The daily production numbers are higher than what is actually delivered to the distribution system from the plant, due to plant recycle flows. The filter backwash water is approximately 2% of the total flow treated in the plant. This backwash water from the filter system was pumped to the front of the plant and mixed with incoming raw water prior to influent flow metering. An additional 95,000 gal/day was used for cooling of the ozone generating system. Therefore, the net production of the plant would be the total measured flow less the backwash and cooling water flow. The net annual average production day is corrected to reflect these in-plant consumptions.

Per capita consumption (gpcd) – The average daily water consumption per person over a one year period.

Net maximum day demand (mgd) – The maximum water production from the City of Stillwater WTP in a single day that year corrected for backwash water and cooling water flow using the same method as outlined in the definition of net annual average production, above.

Peaking Factor (dimensionless or mgd/mgd) – The ratio of the net maximum production day to the net annual average production day.

Population Projection (people). – The estimated population based on various factors; including historical trends, growth factors, etc

Unaccounted water (mgd) – The water not accounted for between productions, sales, and unmetered usage as given by the relationship:

$$\text{Unaccounted water (mgd)} = \text{Net Water Production (mgd)} - \text{Water Sales (mgd)} - \text{Unmetered Usage (mgd)}$$

1.3 Population Projections

A very important aspect of an estimated water demand model is the projected population used to calculate the demand. Three different population projections were considered for use in calculating the estimated water demand for the City of Stillwater. These are:

- Projected population based on historical trend,
- Oklahoma Department of Commerce (ODC) projection, and
- Recommendation of the City of Stillwater Community Development Division (CDD).

Historical population growth for the City of Stillwater is summarized in **Table 1-1**, below.

Year	Population*
1890	480
1900	2,431
1910	3,444
1920	4,701
1930	7,016
1940	10,097
1950	20,238
1960	23,965
1970	31,126
1980	38,268
1990	36,676
2000	39,065

* Compiled by US Census Bureau, reported by ODC.

Table 1-1
Historical Population Records
City of Stillwater, OK

The projected population based on the historical data in **Table 1-1** is very similar to the ODC projection; probably because the ODC used historical trends in their projection methodology. The population from the 2000 census, along with the ODC population projections up to the year 2060 (excluding the OSU campus and students) are presented in **Table 1-2**, below.

Year		2000	2005	2010	2020	2030	2040	2050	2060
Projected Population	ODC	39,065	41,940	44,400	47,780	51,330	54,820	57,290	59,640
	CDD (2%)	39,065	43,131	47,620	58,049	70,761	86,257	105,147	128,173

Table 1-2
Population Projections for the City of Stillwater, OK (ODC)

The third population projection considered was based on the CDD recommendation of a 2% growth rate. This same growth rate was used for the Wastewater Master Plan. The population projections at a 2% growth rate for Stillwater through the year 2060 are also presented in **Table 1-2**, above. The historical population growth, as well as the three different population projections for the City of Stillwater, is shown on **Figure 1-1**, below.

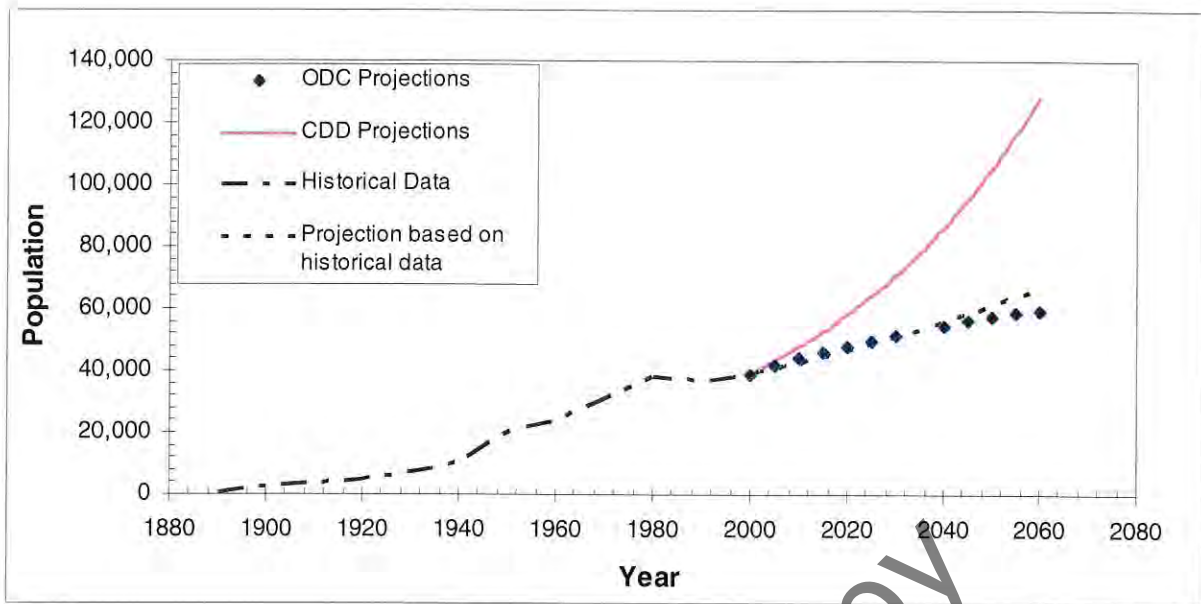


Figure 1-1
Population Projections for the City of Stillwater, OK

The CDD believed that the ODC projections were too low to reflect the acceleration in commercial and residential development of past years. The historical growth rate in the City of Stillwater between the years of 1940 and 1980 was approximately 3.2%. Therefore, the 2% growth rate would result in a more representative population projection. Because of these reasons, the population projections based on the 2% growth rate were used for the water demand calculations, since it was thought to give the most accurate outlook into the future of the City. Additionally, in planning for future water supply needs of a region, it may be prudent to be conservative.

Two other sets of populations that had a significant impact on the anticipated demand on the City of Stillwater WTP were the rural communities outside the city limits, and the OSU student population.

An estimate was made for the population in the surrounding communities based on the water sales from 2004, and the calculated annual average water demand. This population was estimated to be 3,038 people. This population was projected to the year 2060 by using a growth rate of 2.2% per year. The growth rate was increased by 0.2% per year because the outskirts of the city were anticipated to grow faster than inside the city limits. Using this methodology, the estimated population for the communities surrounding the City of Stillwater in the year 2060 is 10,276 people.

Oklahoma State University had already completed its own enrollment projections to the year 2010. The student enrollment projections actually decrease between the years 2005 and 2010; however, overall, between the years 1996 and the projected value in 2010, the average growth rate is approximately 1%. In the Wastewater Master Plan a growth rate of 1.25% per year was used. In this Section, the same annual growth rate of 1.25% was used to estimate the enrollment at the University to the year 2060.

because it is still a conservative growth rate. Based on the 1.25% growth rate, the projected enrollment of OSU in the year 2060 is 42,382 students.

1.4 Water Production

There are many components to the water demand on the City of Stillwater WTP. These include water demand from the City population, demand from the rural areas lying outside the city limits served by the Utility, demand from OSU, and demand from local industries. All of these demands must be met by the total net production of water from the plant.

1.4.1 Average Water Demand

For perspective, the historical net annual average production for the years 2000 through 2004 are shown in Table 1-3, below.

Year	2000	2001	2002	2003	2004
Net annual average production (mgd)	7.6	6.2	7.4	8.0	7.7

Table 1-3
Net Annual Average Production for City of Stillwater WTP

There was a noticeable drop in net water production in 2001. According to the water distribution system report prepared by The Benham Group in 2004 the Stillwater WTP was undergoing major expansion improvement project and was only partially operational in 2001. During the construction periods, a section of the low pressure zone of the distribution system was being served by the Oklahoma State University WTP. This explains the marked decrease in production in 2001. In years 2002 through 2004, the net annual production returned to the pre-expansion annual average production level.

1.4.2 Peak Water Demand

Another important water production planning element is the ability of the water treatment plant to meet peak demand conditions. Historical net maximum production for the Stillwater WTP for the years 2000 through 2004 is shown in Table 1-4, below.

Year	2000	2001	2002	2003	2004
Net maximum day production (mgd)	12.1	11.4	14.0	15.5	12.8

Table 1-4
Net Maximum Day Production at City of Stillwater WTP

Using the net maximum day production and the net annual average production for each year, a peaking factor for each year can be calculated. Peaking factors for years 2000 through 2004 are shown in **Table 1-5**.

Year	Peaking Factor (Max/Average)
2000	1.59
2001	1.84
2002	1.89
2003	1.94
2004	1.65

Table 1-5
Peaking Factors for 2000-2004

To examine the differences in the peaking factor, precipitation data was reviewed for 2003 and 2004. **Figure 1-2** displays the 2003 and 2004 monthly precipitation compared to the average monthly rainfall for Stillwater. The annual average total rainfall for Stillwater is 36.71 inches based on historical data, and in 2003, the total rainfall was 30.7 inches. The lower than average annual rainfall for 2003 explains the higher maximum day water demands for that year. In 2003, rainfall during the month of July is significantly lower than the average rainfall in conjunction with warm weather in July resulted in a high water demand and a high peaking factor as well. The year 2004 had more rainfall than normal with a total annual rainfall of 38.8 in. The higher-than-average annual rainfall in 2004 explains the lower water demand for 2004. This lower water demand from the increased precipitation, in months such as June and July, resulted in lower peaking factors.

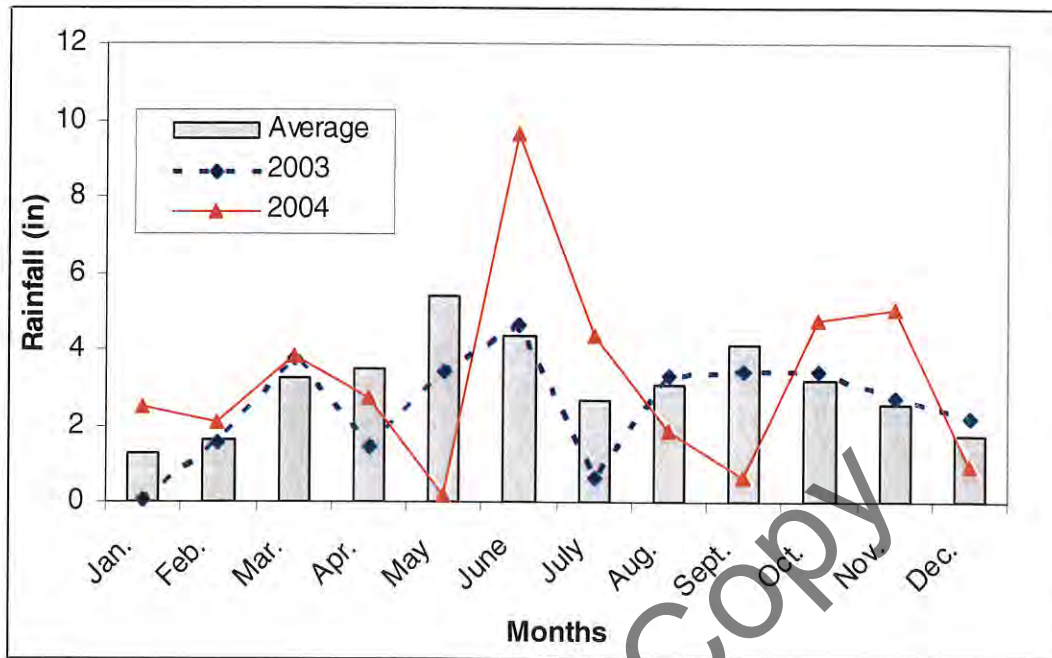


Figure 1-2
Rainfall Data: Stillwater, OK

The rainfall in 2003 was 30.7 inches, which is less than 20% below average. It is statistically likely that dry years similar to or worse than 2003 would again occur in the future. While it is impossible to be prepared to handle all drought conditions, it is prudent to implement a water supply system that covers high probability of all drought situations. A statistical approach was used to determine the peaking factor that may be adopted for the sizing of Stillwater's water system. To cover better than 99% probability, a maximum day peaking factor is calculated using the mean of all the maximum day peaking factors on records, plus three times the standard deviation. The calculated peaking factor was 2.14. If the system has the capability to deliver a flow that is 2.14 times of the average demand, the system can supply adequate water to meet the peak demands of all of its customers 99% of the times.

1.5 Water Consumption

A significant component of water demand is consumption which is accounted for by water sales. The City of Stillwater WTP serves many customers; the City itself, the rural water districts outside the city, the OSU campus, and a number of industries in the area. Historical annual water sales are shown in **Table 1-6**.

Year	2000	2001	2002	2003	2004
Annual Water Sales (MG)	2,034	1,732	1,670	2,079	2,090

Table 1-6
Annual Water Sales from City of Stillwater WTP

1.6 Unaccounted Water

The total sales of water from the City of Stillwater WTP as compared to the net production at the treatment plant displayed some high percentages of unaccounted water. The calculated values of unaccounted water are shown in **Table 1-7**, below.

Year	Total Production (MG/yr)	Total Consumption (MG/yr)	Total Unaccounted Water (MG/yr)	Total Unaccounted Water (%)
2000	2,779	2,034	745	27
2001	2,259	1,732	527	23
2002	2,715	1,670	1,045	39
2003	2,918	2,079	838	29
2004	2,835	2,090	744	26

Table 1-7
Total Unaccounted Water

The percentage of unaccounted water for most water utilities ranges from 10 to 15 percent. This 15 percent mark represents the point where the cost of the water lost roughly equals the cost of identifying and repairing the leaks. It is called the “target economic leakage rate.” Unaccounted water varies for each system depending on the local cost to locate leaks, run a meter verification program, and perform other leakage control measures versus the actual cost of the lost water. In 2002, the total unaccounted water in Stillwater spiked to 39 percent. Because this is well beyond the national norm, Stillwater Utilities Authority should consider implementing a more aggressive program to identify and correct unaccounted water losses.

Unaccounted water losses will also in part be attributable to fire flow, irrigating public property, washing streets, or any public water use that is not metered. Other potential losses are incorrect meter readings, connections where water usage is unmetered, or leaks in the distribution system. However, the unaccounted water must be factored into the calculation on the overall water demand of the Stillwater WTP.

1.7 Demand in 2060

To determine the demand on the City of Stillwater WTP in the year 2060, a per capita consumption value was calculated for the following population divisions:

- City of Stillwater,
- OSU student population, and
- The rural population in the water service area outside the city.

Additionally, it is also important to make a water usage allowance for future growth in the industrial sector.

As an initial step in determining the future water demand, detailed water sales were examined for 2004. The water sales in 2004 including the total water sales to OSU, water sales to rural water corporations, and water sales to local industries, are summarized in **Table 1-8**.

Description	Water Sale Recorded (gallons)
Total	2,090,485,600
OSU	387,134,000
Rural Water Districts	157,108,000
Industries	161,830,600

Table 1-8
Water Sales from City of Stillwater WTP; Year 2004

To determine the water sales to the City alone, the water sales to OSU and the rural water corporations were subtracted from the total water sales. Industry water sales were included in the City's consumption since these industries are expected to grow along with the population of the City. Therefore, the water sales to the City alone in the year 2004 were:

$$2,090,485,600 \text{ gal} - 387,134,000 \text{ gal} - 157,108,000 \text{ gal} = 1,687,640,800 \text{ gal}$$

$$\{\text{Total Sales}\} - \{\text{OSU}\} - \{\text{Rural Water Corporations}\} = \{\text{City of Stillwater Consumption}\}$$

In addition, the percentage of sales that went to industry was:

$$\frac{161,830,600 \text{ gal}}{2,090,485,600 \text{ gal}} = 0.077 \approx 8\%$$

As stated earlier, there are many components to the water demand on the City of Stillwater WTP. The largest component is the City's demand. To calculate a future annual average water demand for the City, per capita water demand was used. It is assumed that the demand per person will stay the same throughout the planning period. The per capita water demand was determined by dividing the total water sales for 2004 by the population served for that year as shown in the equation below. The projected water demand was then calculated using the population projection for a given year multiplied by the per capita water consumption. The average per capita water consumption is about 110 gallons per day.

Average per Capita Water Consumption =

$$\frac{1,687,640,800 \text{ gal}}{42,285 \text{ people} \times 365 \text{ days}} = 109.3 \text{ gpcd}$$

The water use per day in the year 2060 was then predicted to be approximately 14 mgd.

Projected Average Water Consumption for 2006
 $= 109.3 \text{ gpcd} \times 128,173 \text{ people} = 14,009,309 \text{ gpd} \approx 14.0 \text{ mgd}$

There are no recorded estimates for the population in the rural areas outside of the city limits. However, an estimate was made based on water sales in 2004 for 51 East Water and Rural Water Corporation #3, both purchased treated water from the City of Stillwater. In addition, the approximate number of connections in Rural Water Corporation #3 was also obtained.

For this calculation, the approximate number of connections obtained was multiplied by the number from the 2000 Census for the "Persons per household," which was 2.49 for the state of Oklahoma. The Census number for the state of Oklahoma was used instead of the number for Stillwater or Payne County. The Census numbers for the City of Stillwater and Payne County were lower, probably because of the increased number of single person residences in the vicinity of OSU. In the rural areas where this treated water is being distributed, a higher Census number would be more representative of a single family home. This calculation, shown below, yields a population for Rural Water Corporation #3 of 2,739 people.

$$(1,100 \text{ connections}) \times (2.49 \text{ people / connection}) = 2,739 \text{ people}$$

To determine an approximate number for the annual average water demand, losses at 15% were taken out of the overall water sold to the Rural Water Corporation #3. The total amount of water sold minus the losses was then used to calculate an annual average per capita water demand.

$$(141,718,000 \text{ gallon / yr}) \times (1 - 0.15) = 120,460,300 \text{ gallons};$$

$$(120,460,300 \text{ gallons}) / (2,739 \text{ people} \times 365 \text{ days}) = 121 \text{ gpcd}$$

Because the number of connections for 51 East Water was unknown, the same ratio of water sold per connections was used for this rural water district.

$$(141,718,000 \text{ gal}) / (1,100 \text{ connections} * \text{year}) = 128,835 \text{ gal / connection} * \text{year}$$

The amount of water sold to 51 East Water in 2004 was used to calculate the estimated number of connections.

$$(15,390,000 \text{ gal} / \text{yr}) \times (\text{connection} * \text{yr} / 128,835 \text{ gal}) = 119.5 \text{ connections} \approx 120 \text{ connections}$$

As can be seen in the calculations below, the same process as above was used to determine the estimated number of people served by 51 East Water, and the annual average water demand.

$$(120 \text{ connections}) \times (2.49 \text{ people} / \text{connection}) = 299 \text{ people}$$

$$(15,390,000 \text{ gal} / \text{yr}) \times (1 - 0.15) = 13,081,500 \text{ gal} / \text{yr}$$

$$(13,081,500 \text{ gal}) / (299 \text{ people} \times 365 \text{ days}) = 120 \text{ gpcd}$$

Thus, the total population estimated to live in these communities in 2004 was 3,038 people.

To calculate this population in the year 2060, an estimate was made based on the projected growth rate. As discussed earlier, the communities surrounding the City of Stillwater were projected to grow at a rate of 2.2% per year between the years 2004 and 2060, due to the anticipated higher growth rate for the outskirts than areas within the City. Using this growth rate, the future population in the rural communities surrounding the city is estimated to be 10,276 people.

Correspondingly, the water demand expected in these communities in 2060 was estimated to be:

$$10,276 \text{ people} \times 121 \text{ gpcd} = 1,243,396 \text{ gpd} \approx 1.2 \text{ mgd}$$

At this time the City of Perkins, OK is not a customer of the City of Stillwater Water Utilities, and has not been included in the water demand projections. However, in the future Perkins might become a customer, which would require a small adjustment to the water demand projections.

Another significant population that is a present customer of the City of Stillwater Water Utilities is the University population. The student enrollment in 2004 at OSU was 21,576 students. To calculate the per student water demand that year at the University, the water sales to OSU were used:

$$(387,134,000 \text{ gallons} / \text{yr}) \times (\text{yr} / 365 \text{ days}) \times (1 / 21,576 \text{ students}) = 49.2 \text{ gallons} / \text{student} * \text{day}$$

The future OSU student population was developed using a 1.25% growth rate. This growth rate was based on enrollment projections provided by the school, which were also used in the Stillwater Wastewater Master Plan. Using this growth rate, the student population is projected to be 42,382 students in the year 2060. With an estimated water consumption of 49.2 gal/student*day, the water demand of the OSU student body in 2060 was estimated to be:

$$42,382 \text{ students} \times 49.2 \text{ gal} / \text{student} * \text{day} = 2,085,194 \text{ gal} / \text{day} \approx 2.1 \text{ mgd}$$

Combining these various water use categories, the total average water demand on the City of Stillwater WTP in the year 2060 was estimated to be 17.3 mgd. To allow for additional industrial growth in the future, this total was further increased by eight percent to 18.7 mgd. Finally, unaccounted water losses were added to the total. In the year 2004, losses were at 26%. While the City will need to better account for these water losses in the future and hopefully reduce them, it is assumed that the historical unaccounted water loss rate will continue in the future. Considering all of these factors, the total average water demand on the Stillwater WTP in the year 2060 was calculated to be 23.6 mgd. Using a peaking factor of 2.14, the maximum day water demand was calculated to be 50.6 mgd. These values are shown in **Table 1-9**, below.

	Average Demand (mgd)	Maximum Demand* (mgd)
City of Stillwater – Total	14.0	30.0
Communities Surrounding	1.2	2.6
Oklahoma State University	2.1	4.5
Allowance for Future Industrial Demand (8%)	1.4	3.0
Total Based on Demand	18.7	40.1
Net Production Required (with losses at 26%)	23.6	50.6

* Using peaking factor of 2.14.

Table 1-9
Water Demand for the City of Stillwater in the Year 2060

In addition, **Figure 1-3** shows the Maximum Production required from the Water Treatment Plant projected through the year 2060.

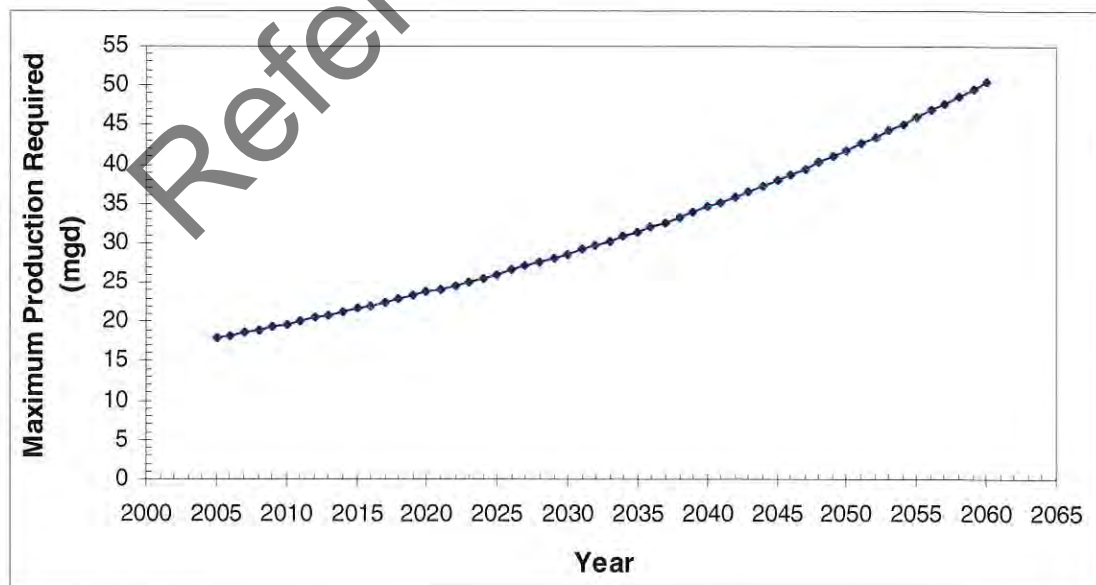


Figure 1-3
Water Demand Projections for the City of Stillwater in Years 2005-2060

Table 1-10 shows the average and maximum demands on the Water Treatment Plant incrementally from year 2005 to 2060.

Year	2005	2010	2020	2030	2040	2050	2060
Projected Population Served*	67,638	73,855	88,138	105,307	125,965	150,844	180,832
Average Demand (mgd)	8.4	9.2	11.1	13.4	16.2	19.5	23.6
Maximum Demand (mgd)	17.9	19.7	23.7	28.6	34.6	41.8	50.6

* Population served includes: City of Stillwater,
Outside Communities, OSU, and Industry.

Table 1-10
Population Projections and Water Demand
on the City of Stillwater WTP
in Years 2005-2060

1.8 Conclusion

Considering all of the various factors which enter into a water demand forecast model, it is recommended that the Stillwater Utilities Authority plan for a future maximum water demand in 2060 of 51 mgd. This demand may be adjusted every 5 to 10 years to reflect new growth trends, or other factors which may change the water demand outlook. The City currently possesses about 53 mgd water rights at Kaw Reservoir and Lake McMurry. However, for long range planning purposes, the Utility may consider securing additional water rights for growth beyond year 2060. A future water distribution system capable of delivering 51 mgd of treated water is also required to meet the service area needs through the year 2060.

Section 2

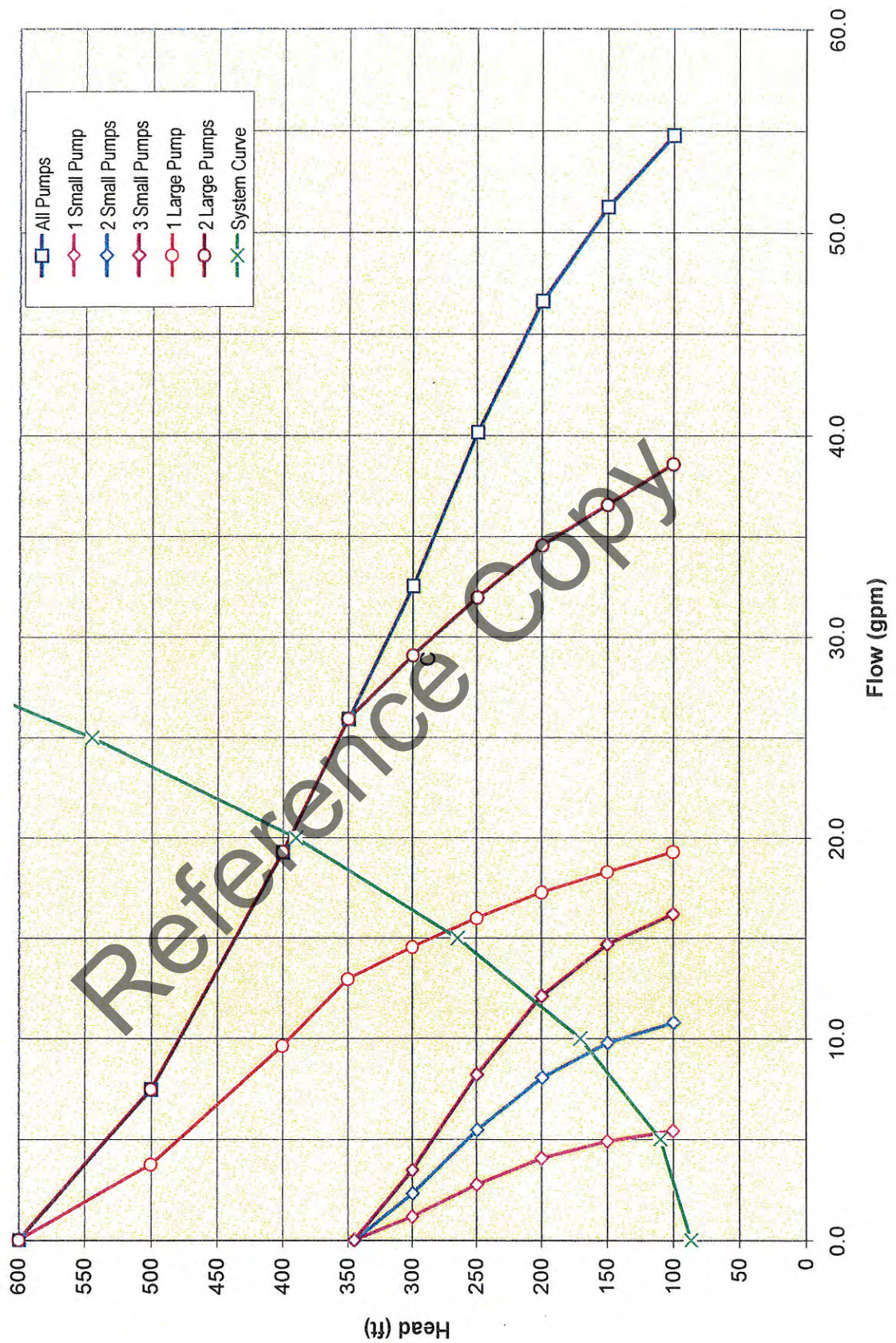
Raw Water Supply System

2.1 Introduction

The City of Stillwater's (City) source of raw water for drinking water supply is the Kaw Reservoir located along the Oklahoma and Kansas border. A pump station conveys raw water from the Kaw Reservoir through a 36-mile long water main to a storage (balancing) tank at the City's water treatment plant (WTP). After the Stillwater WTP site, this water main extends an additional 6 miles to the now inactive Oklahoma State University (OSU) WTP. This 6-mile pipeline is now being used as main transmission line to deliver finished water from the City's WTP.

The pipeline system begins at the Kaw Reservoir with a 48-inch diameter pipe feeding the Kaw Pump Station (Kaw PS), located approximately one third of a mile south of Kaw Dam. The pump station discharges into a 36-inch diameter water main. The discharge pipeline crosses the Arkansas River at two locations. This water main is designed for a maximum flow rate of 35 million gallons per day (MGD) and is made of steel pipes with coal tar enamel lining and externally protected by coal tar enamel with conventional felt and Kraft paper outer wrap. The 48-inch and 36-inch pipes have a wall thickness of ½-inch and 0.312-in respectively. The pipeline has a wall thickness of ½-inch at the river crossings.

The Kaw PS consists of five pumps located outdoors within a fenced area. The pumps are multiple stage vertical turbine units, each installed in a steel can serving as a wet well for the pump. All pump assemblies, valve operators and discharge piping are exposed to the elements. Table 2-1 summarizes the design conditions for these pumps. Figure 2-1 presents the pump curves for all existing pumps and system curve based on current discharge pipe. These pump curves correspond to original equipment manufacturer's information and may be subject to changes due to impeller wear, undocumented modifications or changes, etc. From this figure, it is noted that the maximum flow that the existing pump station can deliver is approximately 20 MGD. The large pumps can deliver a flow of 15 MGD each operating by itself. The large and small pumps however, can not be operated simultaneously due to the different discharge pressures.



No. of Pumps	3	2
Manufacturer	Byron Jackson	Fairbanks Morse
Size & Model	1700 VTL	27M Model 7000AW
Discharge Size	12-inch	18-inch
Suction Size	16-inch	36-inch
No. of Stages	2	4
Motor Size (hp)	200	1,000
Speed (rpm)	1,770	1,185
Capacity (gpm)	2,865 (each)	6,250/11,000 (each)
Head (ft)+	180	400/230

Table 2-1
Kaw PS Design Conditions

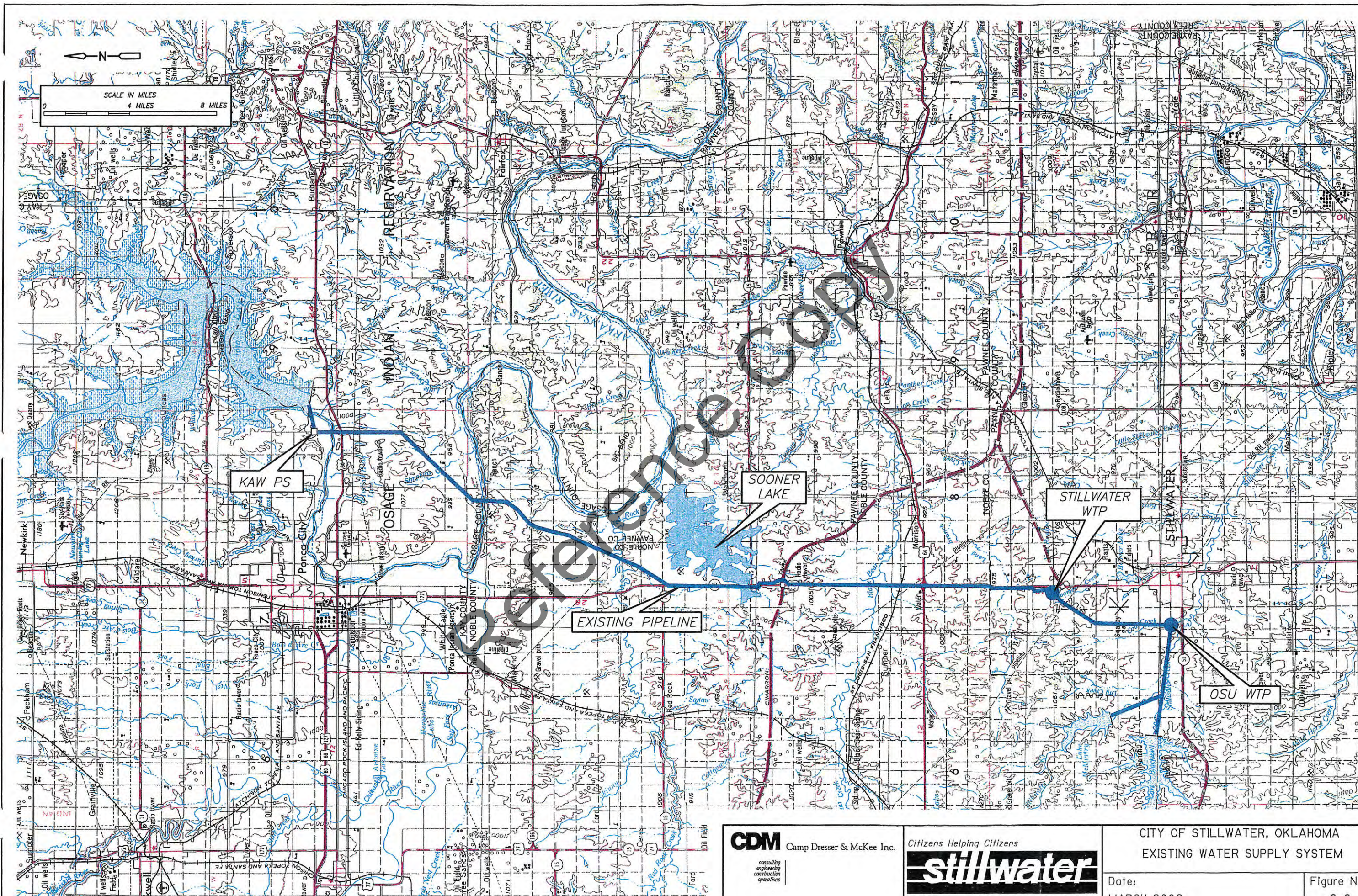
Two manually operated tee-type basket screens are provided to protect these pumps from debris and other large solids that may be present in the raw water. The basket screens are installed upstream of the pumps and can be manually removed for cleaning.

The raw water storage (balancing) tank is located at the Stillwater WTP. The tank has a storage capacity of 4.0 million gallons (MG) and serves as a balancing reservoir between the Kaw PS and the water treatment plant. The water treatment plant is currently designed to produce up to 18 MGD of potable water that meet current drinking water standards.

The Kaw Reservoir intake conduit has a 48-inch gate valve to isolate the Kaw Reservoir from the City's raw water supply system. A 24-inch line branches out of the intake water main and supplies raw water to the Ponca City located about 8 miles west of Kaw Reservoir. **Figure 2-2** shows a schematic overview of the existing raw water supply system and pump station from Kaw Reservoir to the City of Stillwater.

2.2 Concerns of Existing System

In general, operation of the Kaw PS is reliable. Of the five pumps, only two large pumps are required to deliver a flow of 18 MGD to match the capacity of the water treatment plant. There is sufficient redundancy to afford removal of some of the pumps for maintenance. However, there is only one intake conduit and one raw water main to convey water from the reservoir to the pump station and then the Stillwater WTP. The 48-inch intake conduit is made of ductile/cast iron pipes and operates under a system pressure less than 50 pounds per square inch (psi). The intake pipe has provided reliable service since the system was placed in operation in the early 1980s.



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CITY OF STILLWATER, OKLAHOMA
EXISTING WATER SUPPLY SYSTEM

Date:
MARCH 2006

Figure No.
2-2

On the other hand, the raw water main from the pump station to the WTP has experienced leakage several times in the past 10 years. In 2002, a report was prepared by Willbros Engineering summarizing leak repair operations and the results and findings from field inspections. This report indicated that numerous pinhole leaks were present, in addition to numerous corrosion blisters observed throughout the complete interior surface of the pipe.

This report indicated that internal corrosion induced by air entrapment may have caused some of those episodes when the leaks developed near high points of the pipeline. During the most recent leakage event, a hole was found in the lower half of the pipe. In this case, external corrosion might have been the culprit. Also, possible failures of the internal coating or even a flaw or crack have been pointed out as possible causes for the localized corrosion. Remediation by cleaning and coating was recommended to alleviate existing corrosion problems, and individual segments would have to be worked on or replaced at a time. However, the report indicated that this rehabilitation method is long and expensive, primarily due to the requirement of maintaining a water supply (through the use of a temporary bypass line) and the likelihood of failures to occur during the mechanical cleaning process. Remediation can be implemented in a few sections, but if leakage problems continue remediation will no longer be a cost-effective solution.

The pipeline connecting the Kaw PS and the Stillwater WTP is the only one the City currently has; therefore, every leak must be handled as an emergency. Repair must be performed quickly to maintain raw water supply to the City with minimal disruption. However, there are serious concerns that a major or catastrophic failure such as pipe bursting or a major leak could not be quickly repaired and would render the City without water for an extended period of time.

Thus, the existing raw water conveyance system is being reviewed to evaluate different alternatives to provide redundancy that will increase the system's reliability and dependability. The earlier redundancy is provided, the sooner the risk of extended water stoppage will be reduced.

2.3 Water Demand

Currently, the City has water rights to 53 MGD from nearby reservoirs. Of the available water rights, approximately 50 MGD is from Kaw Reservoir and 3 MGD from Lake McMurtry. The current water demand is approximately 8 MGD annual average and 17 MGD during a peak demand day.

Population projections have been developed for the area assuming a 2 percent growth within city limits, 2.2 percent growth for communities outside city limits and 1.25 percent growth in OSU enrollments. Based on the forecast population growth rates and allowing for 26 percent unaccounted-for water, average and peak demand for the year 2060 have been estimated. Average water demands for the year 2060 will be

23.6 MGD. **Figure 2-3** presents a summary of projected water demand through the year 2060. Detailed annual water demands projection was discussed in Section 1 – Population and Water Demand Forecast.

The maximum day water demand was estimated based on the ratio (peaking factor) of maximum daily to annual average daily water consumption between the years 2000 through 2004. The peaking factor utilized for the maximum day water demand calculations is 2.14, which would cover 99% of all water demand situations. Average and maximum water demand estimates include the water needs of the City, allowance for future additional industrial usage (8 percent), surrounding communities, the OSU campus, as well as an allowance for unaccounted-for water. The estimated maximum day water demand is 50.6 MGD for the year 2060. The City's current water rights of 53 MGD are adequate to satisfy this projected peak demand.

2.4 Development of Alternatives

The following alternatives summarize the different approaches that the City of Stillwater can take to provide redundancy to its water supply system. The ultimate solution may be a combination of the alternatives presented below and their implementation may be done in a phased approach to facilitate execution and stage capital expenses.

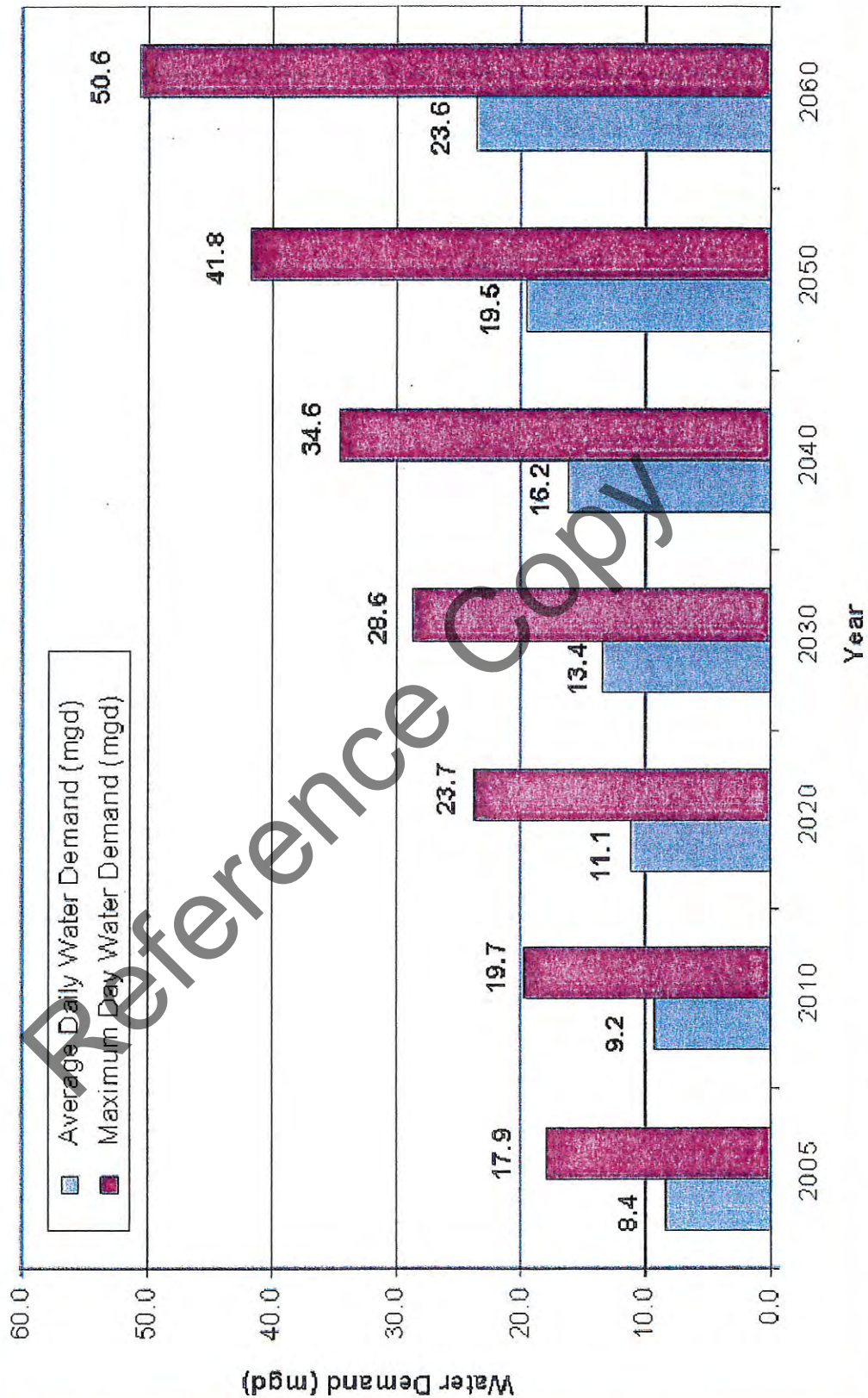
2.4.1 Raw Water Supply

- *Alternative 1* – This alternative includes construction of a new 48-inch discharge line parallel to the existing Kaw pipeline. This water main would be able to handle a maximum flow of 50 MGD, which would cover the peak demand expected for the year 2060. It would also have capacity to handle the City's 50 MGD water rights at Kaw Reservoir. The new water main would extend 37 miles, from the Kaw PS discharge to the Stillwater WTP. The new water main would become the only pipeline, and the existing pipeline would be abandoned in place or rehabilitated and used as a backup system.

In the future, as the population growth dictates the need, the existing Kaw PS would have to be retrofitted with three additional pumps in order to meet the 50 MGD peak demand. The maximum capacity of the existing pumps with the new water main is approximately 31.4 MGD. Therefore, the pump upgrades will be needed by the year 2035.

Table 2-2 summarizes the design conditions of the proposed water main under this alternative. Improvements proposed under this alternative are shown in **Figure 2-4**.

Projected Water Demands through the year 2060



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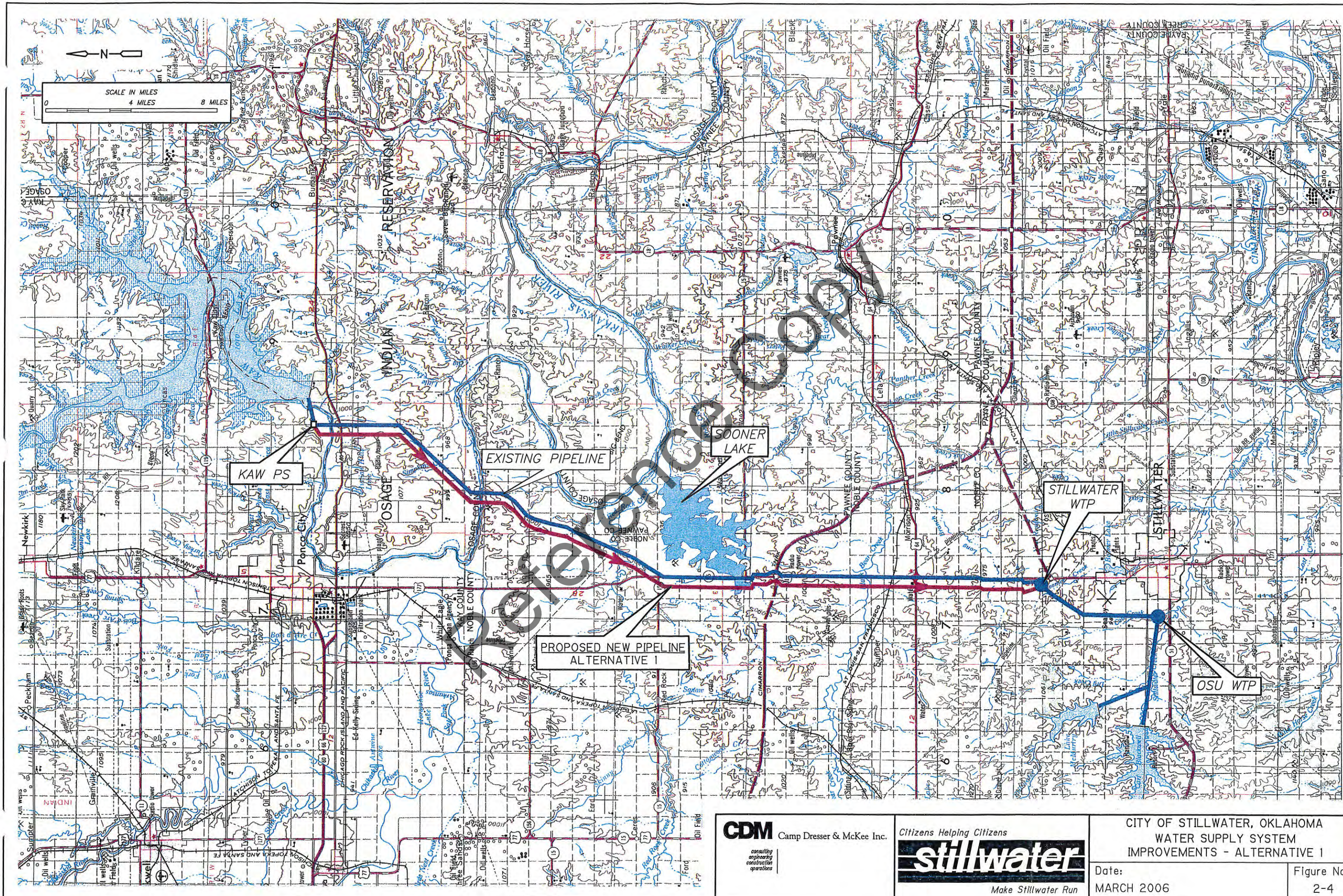


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CITY OF STILLWATER, OKLAHOMA
PROJECTED WATER DEMANDS
THROUGH THE YEAR 2060

Date:
APRIL 2006

Figure No.
2-3



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CITY OF STILLWATER, OKLAHOMA WATER SUPPLY SYSTEM IMPROVEMENTS - ALTERNATIVE 1	
Date: MARCH 2006	Figure No. 2-4

Discharge Pipe	
Maximum Flow (MGD)	50
Pipe Length (mi)	36.4
Nominal Pipe Size (in)	48
Maximum Velocity (ft/s)	4.9
Operating Pressure (psi) ¹	215
Pump Station Upgrades	
No. of New Pumps	3 (duty) + 1 (standby)
Pump Type	Vertical Turbine
Design Flow, each (MGD)	14.2
Design Head (ft)	495
Pump Motor Size (hp)	1,500

¹ Headloss calculated based on C value of 130 (Hazen-Williams coefficient)

Table 2-2
Pipeline Design Conditions – Alternative 1

Figure 2-5 shows a preliminary selection of pumps for this application, upgraded pump station pump curves and the proposed system curve. Table 2-3 shows a summary of capital costs, annual power costs as well as net present worth over 40 years for this alternative.

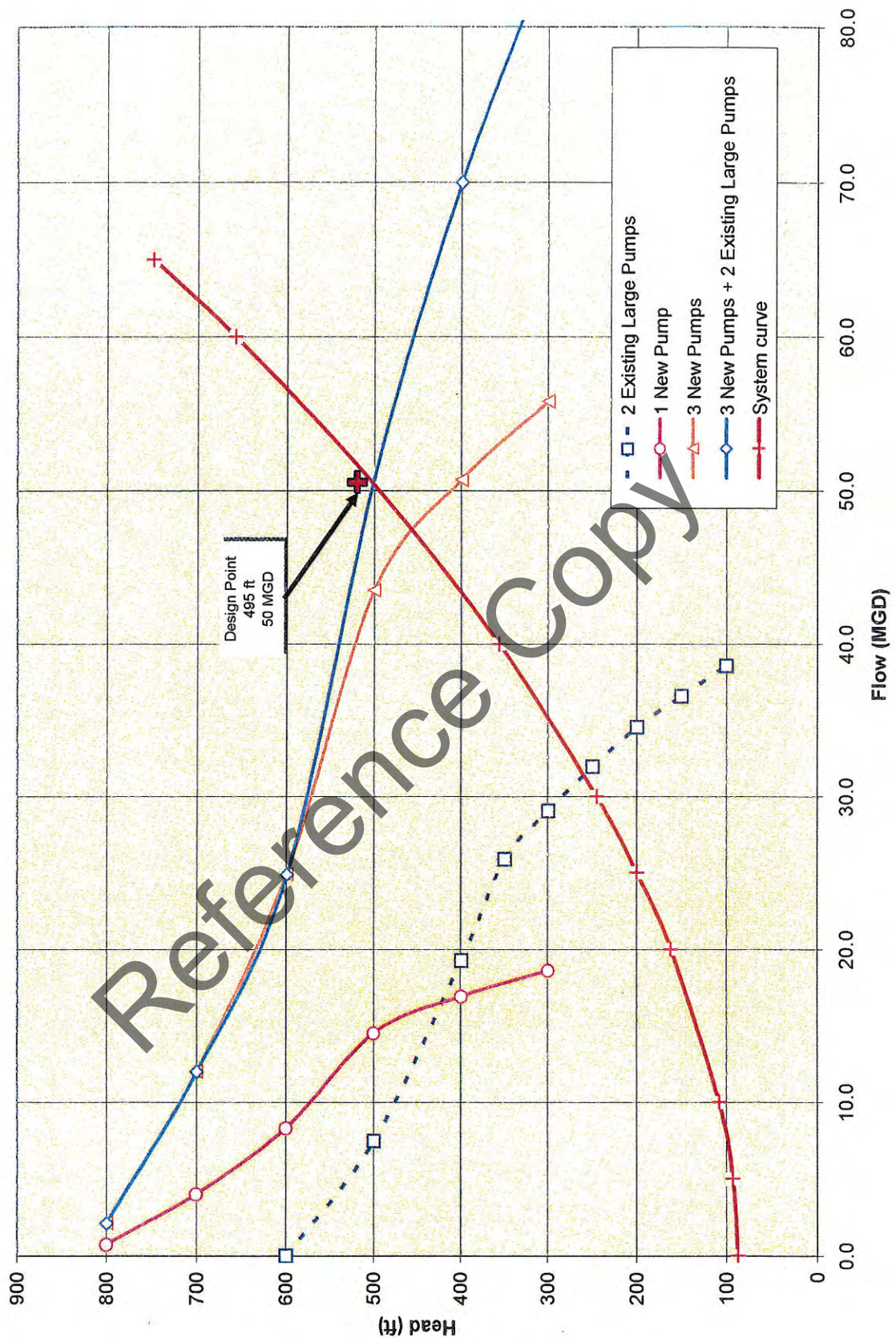
Capital Costs	\$105,564,000
Annual Power Costs	\$446,000
Net Present Worth (40 yr.)	\$117,531,000

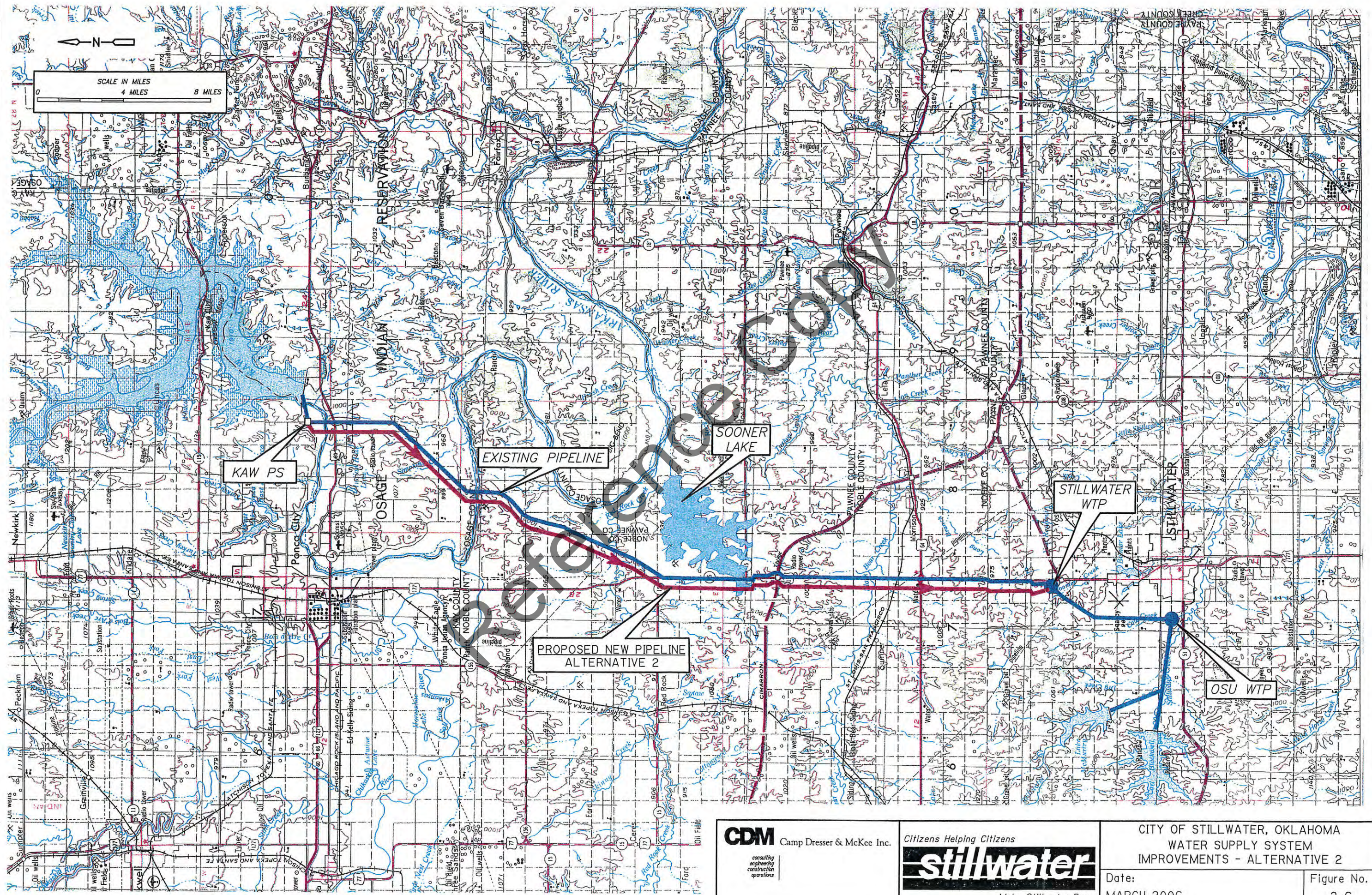
¹ In 2005 Dollars

Table 2-3
Estimated Cost¹ – Alternative 1

- *Alternative 2* – Similar to Alternative 1, this alternative includes construction of a new discharge line parallel to the existing Kaw pipeline. However, this 42-inch water main would be designed to handle up to 30 MGD. This would handle peak demands up to 2032 operating by itself. The pipeline would also be able to handle average demands beyond 2060.

This new water main would be used in combination with the existing line to provide the projected 2060 peak demand capacity of 50 MGD. Once the proposed line is in service, it would allow taking the existing line out of operation for inspection and rehabilitation as required and still provide adequate water supply to the City. Table 2-4 shows the design conditions of the new water main. A preliminary layout of the proposed improvements is shown in Figure 2-6. Because the existing and the proposed water main are not the same size, flows will not split evenly between them when both in operation, but will split 60/40 percent between the new line and the existing line, respectively.





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CITY OF STILLWATER, OKLAHOMA WATER SUPPLY SYSTEM IMPROVEMENTS - ALTERNATIVE 2	
Date: MARCH 2006	Figure No. 2-6

Discharge Pipe	
Maximum Flow (MGD)	30
Pipe Length (mi)	36.4
Nominal Pipe Size (in)	42
Maximum Velocity (ft/s)	4.5
Operating Pressure (psi) ¹	170
Pump Station Upgrades	
No. of New Pumps	2 (duty) + 1 (standby)
Pump Type	Vertical Turbine
Design Flow, each (MGD)	15
Design Head (ft)	390
Pump Motor Size (hp)	1,300

¹ Based on C value (Hazen-Williams coefficient) of 130

Table 2-4
Pipeline Design Conditions – Alternative 2

When the existing 36-inch and proposed 42-inch water main are in operation, additional pumping units would be required at Kaw PS to meet the 50 MGD water demand. Adding pumps similar to the existing ones does not prove effective since they do not increase the pump station output significantly at the required heads. Therefore two new pumps have been selected to provide additional capacity as required when water demand increases. The existing pumps will provide sufficient capacity until the demand is approximately 37.6 MGD in the year 2044. **Figure 2-7** presents a preliminary selection of pumps for this application, upgraded pump station pump curves and the proposed system curve. **Table 2-5** shows a summary of capital costs, annual power costs as well as net present worth over 40 years for this alternative.

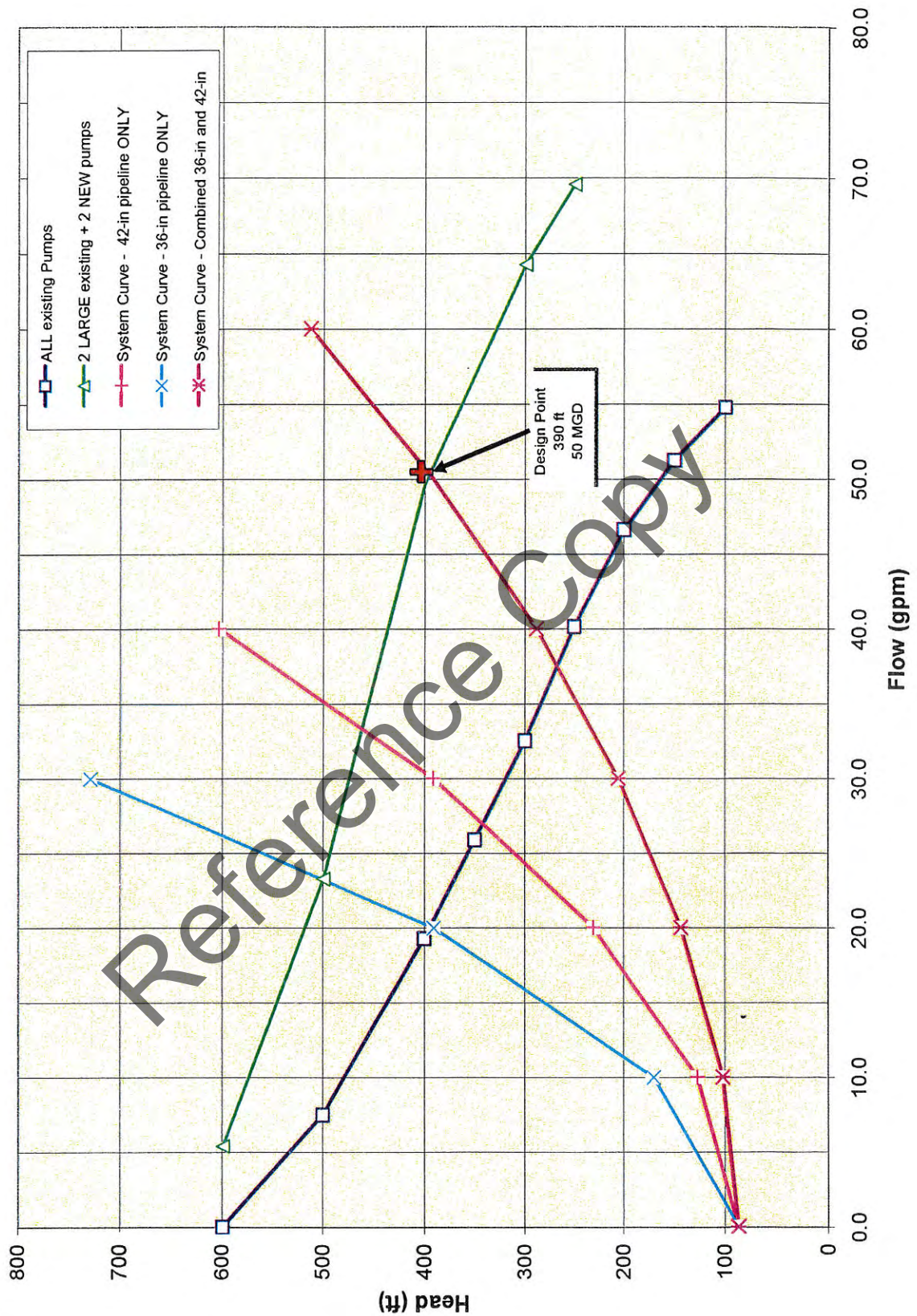
Capital Costs	\$77,314,000
Annual Power Costs	\$379,000
Net Present Worth (40 yr.)	\$87,483,000

¹ In 2005 Dollars

Table 2-5
Estimated Cost¹ – Alternative 2

- **Alternative 3** - This alternative is based on using Lake McMurtry and Lake Carl Blackwell as an alternative raw water source. These lakes are located about 8 miles west of the City of Stillwater. This alternative includes construction of a new raw water pump station and pipeline to convey raw water from Lake McMurtry and Lake Carl Blackwell to the Stillwater WTP.

The proposed pump station would be located near the intersection of the existing raw water lines from these two lakes. A new water main would be provided from this pump station to the Stillwater WTP. This new main would be arranged such that flow can be bi-directional between the Stillwater WTP and Lake McMurtry



and Lake Carl Blackwell. This capability would allow using these two reservoirs as an alternative water source when required, but will also allow transfer and storage of raw water from Kaw Reservoir into these two lakes. The difference in water elevation indicates water can flow by gravity from the storage tanks (balancing reservoir at the WTP) to either Lake Carl Blackwell or Lake McMurtry. If water is discharged into both lakes simultaneously, flows will split 75 percent to Lake Blackwell and 25 percent to Lake McMurtry, approximately. If water is discharged to only one lake at a time, up to 15.8 MGD could be diverted to Lake Carl Blackwell and 11.8 MGD to Lake McMurtry. However, terrain conditions and elevations along the proposed water main route are unknown, and therefore, the feasibility and amount of gravity flow cannot be established with complete certainty. **Figure 2-8** shows system curves for this piping system when water is flowing from the Stillwater WTP balancing tank to Lake Carl Blackwell, Lake McMurtry or both.

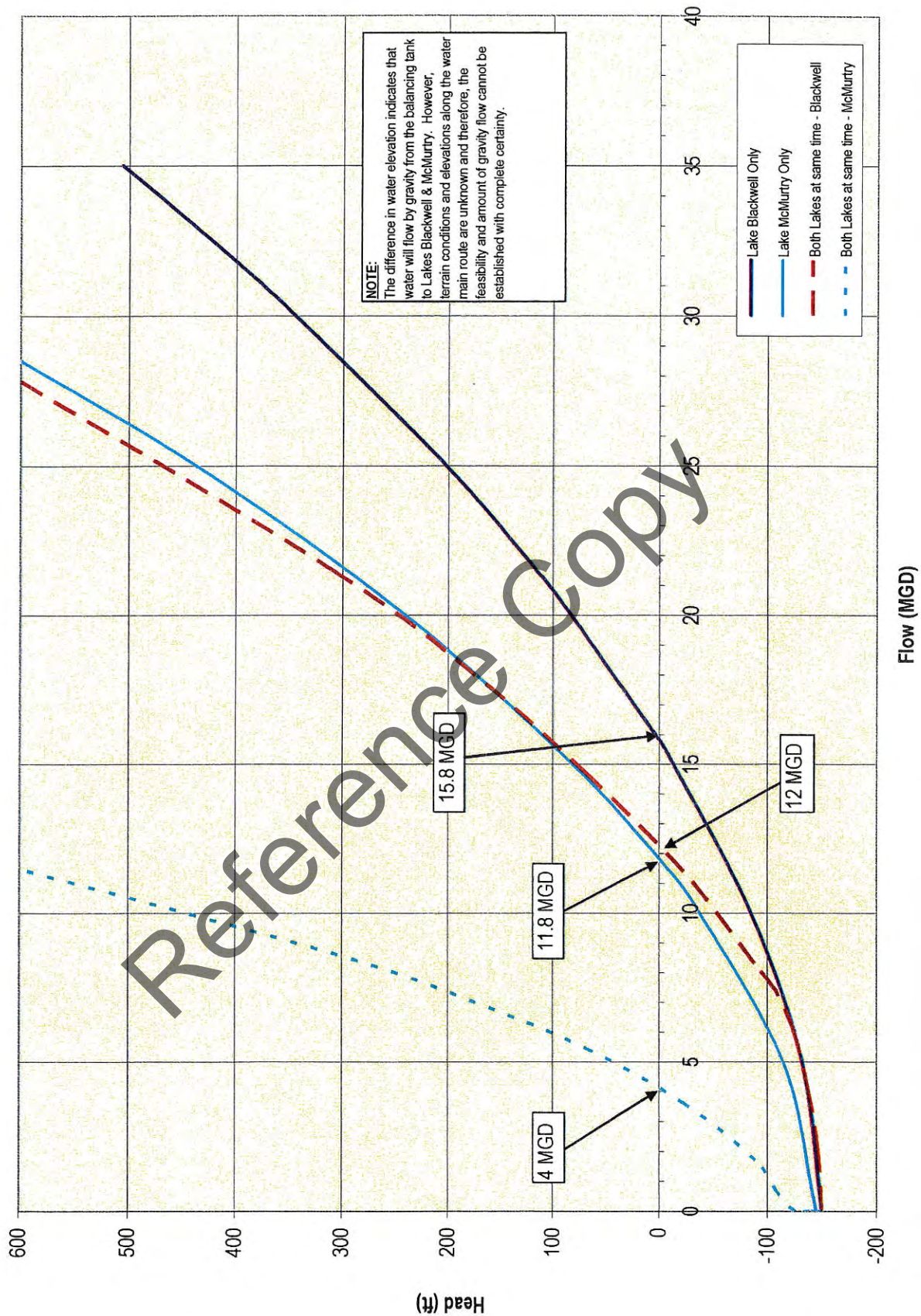
The compatibility of the water quality in the three lakes is also very important in considering inter-basin transfers. **Table 2-6** shows data from a grab sample taken on July 7, 2005 from all three lakes.

Parameter	Kaw	McMurtry	Blackwell
Alkalinity	98.0 mg/L	156 mg/L	154 mg/L
Chloride	38.5 mg/L	17.6 mg/L	32.9 mg/L
pH	7.83 SU	8.26 SU	8.21 SU
Sulfate	22.8 mg/L	15.9 mg/L	20.2 mg/L
Total Dissolved Solids	250 mg/L	198 mg/L	224 mg/L
Total Organic Carbon	6.34 mg/L	5.32 mg/L	5.61 mg/L
Iron	4.1 mg/L	0.99 mg/L	0.95 mg/L
Magnesium	6.3 mg/L	16 mg/L	15 mg/L
Manganese	0.062 mg/L	0.036 mg/L	0.053 mg/L
Potassium (K)	6.1 mg/L	4.1 mg/L	4.3 mg/L
Sodium	29 mg/L	19 mg/L	29 mg/L
Total Hardness as CaCO ₃	110 mg/L	150 mg/L	150 mg/L
Calcium	81 mg/L as CaCO ₃	80 mg/L as CaCO ₃	87 mg/L as CaCO ₃

Table 2-6
Raw Water Quality Data: Kaw Reservoir, Lake McMurtry, and Lake Carl Blackwell

In comparing the values of individual water quality parameter for each source water, they are similar. Kaw has a higher iron content but slightly lower hardness. Kaw also has a somewhat lower pH, while Lakes Carl Blackwell and McMurtry have more alkalinity. However, it should be noted that these results are for one grab sample, and may not be representative of the lakes year round.

Another component of the water quality in Kaw Reservoir is a small zebra mussel veliger population that has been detected through sampling done by OSU. Recent conversations with the Oklahoma Water Resources Board (OWRB) indicate that



because there are no current regulatory requirements for zebra mussels, their transfer between water bodies by boat and other dispersal mechanisms is inevitable. Therefore, OWRB stated that this type of inter-basin transfer would be allowed.

Table 2-7 shows the design conditions of the new water main and pump station proposed under this alternative. A schematic layout of the proposed improvements is shown in **Figure 2-9**. The new pump station would have a capacity of 20 MGD and would consist of two duty pumps and one standby unit. **Figure 2-10** shows the proposed system curve for this application.

Discharge Pipe	
Maximum Flow (MGD)	20
Pipe Length (mi)	8.0
Nominal Pipe Size (in)	30
Maximum Velocity (ft/s)	6.4
Operating Pressure (psi) ¹	172
Pump Station Upgrades	
No. of New Pumps	2 (duty) + 1 (standby)
Pump Type	Vertical Turbine w/Can
Design Flow, each (MGD)	10
Design Head (ft)	395
Pump Motor Size (hp)	900

¹ Based on C value (Hazen-Williams coefficient) of 130

Table 2-7
Proposed Pipeline and Pump Station Design
Conditions – Alternative 3

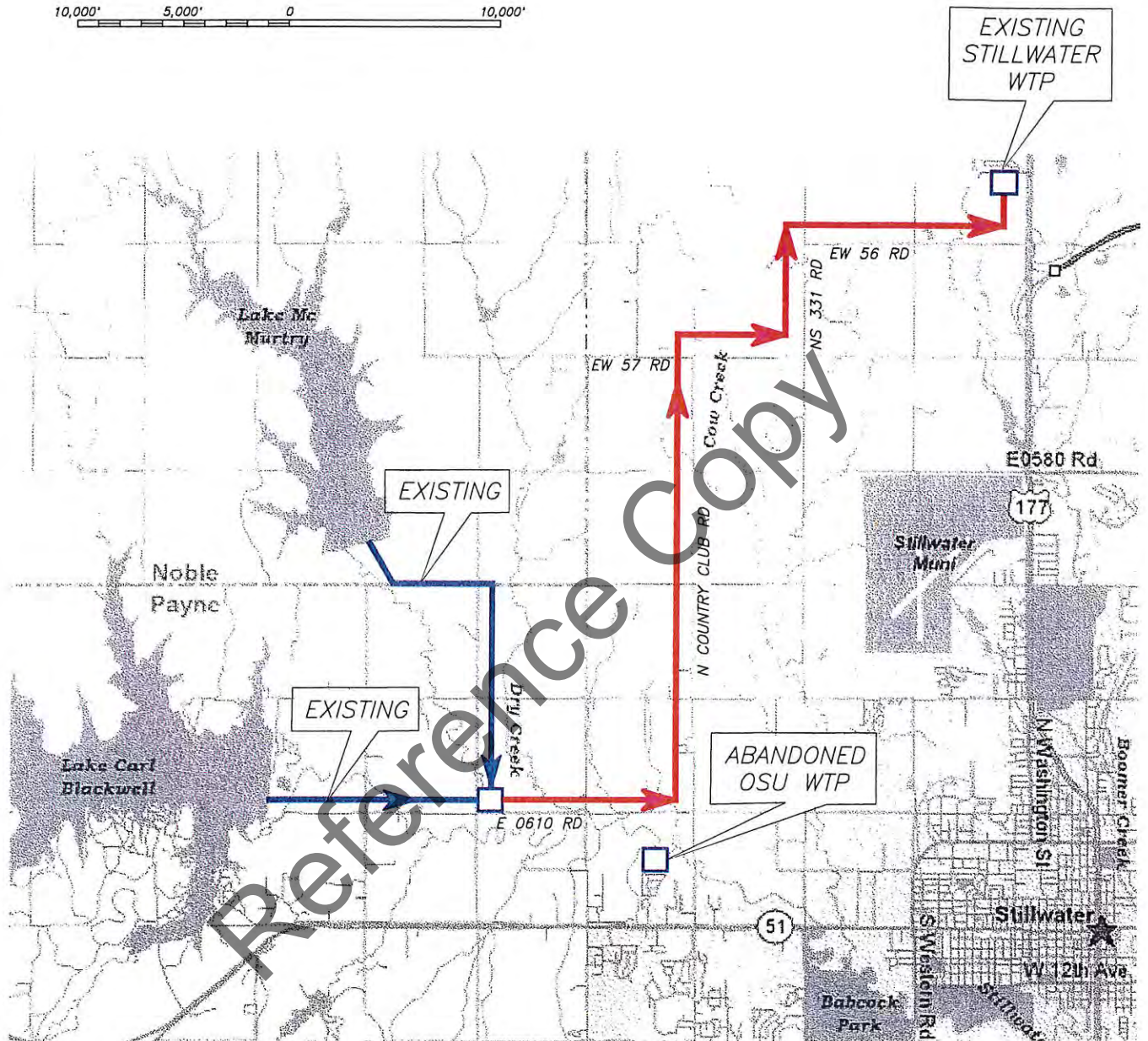
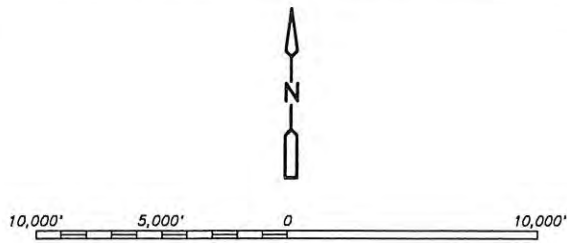
Table 2-8 shows a summary of capital costs as well as annual power costs for this alternative.

Pump Station Capital Costs	\$16,700,000
Right-of-Way Acquisition	\$500,000
Annual Power Costs	\$116,000
Net Present Worth (40 yr.)	\$20,312,000

¹ In 2005 Dollars

Table 2-8
Estimated Cost¹ – Alternative 3

- **Alternative 4** – This alternative proposes using Sooner Lake (an OG&E Reservoir) as an alternate raw water source to complement the Kaw Reservoir and also in the case that water cannot be obtained from the Kaw Reservoir. Sooner Lake is located 20 miles south of the Kaw Reservoir. To convey raw water from Sooner Lake to the Stillwater WTP, construction of a new pump station and water main would be needed. The proposed pump station would be located near Sooner Lake. The proposed water main would be approximately 17 miles long.



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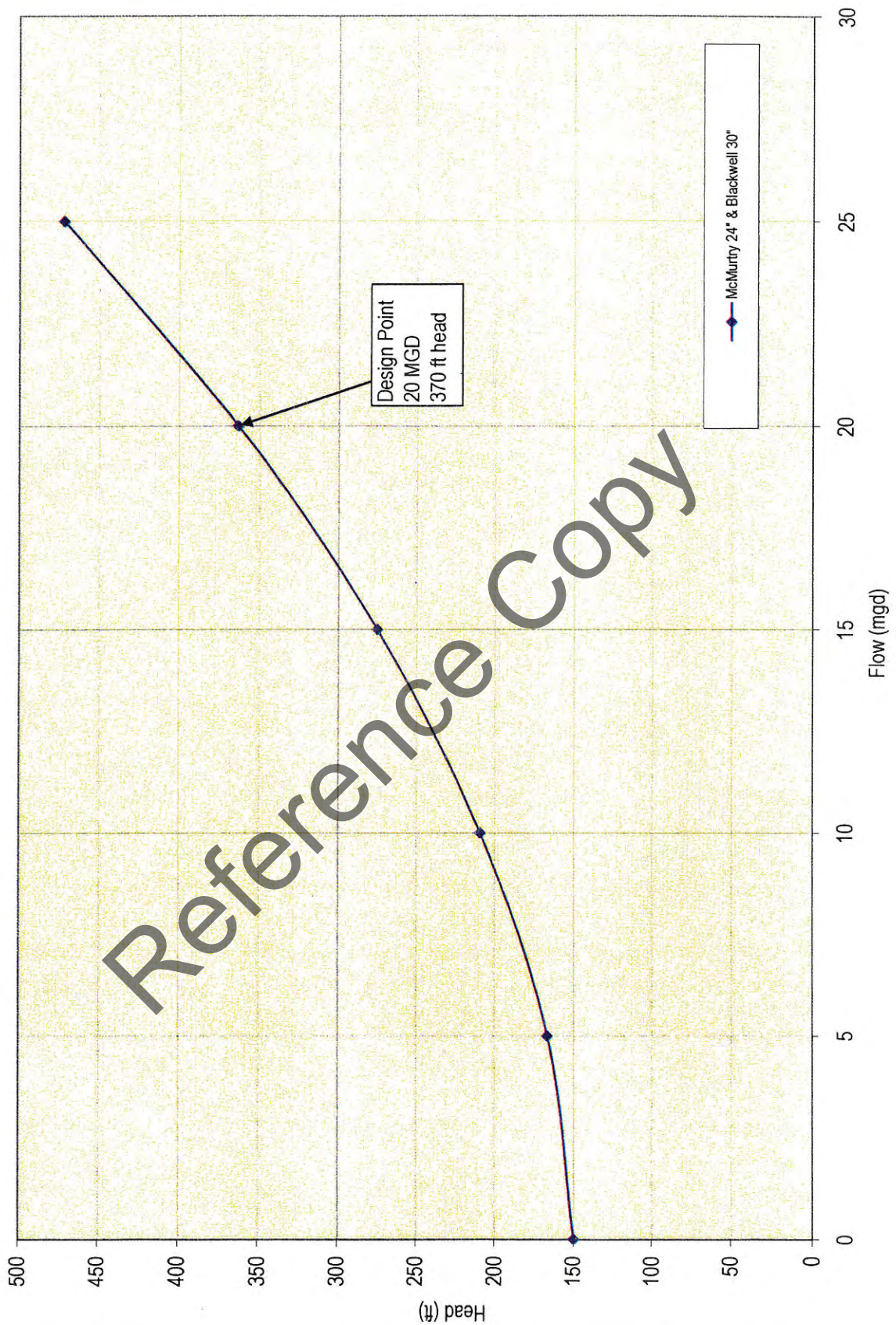
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CITY OF STILLWATER, OKLAHOMA
DISCHARGE
ALTERNATIVE 3

Date:
MARCH 2006

Figure No.
2-9



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CITY OF STILLWATER, OKLAHOMA
PROPOSED SYSTEM CURVE FOR
NEW PUMP STATION - ALTERNATIVE 3

Date:
APRIL 2006

Figure No.
2-10

Water quality from the Sooner Lake is less desirable than that obtained from Kaw Reservoir, Lake McMurry or Lake Carl Blackwell, especially in terms of suspended and dissolved solids. This is due to the water mostly being obtained from the Arkansas River. In spite of this, water from this reservoir can still be used as an alternative water source.

Table 2-9 shows the design conditions of the new water main and pump station proposed under this alternative. Improvements proposed under this alternative are shown in **Figure 2-11**. **Figure 2-12** shows the proposed system curve for this application.

Discharge Pipe	
Maximum Flow (MGD)	20
Pipe Length (mi)	17
Nominal Pipe Size (in)	36
Maximum Velocity (ft/s)	4.4
Operating Pressure (psi) ¹	130
Pump Station Upgrades	
No. of New Pumps	2 (duty) + 1 (standby)
Pump Type	Vertical Turbine
Design Flow, each (MGD)	10
Design Head (ft)	300
Pump Motor Size (hp)	750

¹ Based on C value (Hazen-Williams coefficient) of 130

Table 2-9
Proposed Pipeline and Pump Station Design
Conditions – Alternative 4

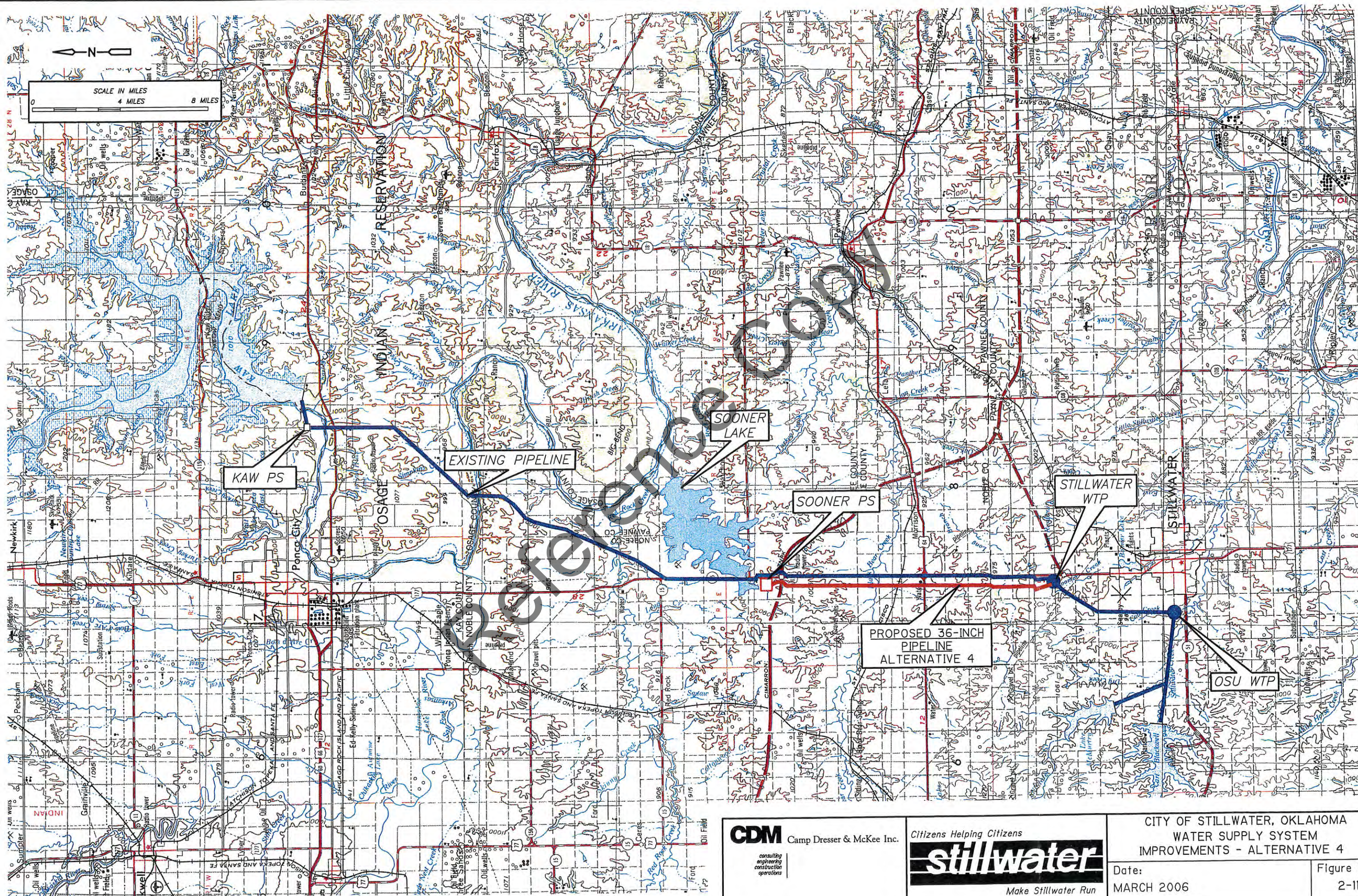
Table 2-10 shows a summary of capital costs as well as annual power cost for this alternative.

Capital Costs	\$34,124,000
Annual Power Costs	\$110,000
Net Present Worth (40 yr.)	\$36,485,000

¹ In 2005 Dollars

Table 2-10
Estimated Cost¹ – Alternative 4

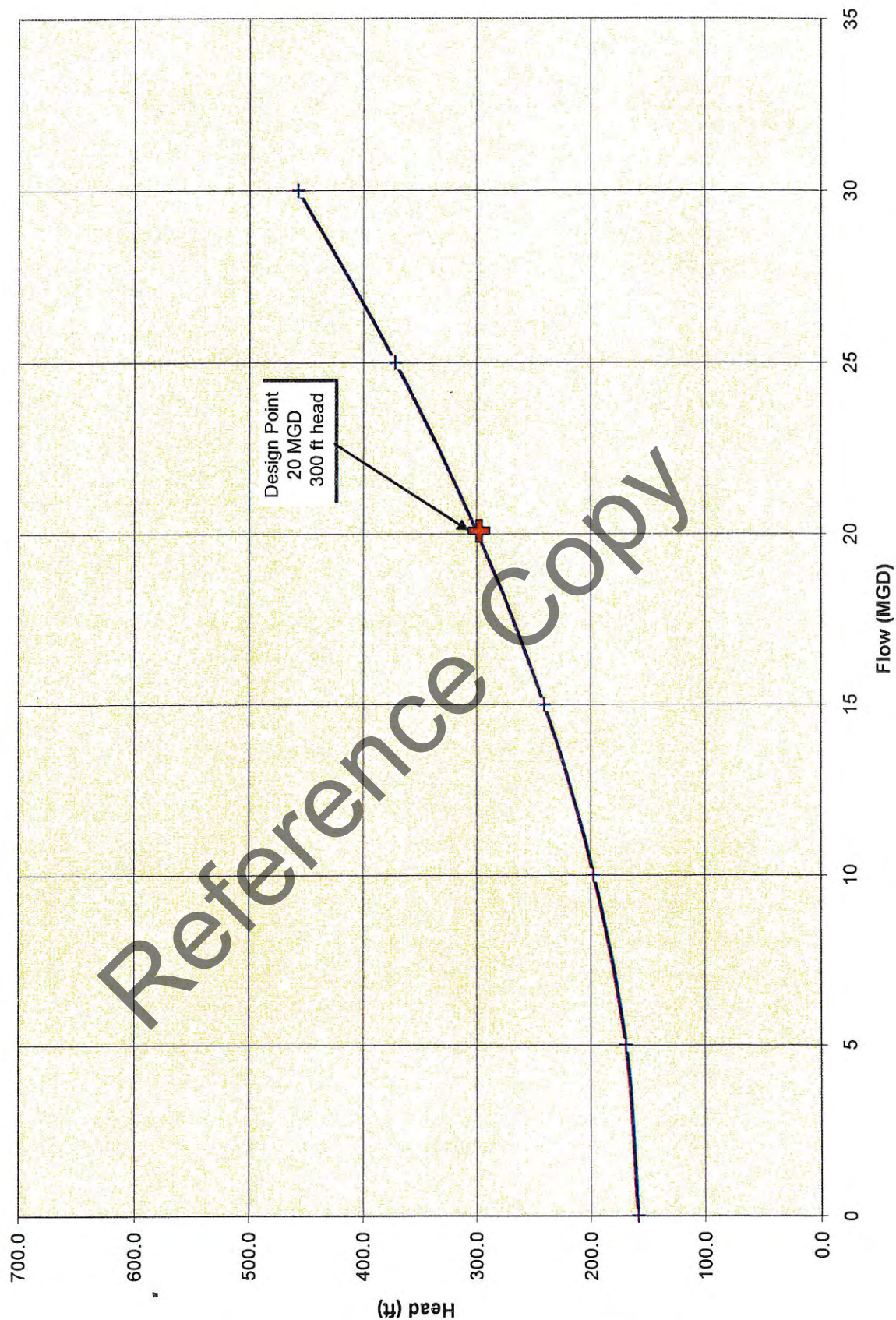
- **Alternative 5** - This alternative includes construction of a new 36-inch discharge line parallel to the existing Kaw pipeline. This new water main would be used in combination with the existing line to provide the required 2060 peak demand capacity of 50 MGD. Once the proposed 36-inch line is in service, the existing line could be taken out of operation for inspection and rehabilitation as required and the City could still receive adequate water supply. **Table 2-11** shows the design conditions of the new water main. A schematic layout of the proposed



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CITY OF STILLWATER, OKLAHOMA WATER SUPPLY SYSTEM IMPROVEMENTS - ALTERNATIVE 4	
Date: MARCH 2006	Figure No. 2-11



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CITY OF STILLWATER, OKLAHOMA
PROPOSED SYSTEM CURVE FOR NEW PUMP
STATION - ALTERNATIVE 4

Date:
APRIL 2006

Figure No.
2-12

improvements is shown in **Figure 2-13**. Because the existing and the proposed water main are the same size, flows will split fairly evenly between them when they are both in operation.

When the existing and the proposed 36-inch water mains are both in operation, additional pumping units would be required at the Kaw PS to meet the 50 MGD water demand. Adding pumps similar to the existing ones does not prove effective since they do not increase the pump station output significantly at the required heads. Therefore three new pumps have been selected to provide the required peak capacity when water demand increases. At that point, the two large existing pumps may be modified to serve as standby units. The existing pumps will provide sufficient capacity until the demand reaches approximately 33.0 MGD in the year 2037. **Figure 2-14** presents a preliminary pump selection for this application, upgraded pump station pump curves and the proposed system curve. **Table 2-12** shows a summary of capital costs as well as annual power costs for this alternative.

Discharge Pipe	
Maximum Flow (MGD)	25
Pipe Length (mi)	36.4
Nominal Pipe Size (in)	36
Maximum Velocity (ft/s)	5.5
Operating Pressure (psi) ¹	237
Pump Station Upgrades	
No. of New Pumps	3 (duty) + 1 (standby)
Pump Type	Vertical Turbine
Design Flow, each (MGD)	16.7
Design Head (ft)	546
Pump Motor Size (hp)	2,000

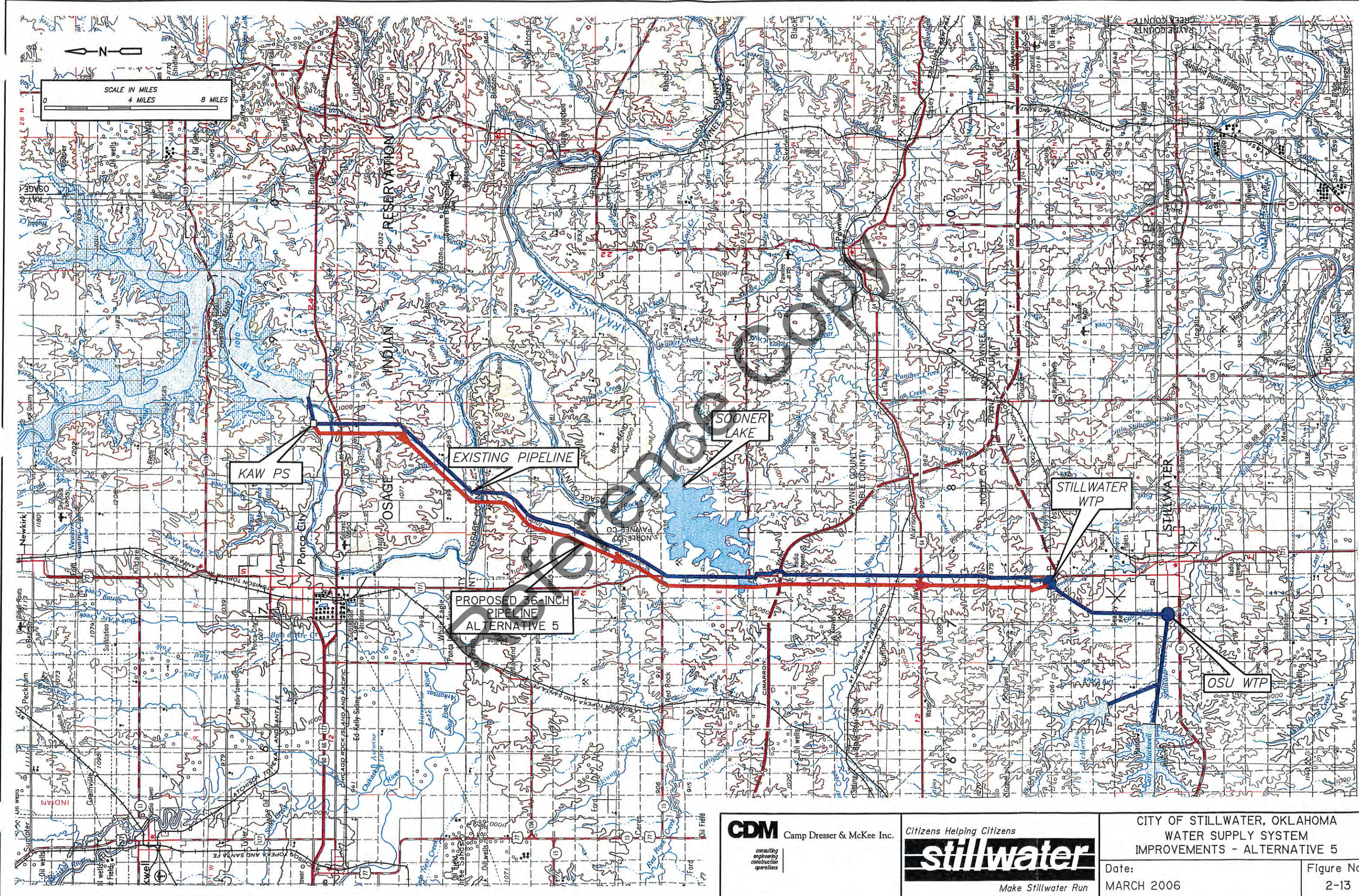
¹ Based on C value (Hazen-Williams coefficient) of 130

Table 2-11
Proposed Pipeline and Pump Station Design
Conditions – Alternative 5

Capital Costs	\$70,182,000
Annual Power Costs	\$480,000
Net Present Worth (40 yr.)	\$83,061,000

¹ In 2005 Dollars

Table 2-12
Estimated Cost¹ – Alternative 5



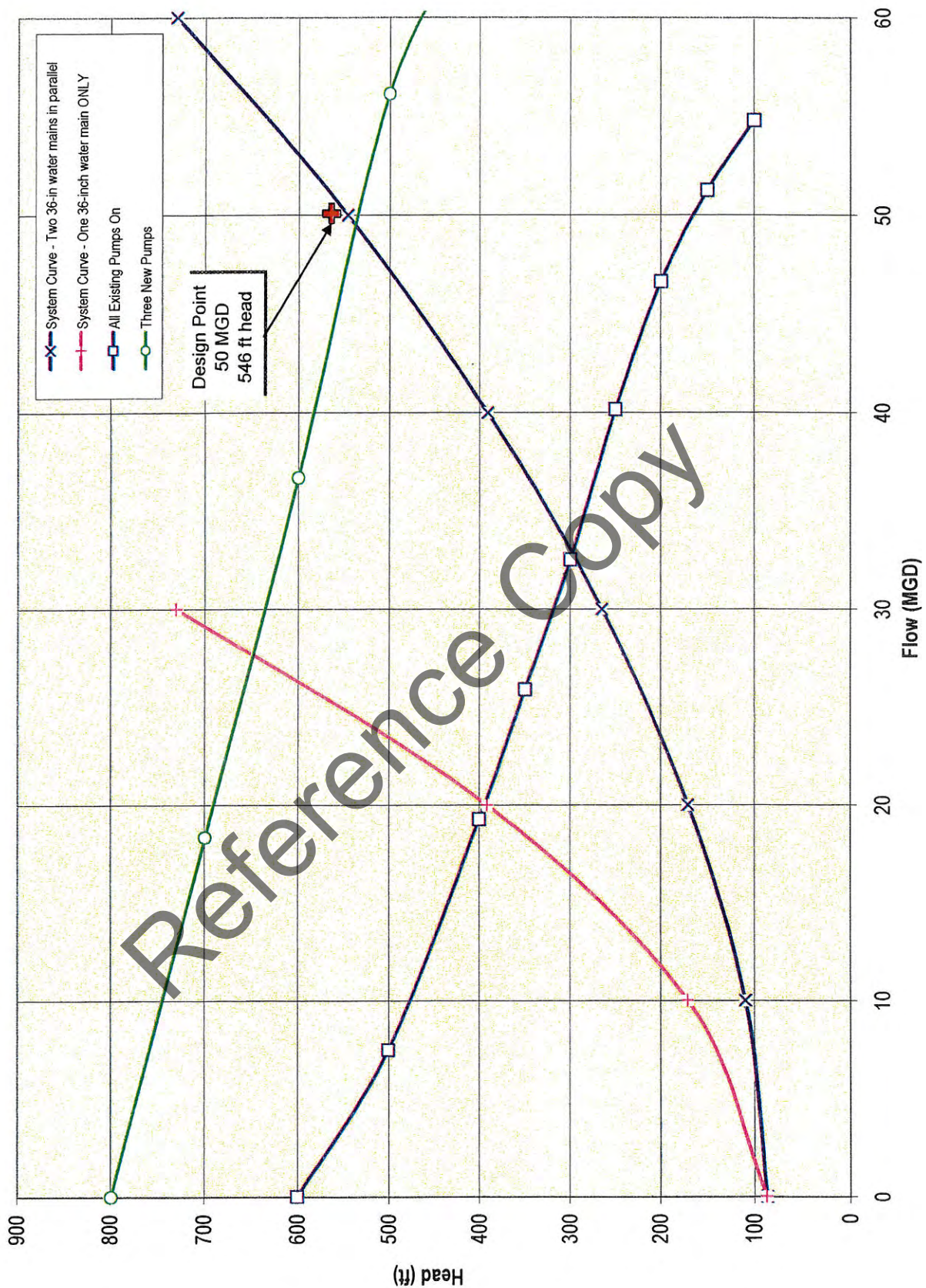
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CITY OF STILLWATER, OKLAHOMA
WATER SUPPLY SYSTEM
IMPROVEMENTS - ALTERNATIVE 5

Date:
MARCH 2006

Figure No.
2-13



2.4.2 Intake System

The existing intake system consists of a 48-inch water main designed to handle up to 65 MGD of raw water. This pipeline is sized to handle the combined water rights of the City of Stillwater and the City of Ponca City, 50 MGD and 12.5 MGD, respectively.

Two alternatives are considered to provide partial redundancy to the existing intake pipe. Because of its proximity with the Kaw Reservoir dam, coordination with and approval by the Army Corps of Engineers will be required for any alternative including work within the dam's vicinity.

- *Alternative A* – This alternative includes construction of a new 36-inch intake line through the earthen portion of Kaw Reservoir dam. This line would extend from this lake to the existing intake line at Kaw Pump Station. This pipe is sized to handle flows up to 25 MGD. This would cover at least the average water demand for the City of Stillwater through the year 2060. This pipeline would have intake located below the low pool level at Kaw Reservoir and would run underground to Kaw Pump Station. This pipeline would be used in combination with the existing 48-inch pipeline to provide back up capacity in case the existing line needs to be taken out of service.

The new intake line would have a 24-inch connection point that may be used to provide raw water to Ponca City. **Table 2-13** summarizes the design conditions of the proposed pipeline under this alternative. A schematic layout for the improvements proposed under this alternative is shown in **Figure 2-15**. **Table 2-14** shows a summary of capital costs as well as annual power costs for this alternative.

Maximum Flow (MGD)	25
Estimated Pipe Length (mi)	1.0
Nominal Pipe Size (in)	36
Maximum Velocity (ft/s)	5.5
Operating Pressure (psi) ¹	9

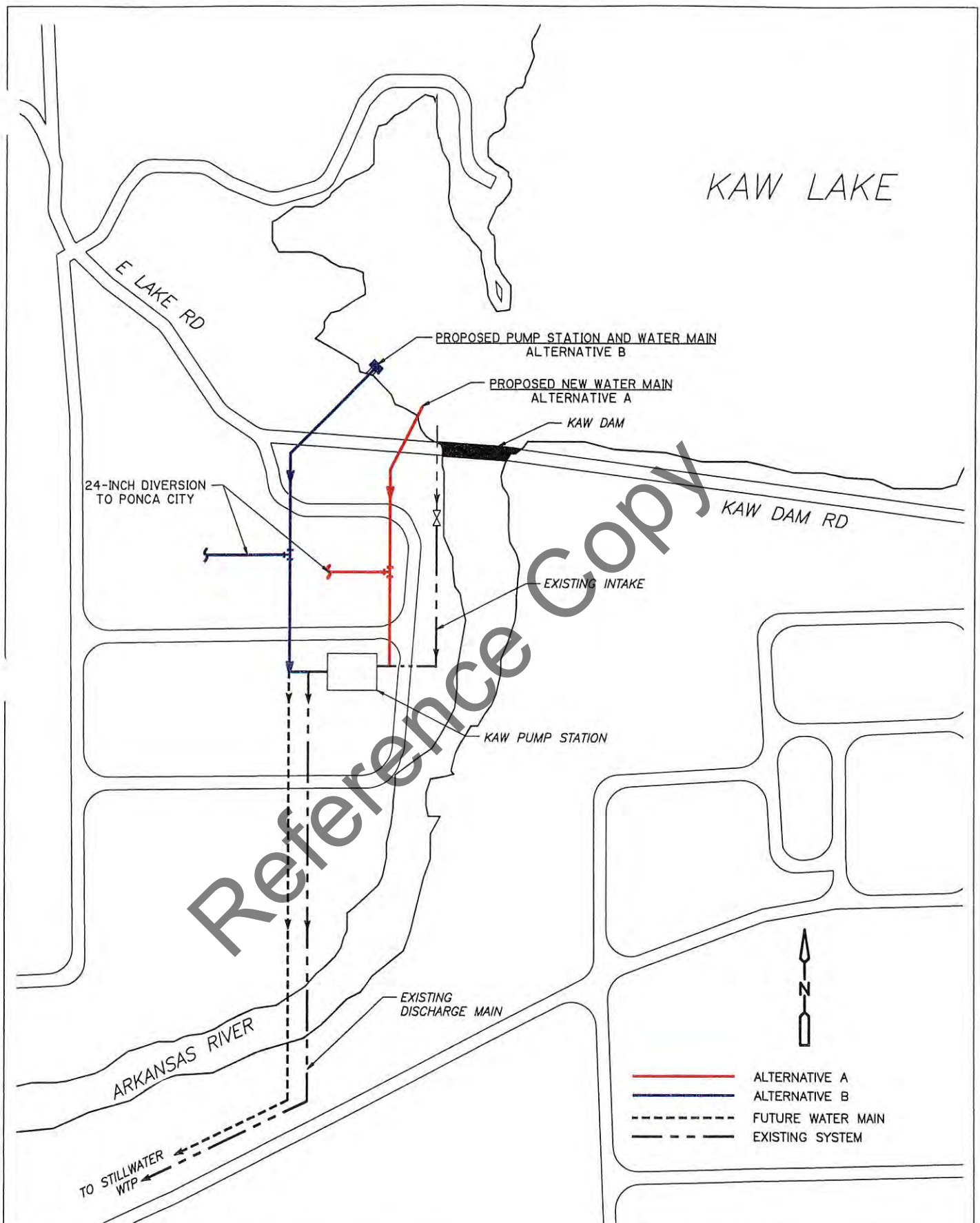
Table 2-13
Intake Line Design Conditions – Alternative A

Capital Costs	\$1,514,000
Operating Costs	\$0
Net Present Worth (40 yr.)	\$1,514,000

¹ In 2005 Dollars

Table 2-14
Estimated Cost¹ – Alternative A

- *Alternative B* – This alternative includes construction of a redundant 25 MGD pump station atop the water surface on the Kaw Reservoir, as well as a new 36-inch water main. The proposed pump station would be located on a platform in the western side of the reservoir, near the dam structure, and would be used by itself or in



combination with the existing Kaw Pump Station. The discharge line would follow the terrain on the western side of the dam and tie into the redundant water mains discussed under Alternatives 1, 2 and 5 at the Kaw Pump Station. It would also have a 24-inch connection for Ponca City. The new pump station would be able to pump at least 25 MGD all the way to the Stillwater WTP via either the existing or a new pipeline. A schematic layout of the improvements proposed under Alternative B is shown in **Figure 2-15**.

Table 2-15 summarizes the design conditions of the new pump station and water main connecting to the existing and redundant Kaw pipelines. **Table 2-16** shows a summary of capital costs as well as operating costs for this alternative.

New Pump station	
No. of Pumps	2 (duty) + 1 (standby)
Type of Pumps	Vertical Turbine
Design Flow, each (MGD)	12.5
Design Head (ft)	550
Pump Motor Size (hp)	1,600
Water Main	
Maximum Flow (MGD)	25
Estimated Pipe Length (mi)	1.0
Nominal Pipe Size (in)	36
Maximum Velocity (ft/s)	5.5
Operating Pressure (psi) ¹	240

Table 2-15
Intake Alternative B – Proposed Line and Pump
Station Design Conditions

Capital Costs	\$1,514,000
Operating Costs	\$0
Net Present Worth (40 yr.)	\$1,514,000

¹ In 2005 Dollars

² Operating costs are included in the alternatives for raw water main

Table 2-16
Estimated Cost¹ – Alternative B

2.4.3 Pipe Material

Depending upon the size of the pipe required by each application and the operating pressure of the system, the following pipe materials may be considered for use:

- Pre-stressed concrete cylinder pipe (PCCP) (AWWA C301)
- Reinforced concrete cylinder pipe (RCCP) (AWWA C303)
- Steel pipe

- Ductile iron (DI) pipe (AWWA C151/A21.51-02)
- Polyvinyl chloride (PVC) pipe (AWWA C905-97)
- High-density polyethylene (HDPE) pipe (AWWA C906-99)

2.5 Alternative Evaluation and Recommendation

In this section, the proposed alternatives will be evaluated and a recommendation for implementation of one or more alternatives will be presented.

2.5.1 Pipe Material

The available piping materials will be evaluated based on cost-effectiveness as well as non-cost factors, as follows:

- Ability to absorb pressure surge
- Ability to resist corrosion
- Ease of installation
- Ease of maintenance and repair

Table 2-17 presents estimated cost for different pipe materials. Plastic pipe (both PVC and HDPE) is more expensive than other alternatives. For pipes between 30-inch and 48-inch diameter, the costs of PCCP and ductile iron pipe are comparable. For 48-inch diameter pipe, carbon steel appears to be the most economical alternative.

Pipe Size	Cost per linear foot installed (\$/LF)				
	PCCP (C301)	Ductile Iron	PVC	HDPE	Carbon Steel
30-inch	\$221	\$192	\$310 (DR18)	\$320	\$261
36-inch	\$275	\$255	\$428	- ¹	\$316
42-inch	\$329	\$298	- ¹	- ¹	\$367
48-inch	\$449	\$457	\$480	\$485	\$420

¹ No standard pipe available on this material for the design conditions

Table 2-17
Estimated Pipe Material Cost

For the purpose of this evaluation, a surge capacity of 50 percent above the maximum design operating pressure is used for all new water mains. **Table 2-18** summarizes the pipe materials that can be safely used based on the operating conditions of each alternative. All materials included in this evaluation, namely, concrete pressure cylinder pipe, ductile iron, PVC, HDPE, and steel pipe can be specified to suit the conditions under each alternative.

Alternative	Pipe Size (inch)	Pipe Length (mi)	Maximum Operation Pressure (psi)	Estimated Surge Pressure (psi)	Potential Pipe Materials
Intake System					
Alternative A	36-inch	1.0	9	13	RCCP, PCCP & DI (pressure class 150) PVC (DR 51) HDPE 3408 (SDR 32.5) Carbon Steel
Alternative B	36-inch	1.0	240	360	RCCP, PCCP & DI (pressure class 350) Carbon Steel
Discharge System					
Alternative 1	48-inch	36	215	323	RCCP, PCCP & DI (pressure class 350) Carbon Steel
Alternative 2	42-inch	36	170	255	RCCP, PCCP & DI (pressure class 350) Carbon Steel
Alternative 3	30-inch	8	172	258	RCCP, PCCP & DI (pressure class 250) PVC (DR 18) HDPE 3408 (SDR 11) Carbon Steel
Alternative 4	36-inch	17	162	243	RCCP, PCCP & DI (pressure class 250) Carbon Steel
Alternative 5	36-inch	36	237	356	RCCP, PCCP & DI (pressure class 350) Carbon Steel

Table 2-18
Ability to Absorb Pressure Surge

Table 2-19 presents the corrosion resistance expected from the proposed pipe materials. Plastic pipes are the most resistant to corrosion, followed by concrete pipes. Carbon steel and ductile iron pipes must be coated to resist corrosion.

Material	Corrosion Resistance
Concrete Cylinder Pipe	■ Good corrosion resistance ■ Susceptible to attack by H₂S and acids when pipe is not coated
Carbon Steel/Ductile Iron	■ Good corrosion resistance when coated
PVC/HDPE	■ Good corrosion resistance

¹ Based on EPA 832-F-00-068 "Wastewater Technology Fact Sheet – Pipe Construction and Materials"

Table 2-19
Ability to Resist Corrosion¹

Table 2-20 summarizes known installation consideration and characteristic of the different pipe materials.

Material	Installation & Repair
Concrete Cylinder Pipe	■ Required careful installation to avoid cracking ■ Heavy Pipe
Carbon Steel/Ductile Iron	■ Heavy Pipe
PVC/HDPE	■ Lightweight pipe ■ Easy to install ■ Flexible ■ Requires special bedding ■ Long pipe sections reduce number of joint ■ Expansion/contraction consideration

¹ Based on EPA 832-F-00-068 "Wastewater Technology Fact Sheet – Pipe Construction and Materials"

Table 2-20
Ease of Installation and Repair¹

Taking into consideration the estimated material cost, ability to absorb surge pressure, ability to resist corrosion as well as ease of installation and repair, PCCP appears to be the most desirable for the sizes of pipe being considered. This pipe is slightly more expensive than ductile iron and carbon steel pipes; however, it has superior corrosion resistant ability, which has been the cause of many problems in the existing system. Construction cost estimates in this study have been developed based on PCCP material for new water mains. Other pipe materials, such as ductile iron and steel would be acceptable with proper protection against corrosion and will be allowed to bid to promote competition and control cost.

2.5.2 Redundant Raw Water Main

Alternatives 1, 2 and 3 are devised to improve reliability and provide redundancy for the existing raw water supply system from the Kaw Reservoir. The City of Stillwater has water rights to 50 MGD from this lake and this is the city's preferred water source. Since Kaw Reservoir, pump station and pipeline is the only raw water supply mechanism for the city, it is prudent to provide redundancy that improves the reliability and removes single point of failure situation. Redundancy to be provided includes the pipeline and the pumping facilities. The target capacity for both pumping and piping systems is 50 MGD.

Alternative 1 provides Stillwater with the capacity of transporting 50 MGD raw water without relying on the existing 36-inch pipeline. Therefore, the existing pipeline can be abandoned in place. The city will not incur cost associated with rehabilitating the existing pipe. However, this alternative once completed still lacks a backup system. Additionally, this alternative has the highest capital cost as well as overall cost on net present worth basis.

Alternative 2 utilizes a new parallel 42-inch pipeline to provide redundancy for the existing 36-inch line. Once the new line is in place, the existing pipeline can be removed from service, inspected and repaired as necessary. This alternative is designed to utilize the combined capacity of the two pipelines to deliver 50 MGD flow. Alternative 2 has lower capital cost than Alternative 1 and has the lowest pumping cost of all three alternatives. With either of the two pipelines in service, Alternative 2 can deliver at least 23 MGD, which is more than enough to satisfy the average water demand through 2058.

Alternative 5 is similar to Alternative 2. This alternative includes a new parallel 36-inch pipeline to provide redundancy for the system. As with Alternative 2, the existing 36-inch line can be removed from service, inspected and repaired as necessary, once the new line is operational. Alternative 5 has both the lowest capital cost and net present worth cost of all three raw water main alternatives. Alternative 5 can also deliver 23 MGD of raw water with either of the two pipelines in service.

The capital cost and overall cost on present worth basis for these alternatives is summarized in Table 2-21.

Alternatives	Capital Costs	Annual Power Costs	Present Worth ^{1, 2}
Alternative 1	\$105,564,000	\$446,000	\$117,531,000
Alternative 2	\$77,314,000	\$379,000	\$87,483,000
Alternative 3	\$17,384,000	\$116,000	\$20,947,000
Alternative 4	\$34,516,000	\$110,000	\$37,468,000
Alternative 5	\$70,182,000	\$480,000	\$83,061,000

¹ Present worth values are calculated assuming 3% annual inflation rate and 5% discount rate

² Present worth value includes annual power cost for a 40-year period

Table 2-21
Summary of Cost of Alternatives

Alternative 5 has the lowest capital cost and present worth cost. It provides full redundancy to the existing pipeline and with one of the two lines in service the system can provide at least 23 MGD raw water and can satisfy the average water demand through 2058. Alternative 5 with a new parallel 36-inch pipeline appears to be the most cost effective and practical and is the solution recommended for implementation.

2.5.3 Secondary Raw Water Source

To improve further the reliability of the raw water supply system, Alternatives 3 and 4 were developed to address this issue. Alternative 3 seeks to obtain raw water from Lake McMurry and Lake Carl Blackwell as a secondary raw water source to Kaw Reservoir. This alternative utilizes a portion of existing pipelines from McMurry and Carl Blackwell to deliver raw water from both lakes to a new pump station of 20 MGD firm capacity and a new 30-inch pipeline from the pump station to Stillwater

WTP. Water quality in these two lakes is comparable with that of Kaw Reservoir. These two lakes produce not quite enough water to meet the city's current demand. The combined yield of these two lakes is estimated to be about 8 MGD while the city current average demand was 8.4 MGD in 2005. These two lakes however, have sufficient storage capacity, estimated to be 4 billion gallons. These lakes may be used to store raw water that is transferred from Kaw Reservoir. The State of Oklahoma will allow Stillwater to use these lakes in a fill-draw operation where the same amount of raw water transferred into the lakes can be withdrawn at a later date.

Alternative 4 is intended to use Sooner Lake as a secondary raw water source. A new pump station of 20 MGD capacity will be constructed near Sooner Lake and a 36-inch pipeline from this pump station to the city's water treatment plant. Sooner Lake is currently being utilized by Oklahoma Gas and Electric Co. to meet its process water needs. Stillwater must obtain approval from the State to be able to use Sooner Lake as raw water source. Water quality in this lake is not as desirable as Lake McMurtry, Lake Carl Blackwell or Kaw Reservoir due to high turbidity and salinity.

The capital cost and overall cost for these two alternatives is presented in **Table 2-21**. Alternative 3 has significantly lower capital cost as well as overall present worth cost. Water quality from Lakes McMurtry and Carl Blackwell is also more desirable than Sooner Lake. It is our recommendation to select Alternative 3 utilizing Lake McMurtry and Lake Carl Blackwell as the city's secondary raw water source.

2.5.4 Intake System

Table 2-22 summarizes the construction costs of the proposed alternatives to provide the intake system with redundancy.

Alternative	Capital Cost	Annual Power Costs
Alternative A	\$1,514,000	1
Alternative B	\$1,514,000	

Annual operating costs are assumed to be similar for the existing and proposed Kaw Pump Station, therefore, they are not included as an additional cost

Table 2-22
Probable Construction Cost - Intake System

The existing 48-inch intake pipe was installed in the early 1980s, and it has provided reliable service since its commission. The existing pump station at Kaw Reservoir has not experienced any problems either and has provided reliable service as well. At this time, there is no indication that either the pump station or the intake piping requires complete replacement or redundancy. Therefore, planning for complete replacement of the existing station with an alternate one may not be justified at this point. The existing pump station has the redundancy to continue the reliable service. As demand increases this pump station will need expansion to gain additional capacity. The expansion cost for this pump station is included in the Raw Water Main alternatives.

The existing 48-inch pipe between Kaw Reservoir and the pump station is a single pipe and represents a potential single point of failure. It would be prudent to provide a parallel line for redundancy. The additional line may not necessarily be the same size as the existing one. A 36-inch pipe would provide more than sufficient capacity to meet the average water demand through 2060.

Alternative A would have a greater cost for the pipeline since certain special techniques may have to be engaged to construct this pipeline. Expansion of pumping capacity will take place at the existing Kaw Pump Station under this alternative. Alternative B is estimated to have lower capital cost than Alternative A. The additional pumping capacity under Alternative B will be provided by a pump station inside Kaw Reservoir. This pump station would be more costly than the pumping expansion at the existing Kaw Pump Station for the same capacity. The additional cost of building an in-lake pump station may be offset by the saving in pipeline cost therefore, Alternative B is considered to have the same construction cost as Alternative A. Further analysis will be conducted during design to make a final recommendation for alternative selection.

2.5.5 Recommendations for Implementation

To improve the reliability of the raw water supply system for Stillwater as quickly as practical, a phased approach is recommended. As a first step, Alternative 3 should be implemented. **Figure 2-9** shows a schematic layout for the proposed improvements. The improvements under this alternative may require approximately 30 months to complete. Upon completion of Alternative 3, raw water could be transferred from Kaw Reservoir to Lake McMurtry and Lake Carl Blackwell for storage. When sufficient raw water becomes available from these two area lakes, the existing 36-inch water main from Kaw Pump Station may be removed from service for inspection. The findings from the inspection will be reviewed and corrective measures will be evaluated and the most economical and practical solution will be recommended for the City's consideration.

Upon completion of improvements under Alternative 3, Alternative 5 may be implemented to increase the reliability of raw water supply from Kaw Reservoir. This project may take approximately 42 months to complete. Improvements to the intake system (either Alternative A or Alternative B) can be implemented during the same period as Alternative 5. **Table 2-23** presents a summary of costs for the recommended capital improvements.

Activity	Estimated Cost
Alternative 3	\$17,200,000
Alternative A or B	\$1,514,000
Alternative 5	\$70,182,000
Total	\$88,896,000
Table 2-23 Estimated Cost for Recommended Capital Improvement Program	

Section 3

Water Distribution System Improvements

3.1 Introduction

The City of Stillwater's water service area is expected to grow from approximately 67,638 people to 88,138 by Year 2020. The average daily water usage in Year 2020 is estimated to be 11.1 million gallons per day (mgd), and the maximum daily usage is estimated to be 23.7 mgd. To accommodate this growth, additional water system facilities are needed. This section addresses the water distribution system pipelines, tanks and pump stations required to provide the projected water requirements until Year 2020. Improvements have not been provided for planning years beyond Year 2020, due to the uncertainty in the amount and location of growth. The historical and project populations and water demands are presented in the "Population and Water Demand Forecast" section #1 dated April 2006.

The City of Stillwater's water service area includes the customers in the City of Stillwater, Oklahoma State University, 51 East Water (rural water purveyor), and Rural Water Corporation #3. The City of Perkins has not been included as a customer of the City of Stillwater at this time. In 2004, The Benham Companies (Benham) prepared a Water Distribution System Analysis Report for the City of Stillwater. The Benham report and the projected water demands prepared by CDM were the basis for the water distribution system recommendations.

3.2 Existing Water Distribution System Pipelines

The existing water distribution system is shown on Figure 3-1, located at the end of this section.

3.3 Future Water Distribution System Demands

The planning periods that have been used for determining water system capital improvements include; immediate needs and years 2010, 2015, and 2020. The population projections, average day and maximum day water demands are provided in Table 3-1 below.

	Year			
	2005	2010	2015	2020
Projected Population Served	67,638	73,855	80,997	88,138
Average Day Demand (mgd)	8.4	9.2	10.15	11.1
Maximum Day Demand (mgd)	17.4	19.7	21.70	23.7

Table 3-1
Population and Water

Demand Projections

From water usage projections, water system improvements can be determined. A capital improvements plan was prepared for the “Water Distribution System Analysis Report”, prepared by Benham and dated 2004. These improvements are based on the projected maximum day usage projections from the Benham report. With revised population projections and revised water demand forecasts, the timing of the improvements provided in the Benham report are moved up 5 to 10 years. For example, improvements indicated in the Benham report for year 2015 are now needed for year 2010. Presented in **Table 3-2** below are the planning periods and peak day projections from the Benham report and the revised peak day water demands and revised planning periods.

Benham 2004 Report		Revised Planning Periods	
Planning Period	Peak Day Water Demand (at beginning of planning year)	Peak Day Water Demand (at beginning of planning year)	Revised Planning Period
2002	15.2		
2005 – 2010	16.3 ¹	18	Immediate Need
2010 – 2015	18	19.7	2005 – 2010
2015-2020	19.5 ¹	21.7	2010 – 2015
2020-2030	21	23.7	2015-2020
2030	24		

¹ Interpolated from previous and future years

Table 3-2
Revised Planning Period Projections

Future water distribution system capital improvements are presented in Sections 3.4, 3.4.1, 3.4.2, 3.4.3, and 3.4.4, with a summary of the improvements in Section 3.4.5. Planning level operation and maintenance costs are presented in Section 3.5. Recommendations for design and construction of these improvements are provided in Section 3.6.

3.4 Future Water Distribution System Improvements

Presented in the following sections are the future water distribution system improvements by planning period. The waterline capital improvements are shown by planning year on **Figure 3-2**, located at the end of this section. The cost estimates for tanks and pump stations were taken from the Benham Report. The cost estimates

from the Benham Report are in year 2002 dollars. To bring year 2002 dollars to year 2006, an inflation rate of 3 percent per year was added. The Benham estimates were based on capital costs from industry manufacturers and experience working on similar water projects in the area with a 10 percent contingency. Easement acquisition costs have not been included in the opinion of probable cost in the Benham costs. The Benham cost estimates also included an allowance of 25 percent of total construction cost for engineering, testing, surveying, administrative and legal expenses.

The cost estimates for the waterline improvements are based on the unit prices shown in **Table 3-3** below. The planning level costs include a 10 percent contingency. An allowance of 25 percent of total construction cost has been added to the total cost of pipeline improvements for engineering, testing, surveying, administrative and legal expenses. Easement acquisition costs have not been included in the opinion of probable cost, since some future line may be placed in future roadway right-of-way. The estimates are in Year 2006 dollars, and do not include allowances for inflation for periods beyond 2006.

Pipe Diameter (inches)	Unit Price (\$ / foot)
12	\$ 78
16	\$ 104
18	\$ 117
20	\$ 130
24	\$ 156
36	\$ 234
42	\$ 273

Table 3-3
Planning Level Unit Costs

Planning level operation and maintenance costs are provided in Section 3.5 of this section.

3.4.1 Immediate Water System Capital Improvements

A 36-inch water main connecting the WTP to the now inactive Oklahoma State University (OSU) WTP is currently being used as water transmission main to deliver finished water from the City's WTP. Originally, the 36-inch line was part of the total raw water supply system beginning at the City's Raw Water Supply Pump Station for Kaw Reservoir. The 36-inch line is constructed of steel with coal tar enamel lining and coal tar enamel with conventional felt and Kraft paper outer wrap for an outside coating. The raw water main from the pump station to the WTP has experienced leakage several times in the past 10 years. Also, a 2002 report by Willbros Engineering indicates numerous pinhole leaks were present, in addition to numerous corrosion blisters observed throughout the complete interior surface of the pipe. It is likely the portion of the line from the WTP to the OSU plant is in the same or similar

condition as the section from the pump station to the WTP. The City anticipates inspecting the line during low demand period to determine the current condition of the waterline. At this time it is not know if the line will require rehabilitation or replacement. The cost of replacing the line has been included in the opinions of probable construction cost.

Presented below in **Table 3-4** and **Table 3-5** are opinions of probable construction cost for improvements with an immediate need for pump station improvements and pipeline improvements respectively.

Description of Improvement	Total Opinion of Probable Cost
Expansion of Range Tower Booster Pump Station	\$ 80,300
Total	\$ 80,300

Table 3-4
Immediate Pump Station and Tank Improvements

General Location of Improvement	Pipe Diameter (inches)	Length of Line (feet)	Total Opinion of Probable Cost
Replacement of line from OSU to WTP	36	32,300	\$ 9,447,700
Total	32,300	\$ 9,447,700	

Table 3-5
Immediate Waterline Improvements

The opinion of probable construction cost for the 36-inch waterline from OSU to the Water Treatment Plant includes replacement of the line. After inspection of the waterline, rehabilitation methods may be suitable in lieu of complete replacement. The total cost for pump station, tank and pipeline improvements for immediate need is estimated to be \$9,528,000.00

3.4.2 Water System Capital Improvements from Year 2008 - 2010

The southwest portion of the City has had the highest growth rate in the City, since 1980, as presented in the Benham report. It was also predicted in the Benham report that the growth would continue in the southeast portion of the City in future.

Presented below in **Table 3-6** and **Table 3-7** are opinion of probable construction cost for improvements needed from year 2008 through year 2010 for the pump stations and pipelines, respectively.

Description of Improvement	Total Opinion of Probable Cost
New Range Tower Booster Pump Station	\$ 1,482,300
New Upper Range Booster Pump Station	\$ 209,300
Total	\$ 1,691,600

Table 3-6
Year 2008 – 2010 Pump Station Improvements

General Location of Improvement	Pipe Diameter (inches)	Length of Line (feet)	Total Opinion of Probable Cost
Southwest	24	4,800	\$ 936,000
	20	7,780	\$ 1,088,800
	16	34,620	\$ 5,070,000
	12	84,220	\$5,460,000
Southeast	12	17,600	\$1,716,000
Total		149,020	\$ 14,270,800

Table 3-7
Year 2008 – Year 2010 Pipeline Improvements

The total estimated cost of improvements anticipated between Year 2006 and Year 2010 is \$15,962,400. The projected maximum day demand is 19.7 mgd for Year 2010.

3.4.3 Water System Capital Improvements from Year 2010 - 2015

The areas that are anticipated to grow between Year 2010 and 2015 are the area north and west of the downtown area and the far northeast portion of the service area. These improvements are also shown on **Figure 3-2**. Presented below in **Table 3-8** and **Table 3-9** are the opinion of probable construction costs for the pump station improvements and waterline improvements, respectively, needed from year 2010 through year 2015.

Description of Improvement	Total Opinion of Probable Cost
Additional Pumps at Water Treatment Plant	\$ 104,700
Total	\$ 104,700

Table 3-8
Year 2010 – Year 2015 Pump Station Improvements

General Location of Improvement	Pipe Diameter (inches)	Length of Line (feet)	Total Opinion of Probable Cost
Northeast zone	12	97,600	\$ 9,516,000
Central	12	15,000	\$ 1,463,000
Total		112,600	\$ 10,979,000

Table 3-9
Year 2010 – Year 2015 Pipeline Improvements

The total estimated cost for improvements between Year 2010 and Year 2015 is \$ 11,083,700. The projected maximum day demand in Year 2015 is 21.70 mgd.

3.4.4 Water System Capital Improvements from Year 2015 - 2020

The areas that were anticipated to grow between Year 2015 and 2020 were the east area of the system, minor additions west of downtown and the north portion of the system. These improvements are also shown on Figure 3-2. Presented below in Table 3-10 is an opinion of probable construction cost for pump station improvements from Year 2015 to 2020.

Description of Improvement	Total Opinion of Probable Cost
Pumps at Range Tower Pump Station	\$ 84,400
Total	\$ 84,400

Table 3-10
Year 2015 – Year 2020 Pump Station Improvements

Presented below in Table 3-11 is an opinion of probable construction cost for pipeline improvements from Year 2015 to 2020.

General Location of Improvement	Pipe Diameter (inches)	Length of Line (feet)	Total Opinion of Probable Cost
West of Downtown	12	30,400	\$ 2,964,000
Northeast	16	15,200	\$ 1,976,000
East	12	65,600	\$ 6,396,000
Total		111,200	\$ 11,336,000

Table 3-11
Year 2015 – Year 2020 Pipeline Improvements

The total estimated cost for improvements between Year 2015 and Year 2020 is \$11,420,400. The projected maximum day demand for Year 2020 is 23.70 mgd.

3.4.5 Summary of Water System Capital Improvements

A summary of the opinion of probable construction cost of improvements for planning Years 2015, 2020, and 2020 are shown in **Table 3-12** below.

Year	Total Opinion of Probable Cost
Immediate Needs	\$ 9,528,000
Year 2008 to 2010	\$15,962,400
Year 2010 to 2015	\$ 11,083,700
Year 2015 to 2020	\$11,420,400
Total for Planning Years Immediate to 2020	\$ 47,994,500

Table 3-12
Improvements Summary

3.5 Operation and Maintenance Opinion of Probable Cost

Historical operation and maintenance expenses for the water distribution system are presented in **Table 3-13**.

The City of Stillwater's system is reported to have approximately 250 miles of pipeline in their system. From this information a cost per foot of pipe for waterline operation and maintenance for year 2005 was determined to be \$0.77 per foot has been used for Stillwater. The cost of O&M is small when the pipeline is new. The \$0.77 was used for pipe to allow for more preventative maintenance programs such as, valve exercising, line flushing and asset management programs.

Item	Annual Cost
Labor – Salaries	\$ 453,350
Labor – Benefits	\$ 64,528
Piping and Values	\$ 149,000
Meters	\$ 83,000
Materials	\$ 150,675
Services	\$ 17,200
Loan Payments lease Dump Truck	\$ 13,752
Misc. Services	\$ 81,000
Repair and Maintenance	\$ 10,450
Other	\$ 0
Subtotal Water Line Management	\$ 1,022,955
Equipment	\$
Total Water Line Management	\$ 1,022,955

Table 3-13
Year 2005 Operations and Maintenance
Cost For Distribution Systems

In addition to the operation and maintenance costs of the waterlines, the addition of new pumps at existing pump station sites and new pump stations will also add to the annual Operation and Maintenance budget. Operations and maintenance cost for additional pumps and pump stations are based on 5 percent and 10 percent of capital costs. The operations and maintenance estimates in this section do not include allowances for electricity. Five percent was used for new pump stations and 10 percent was used for adding pumps to an existing pump station.

Presented below in **Table 3-14** is a summary of the existing and future operations and maintenance costs for the Stillwater Distributions system.

Year	Additional Annual O&M Cost Allocation (Year 2006 dollars)		Total Estimated Annual O&M (Year 2006 dollars)
	Pump Station Costs	Pipeline Costs	
Current Year			\$ 1,022,955
Immediate Needs	\$ 8,030	\$ 24, 871	\$1,055,859
Year 2008 to 2010	\$ 84, 580	\$ 114, 745	\$ 1,255,184
Year 2010 to 2015	\$ 10, 470	\$86, 702	\$ 1,352,353
Year 2015 to 2020	\$ 8,400	\$ 85,624	\$1,446,380

Table 3-14
Summary of Operations and Maintenance Cost

Presented in **Table 3-15** is a year by year listing of annual opinion of probable construction costs, operation and maintenance, total costs and projected peak day demands. The planning periods, in which pump stations were recommended, it has been included in the first year of the planning period. Pipeline work for the planning years have been equally divided among the planning years of the period.

Recommended improvements from Year 2010 through Year 2020 are the anticipation of growth in the service area. The location, density and quantity of the water needed for the future growth may be different than that assumed in the Benham report and herein.

Year	Peak Day Demand (mgd)	Estimated Annual Construction Cost	Estimated Annual O&M	Total Estimated Cost
Immediate Needs	17.9	\$ 9,528,000	\$ 1,055,859	\$ 10,583,859
2008	19.0	\$ 6,448,566	\$ 1,178,687	\$ 7,627,253
2009	19.3	\$ 4,756,933	\$ 1,216,936	\$ 5,973,869
2010	19.7	\$ 2,300,500	\$ 1,255,184	\$ 6,012,117
2011	20.1	\$ 2,300,500	\$ 1,282,994	\$ 3,583,494
2012	20.5	\$ 2,195,800	\$ 1,300,335	\$ 3,496,135
2013	20.9	\$ 2,195,800	\$ 1,317,675	\$ 3,513,475
2014	21.3	\$ 2,195,800	\$ 1,335,016	\$ 3,530,816
2015	21.7	\$ 2,195,800	\$ 1,352,353	\$ 3,548,153
2016	22.1	\$ 2,351,600	\$ 1,377,881	\$ 3,729,481
2017	22.5	\$ 2,267,200	\$ 1,407,687	\$ 3,674,887
2018	22.9	\$ 2,267,200	\$ 1,429,093	\$ 3,696,293
2019	23.3	\$ 2,267,200	\$ 1,450,499	\$ 3,717,699
2020	23.7	\$ 2,267,200	\$ 1,446,380	\$ 3,713,580
Total Cost – Year 2006 – 2020		\$ 47,994,532	\$ 18,406,582	\$ 66,401,114

Table 3-15
Annual Water System Improvement Cost

3.6 Recommendations for Design and Construction

It is recommended that planning and land acquisition activities begin two to three years prior to the published planning period, especially if the construction is located in a highly developed or rapid growth area. This will allow for ample time for engineering, design and construction of the needed improvements. It is also recommended that future improvements be constructed prior to roadway improvements or construction of new roadways serving future developments. Waterline improvements which are within developed areas should be coordinated with street repair and replacement schedules to limit waterline replacements in newly repaired and replaced pavement.

The design and construction of the water system improvements should meet the requirements of Oklahoma Department of Environmental Quality, Title 252, Chapter 626 Public Water Supply Construction Standards. The water distribution system should meet the following subchapters of Chapter 626;

- Subchapter 15, which cover pump stations
- Subchapter 17, Finished Water Storage
- Subchapter 19, Distribution System

It is recommend that the City of Stillwater update their water distribution system model with the revised water usage estimates, to confirm the sizing and location of the capital improvements provided herein.

Reference Copy

Section 4

Water Treatment Facilities

4.1 Introduction

The City of Stillwater (City) currently treats water from Kaw Reservoir, which is located about 45 miles north of Stillwater. Raw water is pumped from the reservoir to the City's 18-mgd water treatment plant located north of Stillwater on Highway 177. The water treatment plant was constructed in 1985 and expanded to 18-mgd capacity in 1999.

As noted in the previous evaluations on water demand and raw water supply that are part of this water master plan, the water treatment facilities will need to be expanded in three phases between now and 2043 to meet the projected water demand requirements. In addition to the capacity expansions, alternative source waters are also being considered for treatment. As noted in Section 2 - Raw Water Supply System, we recommend treating water from Lake McMurry and Lake Carl Blackwell as alternate sources. Thus, water quality from these lakes must also be considered for meeting current and future drinking water regulatory requirements.

This section includes discussions on the following:

- a summary of current and recently promulgated drinking water quality regulations that relate to treatment at the Stillwater Water Treatment Plant (WTP),
- a review of the existing Stillwater WTP components, and
- a discussion of each of the three phased water plant expansions and the recommended improvements.

4.2 Water Quality Regulations

4.2.1 Overview

This section summarizes the provisions of several recent water quality regulations that affect the existing Stillwater WTP and future plant expansions. In particular, the provisions to be discussed apply to public water systems serving at least 50,000 people and less than 100,000 people and using conventional treatment (i.e., coagulation, flocculation, sedimentation, filtration and disinfection) for a surface water source.

The following current and recently promulgated US Environmental Protection Agency (EPA) water quality regulations pertain to the control of microbial risks and the risks associated with disinfectants and disinfection byproducts (DBPs) in drinking water:

- Surface Water Treatment Rule (SWTR)
- Interim Enhanced Surface Water Treatment Rule (IESWTR)

- Long-Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)
- Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)
- Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage 1 DBPR)
- Stage 2 Disinfectants/Disinfection Byproducts Rule (Stage 2 DBPR)
- Filter Backwash Recycling Rule (FBRR)

Figure 4-1 shows the current schedule for the recently promulgated regulations that apply.

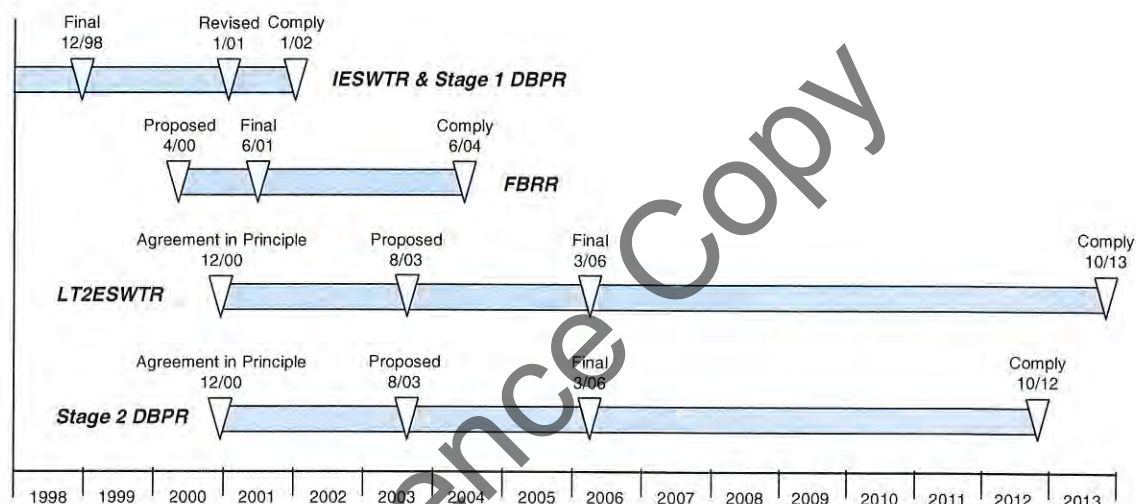


Figure 4-1. Compliance Schedule

4.2.2 Surface Water Treatment Rule

The SWTR, which was promulgated on June 29, 1989 (54 FR 27486), applies to all public water systems using surface water or groundwater under the direct influence of surface water. Filtered water systems had to comply with the SWTR by June 29, 1993.

The SWTR includes maximum contaminant level goals (MCLGs) for *Giardia lamblia*, viruses and *Legionella*; operator personnel requirements; treatment technique requirements instead of MCLs for turbidity, *Giardia lamblia*, viruses, *Legionella* and heterotrophic plate count bacteria; and filtered water turbidity and disinfection standards. A summary of the specific requirements of each component of the regulation follows.

4.2.2.1 Maximum Contaminant Level Goals for *Giardia Lamblia*, Viruses and *Legionella*

The SWTR established an MCLG of zero for *Giardia lamblia*, viruses and *Legionella*.

4.2.2.2 Operator Personnel Requirements

The SWTR requires water systems to be operated by personnel who meet qualifications established by the states.

4.2.2.3 Treatment Technique for Turbidity, *Giardia Lamblia*, Viruses, *Legionella* and Heterotrophic Plate Count Bacteria

The SWTR requires water systems to reliably achieve the following:

- At least 99.9 percent (3-log) removal and/or inactivation of *Giardia lamblia* between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer
- At least 99.99 percent (4-log) removal and/or inactivation of viruses between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer

Systems using conventional treatment meet this requirement if they comply with the filtered water turbidity and disinfection provisions of the SWTR.

4.2.2.4 Filtered Water Turbidity

The SWTR requires water systems using conventional treatment to meet the following turbidity requirements:

- The combined filtered water turbidity must be less than or equal to 0.5 NTU in at least 95 percent of the monthly samples.
- The combined filtered water turbidity must never exceed 5 NTU.

Compliance with the combined filtered water turbidity requirements is based on sampling performed at least once every four hours.

Note, however, that the filtered water turbidity requirements of the SWTR have been replaced by the filtered water turbidity standards in the IESWTR.

4.2.2.5 Disinfection

The SWTR requires water systems using conventional treatment to meet the following requirements for disinfection:

- Disinfection must ensure that the entire treatment process achieves at least 3-log removal and/or inactivation of *Giardia lamblia* and at least 4-log removal and/or inactivation of viruses. Compliance with this rule is as determined by each state.

- Disinfectant residual concentration at the entrance to the distribution system cannot be less than 0.2 mg/L for more than four hours. Compliance for systems serving more than 3,300 persons is based on continuous monitoring of disinfectant residual.
- Disinfectant residual concentration in the distribution system cannot be undetectable in more than 5.0 percent of the samples each month, for any two consecutive months. Compliance is based on samples taken, as a minimum, at the same locations and times as the bacteriological samples collected under the Total Coliform Rule.

To complement the SWTR and provide guidance on implementation of the regulation, the EPA prepared the *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources (Guidance Manual)*. The *Guidance Manual* suggests that well-designed and -operated water treatment plants using conventional treatment should be given credit for 2.5-log removal of *Giardia* cysts and 2-log removal of viruses. Therefore, conventional plants such as the City's water treatment plant must achieve at least 0.5-log inactivation of *Giardia* cysts and 2-log inactivation of viruses by disinfection.

4.2.3 Interim Enhanced Surface Water Treatment Rule

The IESWTR, which was promulgated on December 16, 1998, (63 FR 69478), and revised on January 16, 2001, (66 FR 3770), applies to public water systems using surface water or groundwater under the direct influence of surface water and serving 10,000 or more persons. Water systems had to comply with the regulation by January 1, 2002.

The IESWTR includes the following revisions to the SWTR: an MCLG for *Cryptosporidium*; requirements for removal of *Cryptosporidium*; new filtered water turbidity standards; disinfection profiling and benchmarking requirements; sanitary survey requirements; a new definition for "groundwater under the direct influence of surface water"; inclusion of *Cryptosporidium* in watershed control requirements; and requirements for covering finished water storage facilities. A summary of the specific requirements of each component of the regulation follows.

4.2.3.1 Maximum Contaminant Level Goal for *Cryptosporidium*

The IESWTR establishes an MCLG of zero for *Cryptosporidium*, set at the genus level (i.e., *Cryptosporidium*) rather than the species level (i.e., *C. Parvum*).

4.2.3.2 Removal of *Cryptosporidium*

The IESWTR requires water systems using filtration to achieve at least 99 percent (2-log) removal of *Cryptosporidium* between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer. Systems using conventional or direct filtration meet this requirement if

they comply with the SWTR and the provisions of the IESWTR for filtered water turbidity and disinfection profiling and benchmarking.

4.2.3.3 Filtered Water Turbidity

The IESWTR requires water systems using conventional treatment or direct filtration to meet the following turbidity requirements:

- The combined filtered water turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the monthly samples.
- The combined filtered water turbidity must never exceed 1 NTU.

Compliance with the combined filtered water turbidity requirements is based on sampling at four-hour intervals.

The IESWTR requires water systems using conventional treatment or direct filtration to provide continuous turbidity monitoring of each individual filter and report the following events to the state on a monthly basis:

- Any individual filter with a filtered water turbidity greater than 1.0 NTU in two consecutive measurements taken 15 minutes apart
- Any individual filter with a filtered water turbidity greater than 0.5 NTU at the end of the first four hours of filter operation, based on two consecutive measurements taken 15 minutes apart

A filter profile must be provided to the state within seven days if the water system cannot identify an obvious reason for the abnormal filter performance.

In addition, if an individual filter exceeds 1.0 NTU filtered water turbidity, based on two consecutive measurements taken 15 minutes apart at any time in each of three consecutive months, the system must report the exception to the state and conduct a self-assessment of the filter. If an individual filter turbidity exceeds 2.0 NTU, based on two consecutive measurements taken 15 minutes apart at any time in each of two consecutive months, the system must report the exception and arrange for a comprehensive performance evaluation by the state or by a third party approved by the state.

4.2.3.4 Disinfection Profiling and Benchmarking

The IESWTR requires water systems to prepare a “disinfection profile” if the system’s annual average total trihalomethane (TTHM) concentration is 0.064 mg/L or more, or the annual average haloacetic acids (five) (HAA5) concentration is 0.048 mg/L or more, based on samples taken in the distribution system over one year.

The disinfection profile is to be based on daily monitoring conducted over a one- to three-year period. The disinfection profile must include historical inactivations of

Giardia lamblia and, for systems using chloramines or ozone, viruses. Daily measurements of disinfectant residual, disinfectant contact time, water temperature and pH (where necessary) are required.

Water systems that are required to prepare a disinfection profile must consult with the state before making one or more of the following changes to their disinfection strategy:

- Moving the disinfectant application point (other than routine seasonal changes already approved by the state)
- Changing the type of disinfectant
- Changing the disinfection process
- Making any other change deemed significant by the state

4.2.3.5 Sanitary Surveys

The IESWTR requires the states to conduct sanitary surveys for all public water systems, regardless of system size, that use surface water or groundwater under the direct influence of surface water. Sanitary surveys must be conducted no less frequently than every three years for community systems and no less frequently than every five years for noncommunity systems.

4.2.3.6 Groundwater Under the Direct Influence of Surface Water

The IESWTR revises the definition of “groundwater under the direct influence of surface water” to include *Cryptosporidium*.

4.2.3.7 Watershed Control

The IESWTR requires the control of *Cryptosporidium* as part of the watershed protection program for unfiltered systems.

4.2.3.8 Covered Finished Water Storage Facilities

The IESWTR requires systems to cover all facilities holding finished water for which construction began after February 16, 1999.

4.2.4 Long-Term 1 Enhanced Surface Water Treatment Rule

The LT1ESWTR, which was promulgated on January 14, 2002 (67 FR 1812), applies only to public water systems using surface water or groundwater under the direct influence of surface water and serving fewer than 10,000 persons. The regulation does not apply to the Stillwater’s plant and therefore is not discussed further.

4.2.5 Long-Term 2 Enhanced Surface Water Treatment Rule

The LT2ESWTR was promulgated on January 5, 2006, with the final rule taking effect on March 6, 2006 (71 FR 654). The following elements of the LT2ESWTR apply to

public water systems using surface water or groundwater under the direct influence of surface water and serving 10,000 or more persons:

- Provide additional removal and/or inactivation of *Cryptosporidium* for source waters with 0.075 or more oocysts per liter, as shown in **Table 4-1**.
- Cover uncovered finished water reservoirs or treat the reservoir discharge to the distribution system to achieve at least 4-log virus inactivation, unless approved otherwise by the state.

Bin Number	Source Water Average <i>Cryptosporidium</i> Concentration (oocysts/L) ^b	Additional <i>Cryptosporidium</i> Removal and/or Inactivation
1	< 0.075	None
2	≥ 0.075 and < 1.0	1 log
3	≥ 1.0 and < 3.0	2 logs ^c
4	≥ 3.0	2.5 logs ^c

^a For conventional treatment plants that are in full compliance with SWTR, and IESWTR, LT1ESWTR (as applicable).

^b Based on EPA Method 1622/23 and samples no less than 10 liters, uncorrected for recovery.

^c Must include at least 1-log inactivation using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters or in-bank filtration.

Table 4-1
Additional Removal and/or Inactivation of *Cryptosporidium* ^a

The source water *Cryptosporidium* level (bin classification) for each water treatment plant will be based on the maximum running annual arithmetic average for 24 to 47 months of monitoring, using EPA Method 1622/23 (total oocyst count, uncorrected for recovery). Alternatively, water systems may collect at least 48 samples and use the mean of all samples. Water systems that have equivalent historical data or achieve at least 2.5-log removal/inactivation of *Cryptosporidium*, in addition to conventional treatment, will be exempt from further monitoring.

If required, additional removal and/or inactivation of *Cryptosporidium* will be achieved using methods contained in a “microbial toolbox.” The components of the toolbox include the following:

- Watershed Control Program: 0.5-log credit for State approved program comprising EPA specified elements. Unfiltered public water systems are not eligible for this credit.
- Alternative Source/Intake Management: No prescribed credit. Systems may be assigned to a lower bin based on *Cryptosporidium* monitoring at a new intake location. Re-binning would occur after system begins using the new intake location.

- Pre-Sedimentation with Coagulation: 0.5-log credit (during any month that pre-sedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or alternative State-approved performance criteria) with continuous operation and coagulant addition.
- Two-Stage Lime Softening: 0.5-log credit for second-stage softening with coagulant.
- Bank Filtration: 0.5-log credit for 25-ft setback; 1-log credit for 50-ft setback.
- Lower Finished Water Turbidity: 0.5-log credit for combined filter effluent turbidity ≤ 0.15 NTU in at least 95% of samples each month; 0.5-log credit (in addition to 0.5-log combined filter effluent performance credit) for individual filter effluent turbidity ≤ 0.15 NTU in at least 95% of samples each month and is never > 0.3 NTU in two consecutive measurements in any filter.
- Demonstration of Performance: Credit awarded to unit processes or treatment train based on demonstration to the State with a State-approved Protocol.
- Slow Sand Filters: 2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination.
- Second Stage Filtration: 0.5-log credit for second separate filtration stage in treatment process, if treatment train includes coagulation prior to first filter.
- Membranes (MF, UF, NF, RO): Log credit equivalent to removal efficiency demonstrated in challenge test for device if supported by direct integrity testing.
- Bag and Cartridge Filters: Up to 2-log credit with demonstration of at least 1-log greater removal in a challenge test when used singly. Up to 2.5-log credit with demonstration of at least 0.5-log greater removal in a challenge test when used in series.
- Chlorine Dioxide: Log credit based on demonstration of compliance with CT table.
- Ozone: Log credit based on demonstration of compliance with CT table.
- UV: Log credit based on validated UV dose in relation to UV dose table. To establish UV dose and associated operating conditions, reactor validation testing is required.

The EPA intends to link the implementation schedules for LT2ESWTR and Stage 2 DBPR to balance the risks associated with simultaneously treating water to control microbial contaminants, disinfectants and DBPs. The LT2ESWTR was proposed in August 2003 and the final rule took effect March 6, 2006. The following compliance schedules apply to those public water systems similar to the City of Stillwater, serving

at least 50,000 but less than 100,000 people. Report sampling schedule and sampling location description for initial source water monitoring for *Cryptosporidium* (plus *E. Coli* and turbidity) no later than January 1, 2007. Initial source monitoring for these systems is required to begin no later than April 1, 2007. Initial bin classification is required to be submitted for approval no later than October 1, 2009. Affected water systems will have four years following initial bin classification to meet the treatment requirements associated with the bin (October 1, 2013). States may allow an additional two years for compliance by water systems requiring capital improvements.

The second round of monitoring will begin six years after initial bin classifications are established (October 1, 2015). The bin classifications resulting from the second round of monitoring are required to be submitted for approval no later than April 1, 2018. If the bin classification changes based on the second round of monitoring, the State will determine the schedule for compliance.

4.2.6 Stage 1 and Stage 2 Disinfectants/Disinfection Byproduct Rules

A summary of the Stage 1 and Stage 2 DBPRs is provided below. The Stage 1 DBPR is summarized to provide background information related to the proposed Stage 2 DBPR.

4.2.6.1 Stage 1 DBPR

The Stage 1 DBPR, which was promulgated on December 16, 1998, (63 FR 69390), and revised on January 16, 2001, (66 FR 3770), applies to public water systems (community water systems and nontransient noncommunity water systems) that treat water with a chemical disinfectant or provide water that contains a chemical disinfectant.

Water systems using surface water or groundwater under the direct influence of surface water and serving 10,000 or more persons had to comply with Stage 1 DBPR by January 1, 2002.

The Stage 1 DBPR includes maximum residual disinfectant level goals (MRDLGs) and maximum residual disinfectant levels (MRDLs) for chlorine, chloramines and chlorine dioxide; MCLGs and MCLs for trihalomethanes, haloacetic acids, bromate and chlorite; and treatment technique requirements for DBP precursors. A summary of the specific requirements of each component of the regulation follows.

Maximum Residual Disinfectant Level Goals and Maximum Residual Disinfectant Levels for Disinfectants

The Stage 1 DBPR establishes MRDLGs and MRDLs for chlorine, chloramines and chlorine dioxide, as shown in **Table 4-2**.