CARBON COUNTY, WYOMING-TOWN OF SARATOGA, WYOMING
IMPACT JOINT POWERS BOARD

MASTER DOMESTIC WATER AND SANITARY SEWER SYSTEMS STUDY

PREPARED FOR THE
TOWN OF SARATOGA, WYOMING

1977-1978

WESTERN ENGINEERS-ARCHITECTS, INC.
CASPER, WYOMING

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July, 1978

Town of Saratoga, Wyo.-Carbon County
Impact Joint Powers Board
Saratoga, Wyoming 82331

Ladies and Gentlemen:

We submit herewith 10 copies of our master domestic water and sewer study in accordance with our contract agreements. We have attempted to propose systems placing an emphasis on public health, simplicity and dependability. The report was complicated by the urgent demand to complete some phases of the improvements rapidly. Thus, some portions of the report are currently in service or are under construction.

This report evaluates the existing domestic water and sewer systems and presents a master plan for improvements based upon present and future needs to the Town of Saratoga population of 5000 with systems designed for expansion to 10,000.

It is intended that this report will serve as a guide for detailed planning and project implementation.

This has been a challenging and rewarding project.

Sincerely yours,

Western Engineers-Architects, Inc.

Russell L. Donley
Russell L. Donley, MSE
Wy. P.E. & L.S. #646

Barry Venn
Barry Venn,
Designer

RLD
BV :ell

CARBON COUNTY, WYOMING-TOWN OF SARATOGA, WYOMING

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LIST OF ABBREVIATIONS

Ac.	-	acre
A.	-	area
A-C	-	activated carbon
A.C.	-	alternating current
A.W.W.A.	-	American Water Works Association
BOD_5	-	Biological Oxygen Demand
B.V.	-	Butterfly Valve
C.F.S.	-	Cubic feet per second
Cl_2	-	chlorine gas
C.I.P.	-	cast iron pipe
C.O.D.	-	Chemical oxygen demand
d_t	-	detention time
D.E.	-	diatomaceous earth
D.E.Q.	-	Department of Environmental Quality
dia.	-	diameter
D.I.P.	-	ductile iron pipe
D.O.	-	dissolved oxygen
elev.	-	elevation
E.P.A.	-	Environmental Protection Agency
f.p.s.	-	feet per second
ft.	-	feet
Fl_2	-	fluorine gas
F.S.	-	Forest Service
F.T.R.	-	field transfer rate
gal.	-	gallon
gpcpd	-	gallons per capita per day
g.p.m.	-	gallons per minute
G.V.	-	gate valve
H.P.	-	horse power
hr.	-	hour
I.E.	-	invert elevation
in.	-	inch
J.P.B.	-	Joint Powers Board
J.T.U.	-	Jackson Turbidity Units

LIST OF ABBREVIATIONS (cont'd.)

K.W.	- Killowatt
lb.	- pound
Lab.	- Laboratory
L.H.	- Lamp hole
l	- liter
L.S.	- Lift Station
M.G.	- million gallons
m.g.	- milligram
mg/l	- milligram per liter
ml	- milliliter
m.g.d.	- million gallons per day
M.H.	- manhole
m	- meter
mu	- milli micron
min.	- minute
M.J.D.I.P.	- Mechanical Joint Ductile Iron Pipe
nm	- nanometer
n	- Mannings "n"
NTU	- Nephlometric Turbidity Unit
O_3	- ozone
O_2	- oxygen
p.s.i.	- pounds per square inch
p.p.m.	- parts per million
P,pop	- population
P.R.V.	- pressure reducing valve
P.V.C.	- polyvinyl chloride
p.p.d.	- pounds per day
ppcpd, lb./cap/day	- pounds per capita per day
Q	- Volume of flow, c.f.s.
s	- slope
SS	- suspended solids
sec.	- second

LIST OF ABBREVIATIONS (cont'd.)

T.D.H.	- total dynamic head
T.D.S.	- total dissolved solids
T.E.	- top elevation
temp.	- temperature
T.I.R.	- Totalizing, indicating and recording
T.O.C.	- total organic carbon
u	- micron
U.S.F.S.	- United States Forest Service
V.	- voltage
Vol.	- volume
V.S.S.	- volatile suspended solids
v	- velocity
W.E.A.I.	- WESTERN ENGINEERS-ARCHITECTS,INC.
W.C.D.A.	- WYOMING COMMUNITY DEVELOPMENT AUTHORITY
W.P.C.F.	- Water Pollution Control Federation
W.T.P.	- Water Treatment Plant
wt.	- weight

ACKNOWLEDGEMENTS

The broad and varied parameters of this report required excellent cooperation between the Joint Powers Board, the Town of Saratoga and its employees and our office.

The Impact Joint Powers Board and the Town Council of Saratoga have done everything in their power to expedite the proposed projects.

Special consideration is reserved for three individuals:

Paul Hilliard, Board Chairman, has on many occasions kept the projects on a consistent course, as the Board sought correct solutions to difficult problems.

George McIlvaine, who was heavily involved in the proposal writing and obtaining of the projects funding.

Kathy Glode, Mayor, is singled out for her timely efforts, funding procurement and continuing enthusiasm.

Each Board Member has been active and without exception has made a meaningful contribution to this report.

A recent turnover in key Town maintenance personnel made underground utilities particularly difficult to locate. Dennis Correll, new Public Works Superintendent, aided with maps and field work to help alleviate this situation.

The State of Wyoming, acting by and through the Wyoming Farm Loan Board have funded $2,020,000 of the needed water and sewer improvements. Without this help the impact alleviation improvements would have been extremely difficult to procure.

HISTORY AND INTRODUCTION

HISTORY

In June, 1976 the Impact Joint Powers Board through the Wyoming Community Development Authority applied for a $2,500,000 loan from the State of Wyoming Farm Loan Board for Water and Sewer Improvements.(1) These improvements were necessary as Saratoga was and is experiencing extremely rapid growth caused principally by the rapidly expanding mining activity in the area. In 1960 Saratoga had a population of 1132; in 1970, 1181; in 1976, 2000 people and in 1977, 2500. Growth in 1977 was restricted to three new services per month due to water and sewer system inadequacies. The Town currently has a backlog of applicants well into 1978.

On July 26, 1976 the State Farm Loan Board granted the Impact Joint Powers Board a $2,020,000 Joint Powers Loan at five and one-half percent interest for a period of 15 years.(2) This loan is to be repaid with $2,884,200.00 from the Wyoming Coal Tax Fund over 15 years or $192,280 per year plus $8,972.60 per year from the Town of Saratoga. Table 1 shows the improvements the $2,020,000 was to have purchased including construction, contingencies, and legal fees.

TABLE 1 - WCDA PROJECTED IMPROVEMENTS (1)

1.	Water Treatment Plan (2 MGD) ($1,200,000)	$ 1,200,000
2.	Water Metering System ($110,000)	$ 1,310,000
3.	Water Distribution Lines (Replace all 2" lines) ($270,000)	$ 1,580,000
4.	North Platte River Lift Station Expansion ($70,000)	$ 1,650,000
5.	Sewage Outfall Line ($100,000)	$ 1,750,000
6.	One-Million Gallon Storage Tank ($ 270,000)	$ 2,020,000

In December, 1976 our firm was retained to prepare studies for the domestic water system and shortly thereafter for the domestic sewer system. This report presents the results of those engineering studies suggesting a master plan for corrective action and further expansion.

Scope:

The scope of the work included:

1. Mapping of the existing water distribution system and sewage collection system.
2. Evaluation of the existing facilities.
3. Projection of population and land use.
4. Investigation of quality, quantity and characteristics of water supply.
5. Investigation of infiltration and quantity of sewage collected.
6. Analysis of water and sewage treatment requirements.
7. Analysis of transmission, distribution and storage considering peak domestic demands plus fire flows for water.
8. Analysis of collection and outfall line sizing.
9. Establishment of design criteria.
10. Preparation of water and sewer system preliminary plans.
11. Suggested implementation of a construction program.
12. Recommendations on maintenance and construction priorities.
13. Presentations of capital and operation and maintenance costs.

Operations

From January, 1977 to July, 1978 engineering studies have progressed

Extensive field work has proceeded from this office including 1. visual inspections of all of the facilities of all systems, 2. water flow and water quality testing of existing systems, 3. sewage flow and infiltration testing, 4. sewage meter setting and quantity measurements for sewage flows, 5. sampling and monitoring of many independent laboratory analyses, and 6. locating from existing records and in the field water mains in all systems 2" diameter and larger, and sewer mains 6" diameter and larger.

Coordination meetings were held with the Impact Joint Powers Board on a regular basis, and on several occasions with the Town Council during the progess of the work.

Concurrently and subsequent to field operations literature surveys and consultation with equipment manufacturers and other consultants have progressed in Denver, Fort Collins and in our Casper office. This engineering report was prepared with emphasis placed on providing simple systems requiring a minimum of maintenance but having adequate control to assure safe dependable systems. Economy, feasibility and local conditions are emphasized as all three are important to the implementation of this report.

Report Progress - Current and Future Projects

This report was due in April, 1977. However, several unanticipated events changed this time table. The 1976 WCDA report based its improvement costs and needs on a 4000 maximum population with 2500 population being reached in 1983. The 2500 population was reached in 1977 and the Board required a design population of 5000 with systems designed for expansion to 10,000. A new water intake system was needed as the old intake furnished an extremely silty and colored water for supply. The Board had us defer this report first to design a new water intake system.

Upon completion of the intake design we determined that color removal from the raw water supply was our most difficult treatment problem. Solving of this design problem delayed the report. As growth was curtailed in 1977 the Board again deferred this report to design a new treatment plant, new water storage and a 14 inch transmission main to the new storage tank. When this design was complete the report was again delayed as we designed a new sewage lift station as the old station was a major maintenance problem. Table 2 shows these projects and the approximate contract amounts or costs.

Table 2 - PROJECTS COMPLETED OR UNDER CONSTRUCTION

		$ Accumulation
1.	Replace Old Mains (Frontier) ($100,000)	$ 100,000
2.	Backwashable Infiltration Gallery ($250,000)	350,000

3.	Water Treatment Plant (3.5 MGD) ($900,000)	$1,250,000
4.	Repair Existing Plant (1 MGD) ($50,000)	1,300,000
5.	14" Main & Pressure Reducing Valves ($225,000)	1,525,000
6.	1 Million Gallon Standpipe ($225,000)	1,750,000
7.	Sewage Lift Station ($40,000)	1,790,000
8.	Professional and Misc. Costs on Above ($180,000)	1,970,000
9.	Contingencies on Above ($50,000)	2,020,000

Comparing Table 1 to Table 2 several items were not completed for the initial $2,020,000.

2.	Water Metering System ($110,000)	110,000
5.	Sewage Outfall Line ($100,000)	210,000

Our studies now show that work beyond the $210,000 for Items 2. and 5. above needs to be completed if Saratoga is to take care of 5000 people. Table 3 shows these needs.

TABLE 3 - PROJECTS NEEDED FOR TOWN EXPANSION TO 5000 POPULATION

(costs include contingency and professional fees)

1.	Water Metering System ($275,000)	$ 275,000
2.	Sewage Outfall Line ($160,000)	435,000
3.	Seal Existing Overloaded Sewer Mains ($ 95,000)	530,000
4.	Replace 8" & 10" Broken Sewer with new 10" Sewer ($80,000)	610,000
5.	Upgrade Existing Sewage Treatment (411,000)	1,102,000
6.	New Water Distribution System (2,000,000)	3,021,000

Prioritization of the above projects include:

Items 2. Sewage Outfall Line and 3. Seal Existing Overloaded Sewer Mains need to be completed prior to the Town's being able to allow more growth and are therefor of the highest priority.

Item 1. Water Metering System will be necessary to conserve water or growth will again need to be curtailed at a population of 3333 rather than at 5000 as a 50% water savings normally results when meters are installed.

Item 6. New Water Distribution System is desirable prior to water meter installation to prevent excessive meter maintenance costs. The Town currently has completely inadequate fire protection due to the many 2" and 4" distribution mains.

Item 5. Upgrade Existing Sewage Treatment is necessary as the existing treatment is currently inadequate.

Item 4: Replace 8" to 10" broken sewer with new 10" sewer will be needed if Item 3. does not solve the sewage infiltration problem. A detailed sewer main viewing program is included in Item 3.

ORGANIZATION OF REPORT

A summary of the conclusions and recommendations immediately follows this introduction. The report is divided into a water and sewer section. The design and background data, population, collection, water demands, fire demand, quality, treatment and disinfection are presented in Part I (Chapters 1W-7W). Detailed analysis, evaluation and design recommendations for each system are presented in Part II (Chapters 8W-13W). Part III (Chapters 1S-3S) presents the design and background data, treatment and disinfection for the Sanitary Sewer System. Detailed analysis, evaluation and design recommendations for the Sanitary Sewer System are presented in Part IV (Chapters 4S-6S). Chapter 6S includes the special consideration of contracting with the U.S. Forest Service to allow them to use Saratoga's Lagoon System for summer dumping of recreational area wastes. Part V,(Chapter 1C-2C) presents our recommended plans and priorities for construction implementation. Tables and illustrations are located throughout the report and tabulated Hardy Cross Network Analyses, National Drinking Water Standards and other pertinent data are located in the appendices. References and key Western Engineers-Architects, Inc. project personnel are listed at the end of the report.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Proper maintenance and skilled operation are essential to the successful implementation of the recommended programs.

2. The existing water system needs major improvements. A larger capacity water treatment plant and greater storage capacity are required immediately, and water mains and fire hydrants must be upgraded in most areas of Town.

3. Adequate water collection can be most economically achieved by building a backwashable infiltration gallery under the North Platte River. The water is to be polished by diatomaceous earth filters, ozone will be used primarily to remove color, taste, and odor from the water and secondarily to disinfect it. Final disinfection and a distribution system residual will be maintained using chlorination.

4. An additional water storage tank, a 100 ft. tall standpipe is required with a minimum storage capacity of one million gallons.

5. Major new water transmission lines and additional fire hydrants throughout the system, and large loop lines around the perimeter of the system are required to provide adequate flows for domestic use and fire protection.

6. The water treatment and storage systems proposed should be fully automated and operations recorded.

7. Water meter installation and replacement of service taps are required to reduce consumption and maintenance of individual services.

8. The water treatment systems proposed should be constructed for easy expansion as the Town is growing very rapidly.

9. The existing sewer system needs major improvements. Infiltration from the high water table into leaky sewer pipe seriously overload the sewage collection and treatment systems.

10. A major sewer pipe sealing program is required and some broken lines must be replaced in the parts of Town below the Hugus-Mullison irrigation ditch.

11. The lift station is unreliable and inadequate, and needs renovation immediately.

12. The existing lagoon system is inadequate, and must be enlarged to satisfactorily treat the present wastes and handle anticipated growth. Some improvements can be made immediately and reduce or eliminate spring and fall odors.

13. The poor and deteriorated state of the present water and sewer system is largely due to poor construction techniques, no inspection of the work, little or no maintenance, and use of substandard materials.

RECOMMENDATIONS

The following improvements are recommended. Items with one asterisk indicate construction recommended for immediate implementation:

1. Water Treatment

   * Construct a backwashable infiltration gallery intake, and raw water well under the North Platte River to develop a low turbidity supply. (Completed 1977)

   * Construct a new 3.5 M.G.D. capacity water treatment plant with filtration accomplished by D.E. Filters, color removal and disinfection by ozone, and maintenance of a chlorine residual through slight chlorination. (Started 1977)

   *Renovate the existing water treatment plant to a capacity of 1.0 M.G.D. This plant should be maintained and used as a standby in case of power failure, which also includes renovation and routine maintenance of the existing 240V. power generator. (Started 1977)

   *Construct a 1.0 M.G. water storage standpipe to the South of Town. The standpipe should be 100 feet high. Abandon and obliterate the existing 100,000 gallon concrete reservoir. (Started 1977)

   *Construct a 14 inch diameter water transmission main from the new water treatment plant to the new storage tank. (Started 1977)

   Install water meters on all services as soon as feasible. We recommend a sand blowoff, and line flushing program to eliminate sand from the system prior to installing meters.

   *Abandon and replace all 2 inch diameter water lines with new lines 6 inch diameter or greater. Provide adequate valving and replace service taps to all areas. (Partially complete 1977)

   Abandon and replace all 4 inch diameter water lines with new lines 6 inch diameter or greater, as soon as possible. Provide adequate valving and replace service taps to all areas.

Replace all old or inadequate fire hydrants, and tie them on to feeder lines 6 inch diameter or greater.

Complete a 10 inch diameter main feeding without interruption into the existing elevated water tank.

Locate and accurately map the existing and future water lines including line sizes and locations, fire hydrants and valves.

Loop the entire Town with a 12 inch diameter water main, located around the periphery of Town.

2. Sanitary Sewer System

* Construct a 15 inch diameter outfall line to the lagoons, and replace the lagoon piping with 15 and/or 18 inch diameter interconnecting piping. (Started 1978)

*Replace the existing Lift Station and renovate it to be more reliable. (Completed 1978)

*Provide emergency standby power at the Lift Station(s) to run the pumps and controls in case of power failures.

*Seal and/or replace all sewer lines in the central part of Town located between the Hugus-Mullison ditch and the North Platte River. In addition, seal the Hugus-Mullison ditch to reduce the ground water seepage.

*Construct a 10 inch diameter bypass line from above Hobo Pool across the River to the Saratoga Inn to alleviate present and future loadings on the Third Street main, and provide a system to tie onto for the Saratoga Inn area. This system requires a lift station and a standby power generator. (Started 1977)

Construct a 10 inch diameter bypass line from 6th and Rochester around the slough and into the existing sewer system on Third Street. This should alleviate present and future loadings on the Third St. Main.

*Provide 2 more 5 H.P. aerators in the first cell of the existing lagoon system.

*Begin a routine sampling and testing program at the Lagoons, and record the data.

*Begin applying for funds for construction of a 5 acre pond expanding the present lagoon system.

Construct a 5 acre third cell, at the lagoon.

Provide an adequate sewage collection system for the Saratoga Inn Subdivisions and abandon the present septic tank system.

Locate and accurately map the existing and future sewer lines including line sizes, manhole locations and slopes.

3. Inspection and Supervision of New Construction

We strongly recommend that the Town require all new water and sewer construction projects to be supervised and inspected by a full time resident inspector. In addition, the Town should require that a Professional Engineer certify in writing to the Town that the project has been constructed as designed, before it is accepted by the Town.

PART I - W A T E R -

B A S I S O F D E S I G N

CHAPTER 1W. - GENERAL INFORMATION

Location and Transportation

The Town of Saratoga is located in the South Central portion of Wyoming on the North Platte River, approximately 80 miles west of Laramie, Wy. and 42 miles southeast of Rawlins, Wy. State Highway 130 connects Saratoga northward to Interstate Highway 80, serving Laramie and Rawlins. A paved municipal airport southwest of the Town but within the Townsite perimeter serves the community. The Union Pacific Railroad runs through the east side of Town . The North Platte River divides Saratoga, flowing in a northwesterly direction. Figure 1W-1 is a vicinity map of Saratoga.

Climate

Saratoga is roughly 6800 feet above sea level. Thus, during the summer the climate is cool and pleasant, with daily maximum temperatures in the 90s and early morning minimum temperatures in the 40s and 50s. Annual precipitation is about 15 in. and much falls as snow during the late fall, winter, and spring. Maximum stream flow occurs in late April, May and early June under the influence of melting snowfields. Midwinter temperatures frequently drop as low as -10 degrees Fahrenheit and have been recorded below -40 degrees Fahrenheit. Throughout the summer, the winds are generally from the southwest at 5 to 10 miles per hour.

Population and Growth Potential

Figure 1W-2 shows the Town of Saratoga in 1903 having 1000 people. The 1960 census shows 1132, the 1970 census 1181. The population has rapidly increased above most estimates in the past five years. The Town in December, 1977 had an estimated population of 2500 people, double its 1974 count.

The rapid growth is due in large part to the increased mining and mineral activity in the surrounding areas. Other small industries and businesses serve the Town such as lumber,ranching, tourism and the Union Pacific Railroad. The tourist industry flourishes in the summer months, and in the past has been the greatest contributor toward the towns economy.

The growth potential for the Town of Saratoga is great. A minimum of five new coal mines or expansions thereof, and a new uranium mine all in the surrounding area are predicted for the very near future by the Carbon County Planners Office. The impact on the Town is already apparent by the increasing number of trailer courts and the increased construction of new homes. The population could very easily double again within 3 to 5 years.

The present impact is having a great affect on the Towns water and sewer system. The Town is served by a conventional water treatment plant that was built in 1957. The plant has long since exceeded its design capacity which was for a population of 1250 or 1300. This problem is compounded when the peak demands are exerted during the hot summer months and high tourist inflows.

Meeting The Impact

Impact problems such as needed services for schools, health care, human services and many more face the Town of Saratoga as well as other Towns in Carbon County. However, this report will deal only with the domestic water and sewer problems. Saratoga must meet the demands that will be exerted by the impact of growth. By improving the water system, the fire fighting capabilities of the Town, and sewer system, the community may grow more comfortably and prosper both physically and economically. By providing adequate public water and sewer systems the attraction for the incoming mining industries, and local construction projects, will be enhanced.

With growth being so dynamic the Town can do little more than hope to keep pace with demand. On June 24, 1977 the EPA's Interim Primary Drinking Water Regulations became official. The State of Wyoming has elected not to be responsible for implementing these new standards, so the EPA will do so. This means that the water quality standards for Wyoming will be under the direct control of the EPA. These standards will have a significant effect on determining the type and quality of water supply the Town must furnish to the public. These new standards will be discussed later.

Funding, or portions thereof, for the proposed improvements to the water and sewer systems, may come in small increments and periodically from various loan and grant making institutions. The Town must place priorities on their needs, as some systems are in better condition than others.

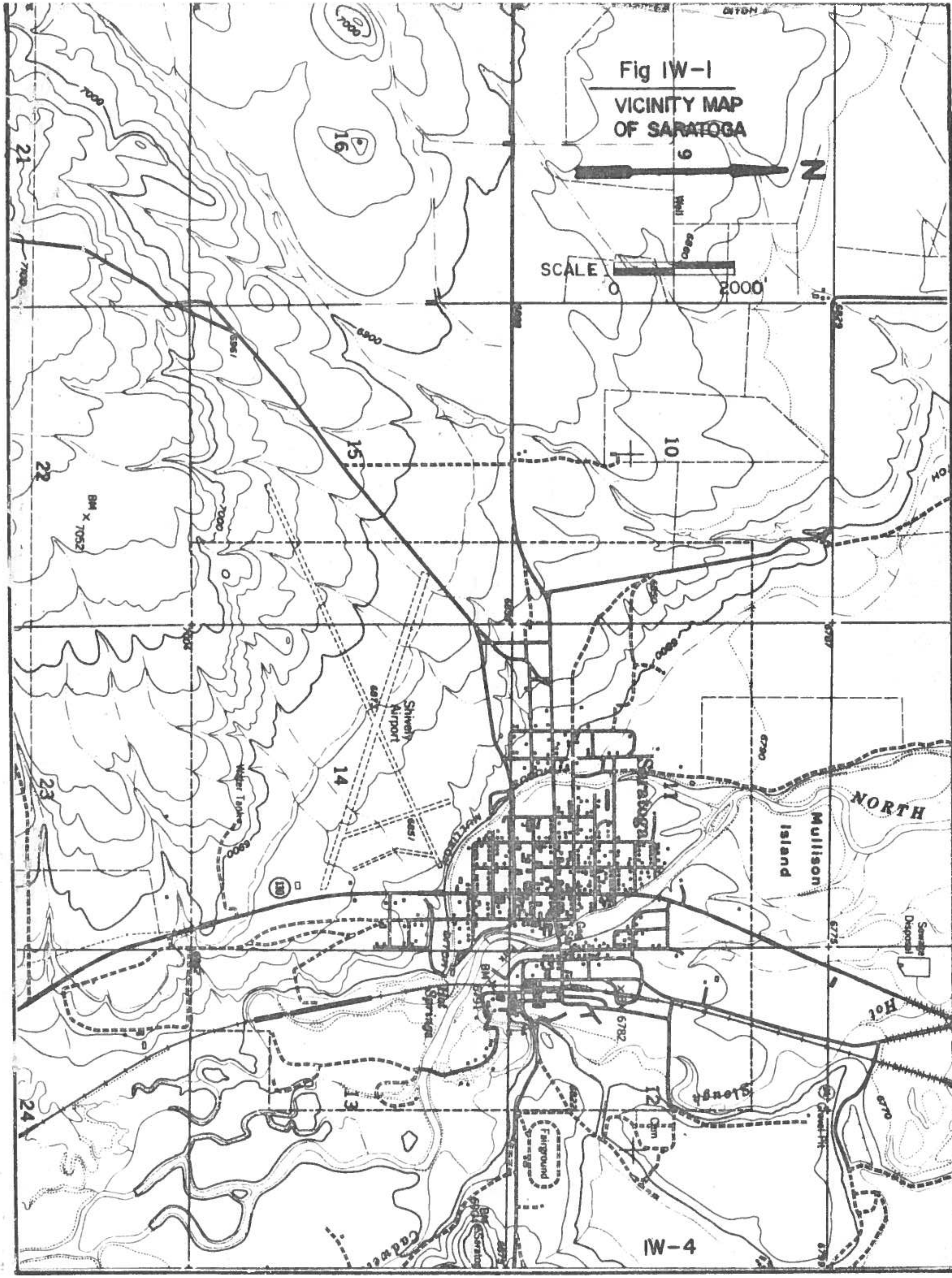
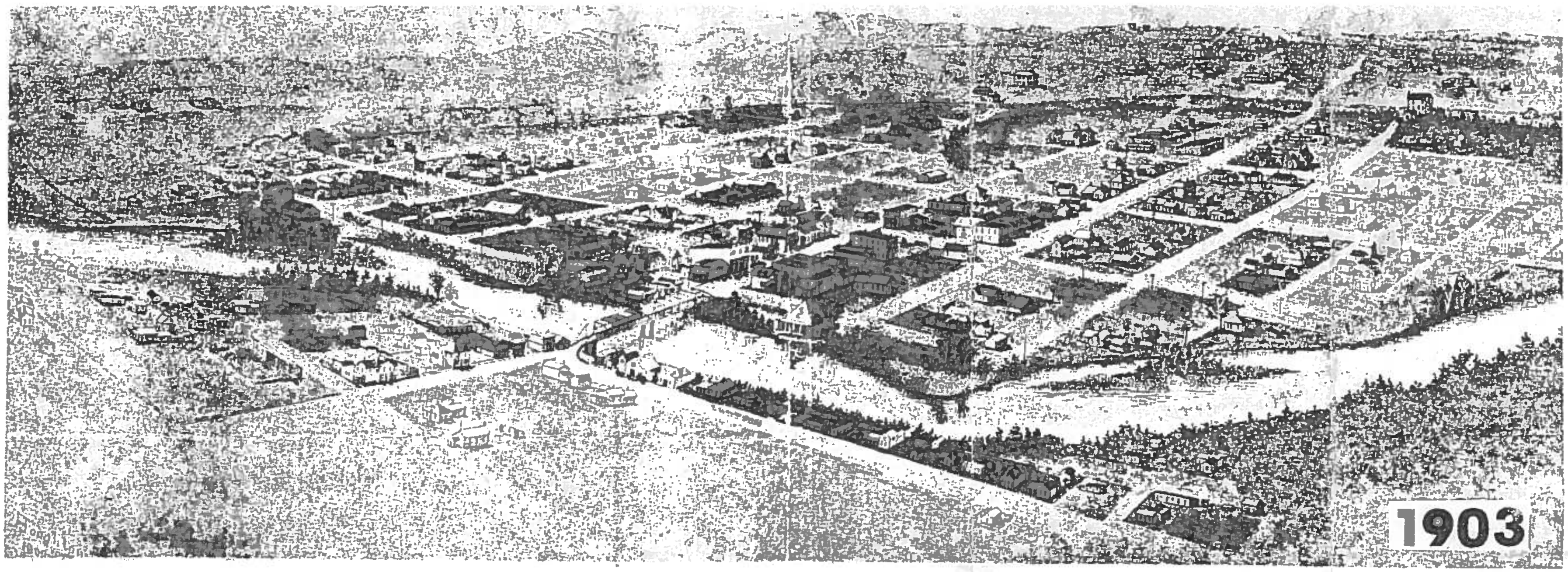


Fig IW-1
VICINITY MAP OF SARATOGA



SARATOGA, WYOMING

Elevation 6,700. Population 1,000.
$20,000 Bonds voted for water system.
Water Power practically unlimited.
Extensive Lime Quarries.
Coal supply 12 miles northwest.
Land under successful cultivation 15,000 acres.
Telephone System.
Two Churches.

Located in Copper Region of Southern Wyoming, on North Platte river, 21 miles from Union Pacific R. R. Six-horse Concord coaches carrying passengers, U. S. Mail and Pacific express runs daily between U. P. Ry., Saratoga, and Grand Encampment. Large tracts of unoccupied Government Land Suitable for Alfalfa, Grain, Sugar beet culture, requiring large investments of capital to irrigate. Wheat and oats from here took first prize at the World's Fair. Ranch property has more than doubled in value during the past three years.

Hot Sulphur Springs.
Pupils from Public School enter Preparatory Department of University.
Pupils enrolled 188. Teachers 3.
Tie Cutting an Important Industry.
Irrigated hay and pasture land 30,000 acres.
Capacity of Electric Plant 1,200 lamps. 700 lamps in operation.

Fig. IW-2

CHAPTER 2W. - WATER SYSTEM DESIGN DATA

A broad study was required to examine and map the existing and proposed water system. Design parameters included the following:

1. Collection of an adequate and reliable supply.
2. Treatment of the supply to make it meet the new National Primary Drinking Water Regulations.
3. Adequate transmission to storage and to the distribution system.
4. Storage for adequate domestic and fire flows.
5. Distribution for adequate domestic and fire flows.

This chapter sets forth the basic design criteria used to estimate the quantity, and quality of the water used in the system, and the hydraulic properties of the system. Population and unit flow allowances were developed and applied following accepted and referenced engineering practices.

This chapter further evaluates several treatment-collection alternatives and states the reasons for the first choice recommendations presented in subsequent chapters.

Population

Estimates of present and future populations should be determined prior to a thorough study of this type.

As mentioned previously, estimates of future populations are difficult to obtain in an impacted area. The population in 1970 was approximately 1150,[12] and in late 1977 was approximately 2700. It is estimated that by the end of the summer of 1978, the population may reach 3200.

To simplify the design and avoid dangerous population predictions, the design was based on population, not time, and divided into two construction phases. The design population used was 5000 for the initial phase, Phase I of construction, and a population of 10,000 for the final phase, Phase II. When the Town reaches a population of 5000, whether it be in 1980 or 1999, Phase II of construction will need to be initiated. This method of design gives the Town control for determining their own growth rate and thus the design period of the system by increasing or decreasing the number of building permits that they approve.

Water Demand

Maximum domestic demand flows coupled with the peak fire demand normally determine the total peak demand for a water system.

Determination of domestic demand flows was difficult to perform because individual services in Saratoga are not metered. The demand flow determination was done by using the number of gallons pumped from the water treatment plant. The data was gathered by the Public Works Department and results were obtained by dividing the number of gallons pumped per month by the population. Documented figures obtained for years past are shown in Table 2W.-1.

TABLE 2W.-1 - CONSUMPTIVE USE (13)

Year	Avg. Consumption G.P.C.P.D.
1954	199
1961	262
1967	299
1968	322
1969	316

The most recent demand data is shown in Table 2W.-2, and is based on a population of 2,000 in 1975 and 2200 in 1976.

TABLE 2W.-2 - RECENT WATER CONSUMPTION DATA

Month & year	Gallons pumped	Gallons per day	PER CAPITA usage (gpcpd)
Jan., '75	12,701,300	409,719	205
'76	8,730,300	281,161	128
Feb., '75	10,709,100	382,468	191
'76	8,475,500	292,259	133
Mar. '75	11,332,700	365,571	183
'76	9,352,200	301,684	137
April '75	11,419,300	380,643	190
'76	8,817,400	293,913	134

TABLE 2W.-2

Recent Water Consumption Data cont'd.

Month & year		Gallons pumped	Gallons per day	PER CAPITA isage (gpcpd)
May	'75	16,881,700	544,571	272
	'76	13,252,400	427,496	194
June	'75	21,184,800	706,160	353
	'76	15,863,400	528,780	240
July	'75	20,269,800	653,864	327
	'76	21,068,700	679,635	309
Aug.	'75	22,751,300	733,913	367
	'76	21,778,600	702,535	319
Sept.	'75	17,444,500	581,483	291
	'76	21,077,700	702,590	319
Oct.	'75	11,682,210	376,845	188
	'76	17,249,100	556,416	253
Nov.	'75	8,847,800	294,927	147
	'76	15,115,500	503,717	229
Dec.	'75	8,712,100	281,035	141
	'76	10,847,900	349,932	159

The peak day in 1975 was June 28th when 486 g.p.c.p.d. was pumped, and in addition, seven days during the summer were recorded over 400 g.p.c.p.d. Peak day in 1976 was July 10, when 412 g.p.c.p.d. were pumped. Only one day in 1976 was over 400 g.p.c.p.d.

From the pumping data, it can be stated that the average daily demand during the summer months (June-Sept.) is about 320 g.p.c.p.d. and about 225 g.p.c.p.d. for the year.

These figures are slightly misleading for several reasons. The Town has many homes with private wells, and supply sources other than the water treatment plant, thus making the above data conservative. The meter in the water plant has been subjected to sand year after year, and may be getting increasingly conservative. The Town is unmetered, and thus encourages more consumptive use. The large number of leaky water mains would make the consumptive use data low.

Generally accepted engineering texts use a figure of 150-200 g.p.c.p.d. for daily per capita consumption for metered systems. Metering all services of a city should reduce consumption to about 50 percent of the consumption without meters.(3) Peak day consumption is usually assumed to be 180-200%

of the average day demand.[4] Maximum hourly demand is estimated to be about 150 percent of the average for that day.[4]

Using the consumption figures from the data in Table 2W.-2 gives the maximum hour demand on the peak day in Saratoga of 225 x 1.9 x 1.5 = 641 g.p.c.p.d. for that hour.

For design purposes, the figure of 650 g.p.c.p.d. for peak domestic demand flow was used. This figure has been found to be adequate for Wyoming towns similar to Saratoga in size. Total demand for a Town of 5000 is 3.25 M.G.D. or 2257 G.P.M., and 6.50 M.G.D. or 4514 g.p.m. for a population of 10,000.

Fire Demand and Storage

Water storage is normally computed from cumulative flow diagrams showing the maximum to be stored at a constant pumping rate on a peak day. Total storage should be equal to the maximum fire flow, plus the peak domestic flow for the duration of the fire minus the peak capacity that the system can put out for the fire duration. A common maximum storage figure is 30% of the peak day design flow. This storage figure for a population of 5000 is 5000 x 650 x 30% = 0.975 million gallons, and 1.95 million gallons for a population of 10,000.

Fire flows are determined by using a formula created by the National Board of Fire Underwriters. The formula is $G = 1020\sqrt{P}\,(1-0.01\sqrt{P})$ where G is the necessary demand for extinguishing in gallons per minute, and P is the population in thousands. Thus Table 2W.-3 shows the required fire flow for a population of 5000 is 2,250 g.p.m. for a duration of 9 hours, and 3000 g.p.m. for 10 hours for a population of 10,000 in the business district,[3] 1000 gpm fire flow is used in the residential areas.[3] Each hose stream is rated at 250 gpm.[3]

TABLE 2W.-3

REQUIRED FIRE FLOW BASED UPON NATIONAL BOARD OF FIRE UNDERWRITERS' FORMULA (3)

POPULATION	REQ'D. FIRE FLOW, g.p.m. for avg. city(1)	DURATION, hr.
1,000	1,000	4
1,500	1,250	5
2,000	1,500	6
3,000	1,750	7
4,000	2,000	8
5,000	2,250	9
6,000	2,500	10
10,000	3,000	10
13,000	3,500	10
17,000	4,000	10

(1) Each flow is required as follows: over 1,000 g.p.m. but less than 1,250 g.p.m., required duration is 4 hr., etc.

The required fire volume for a population of 5000 is 1.215 M.G. and 1.8 M.G. for a population of 10,000. The existing storage capability for the Town is 250,000 gallons (0.25 M.G.).

Total storage for a Town of 5000 assuming a pumping capacity of 2400 gpm is:

1.215 MG + (3.25 m.g.d. x 9/24) - pumping capacity for 9 hrs.

1.215 MG + 1.22 MG - (3.45 x 9/24) = 1.15 MG

As shown later, the recommended pumping capacity of the proposed water treatment plant will be 2400 g.p.m. or 3.45 M.G.D. for the first phase of construction, and 4500 g.p.m. for the second. The recommended storage for a population of 5000 is 1.200 M.G., and 1.8 M.G. for a population of 10,000. Therefore with this recommended storage, the Town should be able to fight the worst fire, and simultaneously pump the maximum peak day demand.

Water Quality, Quantity and Source of Supply

The source of water supply for the Town is the upper headwaters of the North Platte River. The river flows in several shallow channels through the area. Several underground mineral hot springs exist in the area near the existing water treatment plant and also contribute to the river flow.

The volume of flow varies during the year reaching its peak in the Spring and early Summer months, then leveling off during the other months. The volume required for supply is determined by the demand as discussed previously. The Town presently has a water right of 2 C.F.S. or about 900 g.p.m. of water from the river, through permit no. 21744, dated September 28, 1956.

The water quality is good for the majority of the year, as the source is snow melt from the nearby mountain ranges. Tables 2W.-4 and 2W.-5[21] summarize the volume of flow and chemical analyses of the River published by the U.S. Department of the Interior, Geological Survey for 1967. From these results, it is seen that the water is of good quality.

Turbidity, not shown in the data, is defined as those particles in water which are capable of deflecting light when transmitted through the solution. Turbidity readings have been taken and results are shown in Table 2W-6. Turbidity is caused by tiny particles which are suspended in the water and cause it to appear cloudy, or sometimes discolored. These particles are usually removeable since they are not dissolved in solution. Many methods of removal have been successful, however, the problem is only significant during high runoff periods in the spring and following heavy rains.

The real treatment problem that exists and requires further special discussion later in this report are the organic compounds that exist in the water. The water in the River becomes highly discolored in the spring and summer months when runoff is high. This color is best described as a "weak tea" color. It is caused by a leaching effect of the forest vegetation and humic soils by the snow melt and runoff. The organic compounds in the decaying vegetation are washed out into the water, and become dissolved into solution. These dissolved compounds are very difficult to remove from solution by conventional means. Although the compounds are harmless, they cause the water to become offensive in appearance. In addition, some of these compounds have an undesirable odor, and through the present disinfection processes in the water treatment plant, the compounds often impart a "taste" to the water which is unappealing. Table 2W.-6 also shows results of color sampling of the North Platte River.

Hydraulic Design

When considering a distribution system many hydraulic requirements must be met. These are summarized below:[22]

1. Normal working pressure in the system should be approximately 45-70 p.s.i. and not less than 35 p.s.i.

2. The minimum size water main for providing fire protection and serving fire hydrants must be 6 inch diameter.

3. Dead ends on mains shall be minimized by looping whenever practical and when dead ends occur they shall be provided with a fire hydrant or approved blow-off for flushing purposes.

4. Valves shall be provided to minimize inconvenience during repairs and located at not more than 500 ft. intervals in commercial districts and not more than one block or 800 ft. in other districts.

Distribution piping is designed to provide adequate service and fire protection. A complete hydraulic analysis of an entire system is now practical for systems of this size through use of computers, and the Hardy Cross method of pipe network analysis. This analysis will indicate where pressures are too low, or flows not adequate for fire protection and the suspect lines can be sized or redesigned accordingly. The complete computer printout and assumed flows are shown in the Appendix and the system has been designed using this information.

To provide and obtain the desired system pressures throughout the Town, storage tanks, or booster pumping stations must be so placed and coordinated as to be able to continuously maintain the flows and pressures required throughout the system. Pressure in water systems decreases one p.s.i. for every 2.31 ft. of rise in elevation. Therefore, as the distribution system rises above the pumping source, the pressure will drop 0.43 p.s.i. for every 1 ft. of rise, plus that amount due to friction losses and other minor losses.

Practically all of the pipe flows considered were under pressure. As flow is turbulent (non uniform in its flow characteristics) in pipes used for water supply, the friction factors depend upon the roughness of the pipe and also the Reynolds number, which in turn, depends in part upon the velocity in the pipe and its diameter.[14] Therefore the pipe flow formula used should have a roughness or friction factor which varies with velocity and pipe size. The Hazen-Williams formula was the basis used in the design of the water transmission and distribution system and is written

$$V = 1.318\ Cr^{0.63}\ s^{0.54}\ \text{ft/sec.} = \text{F.P.S. and}$$

$$Q = 1.318\ Cr^{0.63}\ s^{0.54} A\ \text{cu.ft./sec.} = \text{C.F.S.}$$

where V = Velocity in pipe in feet per second

Q = Volume of flow in cubic feet per second

C = A constant depending on pipe roughness

r = Hydraulic radius of the pipe

s = Hydraulic gradient

Hazen-Williams roughness valves used were as follows:

HAZEN-WILLIAMS ROUGHNESS VALUES

TYPE OF PIPE	C
Extremely smooth pipes	140
New steel or cast iron	130
Wood, average concrete	120
New riveted steel	110
Old cast iron	100
Old steel riveted	95
Badly corroded cast iron	80
Very badly corroded iron or steel	60

The Hazen-Williams equation is clumsy to use numerically and thus an alignment chart or "Nomograph" is very widely used and accepted. A typical nomograph is shown in the Appendix.

When considering fire hydrants, spacing requires that fire hydrants be provided at each street intersection and at intermediate points between intersections ranging from 350 to 600 feet. Fire hydrant spacings were designed and checked to provide 120,000 sq. ft. coverage in residential sections and 100,000 sq. ft. coverage in commercial sections. Hydrants must be capable of delivering 500 g.p.m. in residential areas and 1500 g.p.m. in commercial and business districts.(3)

Meters must be considered when designing the distribution system. Many meters are now on the market that can effectively perform the same functions. As mentioned before, meters can cut consumption 50% of that for the system without meters.(3) Therefore, by metering the system, the savings in water would allow more consumers onto the system and treatment-pumping costs would be reduced. Meters also make for a more equitable billing procedure.

Period of Design

General practice in municipal water works design uses the following guides in determining design periods.(4)

Water Mains -	40 to 50 years
Pumping and Treatment Facilities -	10 to 20 years

Piping is generally designed for the longer periods of service because the additional cost for increased capacity in the initial installation is generally small in comparison with the cost required for future construction. Also pipe materials have a life expectancy consistent with this long design period.

On the other hand, pumping and treatment facilities usually require mechanical and electrical equipment which has a much shorter life expectancy. Further, improvements in process design could make present forms of treatment obsolete over a period of a decade or more.

Saratoga, like other impacted towns, is growing at a rate which is very difficult to predict. The design period for pumping, treatment and storage facilities will be shortened or lengthened by the rate at which the Town grows. The design period for the distribution system is relatively unchanged except for its sizing. The quality consistency, etc. of the material used will have a design life of 50 years or more. The design period of the water treatment plant will be affected both by the growth of the Town, and whether or not the Town can be effectively metered.

TABLE 2W-4

U.S.G.S. CHEMICAL ANALYSES OF NORTH PLATTE RIVER AT SARATOGA, WYOMING

PLATTE RIVER BASIN--Continued

6-6270. NORTH PLATTE RIVER AT SARATOGA, WYO.

LOCATION.--Lat 41°27'18", long 106°48'16", at gaging station, 1,000 feet upstream from bridge on State Highway 130 in Saratoga, Carbon County, and 1 mile downstream from Spring Creek.
DRAINAGE AREA.--2,840 square miles.
RECORDS AVAILABLE.--Chemical analyses: April to September 1967.
Water temperatures: April to September 1967.
EXTREMES, April to September 1967.--Dissolved solids: Maximum, 244 ppm Sept. 1-18; minimum, 108 ppm May 23-31.
Hardness: Maximum, 146 ppm Sept. 1-18; minimum, 43 ppm May 23-31.
Specific conductance: Maximum daily, 467 micromhos Sept. 9; minimum daily, 110 micromhos May 26.
Water temperatures: Maximum, 71°F Aug. 10.
REMARKS.--Additional samples were collected for more comprehensive definition of water quality at this station.

Chemical analyses, in parts per million, April to September 1937

Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue at 180°C) Parts per million	Tons per acre-foot	Tons per day	Hardness as $CaCO_3$ Calcium, Magnesium	Noncarbonate	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
Apr. 6-15, 1967...	1130	18		29	9.0	20	2.7	129	0	39	4.6	0.4	0.3	0.04	186	0.25	567	110	4	0.8	304	8.0
Apr. 16-30........	794	13		26	8.1	19	1.4	120	0	33	6.4	.5	.2	.02	168	.23	360	98	0	.8	277	7.9
May 1-22..........	962	12		20	8.4	17	2.1	95	0	26	4.6	.4	.3	.03	158	.21	410	84	6	.8	224	7.6
May 23-31.........	3430	11		12	2.9	10	1.4	60	0	11	2.5	.3	.5	.03	108	.15	1000	43	0	.7	133	7.5
June 1-18.........	4610	12		20	4.6	8.0	1.2	81	0	18	2.8	.4	.0	.06	124	.17	1540	70	3	.4	181	7.3
June 19-30........	4970	12		20	6.9	7.8	1.4	96	0	12	1.1	.4	.0	.06	132	.18	1770	78	0	.4	195	7.3
July 1-30.........	2400	14		30	8.8	13	1.8	133	0	30	3.7	.5	.7	.05	174	.24	1130	114	4	.5	270	7.4
July 21-31........	1110	13		31	8.4	14	2.5	124	0	35	4.0	.5	.7	.05	168	.23	503	112	10	.6	268	7.5
Aug. 1-10.........	610	13		32	7.4	15	2.5	132	0	33	3.9	.5	.3	.06	194	.26	320	110	1	.6	285	7.9
Aug. 16-31........	356	15		37	9.1	18	3.1	142	0	45	5.3	.6	.2	.02	240	.33	231	129	13	.7	332	8.1
Sept. 1-18........	310	16		42	9.7	23	2.7	160	0	59	6.8	.6	.0	.05	244	.33	204	146	15	.8	381	7.7
Sept. 19-30.......	563	14		35	9.2	22	3.1	143	0	49	5.4	.6	.2	.03	214	.29	325	127	9	.9	332	7.9
Analyses of additional samples																						
Apr. 6, 1967......	A1370	13	0.23	31	8.8	19	3.6	127	0	49	5.3	0.4	0.4	0.02	198	0.27	732	113	8	0.8	317	7.5
July 13...........	A1730	15	.37	38	11	18	2.3	142	0	51	4.6	.6	.6	.03	238	.32	1110	140	24	.7	351	7.4

A Discharge at time of sampling.

TABLE 2W-4 - CONT'D.

U.S.G.S. CHEMICAL ANALYSES OF NORTH PLATTE RIVER AT SARATOGA, WYOMING

PLATTE RIVER BASIN--Continued

6-6270. NORTH PLATTE RIVER AT SARATOGA, WYO.--Continued

Specific conductance (micromhos at 25°C), April to September 1967

Day	October	November	December	January	February	March	April	May	June	July	August	September
1							--	247	184	--	271	345
2							--	254	167	--	281	--
3							--	231	153	238	276	--
4							--	242	150	237	--	337
5							--	255	149	233	286	341
6							322	257	146	249	280	347
7							316	260	143	250	286	373
8							315	266	--	260	305	398
9							316	226	156	271	283	467
10							310	201	167	276	288	--
11							292	197	--	275	--	401
12							301	202	183	270	--	393
13							285	202	198	284	--	392
14							288	225	196	281	--	389
15							286	236	202	290	--	374
16							268	240	209	--	309	400
17							275	234	213	293	--	--
18							286	208	327	268	308	393
19							275	--	185	265	313	362
20							280	216	184	--	335	331
21							257	171	188	255	352	317
22							255	160	191	257	336	332
23							270	141	188	259	--	328
24							260	132	202	282	--	--
25							278	132	204	256	332	336
26							282	110	195	255	347	335
27							284	111	197	261	345	306
28							292	124	197	260	--	318
29							282	137	203	268	357	342
30							265	137	214	263	348	330
31							--	150	--	271	346	--
Average							285	196	188	263	--	359

Temperature (°F) of water, April to September 1967

Month	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average
April	--	--	--	--	--	42	41	42	43	43	45	46	42	39	42	43	39	44	46	41	43	40	40	40	41	40	44	46	50	44		42
May	39	40	45	42	46	48	54	49	56	54	50	53	46	46	49	53	58	57	--	57	59	59	58	58	58	48	--	--	--	--		51
June	50	52	53	53	51	51	49	--	48	49	--	52	51	51	50	52	53	55	56	56	55	56	56	53	53	56	56	55	56	59		53
July	--	--	64	59	61	62	61	65	68	63	64	62	65	67	64	--	64	62	61	--	63	66	64	67	69	69	65	65	65	67	66	64
August	70	66	65	--	69	63	65	65	64	71	--	--	--	--	--	59	--	68	63	70	63	69	--	--	68	61	70	--	63	--		--
September	--	--	--	--	--	--	--	--	--	--	--	--	50	52	49	51	--	49	45	48	50	52	54	--	54	56	49	49	51	56		--

TABLE 2W-5

U.S.G.S. CHEMICAL ANALYSES OF NORTH PLATTE RIVER AT SARATOGA, WY.

6-6270. NORTH PLATTE RIVER AT SARATOGA, WYO.

LOCATION.--Lat 41°27'18", long 106°48'16", in SE1/4SE1/4 sec.11, T.17 N., R.84 W., Carbon County, at gaging station, 1,000 ft upstream from bridge on State Highway 130 in Saratoga, and 1 mile downstream from Spring Creek.
DRAINAGE AREA.--2,840 sq mi.
RECORDS AVAILABLE.--Chemical analyses: April to December 1967 (discontinued).
Water temperatures: April to December 1967.
EXTREMES, October to December 1967.--Dissolved solids: Maximum, 308 mg/l Oct. 21-31; minimum, 224 mg/l Oct. 1-20.
Hardness: Maximum, 190 mg/l Nov. 24-30; minimum, 142 mg/l Oct. 1-20.
Specific conductance: Maximum daily, 605 micromhos Nov. 28; minimum daily, 318 micromhos Oct. 8.
Water temperatures: Maximum, 15°C Oct. 3; minimum, freezing point Nov. 6.

CHEMICAL ANALYSES IN MILLIGRAMS PER LITER, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	TIME	DIS-CHARGE (CFS)	SILICA (SIO2)	TOTAL IRON (FE)	CAL-CIUM (CA)	MAG-NE-SIUM (MG)	SODIUM (NA)	PO-TAS-SIUM (K)	BICAR-BONATE (HCO3)	CAR-BONATE (CO3)	SULFATE (SO4)	CHLO-RIDE (CL)
OCT.												
01-20	--	458	15	--	39	11	19	2.4	139	0	61	7.4
21-31	--	382	17	--	51	13	30	2.6	154	0	107	11
NOV.												
01-23	--	414	18	--	44	11	21	3.1	154	0	61	7.3
24-30	--	319	22	--	53	14	27	3.1	177	0	93	4.5
DEC.												
01-14	--	336	20	--	48	14	24	2.4	162	0	83	7.8
15-31	--	248	20	--	43	11	18	2.2	154	C	55	6.0
WTD. AVG. TIME	--	--	18	--	45	12	22	2.6	153	0	71	7.5
WTD. AVG. TONS	--	370	18	--	45	12	22	2.6	154	0	71	7.4
PER DAY	--	--	18	--	44	12	22	2.6	152	0	71	7.5
ANALYSES OF ADDITIONAL SAMPLES												
OCT.												
04...	1005	414	15	.18	36	8.6	16	2.8	140	C	41	6.7
06...	0730	540	15	--	41	8.6	19	2.1	131	0	58	7.4

TABLE 2W-5 cont'd.

U.S.G.S. CHEMICAL ANALYSES OF NORTH PLATTE RIVER AT SARATOGA, WY.

6-6270. NORTH PLATTE RIVER AT SARATOGA, WYO.--Continued

EXTREMES, April to December 1967.--Dissolved solids: Maximum, 308 mg/l Oct. 21-31, 1967; minimum, 108 mg/l May 23-31, 1967.
Hardness: Maximum, 190 mg/l Nov. 24-20, 1967; minimum, 43 mg/l May 23-31, 1967.
Specific conductance: Maximum daily, 605 micromhos Nov. 28, 1967; minimum daily, 110 micromhos May 26, 1967.
Water temperatures: Maximum, 22°C Aug. 10, 1967; minimum, freezing poing Nov. 6, 1967.
REMARKS.--Daily samples for chemical analysis composited by discharge. Additional samples were collected for more comprehensive definition of water quality at this station.

CHEMICAL ANALYSES IN MILLIGRAMS PER LITER, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	FLUORIDE (F)	NITRATE (NO3)	BORON (B)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS)	DISSOLVED SOLIDS (TONS PER AC-FT)	DISSOLVED SOLIDS (TONS PER DAY)	HARDNESS (CA,MG)	NON-CARBONATE HARDNESS	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH	TEMPERATURE (DEG C)
OCT.												
01-20	.6	.1	.06	224	.30	272	142	28	.7	371	7.8	--
21-31	.6	.1	.06	308	.43	328	183	37	1.0	489	8.0	--
NOV.												
01-23	.5	.1	.04	242	.34	282	156	30	.7	404	7.8	--
24-30	.5	.2	.10	304	.40	251	190	45	.9	493	8.0	--
DEC.												
01-14	.5	.3	.18	280	.42	281	175	42	.8	463	8.0	--
15-31	.4	.3	.02	232	.35	170	152	26	.6	387	7.8	--
WTD. AVG. TIME	.5	.2	.07	253	--	--	160	35	--	417	7.9	--
WTD. AVG. TONS	.5	.2	.07	255	--	--	161	35	.7	420	7.9	--
PER DAY	.5	.2	.07	--	--	--	--	--	--	--	--	--
ANALYSES OF ADDITIONAL SAMPLES												
OCT.												
04...	.6	.3	.08	196	.30	250	125	10	.6	323	8.1	13
06...	.5	.1	.05	217	.37	394	139	32	.7	360	7.5	10

TABLE 2W-5 cont'd.

U.S.G.S. CHEMICAL ANALYSES OF NORTH PLATTE RIVER AT SARATTOGA, WY.

6-6270. NORTH PLATTE RIVER AT SARATOGA, WYO.--Continued

SPECIFIC CONDUCTANCE (MICROMHOS AT 25° C), WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968
(ONCE DAILY MEASUREMENT)

DAY	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
1.....	--	564	--	--	--	--	--	--	--	--	--	--
2.....	356	403	448	--	--	--	--	--	--	--	--	--
3.....	338	387	--	--	--	--	--	--	--	--	--	--
4.....	419	350	468	--	--	--	--	--	--	--	--	--
5.....	428	--	486	--	--	--	--	--	--	--	--	--
6.....	371	522	432	--	--	--	--	--	--	--	--	--
7.....	--	493	439	--	--	--	--	--	--	--	--	--
8.....	318	462	452	--	--	--	--	--	--	--	--	--
9.....	353	411	433	--	--	--	--	--	--	--	--	--
10.....	363	383	439	--	--	--	--	--	--	--	--	--
11.....	427	376	425	--	--	--	--	--	--	--	--	--
12.....	328	381	436	--	--	--	--	--	--	--	--	--
13.....	339	380	481	--	--	--	--	--	--	--	--	--
14.....	350	353	499	--	--	--	--	--	--	--	--	--
15.....	--	357	382	--	--	--	--	--	--	--	--	--
16.....	348	358	377	--	--	--	--	--	--	--	--	--
17.....	366	369	--	--	--	--	--	--	--	--	--	--
18.....	370	366	386	--	--	--	--	--	--	--	--	--
19.....	371	385	362	--	--	--	--	--	--	--	--	--
20.....	367	385	388	--	--	--	--	--	--	--	--	--
21.....	--	367	370	--	--	--	--	--	--	--	--	--
22.....	--	400	379	--	--	--	--	--	--	--	--	--
23.....	418	--	377	--	--	--	--	--	--	--	--	--
24.....	410	512	--	--	--	--	--	--	--	--	--	--
25.....	502	432	--	--	--	--	--	--	--	--	--	--
26.....	438	465	362	--	--	--	--	--	--	--	--	--
27.....	513	581	366	--	--	--	--	--	--	--	--	--
28.....	--	605	--	--	--	--	--	--	--	--	--	--
29.....	--	472	513	--	--	--	--	--	--	--	--	--
30.....	537	439	--	--	--	--	--	--	--	--	--	--
31.....	577	--	--	--	--	--	--	--	--	--	--	--
AVERAGE	400	427	--	--	--	--	--	--	--	--	--	--

TABLE 2W-5 cont'd.

U.S.G.S. CHEMICAL ANALYSES OF NORTH PLATTE RIVER AT SARATOGA, WY.

6-6270. NORTH PLATTE RIVER AT SARATOGA, WYO.--Continued

TEMPERATURE (°C) OF WATER, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968
(ONCE DAILY MEASUREMENT)

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	AVERAGE
OCTOBER..	--	12	15	12	12	11	--	9	9	9	8	9	6	8	--	4	4	5	6	6	--	--	7	4	6	3	2	--	--	2	3	--
NOVEMBER.	3	3	1	1	--	0	1	1	1	1	4	4	4	4	4	4	3	1	3	1	2	1	--	1	1	1	1	1	1	1	--	1
DECEMBER.	--	1	--	1	1	1	1	1	1	2	1	1	1	1	1	1	--	1	1	1	1	1	2	--	--	1	2	--	2	--	--	--
JANUARY..	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
FEBRUARY.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MARCH....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
APRIL....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MAY......	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
JUNE.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
JULY.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AUGUST...	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SEPTEMBER	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 2W-5 cont'd.

U.S.G.S. CHEMICAL ANALYSES OF NORTH PLATTE RIVER AT SARATOGA, WY.

6-6300. NORTH PLATTE RIVER ABOVE SEMINOE RESERVOIR, NEAR SINCLAIR, WYO.

LOCATION (revised).--Lat 41°52'20", long 107°03'25", in SW1/4SW1/4 sec.13, T.22 N., R.86 W., Carbon County, sampled at railroad bridge 2.3 miles downstream from Interstate Highway 80, 8.9 miles east of Sinclair, and about 12 miles upstream from gaging station.
DRAINAGE AREA.--8,134 sq mi upstream from gaging station, of which 4,073 sq mi is probably noncontributing.
RECORDS AVAILABLE.--Chemical analyses: December 1960 to April 1967, January to September 1968.
Water temperatures: December 1960 to March 1967, January to September 1968.
EXTREMES, January to September 1968.--Dissolved solids: Maximum, 330 mg/l Apr. 7-30; minimum, 126 mg/l June 1-30.
Hardness: Maximum, 195 mg/l Feb. 25 to Mar. 15; minimum, 83 mg/l June 1-30.
Specific conductance: Maximum daily, 579 micromhos Apr. 12; minimum daily, 181 micromhos June 20.
Water temperatures: Maximum, 22°C Aug. 6; minimum, freezing point on many days during February to April.

CHEMICAL ANALYSES IN MILLIGRAMS PER LITER, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	TIME	DIS-CHARGE (CFS)	SILICA (SIO2)	TOTAL IRON (FE)	CAL-CIUM (CA)	MAG-NE-SIUM (MG)	SODIUM (NA)	PO-TAS-SIUM (K)	BICAR-BONATE (HCO3)	CAR-BONATE (CO3)	SULFATE (SO4)	CHLO-RIDE (CL)
JAN.												
10-31	--	247	19	--	44	19	26	2.0	162	0	100	7.8
FEB.												
01-24	--	322	17	--	54	13	29	2.8	159	0	99	8.5
25-29	--	420	16	--	56	13	31	3.2	153	0	121	12
MAR.												
01-15	--	420	16	--	56	13	31	3.2	153	0	121	12
16-31	--	491	15	--	52	12	27	2.8	146	0	102	10
APR.												
01-06	--	754	16	--	43	13	25	3.6	138	0	95	8.3
07-30	--	1200	16	--	48	15	35	4.6	153	0	126	10
MAY												
01-04	--	2030	17	--	34	16	24	3.3	140	0	76	6.4
05-31	--	2780	13	--	27	9.0	14	2.4	99	0	45	3.5
JUNE												
01-30	--	6430	12	--	21	7.3	11	1.8	80	0	31	1.9
JULY												
01-07	--	2330	13	--	32	8.8	15	1.5	119	0	45	3.5
08-31	--	1200	11	-	38	12	20	2.1	148	0	57	3.9
AUG.												
01-23	--	730	13	--	39	12	20	2.2	140	0	61	5.3
24-31	--	434	14	--	44	12	25	2.4	142	0	81	8.5
SEPT.												
01-30	--	361	13	--	45	13	25	5.5	142	0	88	7.9
WTD. AVG. TIME	--	--	13	--	30	9.6	16	2.3	106	0	53	4.0
WTD. AVG.	--	1570	14	--	41	12	23	2.9	136	0	80	6.7
TONS PER DAY	--	--	55	--	126	41	69	10	450	C	223	17

ANALYSIS OF ADDITIONAL SAMPLES

DATE	TIME	DIS-CHARGE (CFS)	SILICA (SIO2)	TOTAL IRON (FE)	CAL-CIUM (CA)	MAG-NE-SIUM (MG)	SODIUM (NA)	PO-TAS-SIUM (K)	BICAR-BONATE (HCO3)	CAR-BONATE (CO3)	SULFATE (SO4)	CHLO-RIDE (CL)
JULY 29...	1625	696	9.0	.13	35	10	19	2.1	134	0	51	5.3

TABLE 2W-6

TURBIDITY AND COLOR FROM NORTH PLATTE RIVER SAMPLES

INTAKE

	Turbidity	Color	pH
4-25-'77	24	55	7.0
4-26	5	5	7.0
4-28	5	10	7.0
5- 2	7	55	7.0
5- 3	6	10	8.0
5- 4	5	10	7.0
5- 9	5	10	7.0
5-10	3	10	7.0

TURBIDITY TESTS

NORTH PLATTE RIVER - 1978

4- 3	320 NTU
4- 4	180
4- 5	105
4- 6	90
4- 7	80
4-10	110
4-11	90
4-12	88
4-13	80
4-18	84
4-19	78
4-20	72
4-21	70
4-25	54
4-26	52
5- 3	92

CHAPTER 3W. - SUPPLY, TREATMENT AND SPECIAL CONSIDERATIONS

The Scope of this Chapter is to provide the design parameters which will govern the types and quality of treatment required by todays public health and drinking water standards.

On June 24, 1977, Congress enacted the National Primary Drinking Regulations as part of EPAs responsibilities under the Safe Drinking Water Act, Public Law 93-523. The regulations define the requirements for treatment and operation of Public Water Systems. The entire Regulation is included for easy reference in the Appendix of this report.

While the Primary Regulations are law and devoted to constituents and regulations affecting the health of the consumers the EPA has also proposed National Secondary Drinking Water Regulations which set recommended standards for maintaining the esthetic quality of drinking water. Although these Secondary Regulations have not yet been enacted as law by Congress, they should be followed as guidelines in the design of supply treatment. The recommended standards set forth in the Secondary Regulations deal with levels of color, taste, odor and corrosion causing agents that when found in excessive quantities, may discourage the utilization of the drinking water supply by the public.

It is intended that the treatment systems recommended in this report meet or exceed the requirements of both the National Primary and Secondary Drinking Water Regulations.

Water analyses have been performed on the raw water supplying the existing water treatment plant by the U.S.G.S. as stated before, and by State and private labs as well. Results from these tests shown in Tables 3W.-1 and 3W.-2 show that for those time periods of testing that the Secondary Regulations are generally met without any treatment except perhaps the iron and manganese content. Iron and manganese can be color causing agents if in high quantities. No tests for the color causing agents (organic compounds) or taste and odor compounds were documented.

W.E.A.I. performed color tests on the raw river water in the Spring of '77 and Spring of '78 as shown in Table 2W.-6. The '77 results ranged as high as 80 color units. On June 2, 1977, a sample of raw water was taken to the University of Colorado in Boulder, Colorado for organic analysis of the colored water. The color in the sample was 60 color units. It was possible through mass spectrophotometry to measure the mass quantity of organic compounds in solution. The total organic carbon, TOC, was measured at 10 p.p.m., a high level for a good quality river. These organic compounds are in great part responsible for the color of the water. In addition when combined with chlorine during the disinfection process, these compounds cause odor problems. The results of the testing in Boulder is documented and listed in the Appendix.

The fact that the raw water being used for the supply is a good source most of the time,makes further treatment more simplistic. The results obtained from treated water testing show that many of the Primary Regulations are being met with the existing treatment processes. Again, color and turbidity measurements have not been documented.

Our testing shows raw and finished water turbidity to range from as high as 100 J.T.U. in the river and 15 J.T.U. in the treated water, and color to range from 80 in the river to 55 in the treated water. It should be pointed out that color and turbidity are difficult to separate for analytical purposes. Color is often in dissolved form, while turbidity is suspended in solution, and filterable. The method of measurement is similar for both in that they are measured by their ability to absorb and deflect light when light is passed through a sample containing color and or turbidity.

The special consideration of this report then is to provide a solution for removing the color and turbidity from the water and will be more thoroughly treated in Chapter 6W., Coagulation.

TABLE 3W-1
CHEMICAL ANALYSES OF WATER PRODUCED
AT WATER TREATMENT PLANT

WATER ANALYSIS
Wyoming Department of Agriculture
Division of Laboratories
P.O. Box 3228
Laramie, Wyoming 82070

Lab No. 4-6467

OWNER or USER TOWN OF SARATOGA - Art Williamson, Director, Department of Environmental
ADDRESS Quality, Water Quality Div. State Office Building, Cheyenne, WY 82001
SOURCE
LOCATION
DESCRIPTION
DATE COLLECTED January 18, 1974
DATE RECEIVED January 18, 1974

CATIONS	meq/l	mg/l	ANIONS	meq/l	mg/l
Calcium	2.02	40	Carbonate	0.00	0
Magnesium	0.76	9.3	Bicarbonate	2.43	140
Sodium	0.71	16	Sulfate	0.93	44
Potassium	0.05	2.1	Chloride	0.25	8.8
			Nitrate	0.01	0.3
			Fluoride	0.02	0.4
Total Cations	3.54		Total Anions	3.64	

U. S. PUBLIC HEALTH

	Standard	Found mg/l		Standard	Found mg/l
Arsenic	0.01	Less than 0.007	Barium	1.0	Less than 0.5
Chloride	250	8.8	Cadmium	0.01	Less than 0.001
Copper	1	0.02	Chromium	0.05	Less than 0.01
Carbon	0.2		Lead	0.05	Less than 0.01
Cyanide	0.01	Less than 0.008	Selenium	0.01	0.001
Fluoride		0.4	Silver	0.05	Less than 0.05
Iron	0.3	0.12	pH		7.9
Manganese	0.05	0.07	Conductance		344
Nitrate	45	0.3	Hardness ($CaCO_3$)		140
Phenols	0.001	0.002	Sodium %		20
Sulfate	250	44	Boron		0.02
Total Dis. Solids	500	212	Silica		19
Zinc	5	Less than 0.02			
M.B.A.S.	0.5	0.03			

B.O.D. 5 days mg/l
Colon Bacilli, per 100 cc. M.P.N.

Date January 31, 1974

Charge $ No Charge

Michael [signature]
Director or State Chemist

TABLE 3W-2
CHEMICAL ANALYSES OF WATER PRODUCED AT WATER TREATMENT PLANT

CHEMICAL & GEOLOGICAL LABORATORIES

P. O. Box 2794
Casper, Wyoming

WATER ANALYSIS REPORT

OPERATOR	Western Engineers & Architects	DATE	December 17, 1976 LAB NO. 22064
WELL NO.	Water Plant Clear Well	LOCATION	
FIELD	Town of Saratoga	FORMATION	
COUNTY		INTERVAL	
STATE	Wyoming	SAMPLE FROM	Clear Well (12-10-76)

REMARKS & CONCLUSIONS:
Total hardness as $CaCO_3$, mg/l - - - - - - - - 156
Fluoride (F), mg/l - - - - - - - - - - - - - 0.32

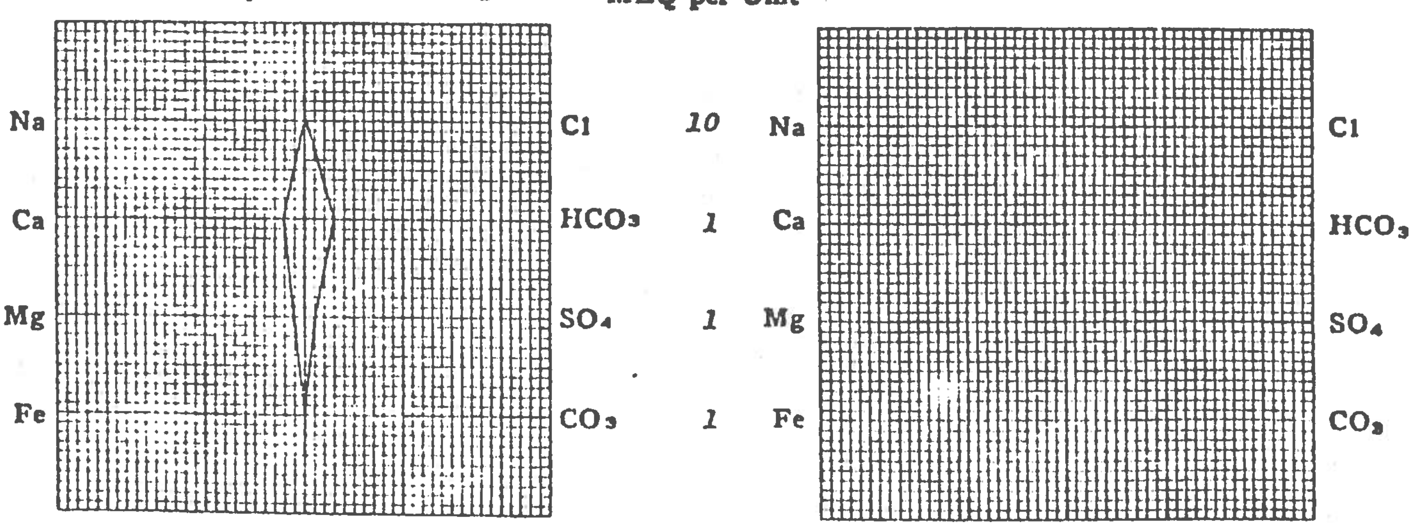
Cations	mg/l	meq/l	Anions	mg/l	meq/l
Sodium	30	1.30	Sulfate	60	1.25
Potassium	3	0.08	Chloride	16	0.45
Lithium			Carbonate	-	
Calcium	41	2.05	Bicarbonate	171	2.80
Magnesium	13	1.07	Hydroxide		
Iron	-		Hydrogen sulfide		
Total Cations		4.50	Total Anions		4.50

Total dissolved solids, mg/l	247	Specific resistance @ 68°F.:	
NaCl equivalent, mg/l	190	Observed	28.0 ohm-meters
Observed pH	7.5	Calculated	30.0 ohm-meters

WATER ANALYSIS PATTERN

Sample above described

Scale
MEQ per Unit



(Na value in above graphs includes Na, K, and Li)
NOTE: Mg/l = Milligrams per liter Meq/l = Milligram equivalents per liter
Sodium chloride equivalent = by Dunlap & Hawthorne calculation from components

CHAPTER 4W. - COLLECTION

When designing collection of the water supply to be treated, the ease of collection and quality of collected water must be given strong consideration. The water source is the North Platte river, the quality has been discussed previously. It is recommended that the Town utilize a backwashable infiltration gallery type of collection system built under the river bottom. The river quality is generally good for 9 months out of the year, and thus lends itself to this type of collection system. A backwashable infiltration gallery is best described as a horizontal well that collects water along its entire length. They are constructed with sand and gravel packing and thus filter out many of the particles that usually require coagulation in conventional treatment processes.

Infiltration Galleries

The proposed backwashable infiltration gallery built under the river is recommended where turbidities are low and last for a short duration of less than three months during low water usage periods. Backwashable infiltration galleries are in common use throughout the world.[30] W.E.A., Inc. experience with high country runoff has shown the sytem to have some distinct advantages for collecting water:

1. The natural stream flow carries most of the turbidity on downstream.

2. The resulting filtered water has turbidity units of less than 5 J.T.U. even when the river turbidity is quite high.

3. When the river bed seals and infiltration decreases, a gentle backwashing will restore the gallery to maximum capacity. Such a system was installed in the Big Horn River for the Town of Thermopolis in 1961. The design capacity was 3500 gpm and after 11 years of operation the capacity was not changed. The Big Horn River has suspended sediment loadings for short durations of as high as 20,000 J.T.U.

4. The need for coagulation of turbidity is greatly reduced.

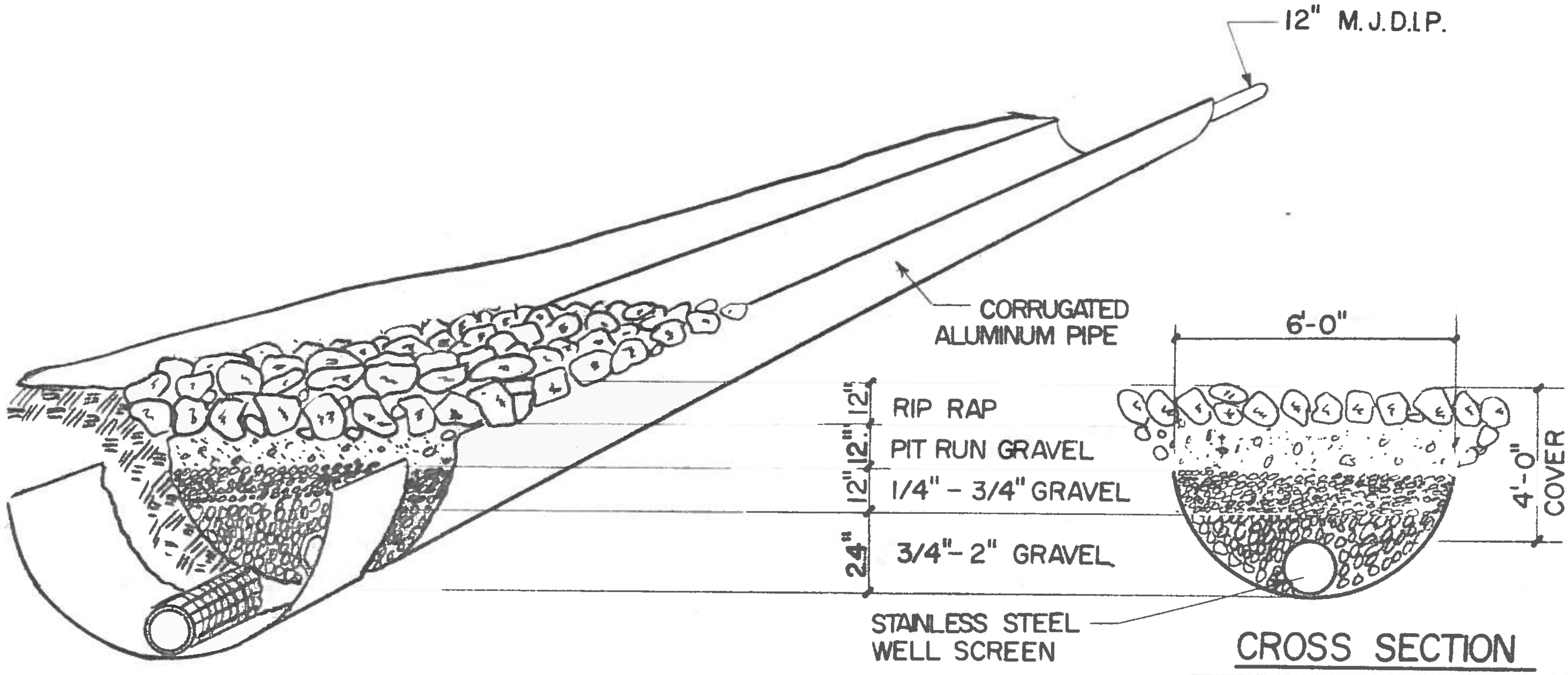
5. The simplicity, low initial cost, adaptability for automation and extremely low maintenance costs preclude consideration of any type of system involving chemical treatment.

However, color normally cannot be removed or substantially reduced by a backwashable infiltration gallery.[(8),(31),(32)]

The chief objection to infiltration galleries is that with continued use, capacity normally decreases. A properly designed backwashable system eliminates this problem. Design is similar to that used for rapid sand filtration,if the system is installed as shown in Fig. 4W.-1, except the backwash rate is reduced to about 6 g.p.m. per ft^2. The backwash water cannot be chlorinated, as the chlorine may endanger fish and other aquatic life.

Although many feel that this infiltration system is a horizontal well, the backwashable infiltration gallery is actually classified as a surface intake. The Towns present water right is a surface right for 2 C.F.S. Design of the new intake system should include appropriation enough for a population of 10,000. As shown in a previous chapter, the water demand for a Town of 5000 is 3.25 MGD or 2257 g.p.m. and 6.50 MGD or 4514 g.p.m. for a population of 10,000. Phase I of construction, the intake is designed for 2400 g.p.m. and will be easily expandable to 4800 g.p.m. for Phase II. And therefore, the Town should apply for a water right of (4800 g.p.m.) 8.70 C.F.S. in addition to the 2 C.F.S. already appropriated, for a total right of 10.7 C.F.S.

The infiltration sytem recommended can be either fully automated, completey manual, or any combination thereof. However, the additional maintenance for a "semi-automatic" system will be more economical in the long run than the cost of fully automating the system. Therefore it is recommended that a "semi-automatic" system, i.e., one that is operated automatically with push button manually initiated control, be constructed.



DETAIL OF INTAKE LINES UNDER RIVER

WESTERN ENGINEERS - ARCHITECTS, INC
801 N SUN DR
CASPER WYO. 82601

Fig. 4W-1

(NO SCALE)