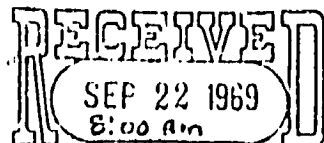


998-2

1. Considered NOVEMBER 12, 1969
2. Name of Applicant CITY OF WALL
3. Post Office Address _____
4. Amount of water claimed .67
5. Source of water supply GROUND WATER
6. Water to be used for MUNICIPAL
Acres to be irrigated —
7. Water to be diverted and used in PENNINGTON county
~~about~~ _____ miles _____ of IN CITY LIMITS
8. Proof of Publication
Received 10-28-69
Not Received _____
9. Application
Approved _____
Subject to _____
Not Approved _____
Action deferred _____
10. Remarks:

Map No. 865-2 Water Division No. 2 BAD RIVER Div. 1
 (Blank to be filled by the Engineer for the W. R. C.)


APPLICATION FOR PERMIT

STATE WATER RESOURCES COMM.
PIERRE, SOUTH DAKOTA

To Appropriate Water within the State of South Dakota

(NOTE - Draw a line through items not applicable)

 1. Name of Applicant City of Wall
 Postoffice address Wall State South Dakota
 If a corporation show date and place of incorporation _____
2. Method of accomplishing work (contract, employment of others, or by direct labor) Contract3. Name of diversion work Water Well No. 34. Amount of water claimed (cubic feet per second) 0.675. Source of water supply Dakota or Fall River and/or Lakota Formation
 6. Location of point of diversion 50± feet east and 1400± feet north of the west 1/4 corner, Sec. 31, T1N, R16E, and 50± feet east and 1550± feet south of NW Corner, Sec. 8, T1S, R16E County Pennington
7. Annual period or periods during which water is to be used All Year8. Use to be made of water (irrigation, industrial, municipal, commercial, recreation, etc.) Municipal

9. For irrigation use, Total number of acres to be irrigated _____

List below each forty acre subdivision, or lot, or fraction thereof and show number of acres to be irrigated in each.

Land Description	No. Acres Irr.	Land Description	No. Acres Irr.

Attach sheet if more space is needed

 10. Time required to complete construction of water supply system 5 years. Additional time required to complete application of water to the proposed beneficial use 4 years.
11. Choice of newspaper for Notice of Intent to Appropriate Water publication Wall Courant, Wall, S.D.

12. Principal Features of the Proposed Water Supply System.

A. Works proposed to divert water from its natural source. Two (2) wells 3240 foot depth with 1240 feet of 10-inch steel casing and 9-inch steel casing to bottom with 100 feet of 8-inch stainless steel screen, each.

B. Works proposed to transport water to place of use. Install 6,000 linear feet of 8-inch asbestos cement water main with required valves.

C. Works proposed to apply water to beneficial use. 1,000,000 gallon ground storage reservoir

Estimated Total Cost \$ 224,000.00
 Attachments: Attach Form 2A if diversion from a well or dugout, or if storage of water, is proposed. Attach map.
 (See instructions concerning preparation.)

STATE OF SOUTH DAKOTA)

County of Pennington)
 I, CITY OF WALL by A. E. Strandell the applicant, certify that I have read the foregoing application and have examined the attached map and that the matters therein stated are true and that I intend, and am able to complete the proposed construction
Signed A. E. Strandell

Mayor of City of Wall

Subscribed and sworn to before me this 12 day of September 1969
John M. Egan
 Notary Public (or other qualified officer)
 City Auditor

WATER RIGHT APPLICATION APPROVAL

The Water Resources Commission hereby approves Water Right Application No. 998-2
CITY OF WALL P.O. Box 314
 (Applicant) (Post Office Address)
SOUTH DAKOTA With the following modifications:
 (State)

Date of first receipt of application SEPTEMBER 22 19 69
 Date of return to applicant for correction, amendments or changes required — 19 —
 Date of receipt of corrected application — 19 —
 Approved NOVEMBER 12 19 69 Recorded in Book 11 Page 42

WATER RIGHT PERMIT NO. 998-2

The Water Resources Commission hereby grants and issues this Water Right Permit No. 998-2 authorizing the construction of the water use system and the putting of water to beneficial use as stated in the Application and as modified in the Water Right Application approval, subject, however, to the following limitations and conditions:

1. The date from which applicant may claim right is SEPTEMBER 22 19 69
2. The equivalent of at least one-fifth of the work above specified is to be completed on or before MAY 12 19 72
3. The whole of said work is to be completed on or before NOVEMBER 12 19 74
4. The limit of time from proof of beneficial use of water appropriated in accordance herewith is NOVEMBER 12 19 78
5. The water appropriated shall be used for the purpose of MUNICIPAL USE

6. The prior right of all persons who, by compliance with the laws of the State of South Dakota, have acquired a right to the use of water must not be injuriously affected by this appropriation.

7. The amount of the appropriation herein granted shall not exceed .67 cubic feet per second; neither shall it exceed the capacity of the above described water supply system, nor shall it exceed the amount of water needed for ~~beneficial use~~ and if for the irrigation purposes said appropriation must be limited to not more than one acre-foot per year and be ~~limited to not more than one-fifth (1/5) of one acre-foot of water per second of time for each acre of land to which water is~~ MUNICIPAL USE actually and beneficially applied for irrigation on or before NOVEMBER 12 19 78; said water to be used during the following described annual period: CONTINUOUSLY

Witness my hand this 14TH day of NOVEMBER 19 69

WATER RESOURCES COMMISSION

By:

[Signature]
 Chief Engineer, Executive Officer

Certificate of Construction Issued December 16 19 80

Water License Issued December 16 19 80

12. Principal Features of the Proposed Water Supply System (continued.)

D. Well Information or Estimates

(1) Drill Hole, Diameter 9" to 1240', Depth 3240'

(2) Casing, Type Steel Diameter 10" Thickness _____
(wood, concrete, steel, etc)

(3) Perforated Screen.

Type Stainless Steel, Diameter 8", Length 100'

(4) Gravel Pack. Thickness 2", Length of gravel pack. 100'

E. Dugout Information or Estimates.

(1) Surface dimensions _____, Depth _____

F. Fill out for Either a Well or a Dugout.

(1) Water Bearing Materials. (Please attach a copy to test well log if available.)

Character of Water bearing materials Dakota or Fall River and/or
Lakota Formations

Depth to top of water bearing material 3140'

Depth to bottom of water bearing material 3240'

Thickness of water bearing material 100'

Depth to water (ground surface to water level) 460'

(2) Distance to nearest existing household or livestock watering wells.

On same owner's property _____ rds. On property owned by others _____ rds.

G. Water Storage Dams.

If the proposed water use system contains one or more water storage dams, please show in the space below, the height, maximum water depth, surface area and storage capacity of each storage dam. The location of each water storage dam should be shown on the water right map.

CITY OF WALL

A. E. Strandberg, Mayor
Signature of Applicant

STATE OF SOUTH DAKOTA

WATER LICENSE NO. 998-2.

(1) WHEREAS, On the 22nd day of September A. D. 19 69
the City of Wall

made Water Right Application No. 998-2 for a permit to use 67 cubic feet per second of the waters
 of groundwater (one well)

County of Pennington, State of South Dakota, for municipal

purposes; and

(2) WHEREAS, On the 12th day of November A. D. 19 69

Permit No. 998-2, with a date of priority of September 22, 1969

was issued to said applicant 9 for the diversion of said water, and provided for the completion of construction of the water
 supply system therein described on or before the 12th day of November A. D. 19 70 and for the
 application to beneficial use of said water on or before the 12th day of November A. D. 19 70

and:

(3) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota
 relating to completion of the construction of the water supply system and is entitled to divert 33 cubic feet
 per second of water for beneficial use and,

(4) WHEREAS, It is hereby certified that the applicant has complied with the provisions of the laws of the State of South Dakota
 relating to the application of water to beneficial use of the following extent,
for water supplies for the City of Wall

(5) NOW, THEREFORE, by the virtue of the authority vested in us by the laws of the State of South Dakota, W. hereby grant and confirm to the City of Wall

_____ of South Dakota
the holder B and owner H of said permit No. 999-2 a water right, dating from September
22, 1969 to use of .33 cubic feet per second of the waters
of groundwater (one well)

in the County of Pennington and State of South Dakota, or so much thereof as may be necessary for the
purposes hereinabove mentioned, to be diverted at a point approximately 200 feet north and
1900 feet east of the W. of Section 31, T1N, R16E

and conducted ~~XXXXXXXXXX~~ thru the City of Wall's distribution system

for the purpose of municipal purposes

Subject to any limitations listed in Water Right Permit No. 999-2 and subject to the laws of the State of South Dakota.

WITNESS, My hand and seal of our office at Pierre, South Dakota
this 16th day of December A. D.
Nineteen Hundred and Eighty

WATER MANAGEMENT BOARD

By: John Hatch
Chief Engineer, Executive Officer
JOHN HATCH

Permit No. 998-2

Water Diversion No. 2 Bad River Water District

CERTIFICATE OF CONSTRUCTION

This is to Certify, That the City of Wall

_____ the holder _____ of
Permit No. 998-2, issued upon Application No. 998-2, bearing date of priority of September
22, 1969 authorizing the diversion of .33 cu. ft. per second of the waters of _____
groundwater (one well) County of Pennington, State of South Dakota at _____
a point approximately 200 feet south and 1900 feet east of the W $\frac{1}{2}$ of
Section 31, T11N, R16E
_____, for _____ municipal

_____ ve
purposes, has _____ complied with the provisions of the laws of the State of South Dakota relating to proof of
completion of the works of diversion set out and described in said Permit; that said works are found in satisfactory
condition for diverting and conveying to the place of intended use .33 cu. ft. per second of water.

Date December 16, 1980


JOHN HATCH, Chief Engineer
Water Rights Division

Form 6 - Notice of Intent to Appropriate Water

J. 998-2

Publish first publication, on or before October 16, 1969

**NOTICE
INTENT TO APPROPRIATE WATER**

Pierre, South Dakota 57501

September 22, 1969

Notice is hereby given that the City of Wall

~~Wall, South Dakota~~, South Dakota, has made an application in accordance with the provisions of the water laws of South Dakota for a permit to appropriate for beneficial use

.67 cubic feet of water per second of time from the ground water through the

City Wells #3 and #4, the point of diversion of which ~~is~~ ^{are} to be located in the

NW 1/4, Section 31, T1N, R16E and in the SW 1/4, Section 8,

of Section, Twp. 19, Range 16E. Said water to be used for the purpose

of providing irrigation on the following described land:

municipal supplies for the City of Wall

This application No. 998-2 will be considered by the Water Resources Commission at their office at Pierre upon the 12th day of November, 1969, at 2:00 P. M. All interested persons may appear and be heard.

cc: Mrs. Etta M. Crouch, Auditor
City of Wall

WATER RESOURCES COMMISSION

By:

BURTON F. JONES, Water Rights Specialist

Form 8 - Proof of Publication - Notice of
Intent to Appropriately Water

No. _____

PROOF OF PUBLICATION

STATE OF SOUTH DAKOTA)
County Penningson) ss.

I, _____ hereby
certify that the annexed printed copy of Notice of Intent to Appropriately
Water was taken from the Ground deep well

A newspaper which during the whole time of publication of said notice
herein after stated, has been and is printed and published in the _____

Penn. Co. Courier of Wall, S. D.

County of Penningson and State of South Dakota;
that the said notice was published in said newspaper on the following
four dates:

October 2, 1969

October 9, 1969

October 16, 1969

October 23, 1969

R. F. Lewis
(Signature)

Editor
(Title)

October 27, 1969
(Date Signed)

No. 098-2

Publish first publication, on or
before October 13, 1969

NOTICE
INTENT TO APPROPRIATE
WATER

Pierre, South Dakota 57501
September 22, 1969

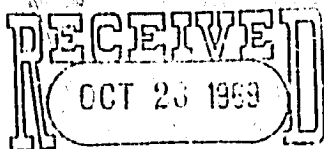
Notice is hereby given that the
City of Wall, South Dakota, has
made an application in accordance
with the provisions of the water
laws of South Dakota for a permit
to appropriate for beneficial use
.07 cubic feet of water per second
of time from the ground water
through the City Wells No. 3 and
No. 4, the points of diversion of
which are to be located in the NW
1/4 NW 1/4, Section 31, T1N, R10E
and in the SW 1/4, SW 1/4, Section 8,
Twp. 18, Range 10E. Said water
to be used for the purpose of pro-
viding municipal supplies for the
City of Wall.

This application No. 998-2 will
be considered by the Water Re-
sources Commission at their office
at Pierre upon the 12th day of
November, 1969, at 2:00 P.M. All
interested persons may appear
and be heard.

WATER RESOURCES COM-
MISSION

By: Burton F. Jones,
Water Rights Specialist
cc: Mrs. Etta M. Crouch,
Auditor
City of Wall

pub. Oct. 2, 9, 16, 23



STATE WATER RESOURCES COM-
MISSION SOUTH DAKOTA

998-2
City of Wall

Place typed "Report of Examination of Works" in folder and hold until final inspection of well No. 4. After November 12, 1974 unless developments indicate otherwise sooner.

1/19
Donald Driscoll

2/18/71

*1561-2
licensed*

RECEIPT

WATER RIGHTS COMMISSION
State of South Dakota

No 4 1818

PIERRE, December 1, 19 50

RECEIVED OF City of Wall, Wall, SD 57790

the following amount in fees for services rendered as provided for by law:

Fee for Application for Permit to Appropriate Water No. _____ (examination, processing, recording and filing) _____		
Fee for Inspecting Construction, and issuing Cert. of Construction No. 590-2	12	00
Fee for Inspecting Beneficial Use, and issuing Water License No. 950-2		
Fee for issuing Location Certificate-Dry Draw, No. _____		
Fee for filing _____		
Fee for certified copy of _____		
Fee for Print copy of map _____		
Fee for Certifying _____		
Fee for _____		
(any other work as provided by law)		
TOTAL	12	00

WATER RIGHTS COMMISSION

By *(John Hatch)*
Chief Engineer, Executive Officer
JOHN HATCH / CH

Permit No. 998-2Water Division 2 BAD RIVER Water District

REPORT OF EXAMINATION OF WORKS AND/OR APPLICATION OF WATER TO BENEFICIAL USE

TO: Water Resources Commission, State Office Building No. 2, Pierre, South Dakota 57501

I have this day made a thorough examination of the water use system constructed by The City of Wallof Wall, S.D. holderof Permit No. 998-2, bearing date of priority of September 22, 19 69authorizing the diversion of 0.67 cu. ft. per second of the waters of ground water (Fall River-Lakota)
for municipal purposes, in Pennington County.I have to report on the condition of the same as follows: Static water level in well is 410' +
Drawdown to 570'
pump setting at 790.7'

The Water Use System consists of,

A. Works used to divert the water:

Well 3160 feet deep
cased with 8 5/8" casing to 800' depth and 4 1/2" casing to bottom, except that
there is a 100 foot, 3 inch diameter stainless steel casing at bottom. Forty
H.P. Reda motor, type 575E-44 and 28 stage Reda pump, Model N.

B. Works used to transport water to place of use,

City distribution system

Two elevated storage tanks, one 100,000 and one 25,000 gallon capacity

C. Works used to apply water to beneficial use.

338 service connections

The system is in the following condition: Exe ExcellentThe point of diversion is located approximately 200 feet south and 1900 feet east of theW 1/2 of Section 31, T1N R16EThe works are capable of diverting and conveying to the place of use 0.33cu. ft. per second of water which is to be used for municipal purposes

Water has been put to beneficial use to the maximum extent as follows:

completed in 1970 and used as indicated since

XX

RECEIVED

FEB 27 1985

DRAFT COPY

**SOUTH DAKOTA DEPARTMENT OF
WATER AND IRRIGATION RESOURCES
OFFICE OF JOURNALING WATER**

PRELIMINARY ENGINEERING REPORT

**WATER SUPPLY ALTERNATIVES
WALL, SOUTH DAKOTA**

MAYOR

DAVID HAHN

COUNCIL MEMBERS

BILL HUSTEAD	DON STRANDELL
NEAL LURZ	STAN ANDERSON
DENNIS SCHONE	JIM KJERSTAD

PREPARED BY:

**UTILITY ENGINEERING CORPORATION
P. O. BOX 2830
RAPID CITY, SOUTH DAKOTA 57709**

DECEMBER, 1984

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SYNOPSIS

The City of Wall presently obtains its water from four wells approximately 3,200 feet deep which draw from the Fall River aquifer. This study was conducted to evaluate the effect of falling static water levels in the Fall River formation on the water supply and to investigate alternative replacement supply systems. The study was based on a review of existing data.

The estimated peak day use in Wall is presently 390,000 gallons and peak day use is expected to grow to 490,000 gallons in the year 2020. Well #1 is not a reliable supply, but Wells 2, 3 and 4 can reliably deliver 490 gallons per minute which produces 470,000 gallons in 16 hours of pumping. The peak day demand can be satisfied with any one of the three operating wells out of service if irrigation is curtailed.

Existing data on the Fall River formation indicate that the static level is falling at about 4.8 to 9 feet per year and is now about 500 feet below the ground surface. Wells 2 and 3 will be affected in 5 to 15 years by the drop in static levels.

Well #4 should operate reliably through the year 2020 without any major modifications.

A study of alternate supplies revealed that the Fall River formation is the most feasible alternative available.

It is recommended that the City proceed with a consistent ground water and well monitoring program to develop data for planning and design. The City should tentatively plan to construct another well similar to the airport well in 1990 with the actual schedule to be dependent on the outcome of the ground water and well monitoring program.

The initial monitoring program is estimated to cost from \$6,000 to \$10,000, and annual costs thereafter are estimated to run from \$1,000 to \$4,000 depending on how the work is completed.

New wells are estimated to cost \$215,000 in 1985 and \$275,000 in 1990.

PRELIMINARY ENGINEERING REPORT

WATER SUPPLY ALTERNATIVES WALL, SOUTH DAKOTA

OBJECTIVE:

This study was completed to:

1. Project future water needs for the City of Wall.
2. Evaluate water production capabilities of existing wells through the year 2020.
3. Investigate alternative water sources.
4. Prepare preliminary designs and cost estimates for recommended improvements.

SCOPE:

Findings and recommendations presented in this Report are based on an analysis of existing data. No field measurements were made as part of this study. Projected population growth and water demands were based on information obtained from the Sixth District Council of Local Governments, previous studies and water system operation records.

Ground water characteristics and geologic data were obtained from:

1. The United States Geologic Survey, Rapid City Office.
2. Dr. Paul Gries
3. Utility Engineering Corporation records.
4. Water system studies and construction reports prepared by Brady Engineering, George Fullerton and Utility Engineering Corporation.

PROJECTED NEEDS:

Current and estimated future water supply needs for the City of Wall are presented in Table I on page 2.

The projected demand rates shown in Table I are based on historical water use as reflected in the Wall Water Department operating records.

TABLE I. CURRENT AND PROJECTED WATER SUPPLY REQUIREMENTS FOR THE CITY OF WALL

<u>Criteria</u>	<u>Estimated Water Demand</u>		
	<u>1984</u>	<u>2000</u>	<u>2020</u>
Average Annual Demand: Million Gallons/Year	45	50	56
Gallons/Day	123,000	136,000	153,000
Peak Month Average: Million Gallons/Day	8.7	9.7	10.8
Gallons/Day	290,000	320,000	360,000
Peak Day: Gallons/Day	390,000	435,000	490,000
Gallons/Min. (Av. 24 Hr.)	270	300	365
Gallons/Min. (Av. 6 a.m. - 10 p.m.)	405	450	550
Peak Instant: (Gallons/Min.)	775	860	970
Minimum Supply Capacity - (Gallons/Min.)	405	450	550
Minimum Supply Capacity with one pump out (Gallons/Min.)	270	300	365

Peak day use dictates how much well capacity is required. The historical peak day demands fluctuate from year to year depending on weather conditions and the volume of tourist traffic. The maximum 24 hour water demand ever recorded was 393,000 gallons in July of 1977. Average annual use is presently about 120,000 gallons per day.

Evaluation criteria used to determine the adequacy of the well water supply system were:

1. The collective well capacity should be adequate to satisfy peak day demands shown in Table I with pumps operating 16 hours a day. This approach insures that reservoirs remain nearly full at all times to provide fire fighting flows and emergency storage.

2. Wells should collectively be capable of delivering peak day demands minus 25% for irrigation loads with one well out of service and the remaining wells pumping 24 hours a day. An analysis of current water use during dry and rainy periods indicated that 25% of the peak day use is for irrigation. It is assumed that irrigation could be curtailed in an emergency.

3. Well pumps should be submerged at least 50 feet under continuous pumping conditions. This is a conservative requirement, but existing data on drawdowns and static levels are not reliable and the safety factor is justified.

4. Reservoir fire fighting and emergency reserves should remain over 50,000 gallons when operating under emergency conditions and 100,000 when all pumps operating.

Minimum water supplies needed to satisfy these criteria are presented in Table I on page 2. Current peak day water demands can be reliably satisfied if the collective capacity of all pumps is at least 405 gallons per minute. A collective capacity of 550 gallons per minute will be needed to satisfy estimated 2020 peak day demands.

EXISTING SUPPLY:

Wall's water supply presently consists of four wells which all draw water from the Fall River formation located approximately 3,100 feet below the ground surface.

Data on each well are presented in Figure 1 on page 4 and Table II on page 5.

The existing wells can collectively deliver up to 675 gallons per minute for short periods, but under sustained pumping, the maximum delivery rate is currently 490 gallons per minute. Well #1 pumps dry under sustained pumping and is no longer a reliable water source.

Water quality in the Fall River formation is good. Table III on page 6 presents comparative water quality data for the Fall River, Dakota and Madison aquifers. The Public Health Service recommended water quality standards are also shown for comparison.

The existing wells presently satisfy all of the evaluation criteria listed previously. Wells 2, 3 and 4, pumping 16 hours a day at 490 gallons per minute, produce 470,000 gallons which exceeds the current estimated peak day demand of 390,000 gallons.

With Well #4 out of service, Wells 2 and 3 can deliver 305 gallons per minute or 440,000 gallons in a 24 hour period. If Well #4 were out of service on a day when peak demands occurred, irrigation would have to be curtailed or fire fighting reserves in the reservoirs would drop to an estimated 20,000 gallons. Eliminating irrigation reduces the demand by an estimated 100,000 gallons which should make it possible to keep the reservoirs nearly full with one well out of service.

TABLE II. SUMMARY OF DESIGN AND OPERATION INFORMATION FOR WELLS 1, 2, 3 AND 4 AT WALL, SOUTH DAKOTA.

DESCRIPTION	WELL NUMBER			
	1	2	3	4
Location	3rd Avenue	"A" Street	City Park	Airport
Year Constructed	1960	1961	1970	1976
Top Casing Depth-Ft. Below Surface	595'	806'	812'	1189'
Present Pump Suction-Ft. Below Surface	580'	763'	765'	920'
Maximum Pump Suction-Ft. Below Surface	580'	791'	798'	1174'
Surface Datum Elevation-Ft. Above Sea Level	2821.44	2842.6	2811.23	2801
Well Capacity - gpm:				
When Constructed	130-150	217	130	200 (1)
Estimated Present (2)	130-0	175	130	200-185
Well Drawdown:				
When Constructed	95' @ 160 gpm	?	125' @ 130 gpm	220' @ 183 gpm
Estimated Present	? (3)	200' @ 175 gpm	175' @ 130 gpm	240' @ 200 gpm
Specific Yield-gpm/Ft. Drawdown (Present)	? (4)	0.88	0.74	0.83
Static Level-Ft. Below Surface				
Original	357-1960	370-1961	450-1970	>480-1976
Most Recent	498-1978	508-1984	498-1984	<463-1981
Estimated Static Level Drop-Ft./Yr.	9'	4.8'	4.8'	?
Pump Horsepower	30	60	40	75
Pump Design Flow and Head (5)	130 gpm @ 600'	217 gpm @ 775'	130 gpm @ 730'	200 gpm @ 870'
Gallons/Min/Hp	4.3	3.6	3.3	2.7

NOTES:

- (1) Well #4 does not have a gravel/pack. Well could produce up to 400 gpm but potential sand problems and pipe hydraulics limit the pumping rate to 250 gpm.
- (2) Based on Superintendent's best estimate. Total short term capacity = 675 gpm. Total sustained capacity = 490 gpm.
- (3) Water level drops below pump suction with sustained pumping.
- (4) No current measurements.
- (5) High water level in reservoir is 2926'.

TABLE III. PREDICTED WATER QUALITY FOR AQUIFERS IN EASTERN PENNINGTON COUNTY AND U. S. PUBLIC HEALTH SERVICE RECOMMENDED STANDARDS.

PARAMETER	FALL RIVER FORMATION	DAKOTA FORMATION	MADISON FORMATION	US PHS STANDARD
Iron as Fe	0.01-0.68	6.1		0.3
Manganese as Mn	0.01-0.11	0.36		0.05
Dissolved Solids	665-714	876	2000 +	1000
Total Alkalinity	284-311	350		400
pH	7.7-8.7	8.6		---
Potassium as K	2.35-3.13	---		---
Sodium as Na	243-257	150		---
Calcium as Ca	2.0-3.4	4.0		---
Magnesium as Mg	0.5-1.0	1.0		124
Nitrate as N	0	0		10
Fluoride as F	2.0	2.0		2.4
Chloride as Cl	10.0-14.0	24		250
Sulfate as SO ₄	213-228	300	500 +	250
Bicarbonate as HCO ₃	346-361	427		---
Calculated Hardness	9	23 ppm		---
Temperature - degrees F	110	100	140	---

The service life of Wells 2 and 3 is limited because of the loss of pressure in the Fall River formation. Dr. Gries analyzed available data from wells in the Wall region and determined that the static water level in the Fall River formation is falling at a rate of 4.8 to 9 feet per year. In reality, the pressures should be falling at the same rate in all wells. The divergence of values indicates that there is measurement error in the data.

A pump submergence of less than 50 feet under sustained pumping conditions is assumed to be a prudent limit for evaluating well reliability. Using the 50 foot limit, Dr. Gries projected that Wells 2 and 3 will reach the 50 foot submergence limit in about 1994 and 2002 respectively. His

analysis assumed that the pumps would be lowered as far as possible in the casing and that the drawdown during sustained pumping will be 200 feet for Well #2 and 175 feet for Well #3.

A more conservative analysis assumes that water levels will be dropping in the Fall River formation uniformly at 6 feet per year (6 feet is the approximate average of all data). At an assumed static water level drop of 6 feet per year, Well #2 will reach the 50 foot submergence limit in 1985 or 1986 and Well #3 will reach the 50 foot submergence limit in about 1991. Both pumps could be lowered about 30 feet which would add about 5 years of service life.

The data on static water levels in the Fall River formation has not been uniformly collected so it is not possible to accurately predict when problems may occur in the wells. The 50 foot submergence limit is also conservative by about 25 feet so the actual service life of Wells 2 and 3 may be extended an additional 4 to 6 years if the City wishes to operate without a safety factor.

It was concluded that the existing wells can be expected to serve reliably until about 1990 if drawdown levels are monitored and pumps in Wells 2 and 3 are lowered approximately 30 feet when pump submergence approaches the 50 foot limit. The existing wells can satisfy peak day demands through the year 1990 with one pump out of service if irrigation is restricted during the emergency period.

ALTERNATIVES:

Several alternative water supplies were investigated as part of this study, but initial cost estimates indicated that the only feasible alternatives involved deep wells into regional aquifers near the City of Wall. Costs of source development, pumping and piping eliminate any source along the Cheyenne River. Wall should continue to work with other communities in rural areas to develop regional water supply concepts. At the present time, there are no viable regional systems being developed which would provide a feasible alternative for the City of Wall.

The Dakota, Madison and Fall River aquifers are all accessible in the Wall region.

The Dakota sandstone aquifer lies approximately 2,715 feet below the surface at Wall and is about 230 feet thick. Logs from existing wells indicate that the Dakota formation could be a good supply, but a perforation test on Well #1 conducted in 1971 produced water very high in iron (6.1 ppm) and manganese (0.36 ppm) and production was relatively low. The

Dakota holds promise and should be investigated further, but at this time it appears that the Fall River is a better source.

The Madison formation lies approximately 4,670 feet below the ground surface at Wall and is approximately 330 feet thick. The Madison can yield good quantities of water, but production rates are unpredictable. Water temperatures would be about 142 degrees so the water would have to be cooled before use. Water quality is acceptable (see Table III on page 6), but the high temperature and high sulfates could be expected to lead to user complaints. Well development costs would be relatively high, but the static water level would be near the surface ($\pm$ 200 feet) so pumping costs would be relatively low.

Based on information and data available at this time, the Fall River formation appears to be the best source of water for the City of Wall through the year 2020. The Fall River formation is a known entity, the citizens are accustomed to the quality and development costs are predictable. The Dakota and Madison aquifers do not offer enough potential advantages to justify the additional investigation costs or potential development risks.

RECOMMENDATIONS:

It is recommended that the City of Wall implement the following work plan:

1. Initiate a consistent ground water and well monitoring program.

Available data are unreliable because they have been collected by different individuals using different techniques. Reliable data on water levels, drawdowns, pumping rates, power consumption and recovery rates would make it possible to properly design replacement pumps to fit changing head conditions; evaluate the condition of pumps; check pump performance against design curves; determine specific yields and plan pump and well replacements. An initial study should be completed which measures the performance on each well during a 24 hour pump test after a 24 hour rest period and then measures the performance of all pumps under simulated peak load conditions. Hydraulic efficiencies and energy consumption should be measured at the same time. Meters should all be calibrated, pressure gauges installed and other preparatory work completed before the tests are initiated. Step pump tests should also be completed as part of the initial testing program to provide background information for future tests.

The Kelley well south of town and other area wells should be used as monitoring wells, if at all possible.

After the initial testing program is complete, annual testing should be carried out using identical procedures. It is possible that the South Dakota School of Mines and Technology could use this program as an annual class project. It is also expected that the United States Geologic Survey and the South Dakota Geologic Survey will provide equipment and professional assistance.

Monthly water records should also be maintained to monitor water levels, drawdowns, pumping rates, hydraulic performance and power consumption.

2. Change replacement pumps to fit new hydraulic conditions. Pumps should not be replaced with identical units because head conditions are changing significantly.

3. Plan to lower the pumps in Wells 2 and 3 at least 30 feet to extend their service life an additional 5 or 6 years.

4. Tentatively schedule a new well for installation in 1990 with actual scheduling to be subject to the monitoring program results.

5. Thoroughly test the Dakota formation when the next well is under construction to evaluate water quality and production potential for this source.

6. Initiate a study by the Insurance Service Office to determine whether or not improved pump delivery rates or expanded reservoir facilities would produce a reduction in insurance costs at Wall.

The existing reservoirs are adequate for supply purposes and will provide approximately 100,000 gallons of fire fighting reserve under peak load conditions.

ESTIMATED COSTS:

The initial water system study will cost an estimated \$6,000 to \$10,000 for labor, equipment, supplies and travel. Annual studies will cost from \$1,000 to \$4,000 depending on how much volunteer help is used.

New wells will be constructed in essentially the same manner as the airport well which cost a total of \$153,000 in 1976. The estimated cost of an identical well in 1985 is \$215,000. Projected costs for identical wells, based on a 5% per year inflation rate, are \$275,000 in 1990, \$350,000 in 1995 and \$450,000 in the year 2000.

SUMMARY:

The four existing Fall River aquifer wells at Wall are currently capable of delivering 490 gallons per minute under sustained pumping conditions of 16 hours per day. This rate produces 470,000 gallons in the 16 hour pumping period which is adequate to satisfy current estimated peak day demands of 390,000 gallons per day. Peak day demands can be satisfied with any one well out of service, but irrigation would have to be curtailed to maintain adequate fire fighting reserves in the 125,000 gallon elevated reservoirs.

Existing data on static water levels in the Fall River formation are not consistent, but it appears that the static levels are dropping at 4.8 to 9 feet per year. At this rate, Wells 2 and 3 will approach critical submergence depths in 5 to 15 years and will have to be replaced. The pump in Well #4 will not be affected by the lowering water levels until after the year 2020.

The Fall River aquifer is the best water supply alternative available for the City of Wall based on information available at this time. It is recommended that the City initiate a ground water and well monitoring program which will produce reliable data for system planning and future design work. The City should tentatively plan to install an addition well similar to the airport well in 1990 with the actual schedule subject to the outcome of the ground water and well monitoring program.

It is recommended that the Dakota formation be tested for quantity and quality when the next Fall River well is under construction to determine if the Dakota is a viable alternative to the Fall River aquifer.

The estimated cost for the initial ground water and well study is \$6,000 to \$10,000 depending on the amount of volunteer help and Government assistance provided. Estimated annual costs for the program are \$1,000 to \$4,000.

The estimated cost for a new well identical to the airport well (in 1985 dollars) is \$215,000. Future well costs, based on a 5% per year inflation factor, are \$275,000 in 1990, \$350,000 in 1995 and \$450,000 in the year 2000.